AMERICAN

HOROLOGICAL JOURNAL,

DEVOTED TO

PRACTICAL HOROLOGY.

VOL. II.

NEW YORK:
G. B. MILLER.
1871.

Union Printing House, 79 John Street, N. Y.

CONTENTS OF VOL. II.

A

B

C

D

E

F

G

H

CONTENTS.

No. I.—JULY.

No. II.—AUGUST.

No. III.—SEPTEMBER.

No. IV.—OCTOBER.

No. V.—NOVEMBER.

No. VI.—DECEMBER.

No. VII.—JANUARY.

No. VIII.—FEBRUARY.

No. IX.—MARCH.

No. X.—APRIL.

No. XI.—MAY.

No. XII.—JUNE.

AMERICAN

Horological Journal.

Vol. II. NEW YORK, JULY, 1870. No. 1.

CONTENTS.

*** *Address all communications for* Horological Journal *to* G. B. Miller, *P. O. Box* 6715, *New York City. Publication Office* 229 *Broadway, Room* 43.

A NEW IMPROVED MERCURIAL PENDULUM.

No. 11 of your Journal contains a communication from Mr. Coffinberry, treating of compensation pendulums. I perfectly agree with Mr. Coffinberry, that it is a great drawback in the mercurial pendulum, that the greater diameter of the column of mercury prevents its being affected and penetrated by changes of temperature as quickly as the comparatively thin rod which it is intended to compensate. But besides this, there is a defect of much more serious character in this pendulum, arising from the different heights in which the compensating parts of it are situated ; the one extending from the point of suspension to about $\frac{7}{8}$ of the total length of the pendulum, while the other occupies a short part of the lower end. A simple experiment will give evidence that these two compensating elements are existing in essentially different temperatures. If you suspend two thermometers on a wall, the one three feet higher than the other, it will be found that in an artificially heated room the upper thermometer shows about 3° R. (= 7 Fahr.) more heat than the lower one, in accordance with well known physical laws. For these two combined reasons, the mercurial pendulum which performs admirably in an astronomical observatory, generally fails in parlors and inhabited rooms. In this particular point the gridiron pendulum offers better chances, because its compensating elements accompany each other nearly in their entire length.

Theoretically, the mercurial pendulum is the most perfect compensation, performing entirely without any frictional resistance, whereas the gridiron pendulum is, to a certain extent, liable to acting by jerks ; for it can be seen that each expansion of the rods is at first checked by the friction in the traverse pieces, and produces a slight deflection of the rods, till the tension of these latter overcomes the friction.

Considering the great advantages to be hoped from the general employment of the mercurial pendulum, only checked by its above-mentioned deficiencies, I thought it an object well deserving earnest study, and made it long since the theme of my meditations in my leisure hours. I hope it will not be without interest for your readers to have the results placed before them, and I also trust that those horologists who have a rich experience in this matter will not think me arrogant when I state it as my opinion that Graham's mercurial pendulum is open to essential improvement. The question to consider is, whether the above-mentioned imperfections are inseparable from the nature of the mercurial pendulum, and I think the best way for investigating this matter will be to treat it analytically.

1. *Is there any reason or necessity for constructing the mercurial pendulum with only one jar?*

According to my opinion, there is not the slightest necessity for it ; on the contrary, several important advantages may be expected by distributing the mercury in more than one jar. The latter will then be thinner and expose a greater surface to the surrounding air, and thus the mercury will be more sensitive to any change of temperature. Besides, there is not so much resistance opposed to a thin jar cleaving the air as to a thick one, and also the eddying of the mercury in a small jar is nothing compared to that in a wide one.

It is surprising, however, that notwithstanding these evident deficiencies, the mercurial pendulum of Graham's arrangement has maintained itself in so great favor in England. The French have been more aware of its weak points, and their best makers construct their mercurial pendulums with 4 jars. The mercurial pendulum of Mr. Winnerl (Paris) has 4 glass jars and may be called a good arrangement. In Saunier's "Treatise on Modern Horology," of which you speak in some of your last numbers with well-deserved praise, there is an illustration and short description of the mercurial pendulum of Mr. S. Vissière (Hávre), constructed with the same number of glass jars, but striking by the exquisite grace and elegance of its arrangement, without sacrificing any scientific advantage, as any one may suppose who is acquainted with the leading principles of Mr. Vissière in his horological productions. I also saw by the kindness of an horological friend in the United States some small woodcuts of clocks manufactured by Messrs. Howard & Co., Boston. Their mercurial pendulums have 3 jars, and show that they have also emancipated themselves from the Graham tradition.

2 *What material is most suitable for making the jars?*

Most of the English makers prefer iron. Some have a jar of cast-iron, which I do not think altogether safe, on account of the porosity of this material, and the readiness with which mercury penetrates through the smallest openings. This point, however, seems to be settled by experience. Wrought-iron or steel is more desirable, and in our time there is hardly any difficulty in getting it of a proper shape for the purpose. Most of the other metals are out of question here, because they enter into chemical action with mercury—even gold and silver not excepted.

Glass jars give a nice appearance to the pendulum by exhibiting the metallic gloss of the mercury, and at the same time its height and movement in the jars. They also facilitate the detection of the air bubbles in the mercury, so injurious to the effect of compensation, which can only be avoided by the utmost care in filling the jars. Glass, on the other hand, is rather liable to injury, rather difficult to get of uniform thickness throughout, and what may be considered the worst of all, it is a bad conductor of heat, thereby retarding the effects of temperature on the mercury. It has been said in favor of the glass that its expansive ratio is much below that of iron, and hence the effect of the linear dilatation of the column of mercury not so much lessened in the glass jar, and consequently the height of mercury required in the glass jar will be less than that which an iron one would necessitate. This argument weighs not very heavy, for I conclude from the circumstances above exposed that it is desirable to have the mercury columns of the greatest height attainable. Besides, the expansive ratio of glass is rather variable according to its composition, while that of iron is more reliable.

For these reasons I incline to the belief that iron jars are preferable for a mercurial pendulum for scientific purposes. If brass and zinc were not liable to deterioration by mercury they would be better still, because their greater expansive ratio demands a still more increased height of mercury.

3 *What material is best adapted for the pendulum rod?*

In this particular point, so far as I know of, all makers coincide in the employment of steel. Steel is a very rigid material and therefor requires but little thickness to make a sufficiently solid rod. The expansive ratio of steel is one of the lowest of all the metals which might be thought of for this purpose. Thus, if a thin rod and a short column of mercury were wished for, there would undoubtedly not exist any better material for the rod than steel. But it seems that we ought to search for the contrary in order to improve the mercurial pendulum, for the conditions of compensation will be all the better if the rod is of the same thickness, or nearly so, with the jars, and if the columns of mercury are of the greatest height obtainable.

From this point of view, I thought I would select a material of great expansive ratio; and of all metals practically applicable here, zinc, expanding three times as much as steel, will answer best. The very inferior strength and rigidity of this material is no impediment to employing it, since we consider a thick rod advantageous for a uniform penetration of the compensating elements by the changes of temperature. The liability of the zinc rod to bending may be overcome by making it a drawn hollow tube and inserting a rod of iron or steel inside.

This arrangement, by the greater weight of the rod and by the required increase of height of the mercury columns, tends to raise the centre of gravity of the pendulum, which at the same time is its centre of oscillation, materially higher than it is situated in Graham's mercurial pendulum, and consequently a pendulum constructed on the principles above described, for vibrating seconds, must be essentially longer than Graham's. But even this is no disadvantage, especially in the United States, where a taste for clocks with large dials prevails, for the pendulum ought to be as much as possible in proportion to the dial.

4. *What relative size of jar is the best?*

When employing three, four, or more jars, it might seem advantageous to make the middle of greater diameter than the outside ones, in order to diminish the resistance of air to the vibrating movement of the pendulum. This advantage, however, is of no great importance, because the resistance of the air is very nearly a constant figure, and, on the other hand, it would be a serious impediment to a good compensation if one or several of the jars were wider than the other ones, because their contents would not receive changes of temperature with the same readiness as the others. Besides, the different capillarities of the jars might also introduce irregularities not easily accessible to calculation. Therefore I think it best to have all the jars the same width. A mercurial pendulum thus arranged will certainly be much less under the influence of the resistance of air than one with only one jar.

The above considerations have led me to the construction of a new mercurial pendulum of about the following dimensions:

	kilogs.	millim.		Eng. in.
Weight of mercury columns.		450	=	17.7
Diameter..................		16.5	=	0.65
Weight of mercury........	5.2			
Outer diameter of the 4 iron jars....................		18.5	=	0.73
Weight of the 4 iron jars...	1.0			
do. frame..........	0.83			
Thickness of zinc rod......		17.5	=	0.69
Weight of do.	1 73			
Total length of pendulum..		about 12.30	=	48.43
Total weight..........	8.26			

It will be easily seen that this arrangement has the following advantages:

1. Equal thickness of the compensating parts, and, in consequence of this, equal sensibility of the same to changes of temperature. (The trifling difference between the diameter of zinc rod and that of iron jars or tubes will be made up by the greater heat-conducting power of the iron.)

2. Considerable diminution of the defect of compensation in the mercurial pendulum, arising from the difference of temperature in the different heights in which the compensating elements are moving. In Graham's mercurial pendulum the mercury constitutes about the sixth part of the length of the pendulum, while the rod, beginning above the mercury, makes up the other five-sixths of it. The above-described improved mercurial pendulum has its zinc rod passing through the frame down to the lower end of the pendulum, and the mercury column constitutes more than one-third of the total length.

3. Reduction of the resistance of the air to the least amount.

The correction of the compensating power of a mercurial pendulum is rather troublesome, especially for smaller differences, and besides the loss of time, it is always followed by an alteration of rate, owing to the addition or reduction of mercury. To obviate these difficulties, I have adjusted into the hollow of the top end of the zinc rod a rod of brass, carrying at its top end the suspension hook. This brass rod occupies a length of about three inches in the zinc tube, and both parts have a number of holes all through, in distances of about one-fourth of an inch, and exactly corresponding with each other. If a pin is put through the topmost of these holes, the acting length of the zinc rod and consequently the compensating power of the pendulum is greatest. By transferring the pin to any lower hole, a corresponding length of brass is substituted for the same length of zinc, and thus the effects of compensation diminished. The expansive ratio of zinc and brass being not very different, this connection will be found sufficiently delicate for very small changes in the compensating power, while it is very easy to operate.

I must confess that I have not had sufficient leisure yet to test the performance of the pendulum made according to these principles, but I think the theoretical principles of it safe enough. At any rate, I believed the matter of sufficient importance to submit it to the criticism of the horological community, after having taken the necessary steps for securing patent rights for this improvement.

MORRITZ GROSSMANN,
Watch Manufacturer.

GALSHUTE, SAXONY, *May* 15, 1870.

——o——

LETTER FROM MR. J. HERRMANN, OF LONDON.

EDITOR HOROLOGICAL JOURNAL:

SIR,—Permit me to thank you for the remittance of the HOROLOGICAL JOURNALS, and the opportunity thus afforded me by your kindness to peruse their contents, which has been to my great pleasure and satisfaction.

Apart from every sense of personal honor, I feel indebted to you for the notice you have bestowed on my paper, entitled *The British Horological Institute, etc.*, in your valuable JOURNAL, and for the manner you have treated your extracts therefrom, in the March number—that being the last I have—thereby supplementing my labors to effect the practical adoption of a proposition from which I sincerely believe great benefit will acrue, and aiding my desire to see such extended upon perfect international principles to all horologists.

I cannot claim the honor of a visit to America, neither did I inquire for or take notice of any facts bearing on the subject, beyond those which were open to my personal observation ; therefore, in as far as my remarks apply to a state of things there, they are not due to any interest or purpose on my part, but simply to a coincidence of circumstances. Believing that simple exposure of any evil, without the application of active stimulants for good, has rather a negative than a positive tendency, I had no object in parading these facts, further than to prove my position in advancing the proposition, that there is a need of better measures, and that the result it promises is desirable. Therefore I do not stop to inquire if the American horological trade is in a better or worse condition than the British or any other, but is it in any position that will still admit of benefit to its members, by the adoption of my proposition ?

Eliciting an affirmative answer to this question from your JOURNAL, I at once disregard all negative difference, looking for and desiring a positive equality.

For this reason—having given this subject serious thoughts—I hope you, sir, and your readers will not consider me assuming if I state that I should be happy to address you again on this point at some future period.

Your closing remarks in your article on *Horological Institutes*, page 274, running thus : "We would like to put this lecture of Mr. Herrmann's before every watch repairer in the land, and we are of opinion that there would be a large demand for works on geometry, and the AMERICAN HOROLOGICAL JOURNAL," remind me of circumstances about which I would beg your indulgence for a few further observations.

That the proposition will tend to a more scientific education among apprentices and workmen, is a principal point in its basis. That such tendency will result in a demand for channels of information, I have no doubt ; but I will not speculate with your valuable space about this question, nor inquire whether a horological workman requires such or not, asking you, sir, and your readers, for the sake of my argument, to grant the supposition (no matter whether real or assumed) that such is needful. Out of this basis rises the question : How is he to obtain it ? or how is such to be imparted to him ? I may here state, that I treat this question in a narrow sense ; that is, the diffusion of scientific knowledge for practical purpose apart from intellectual cultivation; although it must tend to this in effect, yet here I make it secondary. Science is, so to say, a large garden, from which the bouquet of horological science is gathered. To do this presupposes a knowledge which cannot be possessed by an unscientific workman, and hence, as this matter stands, a horological student is compelled to study almost the whole of the sciences in order to find such problems, theories, and axioms, as are applicable to horology, and are of assistance to him in his daily labors. I should be the last to advise any workman not to acquire a knowledge of the whole of the sciences; but this is of course an undertaking requiring labor and perseverance that very few would be inclined to devote to it. What, therefore, is necessary is to put a collection of the sciences, applicable to, and applied to horological objects before the workman. By such a method men of ordinary intellectual capacity and perseverance—both not being synonymous—would have an easy opportunity to obtain some of the most useful scientific knowledge; while at the same time none would be prevented from rising to the highest scientific eminence.

For example: if I take up a book on mechanical or civil engineering, I find that in the outset, the reader—or here better called student—is made acquainted with definitions of terms, and demonstrations of facts, upon which subsequent propositions and calculations are based, so that it is possible for the student to comprehend all subjects under discussion. If, on the the other hand, I take up any work on horology, I find a total departure from this method; either it is endeavored to pursue a mode of explanation that is superficially intelligible throughout, or occasionally the reader is all at once brought face to face with scientific terms, and mathematical formulas, which will perplex and annoy him, but convey no meaning to him. If we consider the principle of the two methods for a moment, we shall easily detect the preëminence of the former over the latter. By the first, the student is supplied with a basis to reason out and calculate, and prove the theory and subjects as they are brought before him; by the latter, he has no other means than to take for granted what he sees in black and white. Should proportions be given in plain figures, he then may prove them in solid material, which is a slow, tedious, and expensive method. By the first, all the powers of the intellect are employed; by the latter, memory only; hence the former is scientific education, while the latter never can be. For these reasons there is a special opening for horological publications, treating its subjects in such a manner; it would open a new field of interest to many readers, and likewise so create a demand, and, on the whole, effect a large amount of good.

It is upon this basis that I pursue my instructions to the classes at the British Horological Institute. Having been apprenticed to the watch trade and engaged at it ever since, I have the advantage over a professed science teacher in a practical knowledge of what a workman requires; hence, I put before him first, the knowledge of such science only that he will require for horological subjects, and then its application. To give examples would require no less than actual demonstration, for which I should have to give definitions or fall into the same fault that I have been condemning; therefore I conclude with this subject by a promise to send you an address upon technical instruction, delivered at the British Horological Institute, which will be published in next number, leaving you, sir, to make such use of it as you think it worth. Begging your indulgence for occupying so much of your valuable space,

I am, Sir,

Yours, etc.,

J. Herrmann.

London, *May* 19, 1870.

[We perfectly agree with Mr. Herrmann in his plan of imparting instruction, and hope he will take an early opportunity of stating his proposition more at length, believing that a large majority of our readers would gladly avail themselves of his practical teachings. So far as the "trade" is concerned in this country, their interest in the entire subject extends as far as their profits are concerned, and no farther; but there are a large number of intelligent workmen who are seeking every means of self-improvement, and it is to them we look for a better state of things.]

THE CHRONOMETER ESCAPEMENT.

There is an opinion prevalent among a large number of the watch-carrying community, as to the chronometer escapement, that it is not the most reliable one for pocket use. The greater number of watchmakers, too, from having had troublesome experiences with it, are perhaps of the same mind. The argument for this opinion derives its greatest strength probably from the fact that so many pocket chronometers have failed to give satisfaction to their owners, because of their frequent stopping, or tripping, as it is expressed, and even experienced workmen have often failed to remedy the evil. While such is the case, it is nevertheless well known that among the best manufacturers of the world the good chronometer is considered as their finest production; that only the most skilful workmen are intrusted with them, and that wherever the most reliable time is required, the chronometer is used. It is admitted that for stationary use it is all that, but for pocket use, where it is necessarily subject to irregular external influences, it is claimed that other escapements, the lever particularly, is much better suited. This might be tested, and the reputation of the good chronometer vindicated as not any more liable to err under the same circumstances; but that is not the object of this article.

Now, it is the writer's conviction, that the cause of so many chronometers being troublesome to the wearers has its foundation in an erroneous construction of some of the parts of their escapements; and the reason why so many workmen are unable to remove it lies in the misfortune of their not possessing a knowledge of the correct principles of the escapement; hence are not able to detect faults, particularly when such are primary ones. It is to this class of chronometers that the following is devoted, and respectfully submitted to the reader.

Not all chronometers are troublesome, and this alone ought to lead the workman to reflect. Next, we can easily distinguish the make and class of chronometers which are troublesome, and that will give us the means of comparison. Badly constructed escapements will often go for a long time without stopping or giving any trouble, and therefore the mere running of a watch cannot be taken as a proof of its being correctly built; but when a watch does stop it is a positive evidence that something about it is not right, and the workman will not be able to discover the wrong unless he has a correct standard to compare it with.

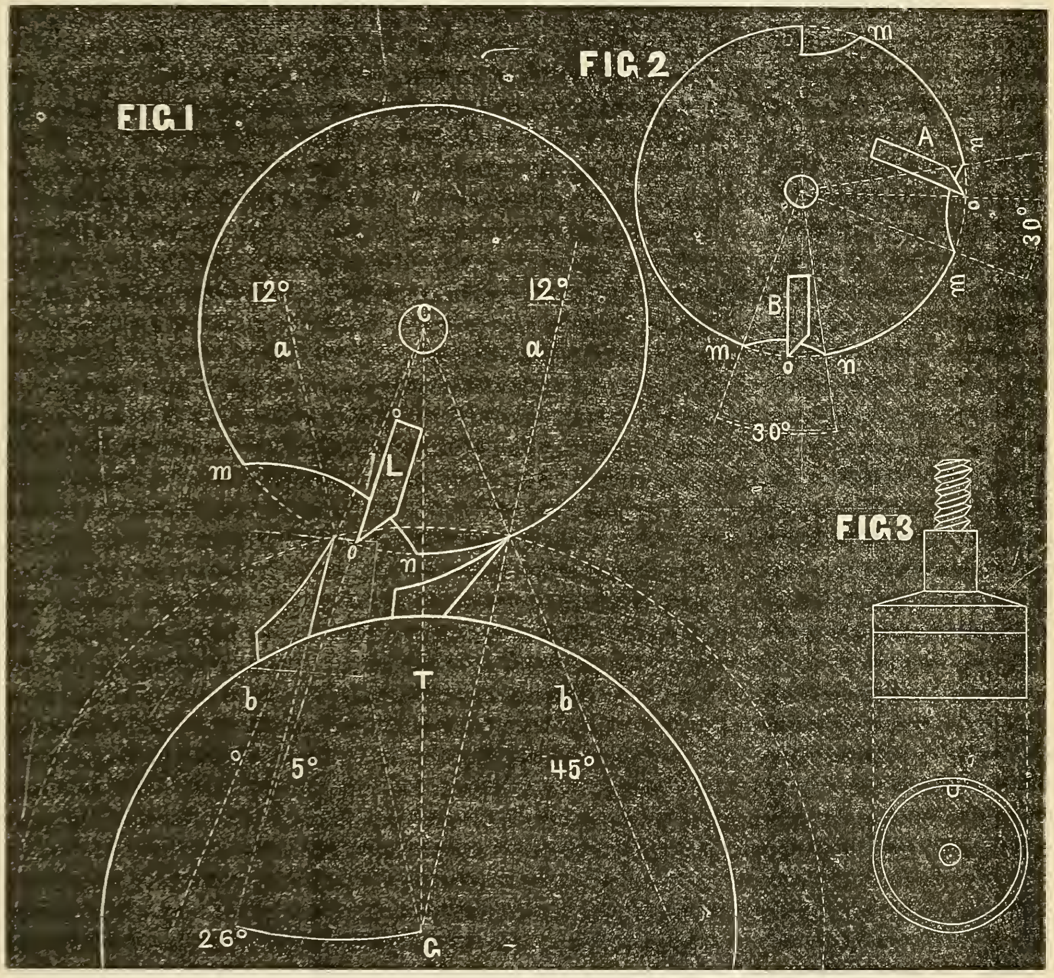
The escapement, when correct, is, like every other part of the watch, constructed according to correct geometrical and philosophical principles, the knowledge of which can be the workman's only safe standard. Now there are a number of chronometers of different makers, among which the well-known "Cowderoy" and "Dixon" are perhaps most prominently known as troublesome ones. If we take one of these and compare it with a "Frodsham," a "Jurgensen," or with one of Morritz Grossmann's model chronometers, as samples, we will find, if everything else in the construction of the escapement as to principle is alike, a difference in the shape and form of the impulse roller. The illustrations will show that difference and serve to explain the consequences thereof.

Fig. 1 shows the development of the two main levers of the escapement and the shape of the roller, according to sound principles. For any given centre distance of escape wheel and balance, with a view to obtain a certain amount of leverage, the relative sizes of wheel and roller are found in the following manner:

It is desired to obtain a leverage impulse of 40°. G, the centre of wheel, and C, the centre of the balance, are connected by a line, T, the distance of which may be *ad libitum.* The wheel has fifteen teeth, therefore the distance between the points of two teeth is $\frac{360}{15}°=24°$. These 24° are laid out by means of a protractor to 12° on each side of the line T, and indicated by lines *a.* Now in addition to the 40° impulse desired, there must be added 5° for the necessary fall, making together 45°, which are also laid out equally on each side of the line T, but from the centre *c*, and marked by lines *b.* Through the points of intersection of these four lines, circles are drawn from the centres G and C, in the peripheries of which the exact proportionate sizes of roller and wheel are found. The roller jewel, L, must be set so that its leverage surface, *o o*, exactly coincides with a straight line to the centre of the roller.

The inclination of the teeth of the wheels to a straight line from the centre of the wheel is generally from 25° to 27° (in diagram 26°), and from this it will be seen that when the roller jewel comes to the position of 5° in front of the tooth, at which time the unlocking of the detent takes place and the wheel falls, the two front surfaces of tooth and jewel will exactly coincide; the tooth will neither fall on its point nor with its front surface on the point of the jewel, either of which cannot but be injurious.

Now for the hollow in the roller which permits the passage of the tooth during the impulse ; and here is where the troublesome



chronometer is generally found wanting. The hollow must be deep enough to allow a tooth of the wheel to pass through without touching, must extend over an arc of the circumference of the roller of 45° (or the degrees of leverage obtained) and be distributed so that two-thirds of it will be from *o*, the point of the roller jewel, to *m*, the commencement of the hollow, and the other third from *o* to *n*, back of the jewel, which will give a space of 30° hollow in front of the jewel and 15° on the back of it. The philosophy of this is as follows : When the balance is slowly moved in the direction from *m* to *n*, and the unlocking jewel in the small roller forms the requisite angle with the impulse jewel in the large roller, the tooth in waiting for the impulse will always fall upon the jewel when 5° in front of it ; but when the balance is allowed to move freely, the velocity which it attains after a few impulses will carry it beyond that point, and the tooth will fall through more than 5° of the arc of the roller. Now it must be borne in mind that the whole movement of the wheel is intercepted between each successive vibration of the balance, and that, however small that may be, the motive power has to overcome a certain amount of inertia in the train after every interception, during which time the balance is moving at an increased rate. Suppose, then, the vibration of the balance to have increased to arcs of 400° or more; the velocity with which it moves then, taking into consideration, too, that it becomes greatest at the centre of oscillation, which is the point where the jewel passes the wheel tooth, will probably carry it to or beyond the line of centre of impulse before the tooth actually gives the impulse, or even actually falls. In that case the tooth will be $22\frac{1}{2}$° of the arc of the roller behind the impulse jewel, and will require that much or more hollow in the roller in front of the jewel in order to clear the point *m* of the roller in its fall; for perfect safety 30° is given it.

By a glance at Fig. 2, which is as near as possible a true representation of the shape of the roller, as well as the position of the impulse pallet of those troublesome chronometers, and comparing the above principles with it, it will at once be apparent to the workman what the whole difficulty is, and what must cause their tripping.

In Fig. 2, the jewel B is so placed that the centre of it (not the leverage surface) is in a straight line to the centre of the roller; and in A it is still worse, standing at an angle to the line, on account of which it will dig out the front surface of the tooth when receiving the impulse; both have but 30° or little more hollow, which at B is divided in half by the front surface of the jewel, and at A not much better. If now, under the above described circumstances, the jewel will, by reason of the velocity of the balance be, carried to the line of centre or beyond before it receives the impulse, both will inevitably collide at the point *m* of the roller and the tooth about to give the impulse, having but 15° or little more clearance; and hence it is that such chronometers will trip more easily when the vibrations of the balance are increased. Now it may be that many chronometers with rollers as in Fig. 2 do not stop; if the train of the watch is a good one, and every thing else perfect so that there is no impediment to a free and perfect transmission of the motive power, it may go without stopping; but the roller is nevertheless constructed badly, and when a watch does stop with such a roller, in all cases a new one must be made, to insure success.

There may be other defects in escapements which may cause their stopping, but seldom such radical ones as the above. The little gold unlocking spring on the detent must be long enough, so that its angular motion effected upon it by the small roller will insure a perfect unlocking, yet not so much as to interfere with the free vibration of the balance any more than cannot be avoided. The locking surface of the jewel in the detent should form an angle of 12° with a straight line from the centre of the wheel, but in Swiss chronometers, where the locking jewel takes the second tooth of the wheel from the roller, and the line of the detent back of the jewel forms at the locking point a right angle with a line from the centre of the wheel, the locking surface of the jewel must be almost in a straight line to the centre of the wheel, and in the best escapements it is found to be so. In all cases the end of the unlocking spring must point directly to the centre of the balance staff when at rest, and to whatever curve it may have been necessary to bend it to suit circumstances, the extremity of it, which is acted upon by the unlocking jewel in the small roller, must again coincide with the straight line of the detent back of its jewel. The tooth of the wheel at rest upon the locking jewel in the detent, should never take more than one-fourth of the width of the jewel. Never work at the detent spring of a chronometer, unless the above conditions are not found in it; one which has never been meddled with is generally in order, for a workman who is not able to make one right, would not be employed by manufacturers on such escapements.

When an escapement of the preceding troublesome class is to be remedied, a new roller must be made. The workman who is called upon to remedy it may not have any experience in making them; and as the writer would recommend to such to learn how to make them, he will proceed to give him the necessary instructions.

First of all, the exact size of the roller must be determined; for this, I would not trust to the size of the old one, but proceed in the following manner—premising that the workman is provided with standard measures on the metric system, as by far the most convenient ones: Measure the diameter of the wheel accurately (the tables of measurement in Grossmann's prize essay on the lever escapement, which every workman ought to possess, will greatly facilitate this); increase its diameter by ten or twenty times, and draw on paper a circle of the diameter of such increased size; then measure the distance from the centre of the wheel, the pivot-hole, to the pivot-hole of the balance staff with a good depthing tool, and increase it also by ten or twenty times, and indicate such increased distance by a line drawn from the centre of the circle outward, and call it line T as in Fig. 1. Now, as in Fig. 1, lay out by means of a good protractor 24° from the centre of the circle to 12° on each side of the line T, corresponding to lines *a* in Fig. 1; through the points of intersection of these lines and the circle, and from the outside end of the line T, draw the lines *b*, as also a circle, and you have found at once the amount of leverage of the escapement and the size of roller required. Now measure the diameter of the last circle, which is the relative size of the roller, and divide it by ten or twenty, whichever you increased the others with, and the quotient will give you the actual diameter of the roller required. The same accurate result could be obtained by trigonometrical calculations, but would require much more experience in calculation. The object of increasing the measurements, as will be seen, is simply to magnify the operation. Now set the obtained diameter of roller down so as not to forget it, together with the amount of leverage found, the latter of which will be the necessary width of the hollow required for the roller.

Next, take the best English round steel, of sufficiently larger size than the roller required, so as to allow it to be turned up true; saw a piece off and file it flat on both sides, and as near to an even thickness as possible. This piece must now be bored and turned up true, which, if the workman is provided with a foot lathe, can best be done on what is called a drum chuck. This chuck is illustrated in Fig. 3, and as it is an inestimably valuable appendage to the lathe, the workman should at once make one. Fig. 3 shows the side and front view of the chuck; it is a common English barrel, fitted to a small lap chuck of the lathe so as to run perfectly true. The lid, as will be seen from the cut, can be removed for the purpose of cementing the work on to it, or examining the same. No better chuck could be used for making jewels, as the lid can be reversed and the other side of the jewel opened without removing it from the cement. For this purpose the seat for the lid in the barrel must run perfectly true, and this is accomplished in the following manner: First, turn the hole in the lid perfectly true on the universal lathe, and with as thin a cutter as will stand the pressure; then gently stretch the outside of the lid by hammering it a little all around the circumference; now turn up a common brass chuck, no matter of how much less diameter than the lid, so that on the end of it you have a projecting centre, like an arbor, perfectly cylindrical, and filling the hole in the lid accurately; not too tight or loose, so as to allow it any play, and be careful that the back of the chuck which is intended for a bearing, is exactly at right angles with its sides; and on to this chuck you now cement the lid with a little shellac, turning the spindle while you are cementing it, and taking care that you bring it solidly against the bearing of the chuck; when cool, turn the circumference of the lid up square and true until it fits the barrel again, but not too tightly. When this is done, remove it; put it into the barrel, centre it from the hole in the lid on the universal lathe again, and turn the lower hole true correspondingly. The lower surface of the barrel, as also the front surface of the lap chuck on to which you want to secure the barrel, must also be turned off perfectly true. This can best be done by means of a slide rest, if the workman has one with his lathe. Now, the chuck must be centred, and a hole bored into it sufficiently large to admit a plug that will, after being turned up true, fit the lower hole in the barrel perfectly, so as not to have to be forced on, nor to have any play when on it. On to this chuck you now secure the barrel by means of three screws equidistant from each other, and in a common circle from the centre, and as far from it as conveniently can be done; this done, pull out the plug which was used for a centre of the barrel, when the whole chuck is finished, and the workman will never regret the trouble of making it.

If, then, the workman has such a chuck, the piece of steel intended for the roller must now be cemented on to the lid, which, for convenience, can be taken off; and care must be had not to put too much cement on; move the piece a little to and fro while the cement is yet warm, applying at the same time a little pressure with a sharp steel, and leave it as near as possible in the centre of the lid; then put the lid into the chuck, applying again a little heat to it, and centre it perfectly by the outside of the piece. It must now be bored; and to obtain a perfectly true hole it should be finished, boring with a small fixed cutter used on the slide rest; or if the workman has none to his lathe, he can remove the lid and do the same on the universal lathe. The exposed side of the roller must now be turned up true, then cemented the reverse way to the lid, and the other side turned true; taking care that it remain still thick enough for grinding and polishing.

When this is done, the piece must be removed, cleared of the cement, and another common brass chuck must be turned up somewhat smaller in diameter than the required size of the roller when finished, and in the same way as before done, for the purpose of turning up the barrel lid true—the arbor point at the end of it fitting the hole in the roller (which must previously have been very nearly adjusted to the balance staff), so that it will go on without forcing, and come up square against the bearing of the chuck; cement the roller on to it, and turn it to very nearly the calculated diameter. If the workman has no foot lathe, the whole operation can be performed with equal precision on the universal lathe. The roller must now be removed from the chuck, cleared again from cement, and the incision for the place of the jewel must be cut. This should be done on a gear cutting machine, if the workman can get access to such an one; and with a cutter which will make an incision as wide as the jewel is thick, so that it will fit in without forcing. Examine the machine, whether the axis of the spindle, which holds the cutter is perfectly horizontal, and at right angles with a line through the centre of the machine. Now, through the centre of the roller draw a line all across the upper surface with a sharp steel; secure it upon the centre of the machine so that this line will coincide with a line through the centre of the machine and at right angles with the cutter spindle; set the latter so that the cutter will make the incision on the right hand side of the line across the roller and just grazing that line; move the rest which carries the cutter spindle up so that the cutter will just touch the circumference of the roller, then mark on the base of the machine on which the rest moves the place by a sharp line drawn across the bar, and move the rest up towards the roller by the feeding screw just the length of the jewel, and proceed to cut the incision by one single cut. If the workman cannot have access to a gear cutting machine, he can do it in the following manner: Prepare two little steel bars, file them flat to pretty nearly the thickness of the roller, make them perfectly straight and square, and after hardening them, smooth one side of each by grinding them on a smooth flat stone, then lay them over the roller, so that the smooth sides will face each other, and one of them just up to the line on the roller, the other parallel to it, just the distance of the thickness of the jewel from it, and fasten them in the vice, leaving the roller to extend above it (the vice) just the length of the jewel; then with a saw of the right thickness the incision can be made, care being had that it be made on the right side of the line across the roller; when this is done, a hole must be bored through the roller directly opposite the centre of the hollow which is to be made for the purpose of enabling you to poise the roller. It should be made as far from the centre as possible without breaking out into the circumference of it;

and here it must be remembered that the point of the jewel must be exactly in the circumference of the roller which has been obtained by calculation, and the roller afterward polished so much smaller, that when it is in action the wheel teeth have one degree play. The roller is now ready (if the jewel fits it rightly) to be hardened and blued. When tempered, the next thing to be done is the polishing of the circumference; this should be done on a live spindle, and on the same chuck upon which it was turned up, and by means of a swing frame attachment, as described on page 118, No. 4 of the Journal (and this is another appendage to the lathe which every workman should make or have made). There are other ways of polishing up a circumference true, without a lathe, but much more troublesome; and as pretty nearly every watchmaker now has a lathe of some kind, or ought to have one, the writer thinks it unnecessary to describe them. When the circumference is polished, as well as the edges taken off and polished, the roller must be finally adjusted to the balance staff. Next, the hollow in the roller must be made, and to do this right, the workman may proceed in the following manner: As before stated, the hollow must extend over an arc of the roller equal to the amount of the degrees of leverage in the escapement. Now, an arc of such extent must be measured off on the roller in this way: Suppose it is an arc of 45°, then 360° are to 45° as the circumference of the circle to the length of the arc; we can find the circumference of the roller by measuring its diameter and multiplying it by 3.141592, then $\frac{C}{360^\circ} \times 45^\circ$. Or, by another rule: The circumference of a circle whose diameter is unity, is 3.141592; if we divide this number by 360 we shall obtain the length of an arc of *one* degree = 0.0087266. If we multiply this decimal by the number of degrees in the arc, we shall obtain the length of that arc in a circle whose diameter is unity; and this product, multiplied by the diameter of another circle, will give the length of an arc of the given number of degrees in that circle. Therefore, $0.0087266 \times 45 = 0.392697$; this decimal multiplied by the diameter of the roller will give the length of an arc of 45° in millimetres and hundredths of millimetres. This length obtained, mark off on the roller so that two-thirds of it will come in front of the impulse jewel, and the other third on the back of it. This done, cut into a pair of old tweezers a V; place the roller between them, so clamping it together with a pair of tongs that not quite the whole length of the arc to be cut will be exposed by reason of the V, and start the hollow with a good half round file till pretty nearly the length marked off. Now turn up a chuck in the lathe to a little less than the diameter of the roller, and cylindrical; apply oil-stone dust and grind the hollow out until it is almost the right size, holding the roller firmly in a pair of tongs against it, and then finish by polishing with rouge or any of the polishing materials, and you will obtain a perfectly circular hollow and highly polished. The roller must now be poised on the balance by means of the hole which was bored into it and which is opposite the hollow, then the sides polished, finally the jewel cemented in with shellac, and it is done.

Now, all this has taken more time to write than it really would to perform the work described; but it must be remembered that it is intended for the benefit of those who wish to learn, not for the learned; and yet it will require all the application of a thinking workman to follow it out in practice. The workman may find it slow work at first, but he must be patient. A watchmaker, above all other mechanics, ought to be provided with an extraordinary amount of patience, and from the almost microscopic accuracy of the work he has to perform, his very nerves must gradually become trained for the utmost carefulness. A man who is not careful, and has no patience, will never make a good workman; but he who can justly be called a good workman, is an artist of no common order. Do not think you will never become a good workman because you cannot do work fast. We hear men boasting of how quickly they can do such and such delicate piece of work, and there is an impression on some people's minds that the fastest workmen are the best. Don't believe it; he who knows by experience what it is to do a piece of work well, will always think it slow work. Work as fast as you can, but work well first.

TH. GRIBI.

WILMINGTON, DEL.

—o—

INFLUENCE OF ELECTRICITY AND EARTH MAGNETISM.

Having in a former article expressed the idea that the hair-spring, as well as the balance, was affected by electricity, I have since gathered the results of experiments made in France and England on the subject, and shall present them to your readers if you deem it acceptable. One of these facts is given by Mr. Vissieu, an eminent French chronometer manufacturer, who says: "From the 26th of June, 1861, having four chronometers in course of rating, I noticed a progressive tendency to slow running (up to the 1st July the weather had been cloudy and stormy), and at first thinking that my astronomical clock was out of order, I made my sidereal observations with a transit and a repetitor circle of Borda, and my observations did not show any difference in the running of the clock. From the 1st of July, and after a heavy thunder-storm, the four chronometers came gradually back to their first running. This effect was illustrated more plainly on board of the steamship New York, whose chronometers were in advance 33′ 58″ on her arrival at Liverpool, in consequence of the ship having been struck by lightning."

And from the *Nautical Magazine* I compile the experiments of MM. Arnold and Dent, on two chronometers where the hair-springs were gold and the balances platinum, silver, and brass. 1. These two chronometers gave under the influence of earth magnetism, a variation twice less than common chronometers. 2. Under the influence of magnetized iron cars, this variation was scarcely perceptible, while other chronometers showed a variation of several minutes. Two other chronometers, one having a gold hair-spring, the other a platinum and brass balance, gave mixed results, the magnetic effect seeming to be pretty nearly equalized between the balance and hair-spring.

A celebrated artist of Switzerland, F. Houriet, having constructed a chronometer entirely without steel, except the main-spring and the several staffs, it was submitted for six days to the action of a magnet able to lift a weight of 30 lbs., and no difference could be detected in the rate. The learned Ansart-Deusy, professor in the Naval Imperial School, sums up a report to the French Academy by saying that the only remedy for the variations produced on chronometers by their place on ships, is to use gold or any other metal but steel for manufacturing hair-springs. This fact has been demonstrated by the regularity of the rates in the chronometers made by U. Jurgensen, who uses exclusively gold for hair-springs.

The practical application of these facts, collected from all parts of the civilized world, seems to suggest the use of another metal than steel for hair-springs. Gold, though very serviceable in ship chronometers, is too heavy for making flat springs, and cannot practically be used in watches. The question, then, would be, to find a metal not any heavier than steel, and as elastic, though the greatest trouble is to find a metal as handy as steel for manufacturing, as most of the compound metals are uneven in texture, and so brittle that they require frequent annealing, thereby increasing greatly the cost of manufacturing. Another practical deduction to be drawn from this known effect of electricity and magnetism on time-keepers is, that no iron or steel should be carried in the watch pocket, since it is well known that a common knife blade will produce a strong deviation on the magnetic needle.

ERNEST SANDOZ.

N. Y. WATCH FACTORY,
SPRINGFIELD, MASS.

—o—

☞ THE NEW YORK WATCH CO.—We are glad to learn that this Company have so far recovered from the effects of the fire as to be again producing watches, and will in the future be able to supply all demands for their goods. The greater portion of their small tools and material having been saved, as was also a building detached from the principal factory, their loss was much less severe than was first reported.

AMERICAN HOROLOGICAL JOURNAL.

In presenting the 1st No. of Vol. II. of the Horological Journal to its friends, the publisher desires to offer his grateful acknowledgment for the very flattering opinions of its merits, as expressed by the majority of its patrons when renewing their subscriptions. We confess to a feeling of pride in this matter, believing, as we do, that no journal published in this country has met with a more hearty endorsement from its readers.

Having in the past allowed the Journal to make its way into public favor strictly on its merits as a practical and scientific exponent of the science of horology, we propose to continue the same line of policy in the future, believing that the intelligent workman will be as sensible of whatever merits it may possess as though we indulged in any amount of self-glorification.

We take great pleasure in presenting to our readers the first of a series of articles from Mr. Morritz Grossmann, of Saxony, the author of the celebrated Prize Essay on the Lever Escapement, and undoubtedly the most scientific practical horologist now living. He has signified several themes on which he proposes to send us communications, and we hope to receive one for each number of the present volume. We have also made him a proposition to translate for our columns the treatise for which he received recently the prize offered by the Board of Trade of Geneva, instead of publishing it in book form as contemplated.

We take the following extract from Mr. Grossmann's letter to show some of the subjects on which he proposes to furnish communications :

"It is with heartfelt interest that I have perused your very ably edited Journal. I congratulate you on so good a beginning, and wish you the success you deserve. I wish to state, without flattery, that I like your Horological Journal, as it has a decidedly scientific tendency.

"I have, since I read your Journal, noted several themes on which I propose to send you communications : On a new and simple mode of rounding wheel teeth in an epicycloidal shape ; On Remontoir escapements and their value; A new Remontoir escapement for turret clocks ; On measuring instruments ; A chuck for centring flat pieces of regular shape (my own invention), etc., etc.

"To make a beginning I beg you will accept the enclosed communication. If you should think it interesting, I would, at a later period, give the calculation of the compensating system, without any mathemathical formulæ, in a plain way, accessible to all who possess the elements of arithmetic. If desirable, I am also ready to furnish the drawing of the pendulum."

We also have the pleasure of introducing to our readers Mr. J. Herrmann, of London, a prominent and active member of the British Horological Institute, whose specialty is that of instructor in practical horology. We gave in the March No. some extracts from a lecture delivered by him before the British Horological Institute, and want of space only prevented our quoting him more extensively on that occasion. As he proposes to submit his views to the horologists of this country through the columns of the Journal we shall refrain from any comments at the present time, feeling assured that they will receive a careful consideration from our readers.

As we stated in the outset of our course, the Horological Journal is intended as a means of intercommunication for the practical workmen ; and one of the leading features of the present volume will be practical articles from that source, several of which will be found in the present No. We are indebted to Mr. L. M. Bissell, of Shelburne Falls, Mass., for the article on the Adjustment of Balance Springs, translated from the French. The entire subject of isochronism and adjustments to heat and cold, and position, will receive especial attention in the future, giving not only the best foreign authorities on the subject, but the individual experience of the best workmen in this country. Judging from the letters we have received on this subject, it is one in which a deep interest is felt throughout the country, and we invite all who have made it an especial study to give the result of their labors.

The watch-carrying public are becoming more and more exacting in their demands for the correct performance of their time-pieces, and it is only by arriving at a very high degree of perfection in his business that a workman is enabled to satisfy his customers in that direction—a fraction of a second of daily rate being considered of more importance than a minute was twenty-five years ago.

ISOCHRONAL ADJUSTMENT OF BALANCE SPRINGS.

Of all the adjustments necessary in the parts of a good watch, the most essential to its performance is unquestionably that of isochronism of the balance spring; for if this adjustment is wanting, whatever may be the excellence of the mechanism in other respects, and however labored its workmanship and other adjustments, it will assuredly disappoint the expectation of the artisan, who will find it impossible of being regulated to preserve the same rate of going in the various positions in which it is liable to be placed.

Suppose, for instance, that by comparison with a reliable regulator the going of a well-made watch is right during twelve hours in four vertical positions where the friction is greatest, and the arc of vibration of the balance considerably diminished in extent (the positions being with the hours 12, 6, 9 and 3 upwards during three hours each), and that it keeps correct time in all these positions, but that in the horizontal position, or with its face upwards, with larger arcs of vibration, the watch gains one hundred and twenty seconds in twelve hours, the friction being lost in the horizontal positions, and consequently the arcs of vibration of greater extent. The proper remedy in such a case is to make a correct isochronal adjustment of the balance spring. A person unacquainted with the adjustment would, however, fail to discover what the true remedy would be, and would follow the plan usually resorted to, in which, by lightening the balance at the twelve o'clock part the times of the vibrations in the hanging and lying positions would be accommodated to each other, but not without increasing in the other three vertical positions, to the great detriment of a nearly perfect watch. Thus it is that many watches, which are fair specimens of workmanship, are frequently injured by false adjustments, and fail to preserve for their makers either credit or satisfaction.

Isochronism is an inherent property of the balance spring, depending entirely upon the ratio of the spring's tension, following the proportion of the arcs of vibration. A balance spring, therefore, of any force whatever, having the momentum required by the law of isochronism, will preserve this property, whether it be applied to a balance having quick or slow vibrations; for which reason, in the present inquiry, every consideration is purposely omitted which gives to the balance its specific character—such as weight, diameter, etc., and it is treated simply as the balance.

Most writers on isochronism consider the vibrations of the balance in its totality, and they have reasoned for the most part on the time of vibrations in their entirety; but a better plan would be to consider the time of each semi-vibration of the balance to consist of some number of minute equal portions of time, and then, by applying the known laws of forces to the balance, to determine what are the specific conditions under which the vibrations themselves shall in their totality become isochronous. The elastic force of the spring belongs to that class of powers called continuous, because the action is not by a single impulse, which then ceases, but by a number of consecutive impulses following each other in such rapid succession as to constitute an uninterrupted and continuous force, but which force is uniformly increasing during the bending of the spring, and uniformly decreasing during its unbending.

The first step towards the comprehension of isochronism is the recognition of the accelerated and retarded motion of the balance; for which purpose it must be followed, step by step, through the entire vibration, on the supposition that the time of each semi-vibration is divided into or composed of any convenient number of equal parts—say ten. If, then, the balance be supposed to be moved by the fingers from the point where it will stand when at rest, over an arc of any number of degres, and be there held, it will be presumed that the spring is wound into tension, and acquires an amount of elastic force proportionate to the angle over which it is inflected, which force is then resting against the finger by which the balance itself is held in a state of rest. By the arc or angle of inflection of a spring is meant the arc passed over by the inner end of the spring, which is pinned into the collet; which arc is always equal to that passed over by any point in the balance when moved from the point of rest. The instant, however, that the finger is withdrawn, the elastic force of the spring will be exerted in overcoming the absolute inertia of the balance, and at the expiration of the first short period of time, or one-tenth of the time of a semi-vibration, the spring will have communicated a slight motion to the balance, and during the second tenth the force of the spring is exerted against the balance in motion, instead of at rest, as it was at the commencement of the first tenth, and will necessarily accelerate the motion that the balance had previously acquired, and so on during each succeeding tenth ; the elastic force of the spring continually decreasing, and constantly accelerating the motion of the balance. The balance having thus returned to the position from which it was moved by the finger, the first half of the vibration is fully completed, and a change of circumstances takes place. The spring which continued to communicate motion to the balance until its whole force had been transferred to it, has now, for an instant, resumed a state of rest. The balance has also assumed a new character, having acquired a velocity of motion and momentum sufficient to carry it through the other half of the vibration; and in so doing to force the spring through an angle equal to that which it was originally moved through by the finger, and to give the spring the necessary tension for performing the next succeeding vibration. During the first few tenths of the second half of the vibration the spring has so little tension that its force retards but slightly the force of the balance ; but during the succeeding tenths the tension gradually increases until the spring acquires sufficient force to entirely arrest the motion of the balance at the same extent of arc on the other side of the place of rest as that to which it was originally moved by the finger.

The specific conditions under which the vibrations themselves, considered in their entirety, whether short or long, should be isochronous, are these :

1*st.* If the time of each semi-vibration be conceived to be composed of the same number of very small equal instants of time, and whatever be the extent of the arc traversed, that the first and last of these minute instants of time precisely compared with the commencement and conclusion of each semi-vibration, the vibrations of such balance, whether long or short, will be isochronous—or performed in equal time.

2*d.* The elastic force of the balance spring increases in direct proportion to the angle of inflection by which it is moved into tension ; and here it is obvious that the increasing and diminishing tension which causes the balance to follow a definite law of acceleration and retardation, must itself also follow a definite ratio of increase and decrease in order that the first and last of these very small equal instants of time shall correspond with the commencement and conclusion of each semi-vibration.

3*d.* It is likewise evident that the ratio of change in the tension may be either one that proceeds too rapidly, and consequently produces a vibration in excess, or one which proceeds too slowly and produces a vibration too short; on which account there are two vibrations of the spring which are not isochronous.

4*th.* In the former variety, producing a vibration in excess, the spring acquires a greater amount of elastic force than that which is due to the angle of inflection in an isochronal spring ; hence it follows that the greater the arc of vibration the greater will be the angles of inflection, and consequently the greater the excess of the undue tension. The effect of this undue tension will be to force the balance forward too rapidly during the first half of the vibration, causing it to arrive at its conclusion before the expiration of the time due to the isochronous vibration. A similar effect is produced during the second half of the vibration by the undue excess of tension accelerating the balance before the full number of instants of time have entirely expired. During each semi-vibration throughout the day some of these minute instants of time will be left unemployed, and their accumulated amount will be the amount gained in the long arcs of vibration, in comparison with the same in the short arcs.

5*th.* In the latter variety the elastic force due to the angle of inflection will not be sufficiently great, and the spring will not have requisite tension to carry the balance over the first semi-vibration of a long arc in the time allotted to it, nor to arrest it so soon as the isochronous term of the second semi-vibration requires. Each semi-vibration, therefore, will occupy too large a number of instants in its performance, and the accumulated amount of them throughout the day will indicate the loss during the long arcs of vibration in comparison with the short arcs.

It is evident that however great may be the science displayed in the inflection of the balance spring, it will be valueless in an isochronal point of view, unless it will remain permanently in the state in which the artisan leaves it. For a spring to possess this indispensable property, a high degree of perfection is necessarily required, demanding care in the selection of the material, skill in the manufacture, and science in the application. Springs are for the most part made of steel, hardened and tempered, though some few have been made of gold, of which metal certain alloys have been particularly recommended, but their elasticity is not always to be relied on. The use of glass for springs was suggested by Berthoud, but was ultimately rejected.

Balance springs must possess as perfect and permanent a degree of elasticity as can be attained ; these requisites depending upon the quality, hardness, and temper of the metal, as well as upon the form or shape of the spring. A soft spring gradually changes its form, and losing a portion of its elastic force, becomes unfit for use, causing the watch to lose on its rate. A hardened tempered spring, on the contrary, has a tendency to gain on its rate ; but this must not be considered as a defect, since it is merely the result of the spring having been set during the process of hardening, whereby it has acquired too great a degree of rigidity. This rigidity, however, wears off after a few months' vibration in the watch, which, during this period almost imperceptibly gains slightly upon its rate, in consequence of the increased elastic force occasioned by the increased flexibility of the spring. When the process of hardening and tempering has been properly conducted, the gaining on its rate will be restricted within very narrow limits, and will entirely cease on the spring attaining its maximum amount of flexibility and elastic force.

Correctness of form or shape has been already stated as one of the conditions requisite to insure isochronism. There are two forms of spring in use, viz. : the cylindrical or helix, and the spiral or flat spring. The former is exclusively used in chronometers, and the latter in all other kinds of watches. The cylindrical, which is the simplest form of spring, is turned in by a suitable curve to accommodate it to the size of the collet into which it is fixed, and the upper end of the spring is turned in by a more or less bold sweep, according to the indication of the isochronal adjustment, and is pinned into a fixed stud. The collet vibrating with the balance, that point on the circumference of the collet, when the spring is fastened into it, is inflected through the same extent of arc as the semi-vibration consists of ; and by examination of the action of the spring during the vibration of the balance, it will be perceived that for each portion of the extent so inflected, there is a corresponding increase or diminution of each of the coils of the helix throughout the entire length of the spring, no part whatever being out of action.

In order to test the isochronism of a spring, the chronometer must be in good going order. If the force of the main-spring be then increased by setting up the ratchet, the arc of vibration of the balance will be increased ; or, if the force of the main-spring be lessened by letting down the ratchet, the arc of vibration will be decreased, and may therefore be regulated to any extent desired. Comparisons of rate in the long and short vibrations are then made during an equal number of hours in each by a good clock, and the difference carefully noted, which difference indicates the state of approximation of the spring to isochronism, and points out the remedy, if it needs correction, according to the following rules :

1*st.* If the chronometer be found to lose in the long arcs, it will prove that the tension or elastic form of the spring has not increased to the amount due to the angle of inflection, or semi-arc of vibration. Hence some minute portions of time are lost in each semi-vibration ; in the first by the balance not being carried forward with sufficient celerity, and in the second by the spring not acquiring sufficient force to stop the balance at the isochronous point. The remedy in this case is to shorten the spring, thereby increasing its elastic force and causing its motion to become more rapid ; but as much time is lost by repeated unpinning of the spring, the effect of shortening may be produced artificially, when the state of the isochronism is within the limits which experience points out, by merely altering the form of the upper curve so as to give it a greater degree of expansion.

2d. If the chronometer should gain in the long arcs, in comparison to the time it keeps when vibrating in short arcs, it proves that the tension increases in a ratio beyond that which is due to the angle of inflection. In this case, if it keeps time when the semi-arc of vibration is one hundred degrees, it will gain when it vibrates two hundred degrees; for, instead of having as much force as would compel the balance to vibrate over double the space with double the mean velocity, which would of course occupy the same time, it will possess an excess of tension which will increase the velocity of each semi-vibration, and necessarily shorten the time of performing them ; causing an accumulation of instants, which will be the gain per diem. The remedy for such a spring is to increase the length of the part in action; but this is not always convenient or possible in the isochronal adjustment; but an expedient is resorted to in which an artificial length is given to the spring by compressing the curve of the part bent inwards at the upper end so as to make the curve commence its inward direction at a point a little farther distant from the stud. Before attempting to make any alteration in a spring, it is advisable to examine the state of the curves, more especially when the chronometer gains in the long arcs, as it will sometimes be found that one of the curves is turned abruptly, which has the effect of causing a gain in the long arcs in consequence of the spring abutting so directly against the curve as to leave a part of its length in very imperfect action. The opinion of early writers on the subject was, that in a certain determinate length of wire there are several isochronal points, to either of which a balance may be adapted, according to the motion of the vibrations it is intended to perform. Suppose, for instance, that a cylindrical spring, having ten turns, be found isochronal ; one of these turns (or more) may be taken away, and a point in the spring still be found that will give the required ratio of increasing tension, and produce isochronal vibration.

The spiral or flat spring is less simple in its form than the cylindrical, and although, whatever may be its form, the principles upon which its isochronism depends are not altered, yet there are circumstances which affect its isochronal perfection in so marked a degree that this requires to be particularly noted ; and the more especially so since the spiral springs are more commonly employed than the cylindrical, and their construction involves several points of greater nicety in their manipulation. The proper length and strength of wire having been selected, the manner in which it is turned up into a spiral is important, for in this operation its natural isochronism may be either partially or wholly destroyed. This will surely be the case if there be any small points or elbows in it, or if the spring be so made that during the vibration any part thereof be either inactive or have an imperfect action. Indeed, the absolute necessity for the spring to continue in free and unrestrained action throughout its entire length, and during the whole period of the vibration, cannot be too strongly urged, because an opinion generally prevails that the outer turns do not come into action until near the end of the semi-vibration. With a cylindrical spring there is no difficulty in producing the same extent of vibration on either side of the point of rest. With a flat spring, however, this is not obtained with an equal degree of facility, nor without the closest attention to its form, as well as to the pinning it in, so that it shall not in the slightest degree depart from its natural shape when out of the watch.

A spiral spring, to be turned up correctly, should lie in several close turns towards the centre, springing off into a gentle curve when it is pinned into the collet, and then gradually and constantly expanding in such a manner that each part of the spiral would cross, but nowhere coincide with, a small circular arc drawn from the centre of the collet and concentric thereto. This is perfectly indispensable to isochronism. If, on the contrary, a spiral springs off from the collet, first by a large bold sweep, and then lies in a few close and large turns, it will be very defective in its action, and quite devoid of the isochronal property. In such a spring the middle of the vibrations will not coincide with the point of rest, for the spring will yield readily to the momentum of the balance during the winding up of its coils, and the whole length of the spring will be brought into action, though imperfectly; but during the expansion of the coils, upon the return of the balance, the action of the inner turn will not be exerted against curves which lie across concentric circles, but such as lie in concentric circles, or nearly so, and will therefore abut so point blank against them as to cause no displacement whatever in a portion of the outer turns, thus giving the effect of a short strong spring, which arrests the balance too soon in this part of the vibration. Such irregularities are obviously incompatible with the requisites for producing isochronal vibrations.

The isochronal trial of a flat spring in a watch is more simple than that described for a chronometer, since the balance of a watch is thrown into the long or short arcs of vibration by a mere change of position, which changes the amount of friction, and consequently the extent of arc. In the horizontal position, with the dial uppermost, the friction is least, and the vibrations of the fullest extent; in the vertical, or the position in which the watch is worn, the friction is greatest, and the extent of the vibration necessarily curtailed. The trial is made by the aid of a good clock, by comparing the rate of running during a certain number of hours in a horizontal position, with the mean result of an equal number of hours running in any two opposite vertical positions. For instance, first with the 12 and then with the 6 upward; and then in like manner with the 9 and the 3 upward; the mean result of two opposite vertical positions being required in order to neutralize any slight irregularities that may exist in the poise of the balance. The indication and the application of the isochronal adjustment are the same as those already described for the cylindrical spring, but under greater restrictions. For, as the balances for watches are, for the most part, unprovided with any means by which their inertia may be varied, as is done in the compensation balance, so as to suit the elastic force of any particular spring and the number of vibrations required to be performed in a given time, the spring must not only be isochronal, but of the precise degree of elastic force demanded by the particular balance to be employed. The selection of a spring in this case, within the limits of isochronal adjustment, must be made by trial in the watch.

The great advantage of an isochronal spring is its innate power of resisting the influences which cause any change of ratio—such as change of position, increased friction as the watch becomes dirty, or the viscidity of the oil in low temperatures. It is surprising to see chronometers return from sea with scarcely a change of rate, although they have been going for three or four years, and even longer periods of time, and the vibrations had fallen off to a very small arc in consequence of the oil becoming so viscid that in some instances a slight degree of force has been found necessary to draw the pivot out of the fourth hole. But what is still more remarkable, some of these chronometers, after having been cleaned, have been known to take up their original rate, although with, perhaps, threefold vibration.

The method by which an isochronal spring arrives at such perfection may be thus explained: The spring's elastic force is presupposed to be both perfect and permanent under similar temperatures; for, as has been previously stated, the elastic force diminishes as the temperature to which it is exposed is increased. The elastic force of the spring is counterbalanced by the resistance it meets with in the work it has to perform, which is of two kinds—the inertia of the balance, and the friction of the rubbing parts, to which all machinery is more or less subject. If the spring is assumed to possess a force equal to 100, and that 10 of those parts are requisite to overcome the friction when at a minimum, there will be 90 parts left for action upon the balance. But the friction will vary according to circumstances, although the spring and balance remain unaltered. If, therefore, the spring has power to carry the balance through a certain arc of vibration when the friction is at a minimum, it will have the power to perform the same amount of work when the friction is at a maximum, but the 100 parts of power will be differently proportioned in the execution of the work. Let it be assumed, for instance, that the friction is trebled ; then will there be 30 parts expended in overcoming the friction, and consequently 70 parts only left for action upon the balance, which will necessarily have less extent of vibration. Now, since the isochronal ratio of the spring's tension remains unaltered, the commencement and end of every semi-vibration will coincide with the first and last of the minute instants of time comprising the isochronous vibration, which is the condition required for correct performance.

So it is, also, with increased friction ; the elastic force of the balance spring being constantly proportional to the angle of inflection, whatever may be the amount of friction, the law of isochronism remains unimpaired, and friction is only an adventitious circumstance, which affects the extent of the arc of vibration, but not the time in which it will be described.

——o——

CALCULATION OF WHEEL TEETH.

The books written on this subject are all more or less so complicated as to almost entirely exclude them from the understanding of the general repairer. This arises from the fact that their problems and solutions are generally carried out in algebra—a study, unfortunately, that very few repairers are conversant with, as I have proved to my satisfaction by actual observation. Such being the case, and believing that a plain practical treatise on this subject was desirable, I have endeavored in the following article to give rules combining simplicity and precision, and so arranging them that any one with a knowledge of the first four rules in arithmetic can easily comprehend and apply them.

Query.—How many revolutions will the last wheel or pinion in a train make for one turn of the first wheel, the number of wheel and pinion teeth being given ?

Rule.—With the product of all the working pinion leaves multiplied together, divide the product of all the working wheel teeth multiplied together, and the quotient will be the number of turns and part of turns the last wheel or pinion will make for one of the first.

Problem.—Suppose the wheel teeth thus: 100, 80, 60, 50, and the pinions 20, 16, 10, 8. The operation would be

$$\frac{100 \times 80 \times 60 \times 50}{20 \times 16 \times 10 \times 8} = \frac{24000000}{25600} = 937\tfrac{1}{2},$$

this number being the turns of the last wheel in this train, for one of the first wheel. The desired result may also be obtained by dividing each wheel by its working pinion separately, and multiplying all the quotients together, thus:

$$\tfrac{100}{20} = 5;\ \tfrac{80}{16} = 5;\ \tfrac{60}{10} = 6;\ \tfrac{50}{8} = 6\tfrac{1}{4};\ 5 \times 5 \times 6 \times 6\tfrac{1}{4} = 937\tfrac{1}{2}.$$

Problem Second.—Given the number of beats in an hour, the number of wheel and pinion teeth ; required the number of teeth to give the escape wheel so as to obtain the given number of beats an hour. (The balance makes two beats, in most escapements, for every tooth in the escape wheel ; therefore, if the latter have 20 teeth, the balance would make 40 vibrations for every revolution of the escape wheel; if the escape wheel have 15 teeth, then 30 vibrations, etc.)

Rule.—Divide one-half the number of given beats in an hour by the number of turns of the escape wheel or pinion for one of the centre wheel, and the quotient will be the proper number of teeth to give the escape wheel.

Example.—Suppose the number of beats in an hour to be 16,800, and the number of wheel teeth and pinion leaves to stand thus : wheels 80, 60, 56 ; pinions 8, 8, 7 ; by the preceding rule we find the turns of the escape wheel or pinion for one of the centre wheel to be 600. The number of beats in an hour being 16,800, the half of this would be 8,400, and this divided by 600 will give 14—the proper number of teeth for the escape wheel.

Problem Third.—How many hours a watch or clock will run before being again wound up, the number of teeth in the barrel, and the number of turns it can make before the spring runs down, together with the number of the centre pinion teeth, being given.

Rule.—Divide the number of barrel teeth by the number of centre pinion teeth, multiply the quotient by the number of turns the barrel can make, and the product will be the number of hours the watch will go before being again wound up.

Example.—Suppose the barrel to have 96 teeth, the centre pinion 8, and the number of turns the barrel can make to be 3 ; 96 divided by 8 gives 12—the number of turns (or hours) the centre pinion makes for one of the barrel, which multiplied by 3, the number of turns the barrel can make, will give $12 \times 3 = 36$—the number of hours it will go without again winding. If it be desired to have the watch go 30 hours, and the number of turns of the barrel to be 3, the barrel would then have to make 1 turn in 10 hours, and consequently must have ten times as many teeth as the centre pinion. If we choose to have 8 teeth for the centre pinion, the barrel must then have $10 \times 8 = 80$; if 6 teeth, then $6 \times 10 = 60$, etc., etc. When the watch or clock is desired to go a longer time, 8 days for instance, it is necessary to have an additional wheel and pinion, placed between the barrel and centre wheel. We will suppose the barrel to have 96 teeth, the additional wheel to have 80, its pinion 12, and the centre wheel pinion 10 ; it will be seen that the additional wheel makes but one turn in 8 hours, as $\frac{80}{10} = 8$, and the barrel only one turn in $\frac{96}{12} \times 8 = 64$ hours, so that the watch or clock, with $3\frac{1}{2}$ turns of the barrel, will go 8 days. On the same principle it may be made to go a month or a year by adding one or more wheels.

Problem Fourth.—What number of teeth to give the wheels in a train consisting of wheels and pinions so that the last wheel or pinion numbers a given number of turns for one turn of the first wheel.

Rule.—The number of teeth in the pinions must first be chosen and fixed upon, these numbers multiplied together, and with this product multiply the number of turns the last wheel is to make ; this will give such a number that, when divided by single factors, as 2, 3, 5, 7, etc., until the product (continuing each prime number until it no more equally divides) will give such prime numbers that can be multipled together in sets to suit.

Example.—We will choose the number of pinions 12, 10, 8, and the number of turns the last wheel is to make (for one of the first) 200 ; these numbers multiplied together give $12 \times 10 \times 8 \times 200 = 192,000$; this divided by prime numbers gives $192000 \div 2 = 96000 \div 2 = 48000 \div 2 = 24000 \div 2 = 12000 \div 2 = 6000 \div 2 = 3000 \div 2 = 1500 \div 2 = 750 \div 2 = 375 \div 3 = 125 \div 5 = 25 \div 5 = 5 \div 5 = 1$; these factors are now multiplied together to suit, in the following manner: $5 \times 5 \times 3 \times 2 = 150$, for the first wheel; $5 \times 2 \times 2 \times 2 = 40$, for the second ; and $2 \times 2 \times 2 \times 2 \times 2 = 32$, for the third wheel, as the following proof will show : $\frac{150}{12} = 12\frac{1}{2}$, $\frac{40}{10} = 4$, $\frac{32}{8} = 4$, and these quotients multiplied together give $12\frac{1}{2} \times 4 \times 4 = 200$. If these numbers are thought not fitting on account of the size of the wheels, they can be arranged differently, thus : $5 \times 2 \times 2 \times 2 \times 2 = 80$; $5 \times 3 \times 2 \times 2 = 60$; $5 \times 2 \times 2 \times 2 = 40$.

Proof.—$\frac{80}{12} = 6\frac{2}{3}$, $\frac{60}{10} = 6$, $\frac{40}{8} = 5$; these multiplied together give $6\frac{2}{3} \times 6 \times 5 = 200$, showing the numbers to be proper.

Problem Fifth.—What number of teeth to give to the wheels in a train consisting of 3 wheels and pinions, when the balance is to make 16,800 vibrations an hour, or in the time the minute-hand makes one turn, and the escape wheel has 14 teeth.

Rule.—Divide the number of beats in an hour by double the number of the escape wheel teeth. This quotient will be the number of turns the escape wheel will make in an hour ; the numbers for the pinions are then chosen, multiplied together, and with the product multiply the former number of turns the escape wheel makes in an hour ; this product is then divided by prime numbers, and multiplied together into sets to suit.

Example.—16,800 being the number of beats given in an hour in the above problem, this, when divided by 28, double the number of escape wheel teeth, gives 600—the number of turns the escape wheel will make in an hour. The pinions are then chosen, which, in this case, will be 3 pinions of 8 ; these multiplied together, and then with the number of turns the escape wheel makes in an hour, gives $8 \times 8 \times 8 \times 600 = 307200$; this, divided by prime numbers, shows them to be 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 3, 5, 5, which can be arranged into the following sets: $5 \times 2 \times 2 \times 2 \times 2 = 80$; $2 \times 2 \times 2 \times 2 \times 2 \times 2 = 64$; $5 \times 3 \times 2 \times 2 = 60$ — numbers very good for practical use.

Problem Sixth.—What number to give to the teeth of wheels in a watch where the seconds hand makes one turn in a minute, or 60 turns in the time the balance makes a given number of beats in an hour.

Note.—The fourth, or seconds wheel must always make 60 turns for one of the minute, or centre wheel.

Rule.—The train is divided by 60, which will give the number of beats in a minute, and this quotient is then divided by double the number of escape wheel teeth, which will give the number of turns the escape wheel will make in a minute; from this quotient is derived the number of teeth for the seconds wheel and the escape wheel pinion. If the quotient is composed of a whole number, then the escape wheel pinion may be any number chosen; the seconds wheel must then have as many teeth as the product of the quotient multiplied by the number chosen for the escape wheel pinion; but should the quotient be a number with a fraction attached, then the number must be altered into an improper fraction—the denominator of which will be the number for the pinion, and the numerator the number for the seconds wheel. If the improper fraction be thought too high it may be reduced.

Example.—Suppose the number of beats in an hour to be 18,000, and the escape wheel to have 15 teeth; 18,000 divided by 60 gives 300 beats a minute; this quotient being divided by 30, double the number of escape wheel teeth, gives 10; this being a whole number, the escape wheel pinion may be of any number. If we choose 8 for the pinion, the seconds wheel must have $8 \times 10 = 80$; if 6, then $6 \times 10 = 60$.

Example.—The beats an hour 18,000, the escape wheel 14, what must be the number of teeth for the seconds wheel and escape wheel pinion? $\frac{18000}{60} = 300$; this divided by 28, double the number of escape wheel teeth, gives $\frac{300}{28} = 10\frac{20}{28}$, or $10\frac{5}{7}$; this altered into an improper fraction, gives $\frac{75}{7}$, being 7 for the escape wheel pinion, and 75 for the second wheel.

The calculation of wheel teeth in planetariums is far more complicated, but as this is not in the line of repairs we will not enter upon it. The preceding rules and examples are so arranged that the first three rules may be applied to any clock machinery; the last three being designed especially for watchmakers.

Charles Spiro.

212 *Broadway, N. Y.*

—o—

DIALING.

NUMBER ONE.

"Watch the dial's shadow moving,
Life and Time are worth improving;
Seize the moments, while they stay;
Seize and use them,
Lest you lose them,
And lament the wasted day."

Dialing, or "Gnomonics," as it is sometimes called, has found its foundation in the astronomical theory of the sun's motions, and very naturally grew out of the observed motion of the shadows cast by its apparent daily rotation.

The earliest mention made of a dial is found in the Bible. "In those days Hezekiah was sick to the death, and prayed unto the Lord, and He spake unto him, and He gave him a sign." Chap. xxxii., v. 34, 2d Chronicles. "Behold I will bring again the shadow of the degrees, which is gone down in the *sundial* of Ahaz, ten degrees backward; so the sun returned ten degrees by which degrees it was gone down." Chap. xxxviii. Isaiah.

The earliest knowledge we have for a certainty, was the "Hemicyle," or concave hemispherical dial of the Chaldean astronomer, Borosus, 540 years before Christ. It was a very natural construction, being a concave hemisphere, with a small sphere or ball supported in the centre of the horizontal plane of the hemisphere. At sunrise or sunset, no shadow would be cast on the inner surface, but as the sun's altitude increased, the shadow was projected on the concave of the hemisphere. This construction of Borosus descended beyond the time of Hipparchus and Ptolemy, and was found in use among the Arabians in the year 900. Four of these ancient dials have been recovered in Italy. One in the year 1746, at Tivoli, supposed to have belonged to Cicero, who mentions having sent such a one to his villa near Tusculum. The second and third were found in 1751; one at Castel Nuovo, the other at Rignano, and a fourth at Pompeii in the year 1762. This latter differs from the others in that the tropics are not expressly on it, the equator only being seen. It seems a little strange that no dials are found among the Egyptian antiquities ; there is nothing of the kind delineated in any of their sculptures or frescos. Some have supposed that the numerous Obelisks found everywhere in Egypt, were erected in honor of the sun, and were used as huge "gnomons," whose shadows served to make apparent the divisions of the day. But it seems hardly probable that such enormous dials should be in use, and none smaller, and far more convenient, be found or heard of among that learned people.

The subject of dialing was greatly agitated during the 17th century by all the writers on astronomy. The 18th century produced some writings on the subject, but clocks and watches had, by this time, begun to supersede the use of dials, and the art of constructing them was pursued mostly as a mathematical recreation.

The subject of dialing was suggested to the mind of the writer by the very excellent series of papers in the Journal on "Astronomy in its Relations to Horology," and that a comparison between the earlier and ruder modes of the ancients, and our present perfected science and instruments, would not be out of place. We do not propose to go into the purely scientific aspect of the subject, for it would be far more curious than useful, and to be fully comprehended, would require a complete knowledge of geometry, plane and spherical trigonometry—in fact, the highest mathematical education. It would be of no utility or interest to the astronomer, having been superseded by modern advancements ; and to the generality of artisans it would be dry and incomprehensible for want of the requisite mathematical education.

The Horological Journal being professedly practical, devoted not so much to *philosophy* as to *fact*, we shall give only in the future articles such plain, arbitrary directions for the construction of various descriptions of dials, as will enable the uneducated to construct them correctly, for their own use or amusement, and perhaps thereby stimulating some of the younger members of the craft to aspire to a more thorough knowledge of astronomical science, as connected with their chosen occupation, and to seek for the *reason* "why these things are thus."

The apparent diurnal motion of the "starry heavens" is perfectly uniform. The sun's apparent diurnal motion about the earth's axis, however, deviates a little from perfect equality by its unequal angular motion in the ecliptic, and its obliquity to the equator. These inequalities need not be attended to in the construction of a dial ; their joint effect is compensated for by the "equation of time," a correction which must always be applied to the time it indicates, which table of equation is every month furnished correctly by the Horological Journal, on its last page. The refraction of light might also be taken into account, but its error being less than that of construction (which is entirely a graphical operation, subject to the imperfection of instruments), it may be neglected. The time, as indicated by a dial, is sufficiently accurate for the ordinary affairs of life. But its error, whatever it may be, unlike that of a clock, is not carried forward day after day — it remains constantly the same ; if it be one minute a day, it is only a minute out of truth, but the incorrect clock is one minute to-day, *two* minutes to-morrow, *three* minutes next day, and so on ; and in a week, or at farthest a month, has gone so far wrong as to be wholly unreliable, until reset to the correct time.

All the knowledge that will be required, is ordinary education, and to know how to draw parallel lines and perpendiculars, and to measure angles ; and all the instruments necessary are compasses, a scale of chords (the construction of which will be shown), or a protractor, for the measurement of angles, and a straight edge rule.

Still, we cannot enter upon these instructions without expressing the hope that every young mechanic will at once, if he has not already, make himself more or less familiar with *geometry;* even a little knowledge of that kind will be found useful *every day,* and the time spent in its acquirement will *never* be regretted.

——o——

METHOD OF DETERMINING DISTANCES.

I send you a table for finding the difference of time between two places, knowing the distance between the meridians passing through them, in statute miles. It was suggested by the table on page 327 of No. 11 of Horological Journal, giving the latitude and longitude of different places in the United States.

Table showing the Distance, in Statute Miles, on any Latitude from 20° to 50°, inclusive, corresponding to 1 Minute of Time, and also for 1 Second of Time.

Lat.	Distance for 1 Min.	Distance for 1 Sec.	Lat.	Distance for 1 Min.	Distance for 1 Sec.
20°	16 25	.271	36°	14 00	.233
21	16.15	.269	37	13.82	.230
22	16.04	.267	38	13.64	.227
23	15.92	.265	39	13.45	.224
24	15.80	.263	40	13.26	.221
25	15 68	.261	41	13.07	.219
26	15 55	.259	42	12 87	.215
27	15 41	.257	43	12 66	.211
28	15.27	.255	44	12 46	.207
29	15 13	.252	45	12 24	.204
30	14 98	.249	46	12.03	.200
31	14 83	.247	47	11 81	.197
32	14.67	.244	48	11 59	.193
33	14.51	.242	49	11 36	.189
34	14.18	.236	50	11.13	.185
35	14.18	.236			

This table gives the distance on any parallel of latitude from 20° to 50° inclusive, corresponding to one minute of time, and also to one second of time. This distance divided into the distance between the meridians of two places, will give the difference of time between those two places in minutes and seconds. It is computed from one adopted by U. S. Topographical Engineers, showing the length of a degree of longitude, in statute miles, on any parallel of latitude, and which also takes into consideration the oblateness of the earth.

I cannot, perhaps, explain the table better than by giving an example requiring its use.

Given the distance between the meridians of Ann Arbor and Grand Rapids, Michigan, as counted by the ranges of townships on latitude 43°=98 miles; required the difference of time of those two places. Looking into the table, I find the distance for one minute on latitude 43°, is 12.66 miles ; this divided into 98 gives 7 minutes, and a remainder of 9.38 miles. This remainder divided by the distance for one second on the same latitude, viz. : .211 miles, gives 44 seconds, so that the difference of time is 7 minutes 44 seconds.

Again, the distance between the meridians passing through Ann Arbor and Chicago, is between 197 and 198 miles, as counted by the township ranges (a range being six miles),—say 197.5 miles. Required the difference of time between Ann Arbor and Chicago, the distance between the meridians being counted near the parallel of 42°.

Looking into the table, I find that on latitude 42°, the distance for one minute is 12.87 miles, and for one second, .215 miles, and 197.5 divided by 12.87 = 15 minutes, with a remainder of 4.45 miles ; this remainder divided by .215, the distance due to one second = 20 seconds, and the required difference of time is 15 minutes 20 seconds, which varies only about *one second* from the time due to difference of longitude of those two places, as given by the table of longitudes referred to in No. 11 of the Horological Journal.

It is to be observed that the distance between two meridians may be measured *on any latitude,* but the distance taken from the table for a divisor *must be from the same latitude.*

In the same manner, and with the help of the table referred to in No. 11 of the Horological Journal, giving the latitude and longitude of different places in the United States, the difference of time, and consequently the difference of longitude of any two places in this vast territory, may be determined to a few seconds of time. Indeed, in the Western States, where the domain is surveyed into six-mile townships, the difference of time between any two places within a moderate distance of each other, may be known to a second.

In Great Britain, local time is ignored, or rather the time of one place, by common consent, is regarded as the time of any other place on the island—the great clock of Westminster ticking the time by telegraph to every town of the kingdom. Not so in America, which embraces more than 3½ hours of longitude.

H. C. PEARSONS.

FERRYSBURG, MICH.,

---o---

☞ Answers to correspondents, as well as other interesting articles, are unavoidably crowded out in this number, but will be attended to next month.

AMERICAN HOROLOGICAL JOURNAL,

PUBLISHED MONTHLY BY

G. B. MILLER,

229 Broadway, N. Y.,

At $2.50 per Year, payable in advance.

A limited number of Advertisements connected with the Trade, and from reliable Houses, will be received.

TERMS OF ADVERTISING.

Inside pages	20 cents per line.
Facing reading matter	25 "
Outside pages	30 "
One column	$15
Half column	8

Special rates per page according to location. Ten words average a line.

All communications should be addressed,

G. B. MILLER,

P. O. Box 6715, *New York.*

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For July, 1870.

Day of the Week.	Day of Mon.	Sidereal Time of the Semidiameter Passing the Meridian.	Equation of Time to be Added to Apparent Time.	Equation of Time to be Subtracted from Mean Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M S.	M. S.	S.	H. M. S.
Fri	1	68.79	3 29.63	3 29.60	0.486	6 37 20.84
Sat	2	68 75	3 41.19	3 41.16	0.475	6 41 17.40
Su.	3	68 71	3 52.46	3 52.43	0.462	6 45 13.96
M..	4	68 67	4 3.42	4 3.39	0.448	6 49 10.51
Tu.	5	68.63	4 14.06	4 14.03	0.434	6 53 7.06
W	6	68.58	4 24.33	4 24.30	0.419	6 57 3.62
Th.	7	68.53	4 34 23	4 34.20	0.403	7 1 0.18
Fri.	8	68 48	4 43.74	4 43.71	0.386	7 4 56.74
Sat	9	68.42	4 52.84	4 52 81	0.369	7 8 53.29
Su.	10	68.36	5 1 51	5 1.48	0.351	7 12 49.85
M..	11	68.30	5 9.75	5 9.72	0.333	7 16 46.41
Tu.	12	68.24	5 17.54	5 17 51	0.314	7 20 42.97
W.	13	68 17	5 24.86	5 24 83	0.295	7 24 39.53
Th.	14	68 10	5 31 71	5 31.69	0.275	7 28 36.08
Fri.	15	68.03	5 38 08	5 38.06	0.255	7 32 32.64
Sat	16	67 96	5 43.98	5 43 95	0.235	7 36 29.20
Su.	17	67.88	5 49 37	5 49 35	0.214	7 40 25.75
M..	18	67.81	5 54.24	5 54.22	0.193	7 44 22.31
Tu.	19	67 73	5 58.61	5 58.59	0.171	7 48 18.86
W.	20	67 65	6 2.45	6 2 43	0.149	7 52 15.42
Th	21	67.57	6 5.76	6 5.74	0 126	7 56 11.98
Fri	22	67.49	6 8.53	6 8.51	0.103	8 0 8.53
Sat	23	67.41	6 10 74	6 10 72	0.080	8 4 5.08
Su.	24	67.33	6 12 37	6 12.36	0.056	8 8 1.64
M..	25	67 25	6 13.43	6 13.43	0.032	8 11 58.20
Tu.	26	67 17	6 13 92	6 13.92	0.008	8 15 54.76
W.	27	67.08	6 13 83	6 13.84	0.017	8 19 51.31
Th.	28	67 00	6 13.14	6 13.15	0.041	8 23 47.87
Fri	29	66.91	6 11.85	6 11.86	0.066	8 27 44.43
Sat	30	66 82	6 9.97	6 9 98	0.091	8 31 40.98
Su.	31	66.73	6 7.46	6 7.47	0.117	8 35 37.54

Mean time of the Semidiameter passing may be found by subtracting 0.19 s. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON

		D. H. M.
☽	First Quarter	5 16 30.4
◎	Full Moon	12 10 35.5
☾	Last Quarter	20 2 17.1
●	New Moon	27 23 18.0

		D. H.
☾	Perigee	8 14.9
☾	Apogee	20 18 0

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1

		H. M. S.
Long.	Harvard Observatory	4 44 29.05
	New York City Hall	4 56 0.15
	Savannah Exchange	5 24 20 572
	Hudson, Ohio	5 25 43.20
	Cincinnati Observatory	5 37 58.062
	Point Conception	8 1 42.64

		APPARENT R. ASCENSION.	APPARENT DECLINATION.	MERID. PASSAGE.
	D.	H. M. S.	° ′ ″	H. M.
Venus	1	3 55 7.65	−18 12 0.2	21 18.5
Jupiter	1	4 43 17.66	+21 41 9.4	22 3.2
Saturn	1	17 34 51.29	−22 4 52.3	10 55.6

AMERICAN

Horological Journal.

Vol. II. NEW YORK, AUGUST, 1870. No. 2.

CONTENTS.

⁎ *Address all communications for* Horological Journal *to* G. B. Miller, *P. O. Box* 6715, *New York City. Publication Office* 229 *Broadway, Room* 19.

THE CHRONOMETER ESCAPEMENT.

Much as it is worthy of a more extensive treatise than can be entered upon within the limits of an article like the present, and much as it deserves the attention of an abler pen than that of the writer's, yet, a great deal in favor of the above escapement need not be said to advocate its superior worth, for no one who is in a measure acquainted with horology will deny that, for accuracy of timekeeping it is the most valuable one; for wherever important operations of both scientific and practical nature depend on the exact measurement of time, it has proved most serviceable. There is, however, a class of chronometers whose performance as timekeepers has not proved worthy of this claim, and in a previous article on this subject the writer has endeavored to show in a measure the reason why and the consequences thereof; there being an opinion, at least, among the uninitiated ones, that the chronometer escapement is not as reliable for pocket use as others, or, as it proves to be, for stationary purposes; this, it was said, might be tested, and the reputation of the good chronometer vindicated, and in this behalf the following is respectfully submitted:

A thorough analysis of the principles of the escapement, as compared with others, would probably furnish the most conclusive evidence in its favor, and would at the same time be most instructive to the student; but as this would involve too much time and space, and as otherwise the superiority of the escapement is already admitted, the writer claims that, if this existing opinion is proved to be erroneous and invalid, the object is attained. It is said by those who hold this opinion, that the chronometer escapement is apt to set when being carried. This could result from no other cause than from external motion, as affecting the vibrations of the balance. As is known, it is not the nature of the escapement to start of itself when the vibrations of the balance are stopped, but the latter requires to be moved through an arc of from 12° to 16° before it will unlock and receive the first impulse; hence it is supposed possible for external motion to counteract the vibrations so as to check them below the amount of motion required to unlock again, and in that case the watch would stop. Now we may be able to form an idea of the possibility of such an occurrence in the following way: In an escapement where the locking takes place at the second tooth from the roller, the balance requires to be moved through an arc of 12° to effect an unlocking. Assuming the vibrations of the balance to be 18,000 in an hour, hence 5 in a second, and supposing them to describe arcs of 400°, and the external motion of the watch during $\frac{1}{5}$ of a second, the time of one vibration, to be 80° of arc, it follows that the motion of the balance is five times swifter than the external motion of the watch; hence the arcs of vibration of the former could only be increased or decreased (according to the direction in which the watch were moved) by $\frac{1}{5}$—that is, increased to 480°, and in the contrary effect decreased to 320°. Again, if we suppose the external motion of the watch to be three times as much, thus to describe an arc of

240° during the time of one vibration of the balance, its velocity would still be $1\frac{2}{3}$ as great as such external motion, and its arcs of vibration could not be increased above 640°, nor decreased below 160°. To effect two successive unlockings during one vibration of the balance it would require an increase of the arcs to 720°, and to check it entirely, so as to stop the watch, the latter would have to be moved through an arc nearly equal in extent to the arcs of vibrations, and in the same time in which one of them is completed. Now it must be remembered that only such external motions of the watch could influence the vibrations of the balance as describe circles, and very small ones too, for the larger the circle of arc the nearer would it be in a straight line; and if a watch were moved in a straght line, however swift such motion might be, it could not have any influence on the vibrations of the balance, for th eeffect of such motion on one side of the line would be counteracted by the effect of the same motion on the other side of the line; and hence the idea entertained by so many workmen, that the simple act of taking a watch out of the pocket and putting it back again is sometimes sufficient to stop it, may be set down as altogether erroneous; and if a watch does stop in that or any other way, the cause of it must be looked for elsewhere. Guided by these reflections, those who have hitherto entertained such an idea, may probably be able to calculate for themselves the chances of the setting of a chronometer from the effect of external motion.

Other and more important considerations determine, however, the superiority of the escapement. We all know the pernicious influence of friction. The lever, for instance, not to speak of inferior escapements, however well all its parts may be executed, can never be made so as not to be subject to a large share of it; while in the impulse-giving and locking action of the chronometer this evil can be reduced to its minimum, and hence the acting portions of this escapement require no oil, which, of itself, is a very great advantage. It is the writer's humble opinion that this escapement is the only one worthy of the tedious labor of the adjustment of a compensation balance, as well as that of the isochronism of the hairspring.

But it is the object of these articles to furnish something of real and practical information to those who are working at the trade, and are desirous of learning. It may happen, by accident or otherwise, that the spring in a chronometer escapement gets broken, or needs replacing with a new one for other reasons, such as when it has been worked at and spoiled by an inexperienced hand; how to replace it properly the following is intended to show:

Lines S in Figures 1, 2, 3 represent the position of the detent spring in three different escapements. Fig. 1 illustrates that of the ordinary English chronometer, where the locking takes place at the second tooth from the roller, and the spring is in the detent itself. Figures 2 and 3 are both of Swiss make, where the detents are levers moving on an axis, and sprung by a hairspring, and both lock at the third tooth from the roller, though their positions are different. In Fig. 1, after G, the centre of the wheel, and C, the centre of the balance, are fixed, and the relative diameters of wheel and roller are developed according to principles given in the preceding article on the Chronometer Escapement, the position of the spring and its locking point is found in the following manner: From the centre, G, a line, E, is drawn, so that it will form an angle of 36° with line T; through the point of intersection of this line, and the circumference of the wheel, and from the centre, C, line S is drawn, representing the line of the detent—its locking point being at E. In Figures 2 and 3, with radii, G C, and C G, circles M and N are drawn, from the point of contact of which, and the centre, G, line E is drawn, forming with line T an angle of 60°—the distance between two teeth and a-half. In Fig. 2, the line S of the detent is drawn as in Fig. 1; but in Fig. 3 at a tangent to the circle of the wheel, and a right angle to line E, E A being the tangent, and the rest afterwards carried out, either in a straight line with another right angle at the end, or in a curve toward the centre of the balance.

With respect to the inclination of the locking surface of the detent jewel, the writer begs

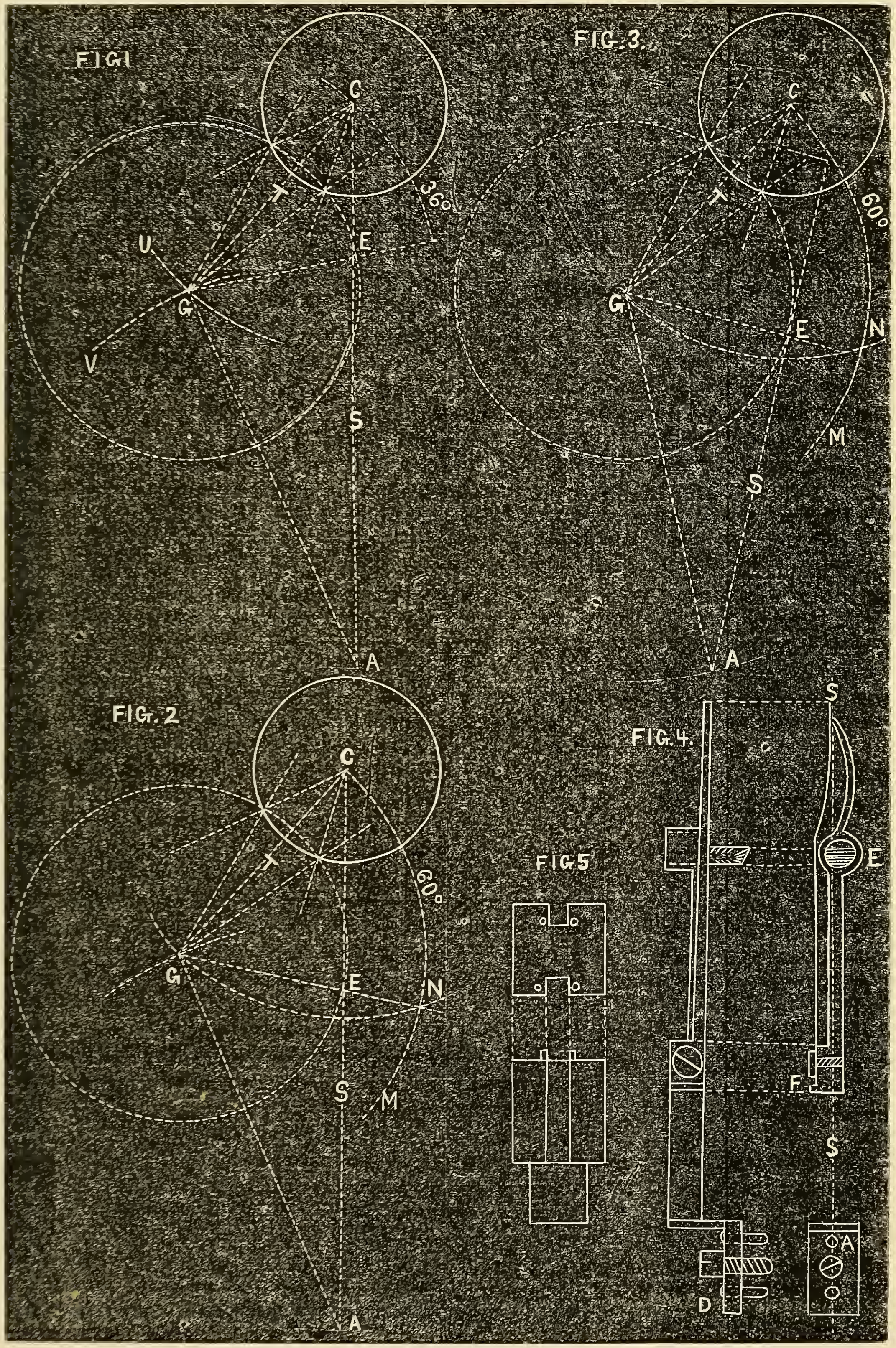


FIG. 1
C
T
36°
U
E
G
V
S
A
FIG. 3.
C
T
60°
G
E
N
M
S
A
FIG. 2
C
T
60°
G
E
N
S
M
A
FIG. 4.
S
E
F
S
A
D
FIG. 5

leave to correct an indiscrimination in the last article, where he says that the locking surface should form an angle of 12°, with a line from the centre of the wheel, which could not be admissible in many instances. The object of its inclination is to create a draw on the detent when the tooth is inlocking. In the case of Fig. 1, 12° inclination to a line from the centre of the wheel would be almost at right angles with the line of the detent, on which there could be no draw, owing to the position of the locking point in the detent; the line of inclination then should be such, that while it is to effect this draw, it should not, on the other hand, offer too much resistance to the unlocking. It dare not be in the same line with the inclination of the tooth in locking, for to effect a good draw, and create the least friction by it, the point of the tooth only must be in contact with the surface of the jewel. In the case of Fig. 1 then, where 12° inclination are not sufficient, and the tooth would have 26°, we may divide the remainder, adding it to the 12°; thus giving the detent jewel an inclination of from 18° to 19°, leaving still enough to the tooth to effect a good draw.

In Fig. 2, the point of locking in the detent is such, that the line of the locking surface of the jewel can coincide with a line from the centre of the wheel; indeed it dare not be otherwise. That in Fig. 3 does not require more than 8° or 10° inclination, owing to the locking taking place at right angles with the line of the detent.

If, then, a spring is to be made for any of the three escapements illustrated, the first thing required to be known is, the true place of the locking point in it. Point A in the diagrams is supposed to be some point in the spring which the line S of the detent shall bisect, and from which, in Figures 1 and 2, the distances to C, the centre of the balance, and G, the centre of the wheel, can conveniently be measured. In Figures 2 and 3, this point is the pivot hole of the detent staff; but in Fig. 1 it may be the screw hole in the foot of the spring; or better still, one of the holes of the steady pins, if such are in the line of the detent. The diameter of the escape wheel must also be measured. Then, by trigonometry, in Figs. 1 and 2, we have A, C, G, minus C, G, E; C, G, and E, G, as well as the angle, C, G, E, being known, the distance, C, E, can readily be found. The value of C E being found, subtract it from C A, and the remainder will be E A—the distance required to be known. In Fig. 3 the work is much more simple, for here it is only necessary to measure the distance G A, and we have the right angle triangle G E A, from which those who are acquainted with Geometry (47 Prop. Euclid) will easily find the value of E A.

For those who are not possessing the knowledge of these sciences the following method for determining the true point of locking may serve, which will be equally correct provided the workman has a good measuring instrument as well as drawing tools, without which it would be useless to attempt it. Supposing a spring, as in Fig. 1, is required to be made; measure the distance C A in the watch accurately, multiply it by ten, and draw a line joining such increased distance, representing line S in diagram 1; then measure the distances A G and C G in the watch, multiply each also by ten, and with such increased distances as radii, draw circles U and V, in the point of contact of which circles the true centre, G, of the wheel is found; connect G C by line T, and from it and the centre G, lay out with a good protractor an angle of 36° and draw line E; now measure the distance E A, divide the sum by ten, and the quotient will be the actual length from the point A, to the true locking point of the detent. If, then, this distance is known, the workman may proceed to make the spring; and here it is necessary to say that great care is to be exercised, as well in the choice of the steel as also in the preparation thereof. Take several bars of the best English square steel, examine them in the break and choose that one which has the finest grain, and of a silver gray appearance; cut a piece of ample length, draw the temper by heating it to a dark cherry red, leaving it to cool off slowly; when cool, hammer it very evenly, but only on those sides which are intended for the sides of the spring, and then file the piece up perfectly square, *i. e.*, all its sides at right angles with each other; now, over both surfaces which are intended for the top and lower side of the spring, and through the middle and the whole length of it, draw with a sharp steel a distinct line—being the line S represented in diagrams 1, 2, 3; in this line drill a hole straight through the piece for the point A, and at the calculated distance from it mark the locking point E by drawing a line across the piece on the upper side and at right angles with the first line. On this last line a hole for the locking jewel must be drilled, and so that the line S will cut one-fourth of its whole diameter on that side which is the inside of the spring; it should be drilled with a drill that will make a hole of exactly the size which the diameter of the jewel requires, so that it will need no reaming out, and on a straight-bore machine or on the lathe, in order to get it perfectly straight through the piece. When this is done the workman may proceed to file up the piece; and, to save a long and tedious description of this process, Fig. 4 has been drawn, showing the top and inside view of a spring according to which pattern it may be shaped. Still, though the intelligent workman will be able to help himself, a few points may be particularly noticed for his guidance. It is advisable to file up D, the foot of the spring, first, and put a temporary steady pin in, and bore the hole for the screw, so that he will be able to try it when filing down the rest of the piece from the top to adjust its height to that of the wheel; when this is filed down to the proper height the line S must again be drawn over the top of it, and in the same way as it was before, for this line must guide him in filing up the rest to its proper shape. The next point is the filing of the round portion at E in Fig. 4. In order to get this perfectly round he may turn up on the lathe two pieces of steel like two screws, whose heads shall be of exactly the same diameters, and of just the size of which the outside diameter of the cylinder is to be; the other part of these two pieces must fit the hole for the jewel; harden these pieces and cement one of them in the top of the hole, the other into the bottom, according to which the rounding can be filed. At F a little projection must be left standing, just a little higher than the rest of that portion, which will serve for a bearing to prevent the gold spring from turning sideways when being screwed on. After all the different heights and sides have been filed to their proper shape, the length of the point of the spring from E on, must be approximately determined by trying it with the unlocking roller in the watch; then the spring portion S must be filed out, and care must be had that the line S will always bisect what is left standing. The whole length of this portion may comprise a little more than one-third of the length from the foot of the spring to the point, E, of locking, and should not be filed too thin yet. The hole for the screw which fastens the gold spring must then be bored and tapped, after which the spring may be hardened. This is often done by careful workmen in a small sheet-iron box filled with powdered charcoal, into which the spring is laid and heated red hot over a forge; but a simpler method is the following: Wash the spring well with soap and water, dip it into alcohol and dry in fine saw-dust; take a piece of flat steel, considerably thicker than the spring, and equally as long or longer, fasten it upon a good piece of charcoal, lay a few other pieces of coal around it so as to concentrate the heat, and upon this piece of steel lay the spring, after which it may be heated with a blowpipe. When it commences to get warm, and before it colors, rub the upper surface with a little soap and then proceed to heat it to a cherry red; care must be had not to blow a pointed flame at it, but evenly diffused, and so that the piece of steel upon which it lays will become red hot too; when both are cherry red, drop the spring vertically into a tumbler of water; the spring should be laid upon the piece of steel so that when it drops the heavy end will be foremost. If it is hardened in this wise it will be found that the side which was touched with soap will come out perfectly clean and white; now color it on the blueing pan to a dark yellow, and then grind all the surfaces of it with oil-stone dust, wash it again in the above mentioned manner, and proceed to temper it to an even blue. After this grind all the surfaces again with oil-stone dust to their final shape, and by means of a soft piece of steel, filed flat, take all the corners off and polish them, and then proceed to grind the spring portion. To this purpose the workman should file up a piece of brass, as represented in Fig. 5, to be held in the vice. The pins on the top must be at such distances apart from each other as the width of each portion of the two shoulders between which the spring is to be ground out requires; and the length of the piece must be such, that the spring part will be clear between the pins. The top should be filed perfectly flat, and the part between the pins filed out on each side vertically, so as to allow the shoulders of the spring to sink below the surface, and the spring to come down flat on it; the whole should be fitted so, that when the spring is laid across it, with the spring portion between the pins, it should be held steady, yet not be cramped. On this piece of brass the workman may now, with perfect safety, grind down both sides of the spring until it is the required thickness, keeping in mind all the time that it represents the line S in the drawings; and with a piece of soft steel, the corners of which are a little rounded off, so that the spring will become a little conical from its shoulders, to prevent its breaking easily. It should thus be ground down to a thickness of 0.03 millimetres. The width of the piece of brass, in Fig. 5, should be full 15 millimetres, which will prevent the side of the spring from becoming rounded or uneven. When in this wise the spring is finished, the jewel must be cemented in; but before that, the inside of the round portion, E, which is to come against the set-screw, must be ground flat. To cement the jewel in properly, a piece of brass or steel of the same size and shape as the jewel must be made and fitted into the hole with it, so that they are both loose enough to be turned around; cement this piece on to the jewel first, with shellac, and afterwards cement them both together in the hole. To examine whether the surface of the jewel stands at the requisite inclination, say 18° to a line from the centre of the wheel, file one side of a brass plate straight; draw a sharp line over the surface of the plate, cutting that side at angles 95° and 85°, and so, that when the plate is held in front of the jewel, and the line across it will coincide with the line of the detent, the angle 95° will be on the outside of the spring; if now the front surface of the jewel coincides with the front of the plate, all is right; if not, it must be made so.

In reference to finishing up the side surfaces of the spring it may be said that, though many workmen pride themselves in doing so, it is quite useless to polish them; a dead oil-stone surface will answer all purposes; or a very beautiful ground surface can be obtained by using fine powdered sapphire, and grinding it in regular lines across the piece. Rotten-stone, used on copper, or any other metal, will produce a similar surface. Much time and labor is often wasted in polishing up surfaces, which are of no importance. Not unfrequently workmen will put an exquisite finish on parts which are seen in the watch, while they may be altogether lacking their geometrical proportion; or the parts which are in action, and ought to be well polished, are left rough. Thus, it is not seldom that we see a fork in an anchor watch beautifully polished on the top surface, while the inside of the fork is roughly filed, too wide for the ruby pin, and the weight of the fork altogether out of poise. Other parts of watches are similarly neglected in their essential requisites.

To return once more to our subject, a detent spring should be made as light as possible, for then the spring in it can also be made weaker, which will offer less resistance to the unlocking, while the locking will be just as safe.

If an unlocking spring is to be made, it should be made of 18 kr. gold, rolled out to very nearly the requisite thickness. It can be filed by holding it in the sliding tongs between two pieces of metal, which must previously have been filed straight, and should be made a little narrower than the front end of the detent. The hole for the screw in the foot of it must be bored and the end fitted against the bearing on the detent so that it will not move side ways when being screwed on. Its sides should be ground with a fine blue water-stone lengthwise on a broad flat piece of steel, holding it down by the foot, and only drawing the stone over it from the foot towards the front end; its front end should be ground to a thickness of 0.06 millimetre, and diminishing towards the foot to 0.02 millimetre. When screwed on to the detent it must be bent to its requisite shape, so that the front end will rest with a little pressure on the end of the detent, taking care that the end of it will again coincide with line S. Its accurate length can only be determined when it is tried in the watch.

The preceding instructions ought to contain sufficient to guide any workman in the making of a detent spring, even should it be required to make a spring for either Figure 2 or 3 of the cuts ; only as in these last the detent is not a spring, but a lever moving on an axis, a weight must be left standing at the outer end to balance the detent perfectly. There may be said to be three requisites for the successful accomplishing of the task: first, that the workman has good and new files, and not very coarse ones ; second, that he understands distinctly how the spring is to be made ; and third, that he does not cease until he has made one so.

TH. GRIBI.

WILMINGTON, DEL.

——o——

MR. GROSSMANN'S NEW IMPROVED PENDULUM ANALYZED.

In the last number of the HOROLOGICAL JOURNAL there appeared a communication from Mr. Grossmann, of Saxony, on the subject of a new improved mercurial pendulum. As I cannot see any advantage that can be gained by using this pendulum over the old Graham one, which I know has its faults ; and as Mr. Grosssman invites criticism, I reply to some of the assertions he advances ; and in doing so, I do not wish to be considered arrogant in presuming to review this production of your distinguished correspondent in Germany.

Mr. G. founds the necessity for his new arrangement upon the following experiment : "If you suspend two thermometers on a wall, the one three feet higher than the other, it will be found that in an artificially heated room the upper thermometer shows about 3° R. (= 7° Fahr.) more heat than the lower one, in accordance with well known physical laws." I have very frequently placed two thermometers, one at each end of a seconds pendulum. These pendulums were sometimes nearly encased in glass, sometimes they were partly encased in glass and stone or marble, and sometimes in wooden cases that were placed in rooms artificially heated ; but I have never noticed more than about 1° Fahr. of difference between the top and bottom of any of the pendulums. Last winter, while experimenting with a new apparatus, designed to regulate the supply of heat that passed into a room artificially heated by hot-air passing through openings in the floor, I placed a number of thermometers in the apartment, in order to test the regularity of its temperature, and there was but a very slight difference between those thermometers that were but a few feet above the others. In talking over the subject in question to a friend the other day, he very forcibly and piquantly said " that if that was so, a man six feet high, and the heat of his body being in a state of perfect equilibrium, would suddenly find his head to be 14° warmer than his feet, in going into an artificially heated room in winter ;" a sensation which probably few people have experienced in this part of the world.

I admit that there is some difference between the temperature of the air near the floor of a room, and the air near the ceiling ; but it must be only under very peculiar circumstances that so much difference as nearly 7° Fahr. takes place in the short distance of three feet ; and most assuredly that difference does not exist between the two ends of pendulums, in the position clocks are usually placed, whether they be in inhabited rooms or in Astronomical Observatories.

Mr. G. further considers that " the mercurial pendulum, which performs admirably in an Astronomical Observatory, generally fails in parlors and inhabited rooms." The stores and shops of marine chronometer makers, may, in many instances, be considered analogous to parlors or inhabited rooms; and I will venture to state that at the present day a majority of the marine chronometers in the world are rated from clocks placed in these rooms, and having Graham pendulums. I have never seen or heard of an instance where a clock made with the most ordinary care, failed to answer every purpose of a private dwelling on account of it having a Graham pendulum. No house clocks are liable to be subjected to greater or more sudden changes of temperature than those that are employed in Astronomical Observatories, where the system of observing by the eye and the ear is still maintained; for when the shutters in the roof, or in the dome, are opened, the clocks are subjected to whatever extremes of temperature may be outside; yet under these severe ordeals the Graham pendulum has earned the reputation it holds at the present day.

Having discussed the question of temperature, I will now proceed to consider the subject of Mr. Grossmann's improvements; but I would first notice that the pendulum he gives us will not beat seconds with a ball 17.7 in. long, and the total length of the pendulum only about 48.43 in. With such a heavy rod it must be made considerable longer to do so. However, this may simply be a mistake, and in no way does it compromise the principles involved in the pendulum itself.

For his improvements, Mr. G. claims as follows:

"It will be easily seen that this arrangement has the following advantages:

"1. Equal thickness of the compensating parts, and, in consequence of this, equal sensibility of the same to changes of temperature. (The trifling difference between the diameter of zinc rod and that of iron jars or tubes will be made up by the greater heat-conducting power of the iron.)"

This is also the idea of Mr. Coffinberry, of Grand Rapids, Mich., that the rod should be the same thickness as the column of mercury, in order that they may be equally affected, by a sudden change of temperature, exactly at the same time. Apparently this is a plausible theory, and doubtless the size of the one should bear a relative proportion to the size of the other; but to make them the same is a fallacy; it is fallacious in various ways. In seeking for compensation, the fundamental laws upon which the fabric of the pendulum is built are violated—gives the pendulum a much longer length than is necessary, and increases rather than diminishes the difficulty of compensation. If the materials that compose the pendulum had all the same natural properties for absorbing and radiating heat, and if the pendulum stood at rest, like a thermometer, then there might be a necessity for having all the parts of the same thickness; but this is not so. And further, when the pendulum is in motion the mercury passes through a greater space of air than the rod, and renders it liable from that cause, in addition to its natural sensitiveness, to be acted upon before the small rod is affected.

It is quite common in some parts of the world to place a piece of plate glass inside the case, in front of the pendulum ball, to protect the mercury from sudden changes if the clock chances to stand before a door, and good results are said to follow. Personally I am convinced, that as a general thing the mercury is acted upon before the rod; and were this not the fact, the short column of mercury usually employed for steel rods would not do the work it does. (See page 311, Vol. I.)

The next claim contains the distinctive feature of the pendulum:

"2. Considerable diminution of the defect of compensation in the mercurial pendulum, arising from the difference of temperature in the different heights in which the compensating elements are moving. In Graham's mercurial pendulum the mercury constitutes about the sixth part of the length of the pendulum, while the rod, beginning above the mercury, makes up the other five-sixths of it. The above-described improved mercurial pendulum has its zinc rod passing through the frame down to the lower end of the pendulum, and the mercury column constitutes more than one-third of the total length."

The inventor, unlike all other inventors that have preceded him, has selected a metal that will expand the most, to make the rod, in preference to one that will expand the least, as is usually done. The object of this selection is, that the columns of mercury will, of a necessity, be much longer than usual, in order to compensate the extra expansion of the rod, and thereby have the top of the mercury nearer the top of the rod, with the intention that it will, as nearly as possible, be subject to the same temperature as the rod, and make it move like the Gridiron pendulum, whose compensating rods accompany each other, side by side, nearly the entire length of the pendulum. Mr. G. appears to forget that the principles of compensation in the Graham and his own proposed pendulum, are altogether different from the Gridiron. In the one the effects of the expansion of the rod is counteracted by the ball being increased or diminished in length, while in the other the entire ball is raised up or let down.

I will illustrate by a familiar example what would be the practical effect of having columns of mercury extend so high above the centre of oscillation—and the inventor would have these columns extend to the top could he so arrange it. It is customary, sometimes, to regulate a pendulum by a small weight that shifts up and down on the pendulum rod. Huyghens demonstrated the theory of this method of regulation, and he graduated a scale to show how much the small ball had to be shifted to make a given alteration in the rate of the clock. These graduations vary in length, as the weight ascends the rod, till a point is reached that whether the weight is moved up or down, the effect on the rate of the clock is the same. Mr. G. makes the mercury to come up to about 20.73 in. from the point of suspension, and Graham has about 36 in. From Huyghens' demonstration it will be observed that the expansion of the mercury columns will have a variation in their value as the length of the columns extend up the rod ; for, as previously stated, the entire effective weight of the ball is not raised by expansion or lowered by contraction, but only part of it ; and if these mercury columns were extended to a given point between the centre of oscillation and the point of suspension, the effect of the compensation would be nearly, if not altogether, neutralized.

In contradistinction to Mr. Grossmann's pendulum, I will instance the glass one, where the cylinder and rod are blown in one piece. These pendulums are very rare, but it has often occurred to me that it was the best way a pendulum on Graham's plan could be made. The little expansion of the material takes but a short column of mercury to compensate it, and allows the mass that constitutes the pendulum to be concentrated as far away from the point of suspension as possible, and thereby comes nearer to the ideal pendulum of "a material point suspended by an imaginary line," than any other form of compensation pendulum that there is.

The inventor also claims :

"3. Reduction of the resistance of the air to the least amount."

Galileo first gave ocular demonstration, from the Leaning Tower of Pisa, in Italy, that if two bodies of the same form and density, but of different sizes, are let fall from a given point at the same time, they will reach the ground together. This same law governs the motion of the pendulum ; and according to Galileo's indisputable theory, *one* of Mr. Grossmann's small jars meets the same resistance as Graham's large one ; they being both of the same shape, and being both filled with mercury, are of the same density, although very different in size. Let us look at it from another view, having no connection with this law. Graham has a cylinder about 2 in. diameter, and 7 in. long, which by calculation gives an outside surface of 43.4 in. Grossmann has four cylinders, each 0.73 in. diameter, and 17.7 in. long, which makes the outside surface 160.2 in. If the nature of the resistance of bodies passing slowly through the air, be the same as bodies passing through water, only in a proportionably less degree, the result must be greatly in favor of the Graham pendulum. To recapitulate : Graham's *one* jar has an outside surface resistance of 43.4 in., while Grossman's four jars have 160.2 in. of surface exposed to the air.

I have now gone over all the distinguishing features of this pendulum, and I hope that the reader will reflect and consider the subject well. Remember that the error that is to be cured is not one of several seconds, but of tenths of seconds. The nearer we get to perfection the approach becomes the more difficult. However simple it may seem at first, it is a subject closely allied to a great many other intricate questions, and superficial thinking, or looking only from one point, will not do. I hope that this discussion will continue till we get a correct compensation pendulum.

I believe, in the Patent Laws generally; it is the inalienable right of every man to receive all due credit and protection for his ideas or productions ; but while that is my expressed belief, I hope that we will have no more patent pendulums ; they savor too much of patent medicine. It is a subject too sublime, and of too little commercial importance, to be made the subject of a patent. Probably I work as hard, and spend as much time on this question, as most people; yet I would as soon think of taking a patent out for a pendulum, as I would if I was successful in squaring the circle, or solving any other equally difficult problem.

CLYDE.

—o—

HEAT.

NUMBER ONE.

INTRODUCTION.—CALORIC—IS HEAT A SUBSTANCE?—OPINIONS AND EXPERIMENTS OF PHILOSOPHERS CONCERNING IT, ETC.

In this number we commence a series of articles on Heat, designed to be of general interest. We propose to exhaust this comprehensive subject in a series of papers describing the nature and effects of heat in general,—the laws of its transmission—its effects on all bodies, especially metals—and its practical application to the many mechanical arts interesting to the Horological community.

Heat is unquestionably one of the most important agents employed by nature in forming the constitution of bodies, and in producing that unceasing change observable in the animal, vegetable and mineral kingdoms. There is scarcely any department of physical science in which the nature and properties of heat do not in some way enter into our consideration. The meaning of the word heat is so well understood, that any attempt to define it is unnecessary. When we say that a person feels heat, or that a piece of metal is hot, the expression we understand readily; yet in each of these propositions the word heat has a distinct meaning. In the first it signifies the sensation of heat, and in the other the cause of that sensation. To avoid the supposed ambiguity of these two meanings to one word, the term caloric was invented by the French to signify the cause of heat. When you place your hand on a hot piece of metal, you experience a certain sensation which is called the sensation of heat. The cause of this sensation is caloric. In ancient philosophy it was commonly said that heat occasioned the warmth and expansion of bodies, and likewise that heat was excited in bodies by the addition of some peculiar kind of matter, or by a certain modification of their particles. The more precise nomenclature of the moderns has tended to correct this error, and led to the invention of the new term caloric, to designate the cause, while the word heat is, strictly speaking, only applicable to the effect. As, however, in all the older authors, the former phraseology necessarily exists as it is adopted in popular language, there is no danger of falling into any error, since the distinction has been so fully pointed out; the word heat is frequently used in this double sense, even by the latest and most correct writers, and it will be used by us in this way in the following articles.

Two opinions respecting the nature of heat have divided philosophers. According to some, like *gravity*, it is merely a property of matter; while others contend that it is a substance, capable of a separate existence, and possessing a material, although very subtile, nature. The latter opinion was at first broached by the chemists, and at present is acceded to by nearly all philosophers; yet there are, on the contrary, many eminent men who regard it merely as a property necessarily attached to other matter, and arising from some peculiar modification or affection of it. Bacon adopted the latter opinion, and conceived that heat depended on a vibration of the particles of matter; a hypothesis which he advanced to substantiate by showing that whatever excited temperature tended also to produce a motion in the particles of the heated body. His description of that peculiar nature signifies "a reaction between the expansive force of heat and the attractive force of the particles of matter toward each other." The idea of Bacon, that heat depends on a vibratory motion among the particles of matter, received the powerful sanction of Sir Isaac Newton; but as observations on the phenomena of nature were multiplied, and especially as chemical science advanced, the hypothesis which considered heat as merely consisting in the motion of particles in matter appeared less easy to reconcile with the new discoveries, and consequently a different doctrine was advanced, in which the effects of heat were attributed to a species of subtile fluid, of a proper material nature, although differing in many important particulars from any other kind of matter.

Our limits will not permit us to take a very full view of all the arguments that have been urged on both sides of the question ; but we must endeavor to give a sketch of some of the principal points that have been adduced by the advocates of each of these opinions. It will scarcely be denied that if we admit the existence of a subtile elastic fluid, the particles of which are endowed with a repulsive power which tends to unite itself to all kinds of matter—to insinuate itself into their pores—to produce their expansion, and, if added in sufficient quantity, to impart to them its own elastic nature, we are possessed of an agent which very conveniently explains a great variety of phenomena ; but this hypothesis, however, has been strongly opposed by Rumford on the strength of the following experiment of developing heat by friction. A piece of brass was fixed in a machine for boring cannon, and a steel cylinder was pressed against the brass, with a force equal to 1,000 lbs., and then made to revolve on its axis with a given velocity. After some preparatory experiments the apparatus was all enclosed in a vessel of water, and after the friction had been kept up for some time, the water was actually brought to the boiling heat. Here a very considerable quantity of heat was liberated, and the only mechanical change effected on the materials, was that a quantity of brass turnings or scrapings were formed ; but neither the brass nor the cylinder itself appears to have experienced any change, except a slight degree of compression. Rumford found, by experiment, that the capacity of these turnings or scrapings would not be affected by the operation ; and the effect of the compression which the metal had experienced, must have been very inconsiderable ; yet, the power of the substance to extricate heat was apparently unlimited ; for there is no reason to suppose that anything like exhaustion was produced, or that the apparatus would not have continued to evolve heat, until its texture had been destroyed by the brass being all reduced to fragments.

Although there is no direct experiment to prove the independent existence of heat, as a material substance, there are none except those of Rumford, and some of a similar nature, to prove the immaterial doctrine. Besides, although we have admitted that there is no direct experiment to prove the independent existence of heat, or at least none against which some exception has not been taken, yet there are facts brought forward, perhaps as decisive on the one side as those of friction on the other. We refer to the transmission of heat through a vacuum. Pictet proved that this takes place in the vacuum of the air-pump, and Rumford himself has shown it is capable of passing even through the Torricellian vacuum.

There seems no method of reconciling this fact with the hypothesis, except taking for granted the existence of some kind of vapor or elastic fluid, with which it is propagated ; a supposition equally gratuitous, and equally unsupported by direct and independent facts, as that for which it is substituted. It seems extremely improbable, if not impossible, that rays of heat are carried along by the air, even when near the surface of the earth, and in coming from the sun they must necessarily travel an immense distance totally devoid of air. Herschel, while employed in examining the sun by means of telescopes, thought of examining the heating powers of the different rays of light, separated by the prism. He found the most refrangible rays had the least heating power, and that the heating power gradually increases as the refrangibility diminishes. The violet rays have of course the least, and the red rays the greatest heating power. It struck Dr. Herschel as remarkable that the illuminating power and heating power follow different laws—the illuminating power being greatest in the middle of the spectrum, and the heating power being greatest at the red end. This led him to consider that the heating power did not stop at the end of the spectrum. On trying the experiment he found that a thermometer placed a little beyond the spectrum rose still higher than in the red ray ; hence it follows that there are rays emitted from the sun which produce heat, but have no power of illumination ; consequently, heat is emitted from the sun in rays, and the rays of heat are not the same as the rays of light.

Professor Leslie, to whom science is so much indebted for so many experiments, adopted the hypothesis which ascribed the effects of heat to a certain motion among the particles of bodies. He conceives that the propagation and transmission of heat is very similar to that of sound ; and, in fact, it consists of certain aerial undulations. The passage of heat is, therefore, of the same velocity with the undulation of the air, or, rather, is identical with it. Professor Leslie, however, seems to have advanced this hypothesis merely as a convenient manner of accounting for his own experiments. He has not stated it in such a way as to apply to all the phenomena of heat, nor has he attempted to reconcile it with the experiments of Herschel and others, which appear decidedly adverse to it.

Before we conclude these observations concerning the immateriality of heat, it will be proper to notice the experiments which have been made, in order to ascertain whether it be actually possessed of gravity, or, rather, whether its weight can be measured by a balance. The best contrived experiments of this description were those of Fordyce. He very carefully weighed a quantity of water ; froze the water, and then again weighed it. Now, he argued that in this process the water must have parted with the latent heat which maintained it in a liquid form ; so that if heat be a ponderable substance it might be expected that the ice would exhibit a diminution in its weight equivalent to that of the caloric which had escaped. The result, however, did not correspond with this idea ; and, indeed, in some of the most accurate trials it seemed as if the body that had parted with its heat had even acquired a slight addition of weight. It is, however, generally admitted that no decisive conclusion can be drawn from such experiments, and that from the conception that we have of the extreme tenuity of heat, it is not probable that any portion which we can have in our power to impart to a body could be detected by the instruments that we employ in ascertaining the weight of bodies.

The further consideration of this subject would involve us in a discussion that would exceed the limits to which we are necessarily restricted. Upon the whole, we are strongly inclined to the opinion in favor of the materiality of heat, because we think it explains the phenomena in general with greater facility, and is encumbered with less difficulties than the immaterial hypothesis ; yet we must remember that it is not decisively proved by any direct or unexceptional experiments, and it must also be acknowledged that it has not received the sanction of some eminent philosophers, both in comparatively ancient and also in modern times.

———o———

THE COMING WORKMEN.

How are they to be educated ? is a problem which seems to be troublesome to solve. At present there is no scarcity of workmen of a *sort*, but really good ones are very difficult to obtain. By good ones we do not mean absolutely scientific as well as practical, but simply good *practical* mechanics. Thoroughly educated ones we never can expect to find as a class, so long as the community are ignorant of the requirements for a good mechanic. As things now are, hand workers, without heads, answer better the demand of the public, which is cheapness, than any other class ; and until they are brought by dearly purchased experience to see the folly of squandering money on that class of workmen, there is no use to urge a higher standard of qualification. But even the race of passably good hand workers seems to be in danger of extermination. The old mode of education seems nearly obsolete ; there are no adequate means (legal) to *compel* persons to become proficients ; the apprenticeship laws are a dead letter, even the " one cent reward " with the picture of a lad with a bundle over his shoulder suspended on a stick, has disappeared from the newspaper advertisements, and with its disappearance all vestige of the mechanical apprenticeship system seems to have vanished, and the trade seem to have settled themselves down to the belief that for anything like fair workmen they must depend upon chance foreigners, who are often driven to emigrate from their own country for lack of the requisite skill to find employment in it. For the rough work, requiring no skill, they depend upon boys who happen along and "want to learn the trade," and they manage to use them to open shop, sweep out, run of errands, turn grindstone, and tinker clocks, till they are filled to overflowing with the idea of having a shop of their own to open, and being themselves "proprietors." These are the kind of workmen that are turned loose upon the community to supply the craving call for cheap labor.

No really good mechanic, who knows his ability and takes a manly pride in it, will be annoyed by such apprentices; there is no profit in it, no pleasure, and no pride in it; the artisan feels that his profession is disgraced by turning out such men, and calling them *workmen.* But the dear public stand with mouths wide agape, like little birdlings in a nest, clamoring to be stuffed with a big morsel of "Humbug," and so they swallow the cheapest workman and are satisfied. Humbug grows rich and fat, and honest skill can scarcely make the two ends meet. The only remedy for this state of things is to educate the public to know and realize the immeasurable distance there is between the two, and in some little degree be brought to understand the necessity for real scientific skill in the repair of watches, even more than in their construction; then they would be more cautious about intrusting their watches to the ignorant workman.

Our requirements here for a workman who can truly be called good are somewhat different from the European standard. In the United States what little constructing is done is confined exclusively to the established factories, and all the knowledge required of the workmen in them is, dexterity in running the various machines. The technical science required in the original designing and laying out the work is not required in the subsequent mechanical manipulations. A thorough understanding how to lay out the work, define the proper place for each part, and determine, with the positive accuracy of science, the proper proportion which each part should bear to every other part, and with the requisite knowledge of isometrical drawing to transfer the design to paper, is the mental capital absolutely necessary to start a watch factory. Then, when the proper automatic machines are constructed, only art is required to run them.

Abroad, both in England and on the continent, each manufacturer gets up his own design, plans his own particular make of watch, and its performance and quality as a timekeeper are in exact proportion to his approximation to scientific principles of construction. For it is established incontrovertibly that there are positive laws of proportion applicable to *every* part of a watch, which cannot be violated without loss of effect. The consequence of this diversity of design and construction is an equal diversity of watches that are cast upon the market. What workman of experience does not know the difference between Coventry and Clerkenwell movements? There is scarcely more difference between a Paris and a Swartzwald clock.

The British Horological Institute was established for the purpose of correcting, if possible, this difficulty, which seemed to threaten serious damage to the whole watch trade of England. The Institute is laboring earnestly to establish classes of workmen for instruction in the principles of the art. Believing that science can only add to, not detract from, a man's ability, however expert he may be in a practical point of view, and that "experience, however extended, could not but be profited by the acquisition of facts, wherever gathered, from learned men of all ages," and to teach such facts, and to communicate all such scientific knowledge as is applicable to Horology, is the primary object of the Institute. Here, with us, we are particularly in want of this knowledge, for the whole business of the American watchmaker is to *mend,* not make. America seems to be the heaven of poor watch workers. An English or Swiss movement, so defective in its construction as to prevent its sale at home, is good enough for export, and will sell in "The States." No sooner do such movements pass the Custom House than they are sent broadcast over the country by Express, C. O. D., and the watchmaker, wherever it goes, is required to make it run, and for ever after to stand godfather to the wretched production cast upon the world and deserted by its depraved parent.

Now, the skill required to make that watch *go* must be far in excess of the knowledge displayed in its construction, and unless a workman knows why and where it is defective, in spite of its high finish, he may puzzle his brains till doomsday and be no nearer ascertaining the true cause of its misbehavior. And this same ignorance of the true principles upon which it *should* be constructed is the real cause of nine-tenths of the watches being *further* spoiled in the hands of this incompetent class of workmen. They have no idea what is the matter, and the consequence is that every screw and wheel, and pinion and pivot, and cock and bridge, is filed, and bent, and twisted, in the faint hope that some of these various punchings may, by accident, hit the real difficulty. Their mode of treatment is the same as that of an ignorant physician, who, in case the patient's disease is quite unknown to him, administers remedies at random, with the forlorn hope that some one of them will cure.

This brings us face to face with the question, How is this state of the craft to be bettered? All good men deplore the situation, and some, no doubt, have theories as to the best plan of remedy. Our own pet theory is, the reformation of the community with regard to the support they give to the most unworthy workman. But how to bring about this reformation is the question. All must feel the truth of the assertion that public opinion cannot be *driven*, it must be *led;* humans, like those quadrupeds whose ears are *not* proverbially short, have a preponderance of inertia—a tendency *not* to move, but when once in motion in any given direction the tendency is equally strong not to *stop*. These little whimsical peculiarities of the public mind make it necessary to resort to an expedient that boys adopt to change the direction of a rolling hoop, without throwing it down—that of applying a gentle pressure, so as gradually to change its direction. Of course it takes time to do this; but if five hundred resolute, good men (and we think there are more than that number in the trade), set themselves seriously and earnestly about it, good results may be expected in a reasonably short time. The general idea of the method to adopt would be for each workman to earnestly impress upon the owner of any watch, that chanced to come in his hands, the necessity of *carefulness* in workmen; he could easily be shown, in his own watch, where it had been marred and disfigured, and he could, in a five minutes talk, be made to understand that all the real damage that could possibly happen to the watch in the the owner's hands, would not permanently injure it in the least if properly repaired. On no account must he get the impression that you are talking against any particular workman, for then your whole harangue will be set down as trade jealousy. In converting him from the error of his ways, you will more than probably make for yourself a permanent customer, and at the same time will, in him, send out a missionary who will sow more of the good seed. There is no better way to make a man careful to whom he intrusts his watch work, than to convince him that it can be so easily spoiled. Now, all this can be brought about by simply telling the *truth*, for we all know these things to be facts. Were it necessary for us, as craftsmen, to make out our case by lying, or even withholding the truth, we should be the very last to make the proposal; but it is truly serving the community, as well as ourselves. As soon as the public *demand* thoroughly competent workmen, we doubt not but the means to supply them will not be wanting.

As our Journal is designed for a free and full interchange of individual opinions, for the good of the whole, we should be exceedingly glad to have any who have given the subject a thought communicate with us, either in private or public. We hold no "patent" on our opinions, and will give earnest attention to any suggestions by any of our subscribers; for by such means we hope to arrive at the best mode for the solution of a difficult problem.

——o——

☞ In the article of Mr. Grossmann's on the Mercurial Pendulum, in the July No., for "Weight of Mercury Columns," in the table, read "Height of Mercury Columns." Typographical errors are very annoying, but seem to be unavoidable. Also, the article on Isochronism should have been credited as coming originally from Mr. Fordsham, of London.

ISOCHRONISM.

It is a well-known fact that when a watch has been running a length of time after having been put in order, the arcs of vibration of the balance grow smaller in proportion to the thickening of the oil, which not only prevents the balance from describing its original arc of vibration, but occasions a "drag" on all the frictional parts of the watch, whereby a part of the motive power of the main-spring is exhausted, and the regulator prevented from exercising its original influence. In addition to this, the watch is also subjected to almost continual outer motion consequent upon usage. These facts, taken together, tend to interfere with the free motion of the balance, and an irregularity in the going of the watch is the consequence; which, unless those faults can be corrected, renders it valueless where correct time is required.

As it is not possible to remedy these inequalities in the arcs of vibration, we are compelled to resort to other means by which unequal (large or small) vibrations become of equal duration, and this can only be accomplished by means of the hair-spring.

The method universally adopted of making the vibrations isochronous embodies the principle that a very short hair-spring, whose whole length is of equal strength, impels large vibrations to move faster than small ones; and a very large hair-spring, with the same conditions, causes the large vibrations to move slower than the small ones. If, then, it is desired to make the vibrations isochronous, a hair-spring must be selected between these two extremes, in which large and small vibrations become of equal duration. The exact size of the spring cannot be determined beforehand, but must actually be tested in the watch, as it not only stands in proportion to the weight and diameter of the balance, but to the strength of the pivots, and the form of the jewel holes.

Experience has shown that the cylindrical spring is the best to establish a correct isochronism, as the coils are all equally distant from the centre, whereby the movement of the coils in the long and short vibrations becomes equal. The diameter of the cylindrical hair-spring should be one-third that of the balance, with about 8 or 9 coils. When there is not sufficient height to admit of that number of coils, they may be lessened; but the diameter must be increased in proportion, as a certain length cannot be deviated from.

The Breguet hair-spring is also a very good one with which to establish a correct isochronism. In form it is flat, with the outer coil bent upwards, and parallel with the remainder of the spring, and forming a part of its circle. The outer coil should be so placed that it be from 1 to 1½ coils above the centre of the spring from the inner to the outer coil. The movement of the coils in this spring are very even, which is a condition required to establish a correct isochronism. When selecting a flat spring, one should be chosen with the coils wound as closely as possible, which renders the movement of the coils more even than one whose length is the same, but whose coils are farther apart. In adjusting the ends of the spring they should be so pinned that one end stands exactly over the other; or, which is the same thing, that the ends form a right angle to the centre, which position, experience has shown, tends to lighten the task of regulating. Indeed, some authorities on this subject have gone so far as to claim that an exact isochronism can be obtained by this means alone. This theory is, however, new, having been recently put forth by Mr. E. Sandoz, of Springfield, Mass., whose reputation as a "springer" is undoubted. Having never made any experiments on his theory, of course I can give no results.

From these considerations we may deduce the fact, that a correct isochronism may be attained by altering the length of the spring, either longer or shorter, so that the large and small vibrations may be made to go faster or slower, as occasion may require. My experience has shown that an exact isochronism is not always desirable. For instance, allowing the small vibrations to describe somewhat faster than the large vibrations, so that a watch, say with arcs of vibration of 350°, regulated to mean time, and then falling off to 150°, should gain five or six seconds in twenty-four hours in the small vibration. The reason of this is, that after the watch has been running a length of time the hair-spring tends somewhat to "draw," whereby a very little irregularity is perceptible ; then there is the thickening of the oil on the balance and train pivots to be considered, which causes a loss of motion of the balance, and an irregular rate in the running of the watch.

Another reason why a perfect isochronous spring should not be used, is, that if the friction of the pivots of the balance staff, when in a horizontal or vertical position, remains the same in a temperature of 14 to 18° R., the motion of the balance will be the same ; but should the watch be placed in a temperature below zero, the friction of the pivots would be increased, and the motion would not be the same, and the watch would not have a regular rate. This would be more perceptible in a vertical position, as the arcs of vibration would become smaller, thereby causing the watch to lose time. If, then, a spring shall be selected that will cause the watch, in the small vibrations, to gain as many seconds as it would lose by reason of the thickening of the oil and the other reasons mentioned, a degree of regularity would be acquired that would be maintained in any temperature.

I will now endeavor, in as few words as possible, to show how the proper length of hair-spring may be determined, so that the above conditions may be fulfilled. The watch should first be in good running order before the isochronism of the spring is tested. This being observed, and the watch being fully wound up, set the hands to the correct time, as indicated by a regulator that can be depended upon, and let it run twelve hours. At the end of this time let the difference of time between the watch and the regulator be carefully noted. Now let down the ratchet so that a very little motive power is exerted, or substitute a weaker main-spring, and then carefully set the hands with the regulator, let the watch run another twelve hours, and then compare the difference between the first and last running. Should the watch have gained two or three seconds in the small vibrations (last experiment), then the hair-spring is one very well adapted to the watch. But should it have gained more than that, or, on the contrary, lost two or three seconds, then the spring is not well adapted to the watch, and its length must be altered, according to the results obtained by the experiment. It is often the case that not till after many experiments have been made, and repeated changes of the spring, that the efforts of the artisan are rewarded with success. CHAS. SPIRO.

——o——

DIALING.

NUMBER TWO.

Knowing that there are many persons in the trade who do not fully understand some of the terms which will be found often repeated hereafter, and who probably will not take the trouble to search out their precise meaning, but may be incited to study them in this connection, therefore we think it best to devote more space to *definitions* than will be thought necessary by the educated, who are prone to assume that everybody knows these things. Having mingled much with craftsmen, and having found among them a great want of scientific knowledge, not that it is undervalued by them, but the opportunity to acquire it has never been presented, therefore we must take people as we find them, and do our best to leave them in a better condition.

Right (*or Straight*) *Line.*—The nearest distance between two points.

Arc.—Any part of the circumference of a circle or other curve.

Radius.—Line or distance from the centre to the circumference of a circle, always equal to the semi-diameter of the circle.

Tangent.—A right line which touches a curve, but which, when produced or continued, does not cut it ; is always perpendicular (or at right angles) to the radius.

Chord.—A right line joining the two extremities of an arc—like the *string* of a bow.

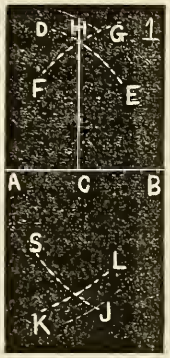
Degree.—The 360th part of a circle ; it is no definite quantity, or distance, for every circle, whatever its diameter may be, is supposed to be divided into 360 equal parts.

Angle—Is the number of degrees contained between any two radii of a circle. The angle between any two lines is the same, whether the lines extend an inch, or a million of miles.

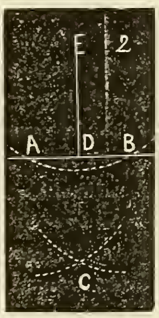
Right Angle.—Quadrature, or quarter of a circle, and is 90° of the circle.

Complement of an arc or angle, is what the arc or angle *lacks* of being 90° ; thus, if an angle or arc is 60°, its complement is 30°.

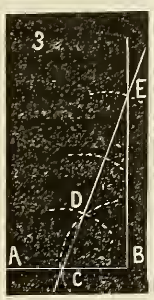
To construct or draw a right angle, as in Fig. 1, or raise a perpendicular to the line A B, set your compass in the line B, and with an opening greater than half the line, describe the two arcs, G F and S J ; from A, with the same opening, describe the arcs D E, and L K ; lay your rule on the intersections of the arcs, and draw H C, which will be perpendicular to A B, and the angle contained between A C H, or H C B, is a right angle.



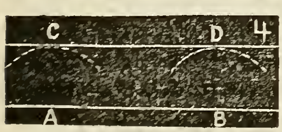
Perpendicular.—A line, or surface, at right angles to another line or surface. To drop a perpendicular from a given point, E (Fig. 2), to the line A B : From E, as a centre, with an opening of the compass greater than the distance E D, draw the arc A B ; then, with the same opening, from the points A and B respectively, as centres, describe the arcs which intersect at C; lay your rule from E to C, and draw the line E D, which is the perpendicular wished.



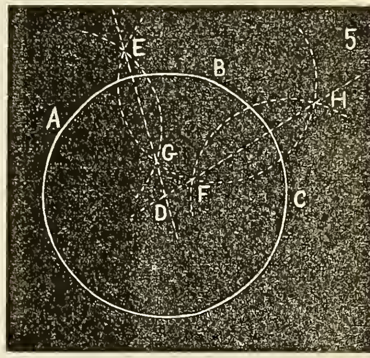
To erect a perpendicular at the end of the line A B (Fig. 3), open your compass to any convenient distance, as B C, and draw the arcs which intersect at D; from C, through D, draw a line prolonged toward E, at pleasure ; take the distance, C D, in your compass, and lay it off from D to E, then a line drawn from the point E to B, will be the perpendicular required.



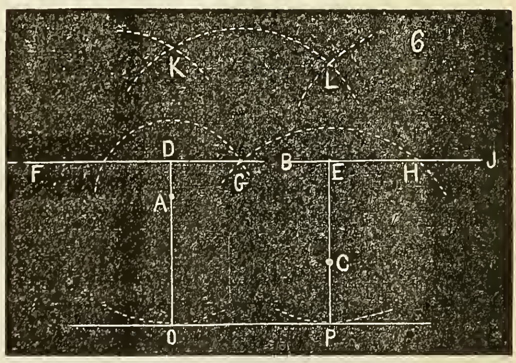
To draw lines parallel to each other (when you have no parallel ruler): From the points A, B (Fig. 4), with an opening of compass equal to the distance desired for the parallel, make the arcs, C, D, then draw a line tangent to both, and you have the line C D, parallel to A B.



To find a lost centre, or to find a circle which shall touch three given points, not in the same straight line : Let A, B, C (Fig 5), be the points ; set the compass in A, with an opening greater than half the distance from A to B, and describe the arc E G; then from B, as a centre, construct the semicircle E F H ; then, from C produce the arc F H. A straight line through the intersections of F H, and E G, will meet at D, which is the centre of the circle in which A, B, C, lie.



Through three points not in a straight line (Fig. 6), to construct a Geometric square:



Though the point B draw the line F J ; set one foot of the compass in A, and draw the arc F G; from C, draw the arc G H; from F and G, draw the arcs which intersect at K, and from G H draw the arcs which intersect at L; from K, through A, draw a line, with the point of your compass, prolonged toward O ; from L draw, in the same way, the line to P, then with the distance from D to E, draw the arcs at O P, and a line tangent to them. Finish with ink the lines O P, P E, and O D, and your square is complete.

After a few Astronomical definitions with a view to fix in the mind the character and relations of the circles, points, lines, etc., of the sphere, called the "doctrine of the sphere," we shall plunge at once into the construction of dials.

Great Circle.—The section of a sphere by a plane cutting it through its centre in *any* direction. *Small Circles* are such as are formed by a plane cutting the sphere in any direction not through the centre, dividing it into two unequal parts.

Axis of a Circle.—A straight line passing through its centre at right angles to its plane.

Pole of a Great Circle—Is the point where the axis cuts through the sphere, and is everywhere 90° from the great circle. The earth is called the terrestrial sphere; the starry concave of the heavens, the celestial sphere. The great circles of the globe, extended every way till they meet the heavens, become circles of the celestial sphere.

The Horizon.—A great circle which divides the earth into the upper and lower hemispheres, and separates the visible heavens from the invisible; this is the *rational* horizon —the *sensible* horizon being the boundary of vision of the observer; still so vast is the distance of the starry sphere that both these planes appear to cut in the same line, so that we see the hemisphere of stars which we should see if the upper half of the earth were removed, and we stood on the *rational* horizon.

Poles of the Horizon.—The plumb line represents the axis of the horizon—directly over head is Zenith, directly under our feet Nadir.

Vertical Circles—Are those circles which pass through the poles of the horizon, and are perpendicular (or at right angles) to it.

Meridian—Is the vertical circle passing through the north and south points.

Altitude.—The elevation above the horizon measured in degrees on a vertical circle passing through that body.

Azimuth—Is the distance of a body from the meridian (measured on the horizon) to a vertical circle passing through it. The poles of the earth are the extremities of its axis, and when prolonged to the heavens, become the poles of the heavens.

Equator.—The Great Circle cutting the axis of the earth at right angles. The intersection of the plane of the equator with the earth's surface, is the *terrestrial* equator, and with the concave of the heavens the *celestial* equator, and is more often called the *equinoctial*, because when the sun is on the equator the nights and days are equal in length.

The meridians, which are always at right angles to the equator (or equinoctial) and also to the horizon, are called *hour circles*, because the arcs of the equator intercepted between them are used as measures of time.

Latitude of a place is its distance from the equator north or south; the *Polar distance* is the angular distance from the nearest pole, and is the complement of the latitude.

Longitude of a place is its distance from some standard meridian, east or west, measured on the equator. The meridian usualy taken as the standard is the meridian of the Observatory of Greenwich, near London. If the place be directly on the equator we have only to measure the arc of the equator intercepted between the place and the point where the meridian of Greenwich cuts the equator. If the place be north or south of the equator its longitude is the arc of the equator intercepted between the meridian of the place and the meridian of Greenwich.

Ecliptic is the great circle in which the earth performs its annual revolution around the sun, its plane cutting the centre of the earth and the centre of the sun. If the axis of the earth were at right angles (or perpendicular) to the ecliptic, the equator would coincide with it; but it is found by observation that the earth does not lie with its axis at right angles to this plane, but is turned about $23\frac{1}{2}°$ out of a perpendicular direction, making an angle with the plane itself of $66\frac{1}{2}°$—the two circles making an angle with each other of 23° 27′ 43″. It is very important to get a correct idea of these two circles and planes, because to them are referred a great number of astronomical measurements and phenomena, and they are the " ground plan" upon which the superstructure of dialing is constructed.

Equinoctial Points are where these two circles intersect. The time when the sun crosses the equator (coming north) is called the vernal equinox (about the 21st of March), and where it crosses the equator going south, the autumnal equinox (about Sept. 22).

Solsticial Points are where the sun is most distant from the equator, north or south. The summer solstice (north) occurs the 22d of June; the winter solstice (south) the 22d of December.

The ecliptic is divided into twelve equal parts, of 30° each, called signs, which, beginning at the vernal equinox, succeed each other in the following order :

NORTHERN.		SOUTHERN.	
1. Aries,	♈	7. Libra,	♎
2. Taurus,	♉	8. Scorpio,	♏
3. Gemini,	♊	9. Sagittarius,	♐
4. Cancer,	♋	10. Capricornus,	♑
5. Leo,	♌	11. Aquarius,	♒
6. Virgo,	♍	12. Pisces,	♓

——o——

WATCH AND CLOCK OIL.

One of the most essential things in a watch or clock, to insure its correct performance and durability, is *good oil.* Probably every watchmaker has at some time learned this by his own sad experience, having suffered much in loss of time and patient labor, by the injurious effects of poor oil on his work. Hence, the importance of this subject, viz., oils for horological uses, to which we will give a brief consideration.

After the watch or clock is carefully cleaned and adjusted, each of the pivots and springs receives its particle of oil, and the delicate machine is expected to keep its continuous motion, with almost the accuracy of the sun, without further attention for a year or more, or until it comes into the hands of the watchmaker again for renewed cleaning or repairs ; during all the intervening time the watch receives no more oil. It becomes then a very important question : What are the essential requisites of the oil that shall accomplish this result ?

The following are undoubtedly the most important, viz.:

1st. It must not corrode on metals.

2d. It must not become gummy.

3d. It must not quickly evaporate.

4th. It must not congeal when exposed to severe cold.

Equally important are the questions : How and where can an oil be obtained that will bear these four tests ?

Is it to be found in the animal or vegetable kingdoms? Chemistry will do much in solving the problem, but we shall find the most reliable test is *experience.* It is of prime importance to consider what the experience of practical men has been in the use of oils on watches and clocks. A writer in the English *Horological Journal,* vol. vii., page 74, says : "After a careful and protracted trial of *Olive, Neat's-foot, Nut* and *Fish* oils, manipulated in many ways, I give as the result of all my experiments, fish oil was found, all things considered, the best."

In the same journal, A. Long writes : "In 1814 and 1815, I was in the Arctic regions, and I remarked that train or sperm oil stood more cold than any other, and that a portion of it never congealed ; this was the oleine, which we preserved and applied to our chronometers, and thus kept them performing through the winter." He then goes on to describe the process by which the oleine was extracted from the blubber of the whale. Others have written to prove that oil, extracted from a certain kind of olive, and at a certain time, called Virgin oil, is best. The writer before mentioned says : "I first turned my attention to olive oil, but after a year or two experimenting with it I gave it up."

All vegetable oils used on watches or clocks, will be found open to these serious objections : They will corrode on metals, and they will become green and gummy in the pivot holes after a time. Others have tried mineral oils with no better success. Not to mention any other serious objections, they will be found to evaporate quickly, leaving the holes dry.

Experiments have also been made with oils of ruminating animals, but they are found to contain *stearine* in large proportion, and are altogether too coarse and hard for horological purposes. Various kinds of nut oils have been tried with no better success ; the principal objection being they corrode quickly.

After all the trials and tests, by practical men, of the various kinds of oils to find the kind that is best adapted to the delicate machinery of watches and clocks, all kinds but fish are found open to some objection. The oil obtained from the head and jaw of a species of the porpoise called black fish by the fishermen, has been used in this country for the last forty years or more, combining all the qualities mentioned above, viz.: Does not corrode, does not become gummy, is not quickly evaporated, and does not congeal in severe cold. The experience of practical men during all that time, and in various climates, goes to prove that the statement made above is correct.

The head and jaw of the porpoise contain a limited quantity of the article which Mr. Long calls oleine, by which he probably means pure oil, free from all other properties. There is great difficulty in procuring the genuine porpoise oil, having to depend entirely upon the fishermen, who, on the sea, or along the shore, catch the fish and extract the oil; a small part of which only can be safely used for horological purposes. The blubber should be boiled out in fresh water, which can be easily done when the fish are taken on the coast, but not so readily at sea, where fresh water is scarce; therefore it becomes important that the oil should be chemically tested, for if salt is detected it becomes positively injurious when applied to the watch. It must also be sweet; if it has become changed, acids are generated which make it injurious. After being sure that the oil is good and of the right kind, it is only by a tedious course of preparation that the crude oil can be put into a condition to stand the four tests spoken of.

A very effectual test of good oil may be made by countersinking a small cup on any old watch plate deep enough to hold a drop; fill it with the oil and set it aside, covered with a glass so that no dust may get to it; if it remains clear and limpid ten or twelve months, three of the essential points are settled. The other point is easily proved by subjecting it to a very low temperature. Manufacturers on the continent and in England, very generally use olive oil on their watches, and on arrival here the oil is usually found to be thick and gummy, rendering it necessary to clean the watch and put on fresh oil before it is safe to warrant it to perform correctly.

They are beginning to appreciate the great advantage which fish oil has over the vegetable and other kinds for horological purposes, and already there is a large market for American oils among manufacturers, and the demand is constantly increasing.

A change for the better is apparent when the porpoise oil is used on imported movements; they move more freely and are in much better order for the pocket on their arrival here, and can be relied upon more surely from the start. In Paris clocks especially, the pivots are clean and free, instead of the green and gummy state in which they have usually been found. No oil will keep good in close proximity with cedar wood; if this wood is used in any part of a clock case, the oil will become gummy in a short time. A like result will be produced on watches kept in drawers made of cedar.

In conclusion, it appears that the oil of the porpoise or black fish has proved by long experience as well as by chemical tests, to be a good oil for clocks and watches. Further investigation may bring to light something better, but until that time arrives, the trade will undoubtedly use it in the future as it has in the past.

Our patrons, after reading this article, may ask us, who are the manufacturers who put up this oil which has been found in practical workings to be the best? In answer, we know of none better than the oil put up by I. M. Batchelder, of which Palmer, Batchelders & Co., 162 Washington street, Boston, are sole agents. It is well known throughout this country and is extensively used in London, Paris, and among the manufacturers of England, France, and Switzerland.

SOFT SOLDER.

Stepping into the shop of a jeweller friend a few days since, I found him putting the stem on to a gilt watch case with soft solder. I remonstrated with him, but he said it was his orders. "You see," said he, "if I hard solder it, it will discolor, and will have to be re-gilt." He kept on, and after three attempts he made it stick until I got away, and if he sent it home done up in cotton, I have no doubt it arrived safe.

Now we have had two commandments given us. The first is, "Never soft solder a job that can by any possibility be hard soldered;" and the second is like unto it, "Never use soft solder on any article of gold or silver that may by chance require to be hard soldered afterward." On these two commandments hang all the tinkers' law and profits.

But it is necessary at times to use soft solder, and I am going to tell you how I do it, having no doubt at the same time that all of my readers can do it better than I can.

Since the good old resinous days have gone by, we have come to the use of soldering fluid, or a fluid that when dried off by heat will leave a coating on the article to which the solder will readily adhere, and also a flux to assist it in the flow.

To make this fluid, I put, say one pound of muriatic acid in a glass jar, set it out in the open air, and add to it some pieces of clean zinc. When the violent ebullitions have ceased I add more zinc than the acid can possibly take up. I let this stand for several hours, then add about half a gill of water, when it will commence eating again. I let this stand again, then add a little water, and continue this so long as I can discern any signs of action on the zinc. I stir it well with a stick each time I add water, and if, after standing, I tap the jar and no bubbles rise, I consider it has ceased action. Then I add one ounce of sal ammonia, let it stand over night, pour off the clear fluid, and throw away the sediment. It should be kept corked, as the strength of the acid is quite exhausted, and when steel is soldered with it, if washed off with alcohol, there is very little fear of its rusting afterward.

The best solder I have ever used, I have bought from the britannia workers. It keeps for a long time without tarnishing, and is far superior in every respect to the rolled solder found at the material dealers. Clean the parts well, and do not apply heat enough to start the temper of brass, silver, gold or steel.

D. W. B.

WATCH CLEANING.

Old Shirts are indispensable to the watchmaker — in fact they are invaluable. Let no one, however urgent his pecuniary necessity, ever yield to the temptation of selling one to the ragman in order to "raise the wind," neither let your washwoman so work upon your sympathetic generosity as to beguile you out of one, on the specious plea that "she can cut it down for the baby." They *are* good for something—don't you, for a moment, listen to the hackneyed expression that they are of no further use to *you* ; they *are* useful, nay more, they are precious.

Of course we would not have you imagine that *new* shirts were not also proper, and necessary, and convenient. But new ones you can dispense with. By the aid of "*modern* improvements" you can "make shift" to do without them ; the thousand and one recent appliances of paper have almost made the shirt obsolete. With a paper dickey, and a paper collar, and a paper tie, and paper cuffs, its absence is rarely noticed ; in fact, the difference between the uses of the new and the old is, that the former is used to conceal dirt, and the latter to remove it.

Several of our correspondents have made mention of their various modes for cleaning watches by brushings, and washings, etc., all very good in their way; but our own plan we like best of all yet tried. Every one knows (or ought to know) the tender nature of cheap gilding, and its liability to removal by the slighest abrasion, and with brushing the corners off, all the cocks and bridges get the most of it. All the under parts, where dirt "most does congregate," we brush with alcohol, and a little chalk if necessary ; all the upper gilded parts we wash with a camel hair pencil dipped in alcohol, and wipe dry with *well worn* cotton or linen cloth, which cleans them perfectly, produces not the least scratch, leaves the work as bright as when originally finished, and we are persuaded that when once tried it will not be abandoned. Of course, when the brush is used the cloth must not be, for the fibre brushes up and lint is apt to get on the parts ; but when used simply as a wiper all the fibres are easily removed by a puff of the breath.

New fabric must never be so used, as it is filled with starch, which renders it harsh. Cut up the cloth in squares of about four inches, packed away carefully in a box or drawer from dust. If judiciously used there is nothing that we have ever tried that so well answers the purpose.

ANSWERS TO CORRESPONDENTS.

G. F. E., *Memphis, Tenn* —There are, as you suggest, other and larger Catalogues of Stars, such as what is known as "The Greenwich Twelve Year Catalogue," a list of 2,156 stars; "The Catalogue of the British Association for the Advancement of Science," containing the positions of 8,377 fixed stars, and others. As they are not published annually, but only at long intervals, their use requires the employment of tedious and difficult formulæ to correct the positions of the stars for any required date; hence the use of these Catalogues is confined principally to the great Observatories.

We doubt whether either of those mentioned can be obtained short of importation from London, but we presume any of the chronometer and nautical instrument dealers would import them to order, that business being somewhat in their line. Address John Bliss & Co., No. 66 South street, N. Y.

As to the adjustment of a transit, aided by the observation of stars passing the meridian at different degrees of declination, no better method can be devised. For this purpose preference is given to those which pass the meridian at or near the zenith, and those of low declination. When the axis of the instrument is accurately levelled, its telescope describes a vertical circle, of course, passing through the zenith, whatever may be the position of the transit. Therefore, if the telescope be placed approximately in the meridian, and a star be selected that passes through the zenith, its observed meridian passage will not be affected by the azimuthal error of the instrument, and consequently the true time may be obtained. If, now, a star of low declination be observed to cross the lines of the transit, the difference between the calculated and the observed time of transit shows the amount of azimuthal error due to that declination, and the frame of the transit must be turned in that direction, east or west, which will lessen this error. When, by repeated trials, the high and low stars show the same amount of error in the time-piece used, allowance being made for its rate, if any, the transit is proved to be in adjustment.

The method by the Pole Star, used by some, while fully as accurate as any, has the advantage of being easily adapted to the wants of the unskilled. The slow motion of the Pole Star is what makes it of value in this connection, as the centre, or meridian line, may be readily adjusted on the star, when on the meridian, small errors in the time-piece used, or slight inaccuracies in the manipulation, affecting the result to a trifling extent only; while a few repetitions of observations of the sun, followed by corrections of the correspondence of the meridian line and the star at its culmination, serve to entirely eliminate any error in azimuth.

H. H., *Murphysboro, Ill.*—I am pleased to answer the query, inasmuch as it affords me an opportunity of pointing out an advantage in the method of developing the escapement, as illustrated and described by Fig. 1, in my article on Chronometer Escapement, in July number. If the gentleman will please take up and examine the description of the drawing again, he will see that it is *from a given centre distance*, which he calls depth, that the relative diameters of wheel and roller are developed with a view of obtaining a certain amount of leverage impulse; and hence it is possible, according to this method, to determine and fix the centre distance in the watch before either wheel or roller is made. If, then, an escapement were constructed on this principle, an error of depthing could not occur, except the wheel and roller were made of other diameters than obtained in the development, which could only be attributed to gross neglect on the part of the workman. Different is it according to another mode of constructing the escapement, where from a given diameter of wheel the relative size of roller is determined, and the centre distance afterwards pitched with the finished roller and wheel. In this case an error of depth could easier take place, though it will be found as a rare occurrence. Should such be the case, it will be easily remedied by making the diameter of the roller either smaller or larger, as the case may require; and to do this, it would be only necessary to move the impulse jewel a little further out or in. This will remedy the fault, though the amount of leverage will be changed a little; but as the diameter of a finished wheel cannot be made other than it is except by a new one, this could not be avoided.

TH. GRIBI.

A.W., *Stamford, Ct.*—There must be some fault in the method of using the *pickle* which we cannot discover. Did you heat the jewelry nearly or quite red hot and plunge it in the pickle? or was it not possible the articles you experimented on were *silver plated?* if so, there is no restoring it except by replating. The plan will certainly and successfully work on solid silver goods, for we have used it for years, and we can scarcely believe that a pickle of 2 parts sulphuric acid and 1 part nitric *diluted* with water (as directed) till it is only *very* sour to the taste, will in the least injure silver, even if it WERE TO REMAIN in it 48 hours.

Key pipes or tubes are drilled to a little more than the proper depth; then a perfectly square punch, the face of which is exactly at right angles to the axis of the punch, is driven to the bottom, forcing before it the amount of metal shaved off in squaring up the round hole; it is then finished off outside—hardened and tempered, if it is intended to be a *good* key pipe.

Mr. English, of Springfield, Mass., makes an excellent patent steel key, both for the pocket and the bench. Most of the keys and key pipes in use are made abroad.

C. W. H., *North Adams, Mass.*—Do you mean the hole through a new pinion, as they come from the material dealer? If so, the best way for you to fit the hole to the arbor of the old square, is to make a "rose drill" of the exact size of the *smallest* diameter of the square arbor where it comes through the pinion under the dial.

The "rose drill" is made from a piece of steel wire fitted to your drill stock, or what is better, in the chuck of an American lathe. Turn down the end of the wire for about the 16th of an inch to the exact size you wish the hole through the pinion; above that turn down a shank, a little smaller, only to give perfect freedom; but not enough to weaken the drill; then round off the *end* nicely to a half-round or less, and file the rounded end into a series of radial grooves, all brought to cutting edges; then harden and temper, and you will have a drill which will surely follow the hole you wish to open. Be careful to have the straight part of the drill *no larger* behind than at the end, otherwise it will *bind.* This drill will not deviate from the centre of the hole it follows, for the smooth sides form a perfect guide.

To give the hole the requisite taper to fit the arbor, a very little opening with a $\frac{5}{4}$ brooch (holding the pinion in the fingers) will be sufficient.

E. C. B., *Newport, R. I.*—The "Turns" you inquire about are nothing more than the ordinary steel bench lathe, which every watch maker has, and they are often spoken of as *dead* centre lathes, to distinguish them from those which run with a band and have a *live* centre.

R. H. L., *Spring Lake, Mich.*—With a diamond point, or the sharp corner of a piece of steel, as hard as fire and water will make it, mark the spot on the glass where the hole is desired. It must be sufficiently deep to hold from slipping the end of a copper wire, which must be charged with emery (about No. 60) and water. The size of emery will depend somewhat on the size of hole you wish; for a small hole coarse emery will not stay with your drill; you can run the drill by a drill-stock and bow, or by a lathe. Glass differs very much in hardness, depending upon its composition; some being very difficult to drill nicely, except with No. 1 diamond dust. The hole, when through, can be enlarged at pleasure, by using a copper wire, sharpened at such an obtuse angle as not to bind in the hole, and charged with emery the same as for drilling. To prevent *chipping,* work from each side of the glass alternately. The most expeditious way is with a diamond drill, which is not always at hand.

J. M. L., *South Paris, Me.*—The method of measuring clock pendulums, so as to get the right length when they are lost or broken, is: First find the number of revolutions or parts of a revolution the scape wheel makes in a minute; multiply the number of revolutions or parts of a revolution by twice the number of teeth that there is in the scape wheel, which will give the number of vibrations the desired pendulum will have to make in a minute; then divide the number, 141,120.0 by the square of the number of vibrations, and the product will be the length of the pendulum in inches.

J. B. M., *Cincinnati, O.*—Mr. Herrmann, our London correspondent, is a German by birth, about thirty years of age, and has been a resident of London some eight or ten years. He is both a practical workman and a scientific horologist. For three years past he has been the instructor of the Drawing Class in the British Horological Institute, a position for which he is well qualified, possessing a degree of patience that is so necessary in a teacher. In the October number we expect to present to our readers a scientific article from him, on the construction of an epicycloidal shaped tooth of any size, by the method of co-ordinates.

AMERICAN HOROLOGICAL JOURNAL,

PUBLISHED MONTHLY BY

G. B. MILLER,

229 Broadway, N. Y.,

At $2.50 per Year, payable in advance.

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For August, 1870.

Day of the Week.	Day of Mon.	Sidereal Time of the Semidiameter Passing the Meridian.	Equation of Time to be Added to / Subtracted from Apparent Time.	Equation of Time to be Subtracted from / Added to Mean Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		s.	M S.	M. S.	S.	H. M. S.
M..	1	66.64	6 4.33	6 4.35	0.143	8 39 34.09
Tu.	2	66 56	6 0.58	6 0.60	0.169	8 43 30.65
W	3	66.47	5 56 21	5 56.23	0.195	8 47 27.20
Th.	4	66 39	5 51.21	5 51.23	0.222	8 51 23.76
Fri.	5	66.30	5 45 59	5 45 62	0.248	8 55 20.31
Sat	6	66.22	5 39.36	5 39.39	0.273	8 59 16.87
Su.	7	66 13	5 32.53	5 32.56	0.298	9 3 13.42
M..	8	66 05	5 25.09	5 25 12	0.323	9 7 9.98
Tu.	9	65 96	5 17.06	5 17.09	0.348	9 11 6.53
W.	10	65.88	5 8.43	5 8.46	0.372	9 15 3.09
Th.	11	65.79	4 59.23	4 59.27	0.396	9 18 59.64
Fri.	12	65.71	4 49 47	4 49.50	0.419	9 22 56.20
Sat	13	65 63	4 39.16	4 39.19	0.442	9 26 52.75
Su.	14	65.55	4 28.30	4 28.32	0.464	9 30 49.31
M..	15	65.47	4 16 91	4 16.94	0.486	9 34 45.86
Tu.	16	65.40	4 5.01	4 5.04	0.507	9 38 42.42
W.	17	65.32	3 52.60	3 52.64	0.528	9 42 38.97
Th	18	65 25	3 39.70	3 39.73	0.548	9 46 35.53
Fri	19	65.17	3 26.32	3 26.35	0.568	9 50 32.08
Sat	20	65.10	3 12.48	3 12.51	0.587	9 54 28.63
Su.	21	65 03	2 58.18	2 58 21	0 606	9 58 25.19
M..	22	64.97	2 43 43	2 43 47	0.624	10 2 21.74
Tu.	23	64.90	2 28 25	2 28.28	0.642	10 6 18.30
W.	24	64 84	2 12.65	2 12.68	0.660	10 10 14.85
Th	25	64 78	1 56.63	1 56 66	0.677	10 14 11.40
Fri	26	64 72	1 40.21	1 40.23	0.694	10 18 7.96
Sat	27	64.66	1 23.40	1 23.42	0.710	10 22 4.51
Su	28	64.61	1 6 21	1 6 24	0.726	10 26 1.06
M.	29	64.55	0 48 66	0 48.67	0.741	10 29 57.62
Tu.	30	64 50	0 30.75	0 30 75	0.755	10 33 54.17
W.	31	64 45	0 12.49	0 12.49	0.769	10 37 50.72

Mean time of the Semidiameter passing may be found by subtracting 0.18 s. from the sidereal time.
The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
☽	First Quarter	3 20 51.5
☉	Full Moon	10 21 13.5
☾	Last Quarter	18 19 50.4
●	New Moon	26 9 25.6

		D. H.
☾	Perigee	3 2.1
☾	Apogee	17 12.6
☾	Perigee	29 10.3

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1

	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20 572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

	APPARENT R. ASCENSION. D.	H. M. S.	APPARENT DECLINATION. ° ′ ″	MERID. PASSAGE. H. M.
Venus	1	6 29 20.43	+22 26 38.2	21 50.9
Jupiter	1	5 10 32.98	22 23 23.9	20 28.4
Saturn	1	17 27 17.33	−22 4 2.1	8 46.2

AMERICAN

Horological Journal.

VOL. II. NEW YORK, SEPTEMBER, 1870. No. 3.

CONTENTS.

*** *Address all communications for* HOROLOGICAL JOURNAL *to* G. B. MILLER, *P. O. Box* 6715, *New York City. Publication Office* 229 *Broadway, Room* 19.

HOW CAN THE CONDITION OF THE COMING WORKMAN BE IMPROVED?

Since we have been the vehicle of inter-communication between our fellow-craftsmen we have been in constant receipt of letters and communications setting forth innumerable hopes, and fears, and grievances connected with the trade. By these interchanges intelligent, energetic, well-read, well-educated men have come to light, and have bid us be of good cheer, and have upheld our hands on either side, like the friends of the prophet of old. And then again there have been developed another class—restless, progressive enthusiasts, such as infest all communities, and all occupations; men whose zeal, were it modified by discreet knowledge, would be most able helpers in any cause. We have also encountered the usual number of misanthropic grumblers, who are dissatisfied with others, and equally so with themselves. Taking the views of the whole together as a unit, we have found a most decided want of unanimity among the trade; scarcely any considerable numbers entertaining the same view of the condition of things; and the ideas regarding the betterment of our condition are equally various. Many are anxious to establish a Trade Union, for the mutual protection of the interests common to all—for the establishment of prices—for the defence of the skilful mechanic against the predatory incursions of the ignorant "hangers-on." Others desire something like a Board of Equalization, with power to decide upon the merits of various grades of workmen, and to award diplomas of merit, which shall be a guarantee to the incredulous community of the character of the bearer. In fact there is no end to the devices which each one wants adopted and enforced *against his neighbor.*

Not as authoritative, nor with the idea of propounding any plan better than any one else, but simply to develop thought that may ultimately assume form and proportion, we will state a few objections to some of the plans mentioned. Trades Union is a subject which is claiming the attention of the best minds of the country, and the discussions, *pro* and *con*, are familiar to all; and it would be egotistical presumption for us to claim new light on the subject. The organization of a society or class of workmen who consider themselves the *best*, or that may be considered so by others, arrogating to themselves, or even receiving authority (delegated) from others, to decide upon the merits of a workman, and to enforce that decision by any pains and penalties, we consider futile, and confess our lack of ability to see what good can come of it. We think we can see in it evil, and only evil continually. The favored few—the aristocrats of the trade—will be the minority, and must necessarily encounter the uncompromising hostility of the majority—the outcasts from the "society"—and we well know how powerless minorities are in a free country. Graded classes, we think, would meet with no better success. No workman would like to hang up his diploma as a second or third class workman; he would rather cast his lot with "outsiders," and trust to his own tact to make his way to a *first-class* notoriety with the community, and snap his fingers at the "society's" diploma. To decide upon the merits of a workman would require the knowledge of a god; to establish any system of test rules would be next to impossible. A good finisher might be a very poor workman, and a first-class workman be a very poor finisher. The possibility of being first-class in some specialty makes it positively impossible to say who is first-class.

If any such ideas should ever become crystallized into form, our conception is, that Principles should be the measure of a man's knowledge—not moral principles, but the known and well-established laws of nature in every department of science that bears relation to a man's chosen profession. There can scarcely be a possibility that a person so informed, so learned, we may say, can ever make any great mistake in the *practice* of his art or calling—which is but the embodiment of those fixed laws. As a familiar illustration of our idea, suppose a watchmaker who knows the principles of correct depthing, was called upon to correct some fault in a watch; would he ever alter the proper relation of wheel and pinion to remedy a fault which he absolutely knew could not exist there? He would of course look elsewhere for the error. Or would a watchmaker who knew the laws pertaining to springs, under all ordinary or extraordinary conditions, be guilty of riveting together the broken ends of a mainspring in a fine watch? He more likely would endeavor to explain to the owner the utter impossibility of such a method of repair ever proving satisfactory, and perhaps show him the reason why; then, if the owner, through cupidity or stupidity, insisted on its being so done—that it would do for the present, etc. —that watchmaker would, if possessed of any professional pride, advise him to take it to some craftsman who had no reputation to lose by such work. If the owner was a sensible man he would say, do it as it should be done; if he proved to be otherwise, the sooner the two part company the better.

We conceive it to be far more important to be thoroughly educated in primary principles than in handicraft. The former are comparatively few, easily and quickly learned, and are immutable; while art-skill in manipulation is endless; the duration of a whole life being insufficient to acquire the ten thousand ways of doing a thing when only one principle is involved. Primary laws being the same for all, their application is infinite, and affords free scope for the endless diversity of taste, and full development of individuality. And however multiplied the forms which adapt themselves to the laws, there is no danger of failure in the ultimate performance of such constructions, because all the endless modifications of form are continually subservient to, and under the control of, and in conformity with, immutable laws. We are pleased with remarks we find in a series of articles on Applied Mechanics, published in the *British Horological Journal:* "It seems to me that in our mechanical teaching we make too much of mechanism, which may be varied indefinitely, and too little of natural principles. The consequence is that by far too much we copy each other's arrangements of mechanism; whereas, if we were taught the natural and mathematical principles, and showed that they could be applied in many different ways, setting each one to find his own mechanism, and letting it be considered wrong for a man to copy other men's mechanical forms and arrangements, within a reasonable period, by so doing, a great change would soon be experienced, if our young men were sent out to explore in the boundless field of mechanism, which lies open to all, instead of repeating the forms and arrangements which have been adopted by others." * * * * "The prominent consideration of the natural principles as thus associated with and determining working mechanism, would impart a dignity to mechanical art." * * * "There is no sound practice without true principles, come from where they may; and practical men are immensely indebted to those philosophers and men of science who frequently and without remuneration take the trouble to investigate first principles, and give them to the world freely and fully, whose labors have been and are now of incalculable value in reducing facts to order, and giving us simple yet comprehensive formulæ for the guidance of construction, and who investigate and lay open the mysterious laws of heat, and other natural agencies, and make plain to the more occupied and plodding busy workers, the wonderful phenomena of the innumerable laws of nature."

Technological education we think has somewhat the same relation to art that the elements of penmanship have to the beautiful art itself. A few up and down strokes, a few concave and convex lines, once fixed in the memory, and there is no end to the elaboration of them into elegant, graceful, charming forms. We, of course, do not expect to change the present condition of things, nor very materially change the views of the working men who now fill their various positions, more or less to the satisfaction of themselves and the community where they operate. But we do hope to initiate a reform in the future education of the young who are to fill our places, and upon whose education will depend, not only the practice, but the science of Horology. We also fancy that we discern, in the dim future, an endless multiplicity of manufacturing industries, directly connected with our art, springing up in all parts of our vast domain—the products of which must eventually supply the ceaseless demands of our growing country; and we should feel a national pride in knowing that all the watch manufactories to come were compelled, by the educated opinion of the trade, to construct their products, however diversified in form, upon truly philosophical and mathematical principles, and we feel that this can be done. Our factories have commenced the good work, and have made creditable progress in the right direction. We all know that our machine-made watches, although far inferior to many foreign in final finish, will compare more than favorably in performance with them. Take the extreme grades of the American Watch Company, for illustration of our idea. The "Home," the lowest and cheapest variety, as compared with the "American Watch Co.," the highest grade, is of the rudest construction; no pains taken in any part of its manufacture, and yet the disparity of performance in the two classes is by no means proportionate to the difference in price. This occurs from the fact that the caliper of each is the same, all parts being made to gauge; the same *principles* are adhered to in the construction of each, and consequently the perfection of performance is only the result of perfection of finish. Therefore we indulge the hope that the principles upon which the Coming Factories will operate shall be correct. We ought surely to profit by past experience, having suffered enough from the shower of "hap-hazard" productions of the Old World that have rained upon us, to take warning, and not copy blindly their errors. We know that "to err is human," but to perpetuate a mistake, plainly seen to be such, is "infernal stupidity;" and in view of the coming factories, the coming workmen, and the coming population, let us cast about us for the best, most expeditious, and most effective mode of education.

—o—

HEAT.

NUMBER TWO.

SOURCES OF HEAT—THE SUN'S RAYS—COMBUSTION—CHEMICAL MIXTURE—THE ELECTRIC AND GALVANIC DISCHARGE, ETC.

Having in our last number glanced at the nature of heat, we will now proceed to look into the sources from whence it is derived; the most important being the rays of the sun, combustion, percussion, friction, chemical mixture, and the electric and galvanic discharge.

The great source of heat to our world, and probably the rest of the solar system, is the radiant caloric that is projected from the sun. Heat from this source has been approximately estimated by Pouillet as being between 2662° and 3202° Fahr. When a sufficient number of rays are concentrated on one spot, either by concave mirrors or convex lenses, the most powerful heat is excited. When the Romans were besieging Syracuse, 213 B. C., Archimedes is said to have used a number of metallic mirrors with such effect as to set fire to their fleet. The experiment has been repeated in modern times. Buffon arranged 168 small plane mirrors in such a manner as to reflect radiant light and heat to the same focus, like one large concave mirror. With this apparatus he was able to set wood on fire at the distance of 209 feet, to melt lead at 100 feet, and silver at 50 feet. The following effects were produced by a large lens or burning glass, two feet in diameter, and made at Leipsic in 1691 : Pieces of lead and tin were instantly melted ; a plate of iron was soon rendered red hot, and afterwards fused or melted ; and a burned brick was converted into a yellow glass. A double convex lens, three feet in diameter and weighing 212 lbs., made by Mr. Parker, of England, melted the most refractory substances. Cornelian was fused in 75 seconds ; a crystal pebble in 6 seconds, and a piece of white agate in 30 seconds. This lens was presented by the King of England to the Emperor of China. It would appear from an experiment of Rumford's, that the great heat excited in these cases depends entirely on the concentration of the rays, and not from any change in their nature, because when he directed a portion of the rays against a substance adapted for absorbing them, the total amount of heat communicated to it was the same, whether the rays were received on the surface in a diffused state or brought into a small focus. What the sun is composed of, that it has for thousands of years poured forth undiminished supplies of heat, astronomers cannot determine. It has long been supposed to be in a state of violent combustion, but the various observations of Dr. Herschel and others render it probable that this notion is erroneous. From them it appears that the sun is an opaque globe, surrounded by an atmosphere of great density and extent ; in this atmosphere there are two regions of clouds; the lowermost of the two are opaque, and similar to the clouds that form in our own atmosphere ; but the higher region of clouds are luminous, and emit the immense quantity of light to which the splendor of the sun is owing. The sun is supposed by some to emit three kinds of rays : the calorific, colorific, and deoxidizing. The first occasions heat, the second color, and the third separates oxygen from various bodies. Captain John Ericsson, the inventor of the caloric engine and the monitor system of naval warfare, has for some time past been engaged on a series of experiments having in view the utilizing the heat of the sun for mechanical purposes. Probably we may be able to give the result of a number of his experiments in a future number.

The most important sources of heat which we have in our power to supply at pleasure, is that which depends on combustion ; and few phenomena are more wonderful and interesting. When a stone or a brick is heated, they undergo no change ; and when left to themselves they soon cool again, and become as at first ; but when combustible bodies are heated to a certain degree in open air they suddenly become hotter of themselves, continue for a time intensely hot, and send out a copious stream of light and heat. When this ceases, the combustible matter has undergone a most complete change, being converted into a substance possessed of very different properties, and no longer capable of combustion.

All bodies, so far as combustion is concerned, may be divided into *supporters*, *combustibles*, and *incombustibles*. By supporters are meant certain bodies, not indeed capable of burning, but combustion cannot go on without their presence. *Air*, for example, is a supporter. Combustibles and incombustibles require no explanation. The following are all the supporters at present known : Oxygen, chlorine, air, nitrous oxide, nitrous gas, nitric acid, and euchloric gas. The combustibles are either the simple substances which have already been described, or combinations of these with each other, or with oxygen without combustion ; in which last case they may be called combustible oxides. During combustion the oxygen or chlorine of the supporter always combines with the combustible, and forms with it a new substance, which may be called a product of combustion. Now every product is either, 1st, water ; 2d, an acid ; or 3d, a metallic oxide. Some products are capable of combining with an additional amount of oxygen; but this combination is never attended with combustion, and the product, in consequence, is converted into a supporter. Such compounds may be called *partial supporters*, as a part only of the oxygen which they contain is capable of supporting combustion. Since oxygen is capable of supporting combustion only in the supporters and partial supporters, it is clear that it is in a different state in these bodies from what it is in products. It is probable that in supporters it contains, combined with it, a considerable quantity of heat, which is wanting in products. It is also probable that combustible bodies contain light as a constituent, for the quantity of light emitted during combustion depends on the combustible; while the heat seems, in some measure at least, to depend on the oxygen. If these two suppositions be admitted, the phenomena of combustion admit of an easy explanation : the base of the oxygen and of the combustible combine together and form the product ; while the heat of the one and the light of the other in like manner unite and fly off in the form of fire.

It is well known that heat is produced by the percussion of hard bodies against each other. Iron may be heated red hot by striking it with a hammer, and the sparks emitted by flint and steel are well known. This evolution of heat appears to be the consequence of the permanent or temporary condensation of the bodies struck. Iron, and most metals, become specifically heavier when hammered, and condensation always evolves heat. When air is condensed it gives out a considerable quantity of heat—sufficient to set fire to tinder. When muriatic acid gas is passed through water it is condensed, and the water becomes hot ; on the other hand, when air is rarefied it suddenly becomes much colder. It is not difficult to see why condensation evolves heat. The particles being forced nearer each other, the repulsive force of the heat is increased, and a portion, in consequence, is driven off. The specific caloric can scarcely be conceived to diminish without the body giving out heat. A part of the heat which follows percussion is often owing to another cause. By percussion, the heat of the body is raised so high that combustion commences, and this occasions a still farther increase of heat. It is in this way that sparks are produced when flint and steel are struck ; the sparks being small pieces of steel which have taken fire and melted during their passage through the air.

Heat is not only evolved by percussion, but also by friction ; and not only by friction of hard bodies, but even of soft bodies, as when the hand is rubbed against the sleeve of the coat ; but no heat has ever been observed from the friction of liquids. The heat evolved by friction seems to be owing to the same cause as that of percussion ; namely, a condensation of the substances rubbed. This condensation is, in some cases, permanent ; but when the bodies rubbed are soft, it can only be momentary. The heat evolved by friction is sometimes very considerable. Thus Count Rumford boiled water by the heat evolved by rubbing a steel borer against a cylinder of gun metal ; and in our own day it has been proposed to heat factories where there is a superfluity of power, by running large metal disks against each other.

In a great number of cases, a change of temperature takes place when bodies combine chemically with each other. Sometimes the compound becomes colder than before, and sometimes hotter. When sulphate of soda in crystal, pounded, is dissolved in water, a considerable degree of cold is produced, and the cold is still more intense if the salt be dissolved in muriatic acid. If muriate of lime, in powder, and dry snow be mixed together, so great a degree of cold is produced that mercury may be frozen, if it be surrounded by such a mixture. Potash and snow produce an equal degree of cold. When nitric acid or sulphuric acid is poured upon snow, the snow dissolves, and an intense cold is produced. On the other hand, when sulphuric acid and water are mixed, so great a heat is evolved that the liquid is considerably hotter than boiling water. Heat also is produced when nitric acid and water, or water and alcohol, are mixed together ; and heat is also produced if sulphate of soda, in a state of efflorescence, is dissolved in water. An intense heat is produced by dissolving quicklime in sulphuric acid. In most of these changes of temperature, water is either one of the substances combined, or it forms an essential constituent of one of them. The heat or cold produced depends often on this constituent. Thus, sulphate of soda, containing its water of crystallization, produces cold when dissolved ; while the same salt, deprived of its water of crystallization, produces heat. If the new compound be more fluid than the two constituents of it, the temperature sinks ; if it be less fluid, the temperature rises. Thus, when snow and common salt are mixed, they gradually melt and assume the form of a liquid, and the temperature sinks to zero. Solid water cannot become liquid without combining with a quantity of heat, and the same rule applies to all solid bodies that become liquid ; hence, the cold evolved in these cases. The water of crystallization in sulphate of soda is solid ; it becomes a liquid when salt is dissolved ; hence the cold produced. When the same salt, free from its water of crystallization, is thrown into water, it combines with a portion of the water, and renders it solid ; hence the heat evolved. When the density of two liquids united is greater than the mean, heat is evolved, because the specific caloric of the new compound is less than that of the constituents. This was first observed by Dr. Irvine, and it accounts for the heat evolved, when water is mixed with sulphuric, nitric acid, or alcohol. Thus it appears that the changes of temperature produced by mixture are either occasioned by the change of state which the water undergoes, or by a diminution of specific caloric, in consequence of the new combination.

The heat excited by the galvanic or electric shock has been commonly referred to a mechanical cause, although upon this point a considerable diversity of opinion has prevailed. The effect, however, is well known to be very powerful, perhaps even more so than that produced by the convex lens ; but it is still more confined as to the extent of its operation. The agency of electricity in evolving heat in bodies through which it passes is powerfully and wonderfully apparent in the discharge of the Voltaic battery. When an extensive series of plates, excited by an acid solution, discharges through points of charcoal, attached to stout wires connected with the opposite extremities of the battery, the heat evolved is most intense. With 2,000 series of 4-inch plates Sir Humphrey Davy obtained an arched stream of light, of nearly 4 inches in length ; fragments of diamonds on being introduced into it disappeared ; and thick wire of platina, one of the most refractory of the metals, fused readily ; all the metals in their laminæ, such as gold and silver leaf, burned vividly. When fine iron or steel wire was made to join the opposite ends of the battery, it immediately ignited ; and stout platina wire was kept at a white heat. The late Professor Daniel, by his new Voltaic battery, exceeded even these effects. With this battery the arc of electrical flame between points of charcoal was so intense, and in such volume, that the eyes of the spectators were seriously affected and inflamed, even though guarded by thick gray glasses, and the Professor's face became scorched by the heat as when exposed to a meridian sun. The rays, when collected into a focus, burned a hole readily through paper many feet distant ; and a bar of platinum, $\frac{1}{8}$ of an inch square, together with other highly infusible metals, such as rhodium, iridium, and titanium, were easily melted. We have ourselves melted iridium through the agency of the electric discharge, when every other means at our disposal failed. Whether in this operation the heat is, as it were, merely forced out of the wire by its commotion with its particles experienced from passage of the galvanic influence ; or whether, as has been supposed under certain circumstances, heat and electricity can be converted into each other, or may be separated by a kind of decomposition, are intricate questions of theory, upon which, at present, it seems beyond our power to decide, and which must depend very much upon the opinion that we entertain respecting the nature of heat. The simple facts, however, independent of hypothesis, seem to indicate that heat and electricity are distinct from each other, whether they are to be regarded as species of subtile fluids, or only the productions of matter.

———o———

The Difference.—Mr. Potance is a first-rate watchmaker. He keeps a neat little workshop just across the street from Goldquartz, the rich jeweller. Potance says that sometimes (when his digestion is bad) it vexes him to see the elegant carriages drive up to Goldquartz's curb-stone, and the stylish occupants go in and leave their valuable watches with him for repair ; because, as soon as the carriage is gone, the watch will be sent to him to do—Goldquartz getting two-thirds of the pay, and all the credit. But he says (with a sneer) there *are* times when those same elegant equipages do call at his door—to sell tickets for a church raffle, or to solicit him to subscribe to a fund to give his pastor (salary $5,000) a three months' recreation in Europe.

DIALING.

NUMBER THREE.

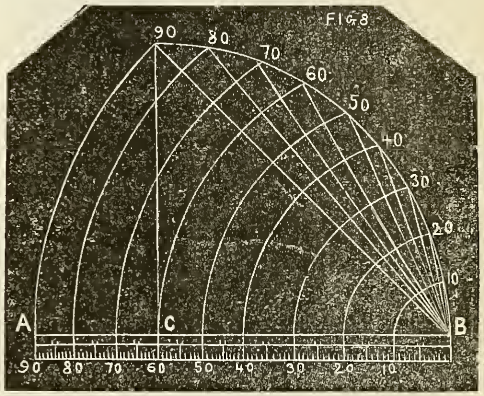
At the present day dialing is a more curious than useful art. Perfected astronomical instruments, and perfected watches and clocks, have very generally superseded it; yet it is no loss to be in possession of any knowledge, and it may be useful to be acquainted with the method of drawing hour lines upon any surface or plane, for any place in the world, thus showing, by the shadow of a *stile* fixed on the plane, the approximate hour. The stile can have but three positions, viz., perpendicular, oblique, parallel. The dial planes upon which hour lines may be drawn are—*Horizontal*, *North or South*, *Erect-direct*, *Erect-declining*, *Reclining-inclining*, *Reclining-declining*, *Convex*, *Concave*.

We shall in this article give concise directions for constructing dials upon many, and, perhaps, all of these planes, and shall begin with the *Equinoctial Dial* as being the ground and foundation of all other dials, and shows how naturally from it lines may be deduced for planes lying in other positions. The plane of this dial is parallel to the earth's equator, and is universal; for lines drawn thereon will show the apparent time of day for any place in the world.

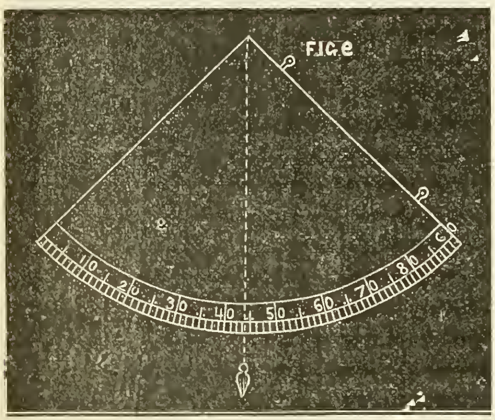
To construct an equinoctial dial, procure a a metal plate about a foot (more or less) in diameter, or a thin board of good hard wood planed smooth on both sides, and secured from warping in the best possible manner.

From a point in the centre draw three concentric circles with your compass, to contain the hour figures; divide the outer circle into 24 exactly equal parts, making a point or dot at each division; then draw lines from the centre to each of the 24 points, and these will be the true hour lines. For the stile, erect in the centre a pin or wire *perpendicular* to the dial plane.

You will remember that 15° is equal to one hour in time; therefore you could have constructed this dial from a scale of chords, which you must construct thus:



Draw a quadrant B C, 90, and divide the arc into 90 equal parts, which number as 10, 20, 30, etc.; set one foot of your compass in B, and draw the arc 90, A. The line A B will be the chord of 90 to the radius C B. Carry all the degrees of the arc B to the straight line A B in the same manner, and number them 10, 20, 30, etc., and you have a scale of chords. You can in the same manner make a scale for any size circle you may have occasion to use. In drawing this dial from the scale of chords, take the chord of 15° and lay it off to the right and left of the meridian line, and it would have given you the 1 o'clock and the 11 o'clock hour lines. 15° more from these lines would have given you the 2 and 10 o'clock; and so on for the whole dial. But because the dial thus drawn will serve but for one half the year, when the sun is north of the equator (or equinox), from the 22d of March to the 21st of September; therefore, to adapt it to the whole year, you must draw a corresponding dial on the other side, and the wire which forms the stile must extend *through* the board or plate 6 or 8 inches, and must be exactly at right angles to both surfaces; it only remains to *set* the dial truly, and it is completed. To do this properly you will need some instrument to measure altitude, and if you have none of the higher class of instruments for that purpose, you can make a *Quadrant*, which will answer your purpose well enough for dialing. Procure a piece of well-seasoned hard wood board of any size, from 6 inches to a foot in diameter, *exactly* square, and paste on one surface a sheet of drawing paper; then from one corner draw a quarter of a circle, as large as the board will admit of, the limb (or arc) divided into 90 equal parts or degrees. To one of the straight edges you may, if you choose, fix sight vanes; then attach a thread at the point from which you described the segment, supporting a lead bob or plumb. Complete the instrument as represented by Fig. 9.

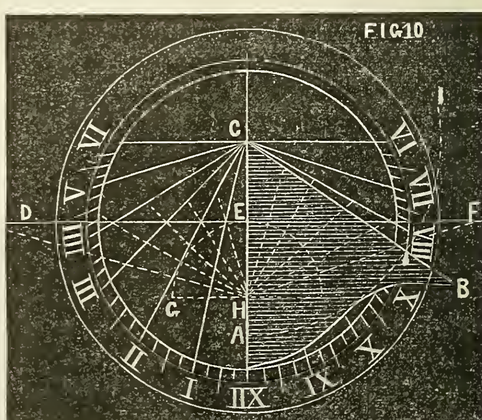


By applying the edge of your quadrant to the stile, and raising it till the thread of your quadrant cuts the degree of latitude of your place, then the top of the stile is parallel to the earth's axis, and the plane of your dial is parallel to the plane of the equinoctial circle in the heavens. Still you need the 12 o'clock or meridian line, which may be found most readily by the method described in the articles on Astronomy in Vol. I. of this Journal. Lest some of our readers may not have seen those papers, and to make our instructions complete in themselves, we will repeat the directions.

TO CONSTRUCT A MERIDIAN LINE.

Prepare a *horizontal* plane of any size you wish, on the sill of a south window, or set up a post in the yard or garden, on which your dial is to stand; make the top of it truly level in every direction, which you can do with your quadrant; on this plane draw several concentric circles as large as the plane will admit of; in the centre set a wire stile exactly upright (a large knitting-needle is as good a thing as you can get). Before noon on any day when the sun shines, observe when the *end* of the shadow cast by the wire touches one of the circles you have drawn, and there make a dot; after noon you must watch when the end of the shadow touches the same circle, and at that point make another dot; draw a line between the two dots, and exactly subdivide it; a line drawn through that point and the centre of the circle will be a true meridian line. You may get the 12 o'clock line more exact by making a series of observations on the several concentric circles and taking the average of the whole. Then set the dial you have constructed, with its 12 o'clock line to correspond exactly with the meridian line you have just found, and fasten the dial in place by two or more strips of iron secured to the post and to the edge of the dial.

Horizontal Dial is one whose plane lies parallel to the horizon, and is the most common and most useful—the sun remaining on it from sunrise till sunset. The form of the plane on which you draw a dial is of no consequence—whether square, round, or irregular—so the surface be a true plane; neither is the size material, only the larger you construct it the more correctly can it be drawn. Fig. 10 represents such a dial, and its mode of construction.



Draw three concentric circles as a margin to contain the figures; draw the line A C, which is the *substilar* or 12 o'clock line (but not the meridian line on all dials), in which line make choice of a point as at C, a little above the centre (by which means you enlarge the hour spaces), through which point draw the line VI C VI, at right angles to A C, for the six o'clock hour line; in the substilar line, as at E, make choice of another point, and through that, at right angles to A C, draw the line D F. Having proceeded thus far, let it be required to construct a dial for a given latitude, say 54° 47′ N; open your compasses to the chord of 60°; set one foot in C, and draw the arc A I I; then take the chord of 54° 47′ and set it from A to B, and draw the line C B, which gives you the true form of the stile, or dial cock, as it is sometimes called; set one foot of your compasses in E, where the line D E F cuts the meridian line, and take the nearest distance to the line C B, or stile's height; turn that point of your compass about and make another mark on the 12 o'clock line at H, which represents the centre of the equinoctial; on H, as a centre, draw the quadrant G E, and divide it into six equal parts; lay a rule to H, and those several equal points, and where the ruler cuts the line D E F, are the points through which the hour lines must pass; then lay the rule to the centre C, and to those points in the line D E F, and draw the hour lines; set off the same distances in the line D E F, from E toward F, and draw the morning hours; those before six in the morning and after six P. M. are drawn by continuing the same hour lines beyond the centre at C. The dial, after being correctly drawn, must be truly set, or it will give erroneous indications of time; therefore the utmost care must be exercised in setting it so that the 12 o'clock hour line will coincide with the meridian you have drawn on the place selected for your dial.

An Erect South Dial is nothing more than an upright south wall (which is the dial plane) and faces the exact south point of the horizon. As in the horizontal dial the elevation of the pole was equal to the latitude of the place, so in this it is the complement of the latitude. The sun never shines twelve hours on this dial, except when it is in the equinoctial, because the plane itself lies in the prime vertical, and from March 20th to September 23d the sun does not come due east until after six A. M., and is due west before six P. M. In constructing this dial draw the line VI VI across the plane you have made

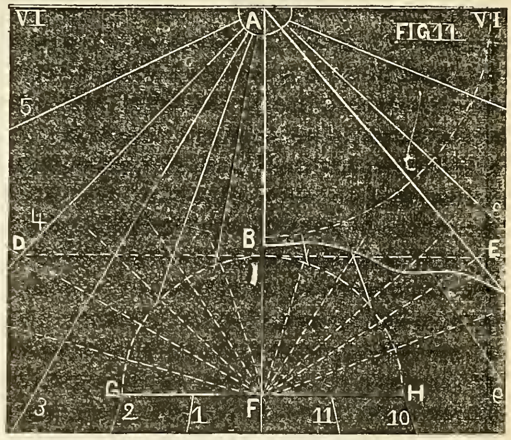


FIG. 11.

choice of for the east and west line, or the hour line of six o'clock; from A let fall the perpendicular A F, for the 12 o'clock line; then with your compasses take 60° from the scale of chords and draw the arc B C VI; then take the complement of the latitude of your place from the same scale, and lay it from B to C, and draw A C, which is the height of the stile; make choice of any place in the 12 o'clock line, as at I, and draw the line D I E, parallel to VI VI; set one point of your compass in I, and take the nearest distance to the line A C; turn your compass down to F, and from that point describe the semicircle G I H, and divide it into 12 equal parts, for the semicircle represents one-half of the equinoctial; lay a rule to those points and to the centre F, and mark the points where it cuts the line D I E; then draw lines from A through those points, and they will be the true hour lines. If you wish the ¼ hour divisions you must divide the semicircle into 48 equal parts and draw the lines the same as for the hours. Of course at the end of the hour lines on the left you place the morning hours, and the afternoon hours on the right.

If your dial be large you had best use an iron rod, about the thickness of the lines you draw for hour lines, being careful to fasten it *exactly* over the 12 o'clock line. The angle it makes with the plane of the dial (complement of the latitude) you can fix by your quadrant. When the thickness of the stile is appreciable, you must make allowance for it in drawing the two quadrants which you divide for the hour distances, and you must take a centre for each at F, just the half diameter of your iron rod or stile distant from the 12 o'clock line, otherwise your dial will go too slow in the forenoon and too fast in the afternoon.

—o—

ADJUSTMENT TO TEMPERATURE AND POSITION.

This subject, although one well worth the earnest consideration of every watchmaker making any pretence to a thorough knowledge of his business, is, nevertheless, but very little understood or practised by repairers in the country. The reason for this may be traced to two causes. *First:* The scarcity of workmen qualified to impart to others this very necessary branch of Horology; and *Second:* That those who *are* qualified, mainly for mercenary motives, keep it a secret—something not to be divulged. This state of affairs is not alone confined to this branch, but to very nearly all branches of Horology; and thus it is, on looking around us, that we see so many poor workmen. Desirous of bringing about a better state of affairs, I shall, in the following article, give my method of accomplishing Adjustments to Temperature and Position.

As it is not possible to keep a watch in one and the same position at all times, it is therefore very essential to the good performance of the watch to adjust it so that the friction in one position shall coincide with that in another; so that the watch in one position loses or gains as much time as in another. To accomplish this I strictly observe the following rules:

First.—The balance-staff pivots must have the least possible diameter in proportion to the size and weight of the balance.

Second.—The pivots must be well hardened, te npered, and polished, so as to cause as little friction as possible.

Third.—The jewel holes must somewhat have the form of an hour-glass, whereby the friction is considerably lessened; that is, more so than if they were cylindrical.

Fourth.—The ends of the pivots must be made nearly flat, whereby the regulation of this adjustment is brought under perfect control.

Fifth.—The hair-spring must be so placed that the coils are perfectly concentric to the balance-staff; and after winding the watch, set the hands to the exact time, as indicated by a good regulator, and allow it to run six hours in a *vertical* position. After this lapse of time the difference between the watch and regulator is carefully noted, and the watch is again wound and set, and again run six hours in a *horizontal* position, and the difference of time likewise noted. On comparison of these two results, should the watch have lost or gained as much time in one as in the other position, then the desired result is already accomplished; but should the watch, for instance, have *lost* more time in a vertical than in a horizontal position, this will denote that there is too little friction in a horizontal, compared to that in a vertical position; and consequently the ends of the pivots must be still more flattened, whereby the friction in a horizontal position is increased, and the watch will lose time in proportion to the amount of face given to the ends of the pivots. But should the watch, on the contrary, have *gained* time in the vertical position, this will denote that the friction in a horizontal position is too great, compared to that in a vertical position; and in this case, by rounding the ends of the pivots in proportion to the time lost in a horizontal, compared to that in a vertical position, the balance will move more free, and the watch will gain time in that position. These alterations of the ends of the pivots must be continued until the watch in every position runs alike. If the watch should by these experiments and alterations have been caused to gain or lose time, it can afterwards be regulated by the hair-spring. Although the watch may be provided with an isochronous spring, it is, nevertheless, of the greatest importance to carefully adjust it to position, even if there is only the slightest difference of time discernible between the different positions.

After the watch is so far completed that it will in every position run alike, and after it has been provided with an isochronous spring, it is then the proper time to adjust to temperature (heat and cold). The first consideration is, that the watch be well-regulated. It is often the case that it gains or loses very slightly, and the regulator (if it has any) is too sensitive to regulate with ; in that case it will be found necessary to resort to the screws on the balance for the desired results to be attained. The manner in which this is effected is thus : If the watch *gain* time, one or more screws on each arm of the balance must be unscrewed, in proportion to the amount of time gained ; if, on the contrary, the watch *loses*, the screw or screws must be turned in further, in proportion to the time lost. It must be strictly observed that the balance, in all these alterations of the screws, remain exactly poised ; when the above directions have been followed and completed, we proceed to adjust to temperature. First, construct a box of tin or copper, with about four or five compartments, one above another; the upper one large enough to hold a thermometer; these compartments must all be hermetically closed ; beneath this apparatus place an ordinary alcohol lamp, and allow it to remain lighted until the upper section shows a heat of 130° to 135° Fahr., which is the limit to which the watch should be subjected, and should be kept up to the same number of degrees, by alternately placing and removing the lamp from beneath the apparatus. The watch is then placed in the upper section, and allowed to run six hours in that temperature (first having wound and correctly set it) ; it is then taken out, and the difference of time noted ; the watch is then placed in a refrigerator where the temperature is 10° to 15° below zero, being wound and set, and allowed to run six hours ; the difference is here likewise noted, and then compared with the first. Should the watch in both temperatures run the same, the desired result is then already attained ; but should the watch while in the heated box have lost time, it will denote that the compensation is not strong enough, and consequently requires strengthening, which is accomplished by moving one or more screws (according to the time lost) towards the cut part on each arm of the balance, whereby the weight of the screws becoming more active, causes the compensation to be strengthened. But if, on the contrary, the watch, while in the heated box, shows to have gained time, it denotes that the compensation is too strong, and to weaken it will require the screw or screws on each arm of the balance to be moved further back from the cut part, in proportion to the time gained. This moving must be continued until the watch, in high and low temperatures, keeps time alike. It sometimes happens that the screws are not of sufficient weight to influence the compensation, although they be moved to the very verge of the cut part ; in that case, heavier screws must be substituted. It also sometimes happens that the compensation of itself is so strong as to require lighter screws to be substituted. It must, however, be borne in mind, that by all these changes of position, and weight of the screws, the balance must not be brought out of poise, and a screw on one arm of the balance must not be moved an iota further than the screw exactly opposite (in a line through the centre of the balance with itself). Care must also be taken that the weight of the balance remain the same. It is strongly advised that the slightest error in the going of the watch in either temperature should not be tolerated, for the regularity in its time-keeping hereafter depends much on the manner in which the watch has been provided with this adjustment.

Having occasion, since my last communication, to adjust a chronometer to isochronism, I resolved to test Mr. Sandoz's theory. After one failure I succeeded in establishing a correct isochronism. I then repeated the experiment on another watch, and the result was good ; and I think his method of causing the vibrations of the balance to become isochronous is one that may be safely adopted.

CHAS. SPIRO.

JEWELLING.

The articles that appeared in the JOURNAL some time ago upon Jewelling, although very interesting, were not "exhaustive," so I have concluded to give my ideas upon that subject. That I am qualified to have "my say," I will premise my remarks by stating that I at one time had charge of the jewelling department in the factory that produces that *unexcelled*

American watch, known as the "Howard watch," manufactured by E. Howard & Co., Boston, Mass., since which time I have, as the Drs. say, enjoyed quite an extensive "private practice."

I shall not stop to detail the evil effects of the method employed by those who have no foot lathe in putting in jewels, as they are too well known to the better class of workmen, but proceed to detail my method, appliances, results, etc., as far as they relate to the ordinary replacing of a broken jewel. If the reader wishes to jewel a watch that has never been jewelled, I refer him to the articles upon that subject that appeared in the Horological Journal some time ago.

As it will not pay for a watchmaker to make his own jewels, he ought to have a good stock of *fine* jewels; and I am free to confess that I have never yet seen a really *fine* article offered for sale by the material dealers in this country. I send to London, England, for mine, and get a very superior article. A good foot lathe is of course indispensable; with which, and his jewels and some diamond powder, he is prepared to do a neat and clean job.

On page 13, Vol. I., No. 1, is detailed the manner of preparing the diamond powder for use; only substitute sperm oil for sweet oil, as the latter will get thick and gummy after it has been exposed to the air for some time, and for a watchmaker three old style oil cups, such as hold over a teaspoonful, will answer the purpose of saucers, and are much more convenient. As so little oil can be used, the first receptacle should only stand some ten or fifteen minutes before decanting off; the second about two or three hours. After all the diamond powder is settled to the bottom of No. 3, the surplus oil can be poured off. Before the powder is prepared it would be best to have a velvet-lined box, made by a manufacturer of jewelry boxes, to hold the three glass cups, as they can always be kept together and free from dust; $\frac{1}{4}$ of a carat will be a sufficient quantity to prepare at once. As the *modus operandi* for jewelling a new or plain watch is given in the articles on Jewelling, I shall, as before stated, confine myself to that class of work that usually falls into the hands of the watch repairer. One frequent cause of a watch performing badly can readily be traced to its imperfect jewels. A watchmaker should always carefully examine every jewel in a watch that he has down for repairs, and if he finds one the hole of which is too large, or very much "out of round"—that is, much wider in one direction than another—it should be replaced by a good one, as follows: If the depth is correct, notice whether the jewel is above or below the surface of the plate; if it is either, then knock it out, and cement the plate or bridge on a chuck in the lathe, being careful to get it on true by the hole lately occupied by the jewel; by means of a burnisher, such as is described on page 106, Vol. I., No. 4, raise the burr that holds the other jewel in, and if a jewel can be found of the proper size and thickness, and the hole not too large, it can readily be "rubbed in" with the burnisher; if the hole is too small, it can be opened, as described on page 75, Vol. I., No. 3. I make these references for two reasons: first, to avoid repeating what has already been written, and, secondly, to call particular attention to those passages in the articles on Jewelling, that should be fully understood before the novice attempts to set or open a jewel. The chuck on which the article is cemented should have a hole from a quarter to half an inch deep in its centre. If no jewel can be found of the right size and thickness, select one a little too large, enlarge the hole sufficiently to fit the jewel, then proceed to fasten it in, as described on page 106, Vol. I., No. 4. If the jewel is broken, of course the same remarks apply to replacing it with a good one, as to an imperfect one. If the jewels are contained in settings screwed in, simply take out the setting and proceed with it the same as with a plate or bridge.

One difficulty that the watchmaker has to contend with in selecting a jewel from such as are sold in this country, is to find one the *hole* of which is in the *centre* of the jewel, as all the refuse and trash in the way of jewels are sent from Europe to this country for sale. Those who wish to obtain a very superior article, every one of which will be perfect, can do so by sending to Samuel Holdsworth, 54 Spencer street, Clerkenwell, E. C., England. I simply mention this gentleman's name, as I have obtained some jewels from him ; no doubt but what other parties there furnish equally good jewels. If a jewel is not true, or rather, if the hole in it is not in the centre, it must be cemented into a chuck in the lathe, trued up by the hole, then turned off with a diamond cutter, and the chamfer carefully trued up and polished again ; while on the lathe it can be turned down to fit the hole in the setting or plate ; the shellac is to be removed from the plate with alcohol. In many instances a chuck will have to be turned up to suit the particular job to be done. Care must be taken in opening, or the jewel will break or chip around the hole. The corners must be carefully rounded by a piece of wire larger than the hole, the end of which is conical. It will take but a moment to do this, but if care is not taken, too much will be taken off.

Now any one who has carefully read the articles upon Jewelling, and are supplied with the tools and materials above mentioned, will, by exercising a due amount of care and patience, be enabled to do a job that he will not be ashamed of.

Jas. Fricker.

Americus, Ga., *August 8th*, 1870.

OHN BLISS & CO.'S IMPROVED TRANSIT INSTRUMENT.

The science of Horology, in its mere mechanical branch, or the art of constructing the most intricate and perfect machines for the purpose of measuring time, would be incomplete without a true and reliable standard to test it by. Moved by an appreciation of this necessity, skilful workmen have at different times exerted their ingenuity to invent the means for obtaining such a standard, and their labor has been variously crowned with success ; but without a question the standard time obtained by means of transit observations of heavenly bodies is the most reliable.

Hitherto the instruments for such observations have been confined to astronomical observatories and colleges, because of the great expense involved in connection with them, and scientific men only have been supposed capable of mastering them, as it required a degree of education not commonly found among others ; but this need no more be the case. Horology is only a part of the great science of astronomy, and the transit instrument really belongs to the trade.

In the beautiful production of a transit instrument by the above firm, the trade is furnished with the means of obtaining a correct standard of time, and at a very small cost compared with the benefit to be derived from it ; moreover, these gentlemen have furnished a method of setting in the meridian and computing transits, so that the most inexperienced cannot fail to accomplish it in the first trials, and their instructions are so simple that any one being able to read can understand them.

The result of their invention is a decided step in advance in the progress of Horology, inasmuch as it brings it within the reach of the poorest storekeeper to possess one of their instruments. Though quite small, it is nevertheless susceptible of the most delicate adjustment, in every respect equal to those in large observatories. An inspection of the results of its operation will establish the truth of this beyond a doubt. The following results, which are copied from the daily account of our observations of the sun, though not absolutely perfect in uniformity as to the fractions, will, nevertheless, testify to the accuracy of the instrument :

		secs.			secs.
July 28.	Clock fast =	8.82			
" 29	"	9.63	....	Gain per day	0.81
" 30	"	10.41	....	" "	0.78
Aug. 1	"	11.66	....	" "	0.62
" 2	"	12.19	....	" "	0.53
" 3	"	12.80	...	" "	0.61
" 4	"	13.47	....	" "	0.67
" 5	"	13.6	....	" "	0.20
" 6	"	14 09	....	....	0.42
" 8	"	15.12	....	"	0.51
" 9	"	15.78	....	" " ...	0.66

The clock was set to correct time on the 15th of July, which for the twenty-five days to the 9th of Aug. makes its average gain per day 0.63 of a second; the greatest deviation from which in the last ten observations is only 0.4 of a second.

In connection with our solar observations, and for the purpose of proving these correct, we also observed transits of fixed stars of different altitudes. On the 5th of Aug. we observed the transit of γ *Draconis* Decl. 51° 30′ North; at 8h. 57m. 49s.53 its true meridian passage was at 8h. 55m. 59s.22, making clock fast 1m. 50s.31. For the convenience of travel the clock is set to Philadelphia time, which is 1m. 36s.43 faster than our time. Subtracting this, makes clock fast 13s.88.

The same day we observed the transit of μ' *Sagittarii* Decl. 21° 5′ south, making clock fast 13s.63; also that of *Vega* Decl. 38° 39′ north, made clock fast 13s.78.

Frequent comparison of our time with that of Wm. H. Harpur, of Philadelphia, also made it, as near as we can tell, correct to the second.

It is doubtful that a much nearer approach to perfection could be made with a transit of larger dimensions; but certain it is, that for all practical purposes this is near enough, and we can recommend it with the utmost confidence to all who take pleasure in their business. It is not only a comfort and satisfaction to be able to determine the correct time, but the money which the instrument costs is invested at large interest.

THEO. GRIBI.

WILMINGTON, DEL.

—o—

PINION MEASUREMENT.

There probably is no part of watch-making, excepting the escapement, that is susceptible of more careful adjustment, than the depthing of the wheels and pinions; for the regularity in the going of the watch depends as much on these depthings, as it does on the careful adjustment of the parts comprising the escapement, and it matters little how well shaped, or how well finished the teeth of either wheel or pinion may be, if the depth is not correct the result will be very unsatisfactory. Then, again, if the size of the pinion is out of proportion to the size of the wheel, the workman will assuredly find it an impossibility to obtain a correct depth. For that reason I have prepared the following table of pinion measurements, which, if exactly followed, will enable any workman to determine the exact size of pinion required. I have purposely withheld a description of the mode of calculation by which these tables have been obtained, for the reason that the majority of repairers have not the education required to fully understand it, and it would, therefore, seem dry and uninteresting. It must be understood that the measurement of the diameter of a pinion, in this table, is constantly on the wheel by which it is driven. A pinion of 6 leaves must have the diameter of 3 teeth, measured on the wheel, from the very top of the first tooth to the top of the third tooth; for clocks, it must have 3 full teeth,—that is, from the outer side of the first tooth to the outer side of the third tooth. A pinion of 7 leaves must have the diameter of 3 full teeth; for clocks, $3\frac{1}{4}$ full teeth. A pinion of 8 leaves must have the diameter of $3\frac{3}{4}$ teeth, measured from the tops of the teeth; for clocks, 4 teeth, also measured on the tops. A pinion of 9 leaves must have the diameter of $4\frac{1}{2}$ teeth measured on the tops of the teeth; for clocks, the same. A pinion of 10 leaves must have the diameter of 4 full teeth; for clocks, the same. A pinion of 11 leaves must have the diameter of $4\frac{1}{3}$ full teeth; for clocks, the same. A pinion of 12 leaves must have the diameter of $4\frac{1}{2}$ full teeth; for clocks, 5 full teeth. A pinion of 13 leaves must have the diameter of $4\frac{3}{4}$ full teeth; for clocks, the same. A pinion of 14 leaves must have the diameter of 6 leaves, measured on the tops of the teeth; for clocks, the same. A pinion of 15 leaves must have the diameter of 6 full teeth; for clocks, $6\frac{1}{8}$ full teeth. A pinion of 16 leaves must have the diameter of $6\frac{1}{8}$ full teeth; for clocks, $6\frac{1}{4}$ full teeth. There is an instrument sold in the tool shops named the Proportion Circle, which has for its object the measurement of the diameter of the pinion by the size of the wheel, and *vice versa;* but this tool is only of use when new, for they are very apt to get bent, and otherwise out of order, which condition renders it useless,—for where there is such precision required, as in the measurement of a pinion, this cannot be tolerated. But if the workman will take the trouble of committing to memory the few directions given above, it will repay him by having not only an instrument always at hand, but one that will never get out of order, and always be correct.

CHARLES SPIRO.

918 *Eighth Avenue, N. Y.*

ORTHO-CHRONOGRAPHY.

In the June number of the *London Horological Journal* is the description of a very useful, simple, and portable instrument for getting the apparent time at meridian.

We shall take pleasure in some future number in giving a full description and mode of using it. We were a little surprised at the name the inventor chose for it. Had it been an American invention, it would not have been strange; but in England, where "Chronography" was well known as a species of literary art, and as samples of it are scattered all over the kingdom—on churches, monuments, dials, books, etc.—it seems hardly correct to apply the name to the instrument described. The inventor calls it an *Ortho-Chronograph.* As we understand the word here, its literal meaning would be *writing the correct time.* Had he called it an *Ortho-Chronoscope* it would have been correctly named, for it really is a *view of the correct time.* It may be of interest to some of our readers to know a little about the quaint art of "Chronography." Here, in the New World, those old fashions, relics of the past, are not constantly before us as they are in Europe, and consequently seldom thought of. The practice of making chronographs for the expression of dates in books and epitaphs (and especially on medals and coins) was a very common literary amusement as early as the sixteenth and seventeenth centuries. One of the most remarkable, commemorating the death of Queen Elizabeth, is as follows: "My Day Is Closed In Immortality." The arithmetical formula of which is M = 1000 + D = 500 + C = 100 + III = 3; the whole sum = 1603.

In the second paper by Addison, on the different species of false wit (*Spectator*, No. 60), is noticed the medal which was struck off to Gustavus Adolphus, with the motto "ChrIst Vs Dec X ergo tr IVMphVs" If you take the pains, continues the author, to pick the figures out of the several words, and arrange them in their proper order, you will find they amount to MDCXVVVII., or 1627—the year in which the medal was stamped.

The following is the quaint title of a book printed in 1661: "Magna Charta; Or the Christian's Character Epitomized. In a sermon preached at the funeral of the Right Worshipful, the Lady Mary Farewell, at Hill-Bishops, near Taunton, by Geo. Newton, Minister of the Gospel there.

D. FareweLL ob It MarIa saLVt Is
In anno
Hosannos posItos VIXIt and Ipsa
VaLe."

The four Latin lines with which the title concludes form a chronogram, or inscription, comprising a certain date and number, expressed by those letters inserted in large characters, which are to be taken separately and added together according to their value as Roman numerals. When the arithmetical letters occurring in the first two lines are thus taken, they will be found to compose the year 1660, when the Lady Farewell died (as the words declare); and when the numerals are selected from the last two lines they exhibit 74, her age at the time, as they also indicate, thus—

D =	500	I =	1
LL =	100	VIXI =	17
		I =	1
MI	1001	VL =	55
LVI	56		—
I	1		74
	1660		

The lady who was commemorated in the inscription was the daughter of Sir Edwd. Seymour, of Berrie Castle, in Devonshire, and was the wife of Sir Geo. Farewell, Knight. It was recorded in the epitaph on his monument at Hill-Bishops, that she died Dec. 13, 1660, and that she was the mother of twenty children.

The above chronograph singularly illustrates a passage in Shakespeare. It will be observed that the Rev. G. Newton takes advantage of the double letters at the end of Farewell to express 100. See how the "good M. Holofernes," in *Love's Labor Lost,* introduces the same thought into his sonnet, as an exquisite and far-fetched fancy—

"If Love be sore, then L, to sore,
Makes Fifty Sores; Oh! sore L!
Of *one* sore I *an Hundred* make
By adding but *one more* L."

On the upper border of a sun-dial, affixed to the west end of Nantevich Church, Cheshire, there appeared, previous to its removal about the year 1800, the following inscription: "*Honor Do MIno propa Ce VLo sVo parta.*"

The numerals, it will be seen, make up the number 1661, which was the year of the coronation of King Charles II., and no doubt the year in which the dial was erected.

The banks of the Rhine furnish abundant examples of this literary pleasantry, on the beams of churches—on the fronts of galleries—over church doors—some in stone, some in wood—many with the capitals rubricated.

When our own wonderful antiquities are investigated, and the buildings and structures and carvings of the great South-west come to be studied, and their hidden meaning (if there be any) is known, possibly the *New World* may prove to be the *oldest.*

NEW STAKING TOOL.

Mr. D. M. Bissell, of Shelburne Falls, Mass., has just obtained a patent on his staking tool, and will immediately take steps to introduce it to the trade.

The nature of this invention consists in the use of a solid block of iron or other metal, in which is closely fitted a cast steel plate spanning a deep groove in the block. In this plate are a series of holes, graduated in size, so as to allow the pivot of a wheel or pinion to pass through, and the wheel to rest upon the flat surface of the plate while being operated upon. A movable guide is so arranged, that a punch or other tool desired to be used may be brought directly over any one of the holes in the plate, and secured by a set screw. This device is very useful for riveting wheels, as well as for rounding and stretching ; also, as a freeing tool, and for finishing bushings, closing rivet holes, removing table rollers from balance staffs, and various other purposes.

Want of space prevents our giving any detailed description at this time ; but its many advantages will be seen from the fact that the small tools used (and to which there is scarcely any limit) all have a perfect guide, so that the working must necessarily be accurate.

JEAN PAUL GARNIER.

Jean Paul Garnier was born at Epinal (Vosges), in November, 1801. His father dying when he was ten years old, left him to provide for himself. Commencing in a printing house, he soon left for a locksmith's shop, and from there to a clockmaker, where he remained contented. When a skilful workman, the great reputation of a master Horologist in Luxeuil attracted him there, where he remained till 1820, when he went to Paris to join Lépine, who was then at the height of his renown. After five years spent with him, Garnier established himself in business alone. Soon after he invented and presented to the Academy of Sciences a free Remontoir escapement of constant force, marking the seconds with a pendulum of half-seconds vibration. This escapement was founded on a new principle, as its pendulum was removed from the variable action of its motive power, and was highly approved by MM. Arago, Molard, and Mathieu.

He presented to the Exposition of 1827 a regulator, with astronomical arrangements, which he constructed entirely without the aid of machinery. It was distinguished by the beauty and finish of all its parts, the simplicity of its mechanism, and the exactitude with which it indicated the most complicated astronomical facts. It also represented the annual revolution of the sun; its entrance into the zodiacal signs ; the equation of time ; the rising and setting of the sun ; as well as the periodical, synodical, and daily revolution of the moon, and its various phases, having but a few seconds of error during the entire year—the effect which different temperature produced on the ball of the pendulum being compensated by two movable bodies which act in an inverse sense and maintain the same arcs of vibration.

His profound knowledge of the most difficult questions of Horology placed him in communication with the most celebrated and accomplished artists of Europe, among others with Antide Janvier, who was proud to complete the instruction of a young man of such rare talents.

Garnier's next invention was a Sphygmometer, an instrument which indicates to the eye the movements of the pulse, and which, till then, had only been known by the touch. This has become indispensable in the study of the circulation of the blood, and has merited the highest encomiums of Drs. Marey and Magendie.

The invention of a new escapement, applicable to portable clocks, by its simple arrangement and easy manufacture, gave rise to a new kind of timepiece, called *Pendule de Voiture*, which met with such success that several millions per annum are manufactured in France. Some years later he improved these, making them give, on the same dial, the days of the week, month, and the phases of the moon.

He next applied to ship chronometers the free Remontoir escapement of constant force, causing the balance to describe arcs rigorously correct, dispensing with the fusee heretofore used in all chronometers. About the same time he invented a new Metallic Thermometer; also a Micrometer so delicate it indicated a variation of $\frac{1}{3000}$ millimetre.

Not content with his already great reputation, he continued his inventions, next making the reckoner, or meter, which, when attached to any machinery, gives its revolutions and movements, arranging the figures on a single line, that they may be read in a moment. So necessary has this become to all machines, that there are now many houses devoted entirely to its manufacture. Afterwards he made it yet more complete by adding an attachment giving the hours, minutes, and seconds. Either could be used separately; and together, it registered, at once, the number of revolutions of the machinery, and the length of time of its working. This was adopted by the Marine and Financial Departments, and applied to steamboats and the Mediterranean mail-packets. It is useless to enumerate single instances, so we will content ourselves with this extract from the report of one of our first engineers: "The Garnier Computing Meter, for locomotives, gives the number of revolutions of the wheels, consequently the distance passed over by their circumference, also the difference between this and the space actually gone over, from which we find the slipping. It gives the attendance and feeding of the engine at the stations. With the clock attachment it gives the number of revolutions during the time the engine has worked. On the arrival of a train, whose time of leaving is noted on the conductor's schedule, this meter gives, by the clock, the time the engine has worked; by the meter, the space traversed by the wheels. The difference between the total time of the trip, and the total stoppings at intermediate stations, gives the mean speed of the train. It shows the comparison of the fuel used with the distance passed over.

"For steamboats it indicates the number of revolutions and the space gone over by the paddle-wheels, or screw, in a given time, as well as the time of working the engine. The variations of effect on the engine by currents of different depths of water are also indicated by it. The detention at stations, and the acceleration by the sails, are given. It gives the motive power—as compared with the speed of the boat—the number of revolutions made by a given amount of steam—the expense per hour of the fuel consumed—and, if furnished with an indicator, the quantity of water vaporized deducted from the specific weight of the steam at the pressure given in the cylinder. This meter, connected with the piston, indicates the volume of water flowing into the boiler in a given time, and compares it with the steam furnished the cylinder."

At the solicitation of the Conseil de la Marine, P. Garnier constructed the Dynamometer, taking the primitive idea of Watt, adding many useful modifications, and using great care in its manufacture. After numerous trials it was judged superior to anything yet known. The Council of Admiralty and the Minister of the Marine ordered all steamers to be provided with it, and allowed no engine to be received unless provided with this apparatus. This Dynamometrical Indicator is indispensable in showing the pressure of steam on the cylinders, and the vacuum obtained by its condensation. It gives the exact motive power transmitted, as well as the amount of power lost by friction. Its undoubted utility made it universally adopted, and we owe to it our most interesting works on the power of machinery.

At the Exposition of 1844, the jury, recognizing that "M. Paul Garnier is at the same time a skilful Horologist and a good constructor of ingenious mechanical apparatus, wishing to reward, in this man, both the learned Horologist and skilful mechanic, award him the Gold Medal."

Garnier now added a third to the preceding Indicators, and including both the others. This measured the total work of the steam, and the air in the cylinder of the engine. This instrument, already used in England by Prof. Moseley, lost its British origin through Garnier's improvements. He substituted Poncelet's horizontal plate, with alternate movement, for Moseley's planimetrical cone with continued movement, adding an arrangement for sketching curves and making diagrams. This last instrument was the cause of a sharp discussion with M. Lapointe. It was first applied, in France, to the pneumatic cylinders of the atmospheric railroad of St. Germain, and it served to estimate precisely this power, in comparison with the steam and caloric engines, the rarification of the air, its compression, and the working of the valves.

Garnier also invented a Horary Indicator for the safety of railroad trains. It was of clock-work, with a dial placed near the road, on which a hand told the minutes and returned to zero after each passing train, thus showing the time between two successive trains. This was in use at Columbia, at Orleans, and on the Northern road.

In the first trials of the Electric Telegraph, M. Garnier participated in the competition, and presented a system of telegraphy by means of a lettered dial. This was not a success; but, thinking electricity might be employed as a motive power to clocks, he turned his researches in that direction, and produced a system of electric clocks, giving the hour synchronically, which were the first and only ones in France. For these he received a gold medal at the Exposition of 1849. The Council of Dock Yards proposed to the Minister of Public Works to adopt this system of electrical horology. The public applications of it in France were made simultaneously at Lille station, on the Northern Railroad, and the stations from Paris to Chartres, and at St. Lazare. This system spread rapidly, and is in use in most of the public buildings. To the sympathy and friendship of the engineers, M. Garnier was much indebted for the introduction of his special apparatus for stations.

A similar regulator gave M. Leverier the precise difference between the longitude of Paris and Havre. He arranged an automatic roller for the rapid and regular transmission of Morse's telegraphic alphabet. This is the indispensable complement to the American telegraph, for it will transmit messages in several directions at the same time. For the perfection given to clocks and electric telegraphs, he was awarded the medal of honor. At the Universal Exposition at Dijon, in 1858, he received a gold medal for a collection of his works. In Besançon, where Genevan and Swiss horology was carefully compared with French works, P. Garnier was chosen member of the jury, and, finally, in remuneration of his numberless services and useful and important inventions, was elected Chevalier of the Legion of Honor. He was a member of the Society for Encouragement of National Industry, and of the Civil Engineers. After the annexation of Savoy, he was chosen to look after the state of watch-making in Chablais and Fancigny, where this work was so well adapted to the habits of the people, and to their climate.

After a careful study of their work, and comparison with that of Switzerland, Geneva, and Besançon, he gave a detailed report, which resulted in locating horological establishments in French Savoy.

Paul Garnier's life was a struggle of talent and labor against accumulated obstacles, before which a less indomitable courage, and a less brilliant intelligence, would have failed. This struggle began in his earliest years, and ended only with his life. He learned in working; he won the esteem and affection of those for whom, and with whom, he labored. Struggling himself against ignorance, he raised a numerous and distinguished family, ever consecrating the largest part of his gains to the education of his children. Now his life is finished, having honored remembrances, and universal regrets.

Why are such examples so rare? Because an inflexible rectitude was its governing power. Exact in his work, in his word, and in his business, in its minutest detail—in the scrupulous and persevering care he gave each one of his works, we see how he inspired respect for his character, trust for his word, and love for his life.

To such memories, a simple recital of their works is the most beautiful and fitting elegy. We have done this, because, for thirty years we have witnessed the works whose history we have sketched, thus briefly and imperfectly.—*Revue Chronometique.*

——o——

INDUSTRIAL EXPOSITION IN ALTONA.

We are indebted to M. Morritz Grossmann for a description of the Exposition in Altona, as furnished the *Industrie Zeitung*, from which we make extracts, not having space for the article entire :

" Among the French exhibitors the important manufactory of Onésime Dumas, at St. Nicholas d'Aliermont, France, received the Diploma of Honor for an excellent chronometer and a meter of peculiar construction. The renowned firm, Louis Breguet, Paris (also among the prize judges), exhibited the finest assortment of watches and scientific instruments. The watches were executed with astonishing care, and showed in their design the ingenious originality which has, for many generations, characterized this family. Among instruments for observation I noticed the Compteur à Pointage (meter for pointing). The index, springing $\frac{1}{5}$ second, bears on the end, beneath its perforated frame, a little printer's ink. Through this frame a needle point pierces (propelled by an outward spring) and by this means produces a dot upon the dial, which, after final observations, can be easily erased. Farther on we see a sphygmograph, an instrument designed to register the accelerations or irregularities of the beating of the pulse, thus greatly assisting the physician in his diagnosis. Yet further, among the Breguet collection, was an electro-magnetic telegraph, which needed no battery, and, as it at all times and without any preparation can be set in motion, it especially adapts itself for use on ship-board. The explosive apparatuses (combustible and spring-ing) for the art of defence and for the management of mines, were finely planned and executed. The watch factory of H. H. Marten, of Freiburg, in Briesgau, exhibited an elegant assortment of beautiful anchor watches, and preparatory works, and single parts of the same, and well maintained its claim to the fame of gold medals received in former Expositions. A similar distinction was awarded Gustav Beeker, in Freiburg-Silesia, who merited it through a rich assortment of beautiful and praiseworthy articles, such as regulators with and without cases. His manufacture exceeds 7,000 pieces yearly. The collection of B. Haas, of Besançon, showed an incredible number of watches and pocket chronometers. Watches in ivory cases with gold rims, watches with glass faces and backs, the dial even of glass, and the plates perforated, so one could see through the whole watch. One watch which opened and closed at the face, was pointed out by the exhibitor as entirely new and of his own invention, though it is known that this was patented two years ago in Birmingham. In a word, there was almost no variety of watch unrepresented, and this, to the non-connoisseur, lent an especial interest to the assortment. Less apparent to the connoisseur was the fact, that the inner arrangement of works must follow determined principles, though they seemed various. The distribution of single parts here and there might almost awaken the belief that pendulums and spring-boxes had been proposed to constructors as fancy articles. Judging from these samples, it seems as if the manufactory of B. Haas, in spite of the remarkably scientific regulations, might not present the greatest success. Some tower-clocks deserving notice were exhibited by Harkensee, of Cutin, Hansen, of Altona, Wenlé, of Bocken, near Hildsheim, and by Dökel, of Hanover. That of Hansen was distinguished by a peculiar method of winding. A stationary warder controlling clock was exhibited by Ortling & Gölze, of Neumünster, and a portable one of the same kind by Burk, of Schevermingen. Toys were scarcely represented. Beside the objects cited, there were displayed (as everywhere on great occasions) a quantity of pendulum clocks, the occasional productions of workmen unaccustomed to their manufacture. These were well done as to order and execution, still not above the level of common work. Finally, the Exposition was injured by the display of a medium assortment of Swiss and Paris manufactures, whose owner, a resident of Altona, or Hamburg, had no other claim to them than that of having bought them. There are many who consider an Industrial Exposition only as an annual fair, so its higher aim is wholly perverted. The Horological section of the Altona collection was very deficient, for reasons formerly given, yet it had an influence to instruct, by means of comparing its own chronometer productions with the same department of French industry.

M. Grossmann.

TRIFLES.

Never, when taking a movement apart, drive the centre square arbor without supporting the bridge in some manner; it is usually very thin and easily bent, but almost impossible to restore to its original appearance when a bend has once got into the surface.

Never open a watch case by inserting a screw-driver, and giving it a twist; it is a bad habit, for which there is no good excuse, and no *workman* will ever be guilty of "haggling" up a case, as such a practice is sure to do.

Never scratch the number of your watch record on a case where it can be seen without the aid of a glass; some reckless tinkers so mar the beauty of a case in this way as to seriously irritate the owner. We once knew a journeyman who barely escaped a sound thrashing from the owner of a watch, in which he had scratched his number in such awkward scrawling figures as to be visible at arms' length.

Never put in a main-spring without examining carefully whether any teeth or pinion leaves are broken or bent in the main, centre, or third wheel; by so doing you will often save yourself the extra trouble of taking the watch down a second time to repair damage done by the recoil of the breaking spring.

Never pour oil from the bottle into the oil-cup; it is wasteful, more being lost by drip than is used, besides the danger of taking up the fine dust adhering to the flange of the bottle. The neat, handy, economical way is to dip your oil wire to the bottom of the bottle, and it will bring away two or more drops, if raised quickly, which let fall into the oil-cup; repeat till you have taken out the requisite quantity.

Never allow yourself, or any one else, to use the plyers, or tweezers, which are for watch work, in the repair of jewelry; they are sure to get a speck of soldering fluid (hydrochlorate of zinc) on them, even the fumes of which at ordinary temperature will rust any steel work with which it comes in contact.

Never leave the wick of an alcohol lamp uncovered; the evaporation of the alcohol from the wick leaving the water behind (which is less volatile) renders it impossible to light it until the lamp is tilted so as to bring a new supply to the top, or the wick pulled up and cut off again; both of which take time and consume patience. An extinguisher slipped over the wick prevents the evaporation, and the lamp is always ready to burn as soon as the match is applied.

ANSWERS TO CORRESPONDENTS.

G. N. L., *Baldwinsville, N. Y.*—The very large proportion of watches coming for repairs which bear indelible marks of carelessness and incompetency, is evidence that those "new to the business" are not the only ones who need instruction.

To begin at the beginning, a good bench is indispensable; for no one can do as well with poor accommodations as if well fixed. A chest of drawers for tools is an important adjunct; tools should be in good order; one pair, at least, of plyers should be lined with brass, to handle polished pieces without marring them. You are now ready to take down, examine, put to rights, and clean a watch—supposing in this case that no new parts are required. First see that the hands and motion work are free; examine the escapement—the depth of lock the tooth has on the pallet; look to the safety action that it is free, and when forced against the roller that the wheel tooth does not get upon the impulse face of the pallet; examine the end-shakes of all pieces—escapement and train; depths of wheels and pinions; see that the pinions are all secure in the wheels; that jewels, holes, and end-stones are firmly set; see that the main spring is the proper width, strength, and length; and as we meet with so many springs that are not correct, it is evident that somebody needs instruction on this point.

The arbor should be one-third the diameter of the barrel inside; the spring should fill the barrel one-third, and if a going barrel, should be of such thickness as to admit thirteen coils—fusee watches requiring ten to twelve coils, according to the calculations. Occasionally a watch requires a variation from the regular rule, stronger or weaker, as the case may be. All bars, bridges, stop-work, etc., should be taken off; the fusee and great wheel should be taken apart and thoroughly pegged; the barrel-bridge (if a going barrel watch) must be taken all in pieces. After pegging the pinions and holes, and removing all old oil from pivots, jewels, etc., with the pith, wash it, using fine Castile soap; rinse in clean water, and put it in best alcohol, taking it out as soon as the washing process is completed, and drying with a clean soft cotton or linen rag; after which go over with a soft clean brush, to remove all particles of lint. To give the gilding the best appearance, brush in circles, breathing on the work occasionally; but little brushing, however, will be necessary. A very pernicious practice prevails with many workmen, of putting their dirty work, all smeared with oil, directly in the alcohol; the result being a change in the complexion of the gilding; and if two pieces are left together you have *two* shades, varying from the original.

In putting up, be careful to use no more oil than is necessary, and to put it just where required—the barrel bridge and click being parts that show "slobbering" most of any. If the proper quantity is put just where wanted, none ever reaches the click; and certainly nothing looks worse than oil "stewing" out, smearing bridge and click. If an adjusted watch, and no damage has happened to balance pivots, or spring, disturb nothing except to put in beat, if not so already. If a common or medium class watch, take off the spring and test the poise of the balance; if not correct, make it so. Put the spring on an arbor in the turns, and with a bow rotate to see if it is true in the spiral and flat; if not, correct it. To get your spring parallel to the balance without bending, make the hole in the stud parallel to the cock, and file a pin to fit the hole; then flatten one side similar to a flat-faced cylindrical ruby pin, until it will enter, with the spring in its place, nearly as far as without it; cut off the point to proper length—rather short—and round it off with a fine file; mark and cut off the pin, leaving a good length of head to get hold of. Now a little twist of the pin will put the spring in any position, and you can in a moment get it perfectly parallel to the balance, without bending. Now set the watch going, with the regulator pins close on the spring, and the regulator well back to slow on the index; and if it does not go very near time, alter the spring until it does so, with the regulator in the position referred to. The object of this is to get the most uniform rate possible, and it is attained with the regulator as near the stud as possible. If the coils are cramped, take the spring from the balance again, without unpinning from the stud, and put them in their places on the cock, and bend, or open the coils, as may be necessary to make the collet concentric to the staff hole. If the spring is greasy, or in any way dirty, dip it in benzine or ether a few seconds—the former is best—and you have it perfectly clean. After you have put it in beat, and are sure that the balance will not have to be taken out again, put oil to the holes, a *little* only to the pallets—none to the fork; if a duplex escapement, oil must be put to roller—none to impulse pallet; a chronometer requires oil only to pivots; set going and your watch is "in order."

Now, many will say that this is too much work for the price of cleaning; certainly it is, and you must make the price according to the time spent upon it. It is cheaper to the customer if you charge *double price for your time*, than if done in the usual style of dry brushing and without the corrections.

W. W. S., *Danville, Ill.*—The reduction of alloys in the reguline or metallic form is a matter of great uncertainty, and is a branch of the subject of electro-metallurgy, which has not been reduced to fixed and definite laws. The action of the voltaic current, in connection with the nature of the surfaces acted upon and the temperature of the solution, all together, or separately, present conditions which seem to elude the researches of the scientific chemist, as well as severely perplex and vex the practical gilder. It is generally understood that the decomposition of the various salts is attributable to the secondary action of hydrogen, termed electro-chemical decomposition, and it is well ascertained that different metals, or even the same metals under different circumstances, evolve hydrogen from the same solution with various facilities. It is natural to suppose that if it be a law, as some assert, that the voltaic circuit is invariably completed in that mode which offers least resistance to the passage of the force, that there are some cases where the nature of the negative plate, on which the reduction of the new deposit takes place, influences the result; this is actually found to be the case, and the difficulty you have experienced seems to be a similar case; for sometimes in the self same solution, when a smooth negative plate is used the circuit would rather be completed by reducing the metal, but when a rough plate is employed, like your low quality chain, by the evolution of hydrogen. This most interesting fact is in no instance better shown than in a slightly acidulated solution of sulphate of zinc, from which bright zinc will go freely down on smooth platinum; whilst from platinized platinum (crystallized) the hydrogen would be evolved. This experiment may be varied in a hundred analogous ways, with results at one time in favor of the evolution of the gas, at another by the decomposition of the compound; but the exact relation which various metals perfectly divided in the solution bear to each other, or even to themselves in different solutions, or in the same solution at different temperatures, is very difficult exactly to determine. As a general principle, to obtain a deposit of two or more bodies on any negative pole you must use a quantity of the voltaic force more than sufficient to reduce the elementary substance from the compounds most readily decomposed; usually you will find that the current will pass through the road which presents the least obstacle, whether it be solid or fluid, elementary or compound, great or small.

Ordinarily, the smoother the surface, the more favorably the deposit will take place upon it; from a rough surface the hydrogen has a greater tendency to be evolved, and the electric current must be suited to these varying circumstances; but in general a feeble current only is required, and the surface of the positive pole exposed to the action of the solution should not exceed the surface of the object to receive the deposit, and the quantity of electricity allowed to pass may and must be regulated to the utmost precicision, by allowing more or less of the positive pole in contact with the solution. To conduct this process with the greatest economy of time, the quantity of electricity should be so regulated to the strength of the metallic solution that the hydrogen is kept below the point of evolution from the negative pole; for you must always bear in mind, that the evolution of hydrogen is attended with evil, as the deposit will then be in one of the finely divided states, or even as a black powder. During the process, particularly if the object have a rough surface, it is a good plan to remove it from the solution before the completion of the process, and rub it with a hard brush and a small quantity of whiting or rotten-stone, and well wash it; by these means any finely divided metal will be removed, and the gold will be deposited in a very even manner. This cleansing will not be required if the deposition takes place very slowly, from the auro-cyanide solution. If the precipitated layer be very thin, the color will be greenish yellow; when thicker it will be the color of pure metal. The state of the surface of the reduced gold varies with the rapidity of the process, in relation to the strength of the metallic solution; if reduced very slowly it will assume the beautiful frosted appearance of dead gold. If deposited more rapidly, the surface will have a brighter appearance; if still more rapidly the surface will again begin to be brown, and quicker than this the operator must not conduct his process, for then the spongy (or crystalline) deposit begins.

The probabilities are that the great extent of surface which your chain presented to the action of the solution, compared with the surface presented by the opposite pole, in some way modified its action. Had you proportionally increased the size of the positive pole, which would in effect have increased the electric current passing, perhaps you might have got a deposit simultaneously of the fine gold and the alloy. Then again, the surface of the chain may have been in such condition (roughened) as to materially change the character of the deposit upon it. The results of the combinations of invisible and unknown conditions are so uncertain as to defy any positive directions in any given case.

A. M. B., *Iowa.*—Marion is only fifteen minutes from Maiden Lane—lying at the west side of Jersey City. Yes ; the Watch Factory is like the engraving on the last page of the Journal, though you cannot get a correct idea of its beauty from any drawing. The main building is 253 feet in length, three stories in height, besides the basement, and is built entirely of iron and glass—light and ventilati on being primary considerations in its construction. We cannot give you a detailed description of the machinery, as that would occupy several complete Nos. of the Journal, but when you come to the city we will endeavor to show you the practical details of manufacturing watches by machinery. Your third query we have no hesitation in answering in the affirmative, fully believing that the United States Watch Company have produced movements fully equal to any made in the country. The prices of their movements are all the way from $8.75 to $300, embracing sixty-four qualities.

"Damaskeening" is simply an improved method of finishing nickel, by the aid of machinery, whereby its beauty is not only greatly enhanced, but entirely overcomes the principal objection to the use of that metal for watch movements—that of tarnishing. This process is so far a secret with this Company.

Having replied to your questions, permit us to say a word of encouragement to the young men who are just commencing in life. Mr. F. A. Giles, the President of the United States Watch Company, as well as the head of the house of Giles, Wales and Co., is a living evidence of the fact that honesty and fair dealing, coupled with energy and frugality, are a much surer guarantee of success in life than inherited wealth. Having been left an orphan at an early age, and being the eldest of a family of children, he was not only dependent upon his own exertions for self-support, but contributed largely to the support of the rest of the family ; and it is to this very fortuitous circumstance that he owes the development of those traits of character—that indomitable energy and perseverance—that is the sole secret of his success as a business man. And Mr. Giles is but a type of a class of men who are to-day ruling the destinies of the world, as statesmen and men of business, and who are in the fullest sense of the word self-made men.

Mr. Wales, the head of the salesroom of the house of Giles, Wales & Co., is no more indebted to the influence of powerful friends than his partner—having won his way to an enviable position as a business man strictly on his merits—and never fails to entertain a kindly feeling for, or to extend a helping hand to, any deserving young man. As Mr. Wales never received a dollar of assistance from any one after he was eight years of age, we are of opinion that most young men have as good a starting-point in life as he had.

And, while on this subject, we will instance another case—that of Mr. C. L. Krugler, of the firm of Quinche & Krugler, 15 Maiden Lane, who commenced his mercantile career as a peripatetic vender of matches—and although he is now an importer of watches, never blushes at the mention of his modest start in life.

An Apprentice wants to know the proper height for a work-bench ; says his master puts him at one so high as to make his shoulders ache.

We incline to the opinion that his master is correct. Of course we don't know exactly the feet and inches that the lad is, or the bench should be ; but have found this rule about correct: Any stick, the size of a cane for example, held under the arm, and parallel with the floor, as close up under the shoulder as possible, the arm being held down by the side, should just clear the top of the bench vise; the same rule to apply whether working at a standing or sitting bench. The pernicious tendency of young persons is to work at a bench too low down, thereby inducing in themselves a stoop of the shoulders, injurious to health, and symmetry; to health, because the lungs—the very citadel of life—are cramped, and restricted in their muscular action (analogous to the opening and shutting of a bellows); and to symmetry, because a round-shouldered, hump-backed man is not "in the image of his maker." Every young man should know, or be taught, that when the arms are elevated so as to be on a line with the shoulders, the shoulders themselves are thrown back, the chest is free from side pressure, the lungs can be fully inflated, the head maintain a natural position, even where the eye-glass is in use, and the spinal column (back bone) is quite upright; which, by the way, is a very important thing to be remembered. The position a person assumes, who has to sit all day, and day after day, is of the greatest moment as regards their comfort and ease. No position is more fatiguing than the "bow-backed." With the back straight up and down—or, mathematically expressed, the weight directly over the base—is the easiest, most graceful, and healthiest position, and should be acquired by all. At first it may be a little irksome, but persevere, and you will reap the benefit during your whole lifetime.

E. C. S., *N. J.*—For information in regard to *London Horological Journal*, address Secretary of British Horological Institute, London.

———o———

☞ We are very anxious for a few copies of Nos. 4 and 5, Vol. I, of the HOROLOGICAL JOURNAL, and will pay a liberal price for them.

AMERICAN HOROLOGICAL JOURNAL,

PUBLISHED MONTHLY BY

G. B. MILLER,

229 Broadway, N. Y.,

At $2.50 per Year, payable in advance.

A limited number of Advertisements connected with the Trade, and from reliable Houses, will be received.

☞ MR. J. HERRMANN, 21 *Northampton Square, E. C., London, is our authorized Agent for Great Britain.*

All communications should be addressed,

G. B. MILLER,

P. O. Box 6715, New York.

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For September, 1870.

Day of the Week.	Day of Mon.	Sidereal Time of the Semidiameter Passing the Meridian.	Equation of Time to be Subtracted from Apparent Time.	Equation of Time to be Added to Mean Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	M. S.	S.	H. M. S.
Th.	1	64 41	0 6.10	0 6.11	0.782	10 41 47.28
Fri.	2	64.37	0 25.00	0 25 01	0.794	10 45 43.83
Sat	3	64.33	0 44.19	0 44.21	0.806	10 49 40.38
Su.	4	64 29	1 3.67	1 3.70	0.817	10 53 36.94
M..	5	64.26	1 23.42	1 23.44	0.828	10 57 33.49
Tu.	6	64.23	1 43 40	1 43 42	0.838	11 1 30.04
W.	7	64 20	2 3 60	2 3.63	0.847	11 5 26.60
Th.	8	64 17	2 24 01	2 24 04	0.855	11 9 23.15
Fri.	9	64.15	2 44.59	2 44.62	0.862	11 13 19.70
Sat	10	64.13	3 5 32	3 5.35	0.868	11 17 16.25
Su.	11	64.11	3 26.18	3 26 23	0.873	11 21 12.81
M..	12	64.09	3 47.14	3 47.20	0.877	11 25 9.36
Tu.	13	64 08	4 8.19	4 8.26	0.880	11 29 5.91
W.	14	64 07	4 29.31	4 29.38	0.882	11 33 2.46
Th	15	64.07	4 50.48	4 50.56	0.885	11 36 59.02
Fri.	16	64 06	5 11 66	5 11 74	0.883	11 40 55.57
Sat	17	64.06	5 32.84	5 32.92	0.883	11 44 52.12
Su.	18	64 06	5 53 99	5 54 08	0.882	11 48 48.67
M..	19	64.07	6 15.10	6 15.20	0.880	11 52 45.22
Tu.	20	64.08	6 36 16	6 36.27	0.877	11 56 41.78
W.	21	64 09	6 57.13	6 57.24	0 873	12 0 38.33
Th.	22	64.10	7 18.01	7 18.12	0.868	12 4 34.88
Fri	23	64 12	7 38.79	7 38.90	0.863	12 8 31.44
Sat	24	64.14	7 59.42	7 59.53	0.857	12 12 27.99
Su	25	64.16	8 19.89	8 20.01	0.851	12 16 24.54
M..	26	64.19	8 40.21	8 40.33	0.844	12 20 21.09
Tu.	27	64.22	9 0 34	9 0.47	0.836	12 24 17.65
W.	28	64.25	9 20.27	9 20.40	0.827	12 28 14.20
Th.	29	64.28	9 40.00	9 40.13	0.818	12 32 10.75
Fri.	30	64.32	9 59.49	9 59.62	0.808	12 36 7.30

Mean time of the Semidiameter passing may be found by subtracting 0.18 s. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
☽	First Quarter	2 1 57.9
☺	Full Moon	9 10 11.6
☾	Last Quarter	17 13 29.9
●	New Moon	24 18 34.0

		D. H.
☾	Apogee	14 7.0
☾	Perigee	26 7.9

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1

	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20 572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

		APPARENT R. ASCENSION.	APPARENT DECLINATION.	MERID. PASSAGE.
	D.	H. M. S.	° ′ ″	H. M.
Venus	1	9 7 9.82	+17 12 11.2	22 26.3
Jupiter	1	5 31 52.46	+22 43 38.1	18 47.4
Saturn	1	17 25 13.15	−22 7 50.8	6 42.3

AMERICAN

Horological Journal.

Vol. II. NEW YORK, OCTOBER, 1870. No. 4.

CONTENTS.

*** *Address all communications for* Horological Journal *to* G. B. Miller, *P. O. Box* 6715, *New York City. Publication Office* 229 *Broadway, Room* 19.

PRACTICAL EDUCATION.

In the infancy of the world, knowledge was rare; in its youth, it was a "dangerous thing." Wise men were few, and fewer the sages who held even *one* of Nature's hidden laws. The Alchemist—regarded almost as a wizard—concealed carefully his discoveries from the public gaze. He pursued but one object—the conversion of the base into precious metals; hence every occurrence which he deemed irrelevant to his purpose was entirely neglected, or foolishly philosophized upon. He sought to teach Nature, rather than follow her guidings; therefore it cannot surprise us that, under his auspices, science made little progress. Now, as a Chemist, he proclaims to the world the results of his profoundest research—gaining increased power and influence from this diffusion of knowledge.

The skilful artisan is no longer made famous by the few specimens of his work, laboriously wrought in secret by his own hand, lest others, seeing, should appropriate the results of his arduous thought; but he speaks to all peoples by the creation of great factories, and the numberless specimens of his craft produced by these his mighty servitors. By lectures he teaches the parents; in schools he instructs the children; through the press he informs the world; and by these means he gains wealth and influence, and thus knowledge becomes power. In the rudimental condition of art or science, isolated facts—sometimes the result of accident, but oftener of systematic observation—are the first rays which penetrate the gloom obscuring them. Systematic classification of these facts are the tints of dawn which brighten the Eastern sky. Then some master mind breathes on this cumulous mist—the clouds disperse, and there bursts upon the world the glorious sunlight of a new science.

Let us glance at the developments of Terestrial Magnetism. At first iron alone, in its various forms, was considered magnetic; and nothing beside was thought susceptible to its influence. Soon it was seen that other substances were acted upon, though in different ways. These were called dia-magnetics. A heavy bar of solid glass, which is eminently dia-magnetic, being suspended, moving freely between the poles of a horse-shoe magnet (called a magnetic field), gradually assumes a position at right angles to the current passing through the field. Being replaced, it again assumes the same position, showing an opposite action to a magnetic substance under the same circumstances. Other experiments on solids and liquids, as well as on all the known gases, pointed unerringly to the law that all substances are either magnetic or dia-magnetic. The particles of a magnetic body are attracted to, while those of dia-magnetic are repelled from, each other; and these peculiarities are retained by each substance in all conditions and combinations. The action of any compound under magnetic influence is exactly in accordance with the preponderating substance. Thus water (dia-magnetic), holding a solution of iron (magnetic), assumes position in the magnetic field in accordance with the strength of the solution;

being magnetic, if the iron preponderates; or dia-magnetic, if the water exceeds.

The mechanical arts and the science of mechanics are no exception to the same cumulative growth. Philosophers did not discover the lever, the wheel, the wedge; poor ignorant laborers were the first discoverers—their necessities were the mother of their inventions; these powers, in some simple form, were daily used, and their prodigious effects noticed, and their use spread from hand to hand; new adaptations multiplied; facts regarding their application were remembered; certain relations were noticed to produce invariably certain effects. At length these effects were generalized and arranged; and at once the *law*, certain and clear as the sunlight, was deduced. Experiment became the foundation—fact the superstructure theory, only the scaffolding of the perfected temple. As soon as the system was adopted of tracing causes from their effects, experimental science advanced with rapid strides. From its lofty abode in the time of Copernicus and Galileo, it has since descended and become the household god of all in our land; the cause of the conveniences and comforts of our existence. Had the first man who moved a stone more ponderous than himself, by means of a *lever*, concealed from his fellows the means by which he accomplished it, who can say how long the world might have remained in ignorance of the complete science of mechanics?

So it may be with our own craft, if each gives to the world the facts gathered by himself; though they be in themselves insignificant, yet their accumulation from all sources, and all pointing in one direction, may lead to the discovery of a valuable law. For example, suppose every watchmaker were to observe carefully when, how, and under what circumstances every mainspring was broken that came under his observation. Whether at the time the temperature of the weather was hot or cold; was the condition of the atmosphere unusually electrical or otherwise—cloudy or clear; was the wind from the north, south, east, or west; the moon full, or at first or last quarter; day or night; wet or dry; the height of the barometer; was the spring in motion or at rest; coiling or uncoiling; was it oiled much, little, or not at all; was it tempered blue or yellow; had it been long in use, or was it new; was the user in health, or ill; in anger, or at ease; his habits active, or sedentary; and a hundred other little facts gathered in various sections and in various countries. Who can say that from some such aggregation a law might not be deduced by which we might determine what now no man pretends to know—namely, why a mainspring breaks?

By the systematic observation of facts of any kind, and the fullest diffusion of them among those who are interested, no one knows how soon the accumulated mass may be seized by some master hand and moulded into form.

Although, in order to be a practical workman, it is not necessary to tread the stately measures of Euripides—with Horace, to celebrate the beauteous Roman dames, or with Juvenal, to "shoot folly as it flies"—yet, while we are endowed with a higher nature—with understanding as well as senses—with faculties more exalted, and enjoyments more refined than any to which the bodily frame can minister—let us pursue such gratifications rather than those of mere sense, fulfilling thus the most exalted ends of our creation, and obtaining a present and future reward. Let us mark the practical applications of science (which in its most comprehensive sense means knowledge reduced to a system) to the occupations and enjoyments of all, beginning with the greatest portion of every community, the working classes.

The first object of every one depending on his own exertions is to provide for his daily wants, for this includes his most sacred duties to himself, his kindred, and his country. Though in performing it he is influenced by his necessities or interests, yet it renders him the truest benefactor of his community. The hours devoted to learning must be after the work is done, for independence requires first a maintenance for himself and those depending on him, ere he earns the right to any indulgence. The progress made in science helps every trade or occupation. Its necessity to the liberal professions is self evident, but other departments of industry derive hardly less benefit from the same source. To how many kinds of workmen is a knowledge of mechanical philosophy necessary? To how many others does chemistry prove useful? To engineers, watchmakers, instrument-makers, and bleachers, these sciences are essential. Are those who work in various metals the less skilful for knowing their nature, their relations both to heat and other metals, and to the gases and liquids with which they come in contact? If a lesson be learned by rote, the least change of circumstances puts one out. Cases will always arise where a rule must be varied to apply; so if the workman only knows the rule, without the reason, he will be at fault when required to make a new application of it. Another use of such knowledge is, that it gives every man a chance, according to his talents, of becoming an improver of his art or trade, or even a discoverer in the sciences connected with it. He daily handles the tools or materials with which new experiments are to be made—daily sees the operations of Nature in the motions and pressure of bodies, or their actions on each other; and his chances are much greater, applying his knowledge to new and useful ideas, to see what is amiss in the old methods, and, taking advantage of it, improve and renew them, and he may make discoveries which may directly benefit himself and mankind. To pass our time in the study of science, to learn what others have discovered, and to extend the bounds of human knowledge, has, in all ages, been called the happiest of human occupations. But it is not necessary a man should do nothing but study known truths, and explore new, to earn the title of philosopher, or lover of wisdom. Some of our greatest men have been engaged in the pursuits of active life. An earnest devotion of the most of our time to the work our condition requires, is a duty, and indicates the possession of practical wisdom. He who, wherever his lot may be cast, performs his daily task and improves his mind in the evening, richly deserves the name of a true philosopher. It is no mean reward to become acquainted with the prodigious genius of those who have almost exalted the nature of man above this sphere, and to discover how it comes to pass that, "by universal consent, they hold a station apart, rising over all great teachers of mankind, and named reverently, as if Newton and Laplace were not the names of mortal men." By means of the laws of gravitation and the movements and changes of the celestial bodies, we have taken "note of time," if only by its flight.

In diffusing valuable information it is by no means necessary that a person should be learned, or even educated; if they have some complete idea, well thought out before they attempt to utter it, there need be no fear of failing in expression; for this thinking has been done *in language*, and the expression of the idea is only thinking aloud. Education is desirable; every species of knowledge is of service, and our hope for the future is to have it attainable by all. By education we do not mean a *classical* education; in fact we fully believe it a waste of time and money in a person who does not intend to make literature his profession. We believe that every man's education should have direct reference to the occupation he chooses, or that is chosen for him, and that all the mental discipline he wishes to undergo should be in the line of that profession. The study of the classics to a mechanic are a waste of mental energy. An equal amount of mental training can be had by studies bearing directly on his business. The whole line of mathematical studies are eminently calculated to discipline the mind, foster deep thinking, and cultivate the most rigid exactness in diction as well as thought, and every acquirement in that branch is a direct stepping-stone to the attainment of eminence in any mechanical calling.

Three words comprise all that is necessary for a mechanical education, viz., reading, writing, and arithmetic. *Reading* being the means of acquirement of every species of general information from all accessible sources; *Writing*, the correct use of language by carefully studying the best examples within our reach, and *Arithmetic* embraces the whole course of mathematical studies. A large proportion of the time spent by collegiate students is lost—or at least the benefits derived are very indirect, if not questionable. How many graduates can be found who know or care a straw for Plato, or Æschylus, or what do they remember of Horace, except a few stale quotations? Indiscriminate *classical* must, sooner or later, give place to *technological education*. No man's life being long enough to acquire *all* knowledge, the consequence will be, devotion to particular *branches* of learning. "To that complexion must we come at last," and the sooner we set ourselves about organizing the proper means to secure such desirable results, the better.

We trust the day is not far distant when the colleges of the past will give place to technological institutes whose efforts will be mainly in the direct education of its students in the practical pursuits of life, rather than a devotion of their energies to the study of the dead languages. The mental discipline is fully as severe in the one case as the other, and in technological education it leads to practical results. In short, the truths of modern science, and a familiarity with mechanical principles, are of much greater importance to-day, than a familiar knowledge of the loves, and intrigues, and warfare of all the heroes of the past ages.

Why can we not have *Horological* Institutes as well as *Medical?* and have "Anatomical Lectures before the class," with "free clinics every Friday, and treatment of the poor (watches) gratis?" a "Museum of Morbid Anatomy" (subjects are plenty), "Chemical and Philosophical Experiments," "Illustration of the use of Instruments" (tools), call our best workmen "Professors," and our apprentices "Students," have "Theses" read on various subjects, grant "Diplomas," and class Horologists among the liberal professions?

☞ We confidently expect to be able to present to our readers, next month, an article from Mr. Grossmann. In his letter of June 23d, he proposed to forward the next week, drawings of his Mercurial Pendulum; but it failed to come to hand, which is probably attributable to the fact that, in consequence of the war between Prussia and France, the mail service with all the German States has been very much deranged. Undoubtedly he will also, in reply to "Clyde," in the August No., support the propositions laid down in his former article on the Mercurial Pendulum.

A SUGGESTION TO WATCH MANUFACTURERS.

The growing popularity of American watches with the watch-carrying public—thereby rendering it incumbent upon all dealers to make them a part of their stock—is raising the question among the most intelligent workmen as to which of the various manufacturers really produce the most reliable time-piece; and which one he can conscientiously, and with the most interest to himself, recommend to his customers. By "interest to himself," we do not mean the watch on which he makes the most immediate profit. The most important consideration to the thoroughly practical mechanic who takes a pride in giving to his customer the nearest possible approach to mechanical perfection in the time-piece he sells him, is, what watch will give the best results in that direction, and give to him the best reputation as a dealer.

To watchmakers, certificates, even from eminent men, prove very little, as, from the very nature of the case, the testimony of the wearer of a watch is confined to a single one, and all the certificates any manufacturer publishes must necessarily bear a very small proportion to the entire number manufactured. Besides, few, if any, have the means of making correct comparisons, even had they the disposition to do so. The comparison of a watch to-day with any standard authority, and a comparison with the same authority at the expiration of twelve months, and showing very good results, proves nothing; for possibly there might not have been any period in the intervening time when the comparison would have resulted so favorably. A comparison of rates with the best chronometers or regulators at the command of the watchmaker is eminently satisfactory, but they are not infallible; in fact, they invariably have a daily rate of gain or loss, and frequently errors, either concealed from the public, or not known to the watchmaker himself, and nothing short of a frequent observation of the heavenly bodies will give a reliable indication of the real performance of the watch.

Again, one watch selected from a hundred may give results bordering on the marvellous, and still the other ninety-nine be very indifferent time-keepers; the average performance, perhaps, being much below the same number of another maker, who, on a single watch, could not show as high a degree of perfection as his competitor.

The highly creditable display of American watches, now on exhibition at the Fair of the American Institute in this city, is well designed to add to the growing interest felt in this branch of national industry; but it occurs to us that something more than the mere display and extensive advertisement of goods is required; and that is, that competitive trials, in some form, should be instituted. Just now such trials should be conducted so as not only to secure an honest verdict, but at the same time satisfy the public of the thoroughness and practical nature of the tests. It may not be easy to fully prescribe the details, but as tending in that direction we make these suggestions:

1. It should, of course, be a condition that the watches entered were entirely of American manufacture.

2. It would be manifestly unfair that watches that merely *chance* to possess remarkable properties should be selected from a large number, and which were not a fair sample of the average manufacture; for then the advantage would be with the largest producer. A definite number only on the part of each maker should be entered, and these numbered in rotation before springing—none being duplicates of other numbers. Or, perhaps it would be better to dispense with these conditions by presenting a certain number on the part of each maker, from which a random selection should be made by the appointed judges.

Of course the watches of the different makers should be of the same price, and might include all the grades that could fairly enter into competition from each of the factories. The object being to determine who places the most reliable time-piece on the market, it would be manifestly proper that they should be taken as they are offered to the public, and not as they might be gotten up for a competitive trial. On watches prepared for trial, it would be expected each maker would bestow the highest skill in adjusting, even though it should considerably raise them above the average character.

The comparative trials might include tests for isochronism, position, and temperature, and even be exposed to carriage on a railroad, as the final test of all watches is that of ordinary wear; but it would be impracticable, and even unfair in a public test to attempt this mode of testing, as they would hardly receive uniform treatment; but a test protracted through many weeks might be made; the watches to be exposed to variation of position and temperature, without noting the effect of each change, each receiving the same treatment, and the changes being simultaneous. No account of the smallness of the rate should be taken, but only the *uniformity of rate;* the amount of rate being a mere matter of regulation, and having no bearing on the perfection of adjustment.

We hope the day is not far distant when some one of the American watch companies, confident of a higher average of excellence in time-keeping than any others, will throw down the gauntlet in the form of a challenge to all, to enter the tests in a public trial. No higher honor than the victory in such a contest could be desired. Nothing would so speedily educate the public up to a taste for fine time-keepers. Nothing could so stimulate the artisan in the attainment of the highest skill in accurate adjusting, for there would be a wider demand for such labor, and under such a system of competitive trials we should see the name of an American watch becoming the synonym of perfection in time-keeping.

——o——

TAKING IN WORK

EDITOR HOROLOGICAL JOURNAL:

I will tell you how I take in work and defend myself from the anathemas showered on many of the craft.

In taking in a watch I always request my customer to call in at a certain time, and I will let him know what his watch needs to have done to it, as the universal remedy (cleaning) is not always a specific cure for the evil of stopping.

I examine a watch in this way as I take it down: 1st, I see whether the cap jewels are well fitted; try the end shake of the balance staff; note the length of the lever; try the banking, and examine the fork and roller jewel; then I take out the balance, see whether the roller jewel is firmly set, and the edge of the roller smooth, examine the pivots, take off the hair spring, and try the poise of the balance. I now find out about the locking, slide and drop of the pallets; after that I let down the spring, take out the pallets and barrel, take out the mainspring, and put the barrel back, to see whether all the train is free; examine the depthing and side and end-shakes, then take down the train, having a small block to put my screws in to avoid getting them mixed; then examine the pivots, and try the jewels to see whether they are firmly set, and the holes true and perfect. If a solid ratchet, see that it is solid and well fitted, see how the spring is adapted, and that the stop-work performs well, and that the dial wheels are all right. I try them when I first take off the dial.

Now, for whatever I find to be done, I have a regular price, and I charge for it. If the customer will not have the watch put in order, then, of course, I will not warrant it. There are comparatively few but what have their watches put in order, and most of those who do not will get the best done they can, and have it run; and those who will not have anything done I charge, as some M. D.'s do, for the examination. In cleaning, I wash in warm water and Castile soap, using a fine brush, rinse in alcohol, and dry in fine boxwood sawdust. Of course all the false plates are stripped so that the dust can be removed with a fine brush. The train I wash simply in alcohol, and dry it off before I put the plates in the sawdust, to avoid the danger of breaking the pivots. In this way I find out all the defects of the watch, and take nothing for granted, and I am sure it pays me. I test my alcohol by putting in a piece of polished steel, and if it does not change the color of it, it answers my purpose.

J. H. L.

Concord, N. H.

HEAT.

NUMBER THREE.

LATENT OR SPECIFIC HEAT—TRANSMISSION OF HEAT BY CONDUCTION, BY CONVECTION, BY RADIATION—FAMILIAR EXAMPLES, ETC.

When two different bodies are exposed to heat, under exactly the same circumstances, both will finally reach the same temperature; but one of them will always take a longer time in doing so than the other. Thus, if two similar and equal vessels, one containing mercury, the other water, be placed on the same stove, the mercury will be raised to 212° before the water boils; and yet the mercury, if of equal bulk with the water, is more than $13\frac{1}{2}$ times as heavy, and might have been expected to have taken $13\frac{1}{2}$ times as long to reach the same temperature. It is obvious, therefore, that *all* the heat which was received by the water has not appeared in a sensible form, and it is also possible that *all* received by the mercury is not sensible.

When a solid is converted into a liquid, or a liquid into an elastic fluid, the conversion is brought about suddenly. The substance in question, before changing its state, continues to receive heat, is expanded to a certain degree, and has its temperature raised; but if an additional quantity of heat be still given to it, the expansion no longer goes on in the same manner, and the temperature is no longer elevated, but it assumes a new form, becoming, according to circumstances, either a liquid or a vapor. It was formerly supposed that this change did not depend upon any peculiar or specific action, but that the mere addition of a certain small portion of heat was adequate to effect it. Dr. Black, a celebrated Scottish Professor of Natural Philosophy, and the friend and adviser of James Watt, perceived the insufficiency of the opinion usually entertained on the subject, and was induced to investigate it with great assiduity; the result of which was to establish his celebrated theory of LATENT heat. It would carry us far beyond our prescribed limits were we to give an account of the experiments which were performed by Dr. Black for the purpose of establishing his theory, which is generally accepted. The fundamental position of the theory is, "that when a solid is converted into a liquid, or a liquid into a gas, a much greater quantity of heat is absorbed by it than is perceptible by the sensation, or the thermometer, the effect of which is to unite with the particles of the body, and thus to alter its form. When, to the contrary, the vapor is reduced to the state of a liquid, or a liquid to that of a solid, heat is disengaged from it without the subject in question indicating any diminution of temperature, either to the sensation, or to the thermometer." Although we cannot determine the number of degrees, by any thermometer, that will become latent, the capacities of bodies to contain it are determined by taking one of them as a standard. Water is generally used for this purpose, and the capacities of most metals for latent heat are represented by the following figures :

Bismuth	0.0288	Zinc	0.0927
Lead	0.0293	Copper	0.0949
Mercury	0.0290	Nickel	0.1035
Gold	0.0298	Iron	0 1100
Platinum	0.0314	Cobalt	0.1498
Tin	0.0514	Sulphur	0.1880
Silver	0.0557	Water	1.0000

The capacity of bodies for latent heat may be changed by mechanical means. The capacities of atmospheric air and gases are acted upon in this manner. Thus, if we force a piston into a syringe, and a piece of timber be placed on the piston, it will be set on fire. Inflammable mixtures of gases will be exploded by the same instrument, and some are said to be heated to such a degree as to become luminous. Air rushing from a vessel in which it has been condensed, will produce a dégree of cold sufficient not only to convert the vapor with which the air is mixed into water, but to freeze it into the form of a ball. In the atmosphere of the earth, those portions of it which are nearest the level of the sea are compressed by the weight of those above them ; they have, therefore, a small capacity for latent heat, and their temperature is higher than that of the air in higher regions, when the pressure being less, the capacity for latent heat is greater. We may thus account for the great cold experienced on rising in a balloon, and on the tops of lofty mountains, which, even when the sun is vertical, are covered with perpetual snow.

Heat tends to diffuse itself equally among bodies of different temperature ; so strong is this tendency, that, unless fresh supplies are received, the hottest bodies soon become cool, in consequence of parting with their heat to surrounding bodies cooler than themselves. The cause of this tendency of heat to fly off from bodies, or to pass from one to another, and thus diffuse itself among them, is attributed to its possessing an *inherent repulsive force.* The particles of all kinds of ponderable matter are necessarily attracted to each other, unless some counteracting cause prevents their union. This is equally exemplified in the attraction which prevails between large masses of matter, by which the planets are kept in their orbits, called the attraction of gravitation, and the attraction which exists between the indivisible particles of matter, and which influences many of the minute operations of nature under the denomination of chemical attraction. The repulsive power which appears to be an inherent quality of heat, may be regarded, in general, as the cause of its diffusion among bodies. This equal distribution of heat, as it has been called by some writers, or the equilibrium of caloric, as has been styled by others, has been the subject of much observation and experiment, and has also given rise to much hypothetical discussion, which we will not dwell on, but proceed to give the generally accepted modes by which heat seeks to attain this equilibrium of temperature.

When heat passes from one particle of a solid substance to another, it is said to be conveyed by *conduction.* Suppose we pick up a piece of metal when the atmosphere surrounding it is of an ordinary temperature, we feel it to be a hard and heavy body, but it neither warms nor chills us ; the temperature of the metal on the one hand, and our sensations on the other, remain unchanged ; but if we place one end of the metal to some source of heat, the particles of the metal nearest to that source become violently agitated, the swinging atoms strike their neighbors and expand their distance apart, which finally reach our hand and cause the sensation known as hea t; but although a familiar example, it must not be understood to be, in all cases, a *test* of temperature, or the quantity of heat that exists in bodies. To prove this, arrange three bowls, containing water at 32°, 90°, and 150°, respectively. Dip the two hands into the first and third bowls, and then at the same instant into the centre bowl, containing the water at 90°; to the one hand it will feel cold, to the other warm. When heat is conducted through bodies, it does not flash through them instantaneously like electricity, but passes successively from particle to particle, requiring an appreciable time for the passage. It passes through bodies with different degrees of rapidity, some permitting it to pass through them quite rapidly, others only very slowly, and others almost entirely intercept its passage. The imperfect conducting power of snow, for instance, arises in a great measure from the above cause. When newly fallen, a great portion of its bulk consists of the air which it contains, as may be readily proved by the comparatively small quantity of water it produces when melted. Farmers in cold countries always lament the absence of snow in winter, because, as a consequence, the frost penetrates to a great depth, and does much injury to the grain sown the previous autumn. So great is the protecting power of snow that in Siberia it is said that when the temperature of the air has been 70° below the freezing point, that of the earth under the snow has seldom been colder than 32°, verifying that passage of Scripture which says, "God giveth snow like wool." It has also been observed, that the heaving up of the ground by frost, when protected by snow, is much less than when it is uncovered and exposed.

Our readers will all be more or less familiar with instances where, in the back woods of our own country, travellers having been obliged to sleep in the open air in the winter, find themselves in a glow of heat on waking up in the morning, with several inches of snow over their water-proof coverings. For the same reason, many substances which in the solid state are quite good conductors of heat, when reduced to powder are very poor conductors. Thus, rock crystal is a better conductor than bismuth or lead; but if the crystal be rendered to powder it becomes a very poor conductor indeed. Rock salt, when in the solid state, allows heat to pass through it with great facility, but table salt, in fine powder, obstructs its passage almost entirely. Sawdust powerfully compressed allows heat to pass through it with the same facility as solid wood of the same kind, but when loose and unconfined it is one of the poorest conductors known. Sand is an excellent non-conductor, and is often placed beneath the hearths of fire-places to guard against accidental fire. At the siege of Gibraltar, the red hot balls fired by the British, were carried from the furnaces to the guns in wooden wheel-barrows, protected only by a thin covering of sand. Near the summit of Mount Ætna, ice has been discovered beneath currents of lava which had flowed over it when in a liquid state, which was only protected from melting by a thin layer of volcanic sand. The ice gatherers of the same mountain export their ice to Malta, and distribute it through Sicily, protected by envelopes of coarse straw matting; and ice is conveyed from our own country to the most distant parts of the earth packed in straw, sawdust, or shavings. Asbestos, a fibrous mineral substance, is woven into an incombustible cloth of such poor conducting power, that red hot iron may be handled with gloves made of it. Glass is another poor conductor of heat; so poor is it that a large red hot molten mass of it may be ladled into cold water and the interior remain visibly red hot for several hours.

Heat is conveyed through all liquids and gases by a *change of place* among the particles. These particles are transferred in whole masses from place to place, and convey the heat along with them, and is called *convection*, in contradistinction to the process of *conduction*, just now described. If any fluid body be heated from beneath, the part which receives the heat first becomes specifically lighter than the rest of the liquid; this part will therefore rise to the surface, and its place is supplied by the denser part of the liquid. A continual current of the colder liquid from the surface, and the heated liquid from beneath, will thus be formed. This current may be rendered sensible as follows: Place water in a transparent vessel, and put a little powdered amber into it, which has almost the same density as water. On applying a lamp to the bottom of the vessel, the powdered amber will be seen to circulate with the water, and thus exhibit the nature and direction of the currents ; while on being allowed to cool, the process is reversed. In summer, when there is no breeze, we feel oppressively warm, because the air does not carry off the heat generated within us. Fanning cools us, because it carries off the air heated by contact with our bodies. In this case it will be seen that it is carried off by *convection* and not by *conduction*. The existence of *currents* produced by convection is seen on a grand scale in nature in the existence of trade winds, the Gulf Stream, and other ocean currents. The air and the water in both cases are not heated from the direct rays of the sun, as will be explained in the next paragraph.

A body *not in contact* with the source of heat cannot be heated by conduction or convection, and if it receives heat at all it is by a third process, called *radiation*. All substances radiate and absorb heat, but not equally well ; much depends on the character of their surfaces. When radient heat falls upon bodies it is either absorbed (in which case it raises its temperature), or it is reflected or turned back towards its source, or it is refracted or bent out of its original straight course, which occurs only when it falls at an angle less than a right angle, upon some medium which it is capable of traversing ; or it is transmitted or passed through unchanged when it falls perpendicular upon some medium capable of transmitting it, although this rarely takes place without more or less absorption. Radient heat does not affect the temperature of the media through which it passes. A hot stove sends forth rays of heat in every direction, that pass through the air without heating it, but raise the temperature of all bodies upon which they strike. In like manner the earth is warmed by rays which emanate from the sun, and have passed through the air without raising its temperature.

Many other interesting phenomena might be mentioned in connection with the radiation of heat ; but having given our readers a condensed dissertation on heat and its modes of transmission, which, with a little reflection, will enable them to form an intelligent comprehension of some of nature's grandest laws, we will, in our next number, proceed with a detailed description of the practical effects of heat, interesting to young and old, to the merchant and to the mechanic.

EXPLANATION OF ASTRONOMICAL TERMS RELATING TO TIME.

It is because there is so much confusion in the minds of those who have not investigated the subject of Astronomy, that we are often met with inquiries relating to the difference between Apparent and Mean Time, Sidereal and Solar days, etc., and we are led to an explanation of these terms ; not that there is anything new to be presented, but that, by "line upon line," certain fundamental facts in Astronomy may be made more familiar, and to watchmakers especially, inasmuch as the subject is intimately connected with their art. For, it will take but little consideration to show that while Horology grows out of the demands of Astronomy, the mutual relation becomes so intimate, and the requirements of each so interwoven, that neither can fulfil its high purpose without being supplemented by the material aid furnished by the other.

Astronomy discovers and defines certain intervals of duration, determined by the movements of the various members of the Solar and Stellar systems ; and according as it accepts one or another of these intervals as a unit, it measures the length or varying durations of the others ; and the interval of duration between a particular epoch and another such is called Time.

The diurnal motion of the earth on its axis furnishes most readily a basis for the measurement of time, since the exact recurrence of each complete revolution constitutes a distinct interval, which we are compelled by our senses to accept as a unit of measure, because, as one side or the other of the earth is presented to the sun, we have the alternations of light and darkness, which, taken together as a whole, make what we call a Day. But the length of the day, or a complete revolution of the earth on its axis, depends on how we measure it; for, if we do so with reference to the sun, we shall find it of a certain length of duration, while if noted with reference to the stars, it will be quite different. Let us illustrate this. Suppose we were situated on the edge of a horizontal revolving disc, and we notice at one point of our revolution that two remote objects, lying beyond the circumference of the disc, are in range, one of them being comparatively near. Imagine a line drawn from the centre of the revolving disc through the point we occupy. It is evident every time we make a complete revolution we know it by the coincidence of this line with the two objects in range. Now, suppose while this disc is revolving about its own centre, it also revolves about the nearer of the two objects, so that while it makes one revolution about its own axis it moves the $\frac{1}{365}$ part of a circle around the near object. It will be equally clear that after one revolution our imaginary line will not point to both the near and far objects at the same time; for when a complete revolution of the disc is made with reference to the near object, the farther one will not be in range, and consequently the length of the revolution of the disc will differ accordingly as we refer it to the near or distant object.

Now, if we transfer this idea to the Solar system, we shall find the same state of facts. We shall find the earth moving from west to east on its axis; the distant object will be a fixed star, and the comparatively near one the sun. Suppose we set up a transit instrument in the plane of the meridian so we may know exactly when the sun or the star, by the revolution of the earth on its axis, appears to cross the meridian line. When the earth has made a complete revolution on its axis, it will also have moved forward in its orbit about the sun one day's march, and the same effect will appear as in the illustration, for the earth will revolve so as to get the transit instrument in line with the star earlier than with the sun. We may remark here that this fact accounts for the apparent movement of the sun among the fixed stars; for although they, from no part of the earth's orbit, present any change in their relative positions, by reason of their almost infinite distance, yet, as we revolve about the sun, that luminary is successively brought in range with, and appears to traverse the space occupied by the constellations comprising the twelve signs of the zodiac.

Now, if one revolution of the earth on its axis constitutes a day, how shall the length of the day be determined; with reference to the sun, about which we revolve, or by reference to the stars, about which we do not revolve? We cannot use both intervals of time as the same basis of measurement. Astronomers, therefore, apply different designations to these unequal intervals, and call that marked by the successive arrival of a certain point in the heavens, called the *first point of Aries*, which is otherwise known as the intersection of the ecliptic and the equator, at the meridian of any place, a Sidereal Day, because made with reference to the stars; and that interval caused by the successive arrival of the sun at the same meridian a Solar Day, for the reason that it is determined by the sun. So also, if the diurnal revolution of the earth be measured with reference to the moon, it will be still different, and such an interval would be known as the Lunar Day. Here we have, then, three distinct intervals, yet each generically termed a day.

The Day, then, being a natural unit of time, may be resolved into any number of subdivisions for the purpose of expressing smaller intervals of time; but custom arbitrarily divides it into twenty-four parts, or hours, and these again into minutes and seconds, as all understand, while the longer intervals are expressed in months and years. The subdivisions and multiples of the unit day are referable to the kind of day we take as the basis of division. Thus, Sidereal Time is duration expressed with reference to the Sidereal Day.

It has been found by long continued observation that the diurnal motion of the earth on its axis is exactly uniform, if measured with reference to the fixed stars; so that the interval between the successive transits of any fixed star is always precisely the same length; but this interval, or length of the Sidereal Day, is proved to be shorter than the Solar Day; and if the latter be taken as the unit, or 24 hours, then the former will be 23h. 56m. 4s.09 of solar time.

The Day we most naturally fall into the use of is that determined by the revolution of the earth with respect to the sun, as already explained, and is of that length of time that elapses between the successive presentations of any point or meridian on the earth to the sun ; or, as it *appears* to our senses, the upper transits of the sun across the meridian of any place, and is, therefore, identical with the day indicated by a correct noon mark, and is properly described as an Apparent Solar Day.

When the sun's centre crosses or transits the meridian of any place, that instant is called Apparent Noon, and time reckoned forward from this instant to the return of the sun on the meridian, is called Apparent or True Time. And yet it is not the kind of time we use in civil affairs, or the ordinary customs of society ; for, owing to the want of uniformity of the motion of the earth in its orbit, and to the inclination of the poles of the earth to the plane of its orbit, an inequality arises that causes the successive return of the instant of apparent noon with considerable irregularity ; and the construction and use of a time-piece that would keep this irregular, or apparent time, would be inconvenient, if not impossible. So astronomers have devised a kind of time, based on solar time, in so far as it has the same number of days in the year, and is represented by a fictitious or supposed sun having a uniform motion, its time, therefore, showing a regular and equable increase, but each day of 24 hours being the mean or average of all the days in the year, and this is denominated Mean Solar Time. The term Day, expressed with reference to the movement of the mean sun, is called a Mean Solar Day. Mean noon is the instant when this suppositious sun is on the meridian, apparent noon sometimes preceding, and at others, succeeding it. The difference between apparent time and mean time is called the Equation of Time, and is given in tabular form, in any nautical almanac, for every day of the year. By its use we may convert apparent into mean time, and *vice versa.* If the transit of the sun be observed with any instrument designed for that purpose, but preferably a transit instrument, the immediate result is the finding the instant of apparent noon by the time-piece used. By applying the eqration of time to this result, according as it is additive or subtıactive, the instant of mean noon is found, as shown by the same time-piece; or, in other words, its error, whether fast or slow.

In the method of reckoning, in ordinary use, the Civil day begins at midnight, and reckons forward 12 hours to noon, and thence 12 hours again, to the next midnight. The Astronomical day commences at mean noon, and 12 hours later than the Civil day of the same date, and its hours count from 1 to 24 continuously, to the succeeding noon. Thus, Oct., 1 day 18 h., astronomical time, would correspond to Oct., 2 days 6 h., A. M., civil time. In nautical usage, the Sea day begins at the noon preceding the beginning of the Civil day of the same date.

THE LEVER ESCAPEMENT.

No portion of the structure of a watch has so much labor bestowed upon it—receives so much of the thought and skill of the scientific and practical horologist—as that portion comprising the escapement ; for it is this part of the mechanism of the watch that divides time into small equal instants, and it cannot be too perfectly proportioned, nor too carefully finished.

There are many varieties of escapements, but the most important and the most interesting is unquestionably the detached lever escapement. From its beauty of combination, the durability of its structure, and the accuracy of its performance, it has won the favor of very nearly all European, and every American manufacturer, and it is to-day the most popular escapement extant. When well carried out, as to principle and finish, it is susceptible of excellent time-keeping qualities (in the ordinary acceptation of the term), and this, taken in connection with the comparatively small cost for which it can be made, places it far above any other escapement.

The detached lever, as invented by Mudge, in 1751, although differing somewhat from the present manufacture, has nevertheless served as a prototype to all escapements on the same principle, but differing somewhat in form. It is not the object of the present article to furnish a complete treatise on the lever escapement, as that would occupy more space than could be allowed in the JOURNAL, and besides, there are already many very excellent treatises on the subject, from eminent horologists ; but the design is to *aid* those repairers who are seeking to acquire a knowledge of the *principles* involved in a good lever escapement, the better to fit them to make the necessary repairs, when occasion requires. From these considerations there will be given only the two most common forms of this escapement—the English and the Swiss ; the difference being principally in the shape of the tooth of the escape-wheel—the English using ratchet teeth, and the Swiss club teeth.

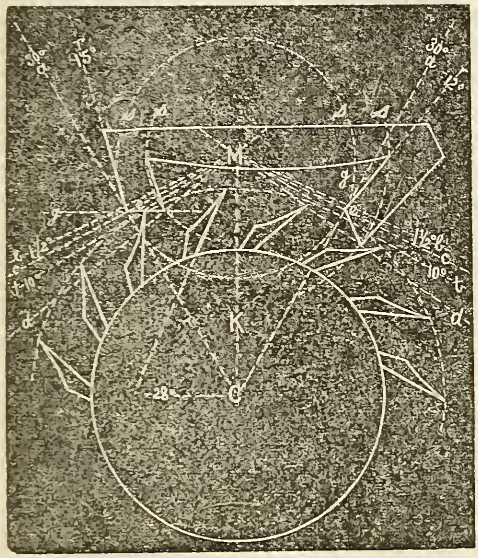
This escapement is composed of two distinct actions, viz. : that of the wheel and pallet, and that of the lever and roller. From this enumeration it will be seen that the escapement consists of four acting parts—wheel, pallet, lever, and roller. The action of the wheel and pallet is simply that of rotary converted into that of vib atory motion, and is effected by means of driving planes on each arm of the pallet, acted upon by the wheel, and is called the lifting action. There is also an action of the wheel and pallet, very necessary to good performance, called the " raw," which is produced by means of a slight deviation from the line of the locking-face on each arm of the pallet, causing the pallet to be drawn in towards the wheel after the latter has given its impulse, thus completely detaching the vibrations of the balance from its connection with the other parts of the escapement, until the return vibration again completes the connection by means of the ruby-pin in the roller ; hence its name.

The action of the roller embodies two functions—that of impulsion, and that of unlocking. The pallet, being of one piece with the lever (so to speak), is forced by the action of the wheel on the p llet, as already described, to communicate the impulse derived to the balance, by means of the ruby-pin in the roller. On the return of the ruby-pin to the slot in the lever, it carries it forward just far enough to unlock the locking tooth from its resting place against the pallet, receiving immediately after an impulse on that arm. As soon as this is accomplished, another tooth communicates another impulse to the balance by means of the plane on the other arm of the pallet, and which action is continuous.

There is another action, called the safety action, which is also very essential to good performance in watches, and has for its object the prevention of the lever being thrown out of position while the balance is detached from the lever, in one of its vibrations ; this is effected by means of the roller, which, being perfectly round, prevents the lever, when disturbed by violent external motion, from passing the roller by means of a pin or abutment on the lever striking against the edge of the roller when disturbed, but immediately returning from that place by the action of the "draw," when released by the stoppage of external motion.

There is yet another function of this escapement, also very necessary—that of "banking ;" which is nothing more than two pins placed at proper distances from each other, on each side of the lever. The object of these pins is to keep the lever in position, but in a contrary manner to that of the "safety action." The lever, if not controlled by the banking arrangement, would pass out of reach of the ruby-pin, acted upon by the "draw" already described, on the return vibration of the balance. From what has been already said of the action and functions involved in a lever escapement, it will be seen that it is somewhat complicated, though not more so than many others that are inferior in principle and performance ; and besides, in these very complications it is yet simple, that is, easy of execution. Now the end we aim to attain is, to find the d stance of any given size wheel from the pallet, and the pallet's proportion to the size of the wheel ; its arms, its driving planes, its locking faces, the size of the roller, etc., etc. We will treat of the action of the wheel and pallet, and of the lever and roller separately, considering that of the wheel and pallet first.

To find the exact proportion of the size of the pallet to that of the wheel, and the exact distance of the wheel from the pallet, first fix upon any size wheel, and increase its dimensions ten or fifteen times, the better to carry on the operation, and draw this circle on paper; from the centre of this circle (or wheel, as we shall hereafter call it) draw a line K, as shown in Fig. 1. The number of teeth the



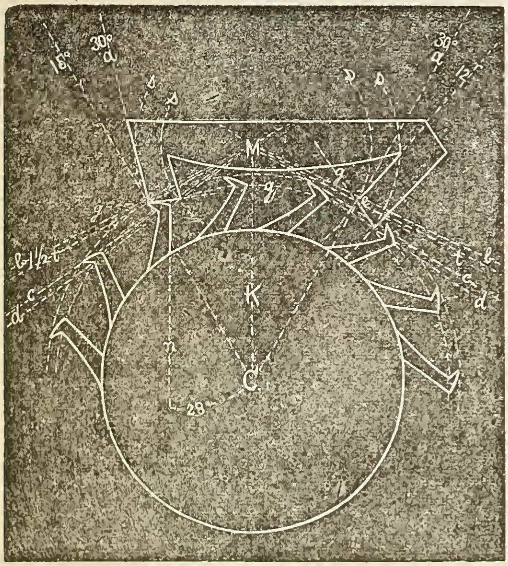
wheel has (in this case 15) must be known; the pallets are to span $2\frac{1}{2}$ teeth of the wheel; this will then form an arc of 60°; as 360°, the whole circumference of the wheel, divided by 15, the number of wheel teeth, equals 24°, the distance from one tooth to another, this quotient multiplied by $2\frac{1}{2}$, the number of teeth the pallet is to span, will give $24° \times 2\frac{1}{2} = 60°$; which are laid out, with the aid of a protractor, to 30° on each side of the line K, and marked *a*, from the centre of wheel C. Next proceed to draw lines *t*. These lines must be drawn so as to touch the periphery of the wheel, and form a right angle with the line *a* and the point where the lines *t* cross each other will indicate the centre of motion of pallet M.

Next proceed to determine the strength of the arms the pallet is to have, which must be equal to one half the space from one tooth to the other, which is 12°; but from this we must take 3° for the requisite fall of the tooth after giving the impulse, which gives us 9° for the strength of the pallet arms, which we mark on the right side of the line *a*, from the centre of wheel C, and draw into curves from the centre of pallet M, and marked *s s*, as shown in the figure, thus making the locking faces equidistant.

Now proceed to determine the lifting and locking faces of the pallets. In this case we have taken 10° for the lifting plane, and $1\frac{1}{2}°$ for the locking face; the whole movement of the pallet will then be $11\frac{1}{2}°$, which we draw from centre of pallet M, and equidistant on each side of the lines *t*, and marked *d, b;* but $11\frac{1}{2}°$ being the whole movement of the pallet, and as we already know that 10° is the lifting plane, and $1\frac{1}{2}°$ the locking plane, so, to distinguish the lifting from the locking, we draw a line, *c*, from the centre of pallet, M, $1\frac{1}{2}°$ distant from and below the line *b*. To find the face of the pallet arms, draw a line from the point where the line *c* crosses the curve *s*, to the point where the line *d* crosses the curve *s*.

Next proceed to determine the angle to be given the locking faces, so as to create the "draw." From the point *e* draw a line, *r*, on the right side of the line *a*, at an angle of 15° on the arm where the tooth commences its action, and 12° on the arm where the tooth ends its action; these will give the proper locking faces, with the tendency of the pallets to be drawn towards the wheel when the tooth is at rest. We finally determine the inclination of working faces of the teeth from a straight line to the centre of wheel, C, which is generally from 26° to 30°; but in this case it is 28°, which is drawn from the point of any tooth, as shown in the figure.

The escapement just analyzed is the English method of carrying out the lever escapement, and the escape wheel has ratchet teeth. We will now consider the lever escapement as adopted by the Swiss—having club teeth, and where the driving planes are partly on the teeth of the wheel, and partly on the arms of the pallet. To plan this escapement, fix upon the size of the wheel and the number of teeth it is to have, and then increase the dimensions of the wheel ten or fifteen times, and draw the circle or wheel on paper, as shown in Fig. 2; then draw line K, from the centre of wheel, C; as we purpose to have the pallets span $2\frac{1}{2}$ teeth, and the number of wheel teeth to be 15, we will then have 360°, the circumference of the wheel; divided by 15, the number of wheel teeth, gives us 24° for the span from one tooth to the other; this multiplied by $2\frac{1}{2}$, the number of teeth the pallet is to span, gives $24° \times 2\frac{1}{2} = 60°$, which are laid out, by the aid of the protractor, on each side of the line K to 30°, and marked *a*; next draw the lines *t*, so that they touch the periphery of the wheel and form a right angle with the line *a*. Where the lines *t t* cross each other is the centre of motion of



the pallet, marked M. We must next proceed to determine the strength of the pallet arms and the wheel teeth, thus: 24° being the space from one tooth to another, we take a sixth part of this (4°) for the strength of the wheel teeth, and will then have 20° left; from this take one half (10°) for the strength of the pallet arms, deducting 2° for the requisite fall of the tooth after giving the impulse, which leaves 8° for the strength of the pallet arms; these 8° we now mark on the right side of the lines *a*, from the centre of wheel, C, and then draw into curves, *s*, *s*, from the centre of pallet, M. We next give to the wheel teeth their proper inclination or driving planes, which, in this case, should be 4°, and which are drawn below the line *t* from the centre of pallets M, and marked *c*, from this point where the lines *a*, and *c*, cross each other, we draw a circle from the centre of wheel, C, and marked *q*, as shown in the diagram, which determines the proper place for the fore end of the wheel teeth.

The next thing to determine is, the lifting and locking faces. The lifting face in this case is proposed to be 6°, and the locking $1\frac{1}{2}°$ for each pallet arm, which we proceed to draw thus: From the centre of pallet, M, draw the line *d*, below the line *c*, 6° distant from the line *t*, which gives the lifting angle proposed, and from above the line *t*, $1\frac{1}{2}°$ distant, draw from the centre of pallet, M, the line *b*, which gives the locking-face as proposed. To find the face of the pallet arms, draw a line *g*, from the point where the line *t* crosses the curve *s* to the point where the line *d* crosses the curve *s*, the driving planes of the pallet arms. Then proceed to determine the angle to be given the locking faces in order to create the requisite "draw;" this, as in the preceding case, has 15° on the arm where the tooth commences its action, and 12° on the arm where the tooth ends its action, drawn from the point *e*, and marked *r*.

To give the teeth their proper shape, we give for the breadth 4°, before determined, marked from the wheel centre, C, by reason of which are found the driving planes of the wheel teeth; that is, a line drawn from the fore end of the tooth in the circle *q*, to the periphery of the wheel in the limit of 4°, as shown in the diagram. We finally determine the angle of the working faces of the teeth, which, in this case, should be 28°, drawn from the fore end of a tooth. When it is required to reduce the proportion found of pallet to wheel, arms, locking face, lifting plane, etc., etc., each part will only have to be diminished as many times as the original size of the wheel was increased.

By the method above given a repairer will be enabled to test the soundness in principle of the action of any wheel or pallet of which he may be doubtful. The description has been purposely minute in order that those having never planned an escapement will be better able to understand it and apply it. In the next number of the Horological Journal will be considered the action of the lever and roller.

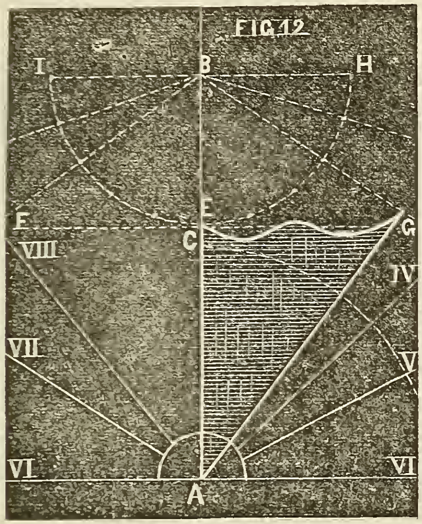
N. Y., Sept., 1870. Chas. Spiro.

[☞ We are requested by Mr. Spiro to state that it will not be possible for him to take any more orders, as he expects to leave for San Francisco in about two months, from which place he will continue to correspond with the Journal.]

DIALING.

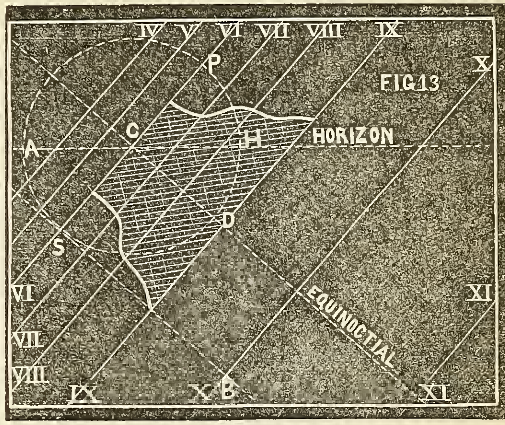
NUMBER FOUR.

A North Erect Dial (Fig. 12) is constructed



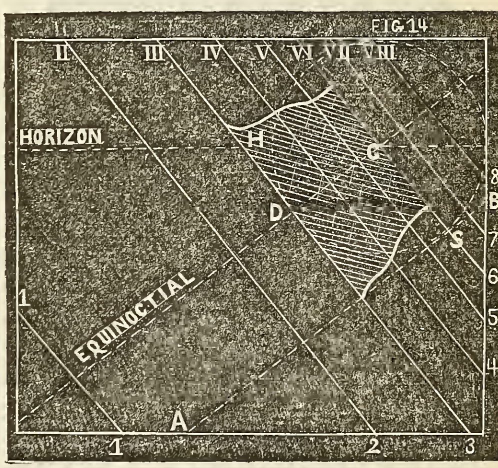
on a wall, or plane, facing the true north point. This dial is useless from September 22d to March 21st, while the sun is in the six southern signs (to those who inhabit the northern hemisphere), because it can only show the time from the sun's rising until six in the morning, and in the evening from six till sunset; consequently we shall not give its construction particularly, but only say it is exactly the same as the South Erect dial, only the stile points *upward*, and the line VI. VI. is drawn at the bottom instead of the top of the dial-plane.

A Direct East Dial is drawn on a plane parallel to the meridian. Consequently the hour lines are parallel to the earth's axis, and to each other. The sun comes on it at its rising and continues on it until noon. The VI. hour line is the substilar line, and the stile may be a thin plate of metal or an iron rod. At about two-thirds the distance from the lower edge of the dial-plane draw the horizontal line A C H. (Fig. 13.) At some convenient distance, as at C, draw a circle with a chord of 60°; then take the chord of the latitude of the place and set from H to P, and draw the 6 o'clock hour line P G S, which is the substilar line, to which, at right angles, draw the equinoctial, C D. Next draw the line A S B, parallel to the equinoctial; divide the quadrant S D into six equal parts, lay the ruler at C, and to those parts in the circle, and it will cut the line A B in those points



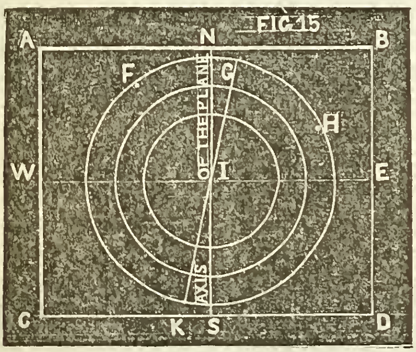
through which the hour line must pass; through those points draw them parallel to the 6 o'clock line and you will have the proper hour lines. The smaller subdivisions of course you can construct by subdivision, as in the other dials. The stile fix on the 6 o'clock line, at right angles to the plane of the dial; its height equal to C D.

An Erect-Direct West Dial is constructed exactly like the east dial, except that you draw your circle to the right, on the horizontal line, instead of at the left, as in the East dial; cons quently the hour lines will be elevated to the left instead of the right, as shown in Fig. 14.



In drawing dials for planes *not* direct—that is, declining to the east or west—it becomes necessary to ascertain the amount of declination; and this can be determined by a very simple instrument, which you can construct yourself. Get a good-seasoned bit of board, *exactly square;* cover one side with paper nicely pasted on, and draw on it, from the centre, two, three, or more, concentric circles. Through the centre at I, let there be a hole to receive a straight wire to screw (or slide) up or down at pleasure, and to constantly stand at right angles to the plane of the board itself ; draw two diameters exactly perpendicular to the edge of the board, and mark them N. S. E. W. ; when the north edge of the board is placed against an *exact south* wall, the line N. S. becomes the 12 o'clock line ; or whatever the wall declines, that line is perpendicular to the wall itself.

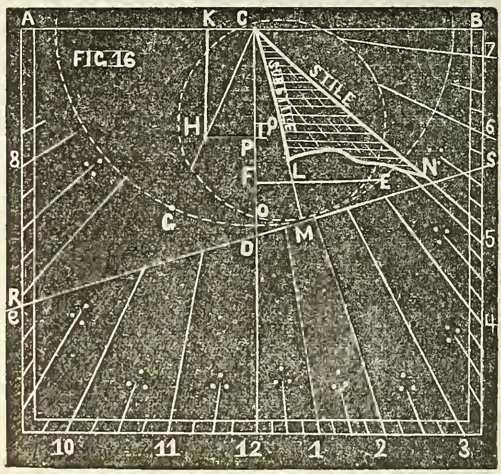
To take the Declination.—In the forenoon, when the sun is shining, apply the edge of the instrument, A B, to the wall ; set it perfectly horizontal by your quadrant ; screw up the perpendicular pin in the centre till the top of its shadow touch any one of the circles, say at the point F (Fig. 15) ; let things now rest



until afternoon, and observe when the top of the shadow is on the same circle, and there make a dot at G. Take down the instrument, and with your compasses subdivide the arc F H at G, and draw a line through the centre to K, and you will have the true 12 o'clock line. The angle N I G is the degree of declination of the wall, which amount you can find by applying the distance N G to your line of chords. When the line G K falls on the east side of N S, the declination is east ; and when on the west side, it is west.

Erect Declining Dials.—As we have before mentioned, those upright dial planes, which decline from the north or south points toward the east or the west, are called declining dials, and the first thing to be ascertained before attempting their construction, is the amount of the declination of the dial plane.

Suppose you wish to make a dial on a south erect plane, whose declination is 21° 10′ West, for the lat. of 52° 25′ N. Draw the horizontal line A B (Fig. 16); from C, let fall



the perpendicular, C 12, for the 12 o'clock hour line, and from the line of chords take 60°, and with one foot of the compass in C, draw the semicircle A D B ; take the complement of the lat. (36° 35′) from the line of chords, and set it from D to E, and draw E F parallel to A B ; this done, take in your compasses the plane's declination (21° 10′) from the line of chords, and set it from D to G ; take E F in your compasses, and set it from C to H, and draw H I parallel to A B ; take H I and set from F to L, and draw C L M. Now, D M, measured on your line of chords, is 15° 21′—the distance of the substilar line from the 12 o'clock line.

For the Stile's Height.—From the point H draw the line H K parallel to C D ; then take H K in your compasses, and set from L to N, and draw C N for the top of the stile.

For the Hour Lines.—In any convenient place in the substilar line (depending on the size of the dial), as at M, draw the line R S at right angles to the substilar line C M ; set one foot of the compass in M, and take the nearest distance to the stile's height ; one foot resting in M, turn the other to Q, in the substilar line ; upon Q as a centre, with the distance Q M, draw the dotted circle which represents the equinoctial; lay a ruler from the centre at Q, to the point where the lines C 12 and R S intersect (D), and where the ruler cuts the dotted circle (at O); there begin and divide it into 24 equal parts, which mark with little dots; lay the ruler to the centre, Q, and to every one of the equal divisions in the equinoctial, and where the ruler cuts the line R S, there make a mark; then by drawing lines from the centre of the dial at C, through each of those marks in the line R S, you have drawn the correct hour lines, which you may then number in the margin of the dial. The stile must hang directly over the substilar line, and the top be so placed, by your quadrant, that the thread will cut the exact latitude of your place on the limb of the quadrant.

In constructing this dial you have, in fact, drawn four dials, viz.:

South,	declining	East	21° 10′
"	"	West	
North	"	East	
"	"	West	

You will observe that it is not the stile that changes its position but the plane itself, for the style, answering to the latitude of the place, remains constantly the same in *all* declinations; so that if you conceive a plane declining (as in the example) 21° 10′ westward, the substilar line falls between the hours of one and two in the afternoon. Suppose the same plane to be moved to the eastward 21° 10′, the substilar line will then fall among the morning hours; and it always follows, that if the plane declines eastward, the substilar line will fall among the morning hours, and if to the west, among the evening hours; consequently the *name* of the hour lines must depend on the direction of the declination, and by reversing the dial (turning it upside down) you have a north declining dial for whatever degree of declination it is constructed—which in the example is 21° 10′.

Declining-Reclining Dial.—Such planes as directly face the North or South points, but which *recline*, that is, lean from you as you face them, like the roof of a house, are called North or South direct planes, reclining so many degrees as they deviate from a perpendicular. You can find the degree of reclination by applying the edge of your quadrant to the plane, and the thread will cut the limb in the number of degrees which the plane reclines. There may be six varieties, three South and three North, either of which may be reduced to *new latitudes*; then they become horizontal planes for all purposes of construction, and consequently the hour lines can be drawn on them as previously directed.

Direct South Recliners.—Suppose a direct South plane in the latitude of 52° 12′ N., which reclines from the zenith 26°; in what latitude will that be a horizontal plane? Now, because the reclination is less than the complement of the lat. (37° 48′), subtract the plane's reclination (26°) from the complement of the latitude, and the remainder (11° 48′) is the new latitude.

Operation:

	90°	
Latitude of place - - -	52	12′
Complement of lat. - -	37	48
Reclination of plane - -	26	
New latitude - - - - -	11°	48′

Therefore a horizontal dial, drawn for a lat. of 11° 48′, will be the proper construction of a dial for the lat. 52° 12′ N., with a reclination of 26°. If the reclination of the plane equals the complement of the lat., then the new lat. is nothing; that is, the pole has no elevation above such a plane, and the hour lines upon it will all be parallel to the plane itself; in fact, it becomes a polar dial. If the reclination exceed the complement of the lat., the complement must be subtracted from the reclination, which will give you the lat. for the construction of a dial for that locality.

Example: A plane whose reclination is 56° in the lat. 52° 42′. N.

Operation:

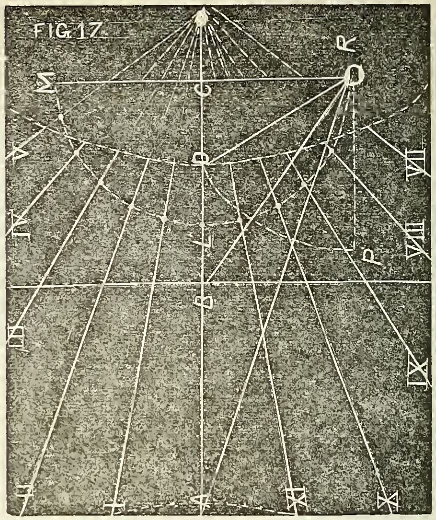
Reclination - - - - -	56°	
Comp. of lat. - - - - -	37	18′
Correct lat. for construction -	18°	42′

In finding the new lat. for north recliners, if the reclination be less than the complement of lat., add them together. Such dials (north) are so seldom desired, owing to the very short time the sun is upon them, that more extended rules for drawing them are not deemed necessary, nor shall we devote valuable space to directions as to such unusual positions as East and West reclining dials.

Reflecting Dials—May be convenient in many situations, and are made by placing a small horizontal mirror so as to reflect the sun's rays to the ceiling. It is a very neat arrangement for a watchmaker who has a south window, for in this manner he can construct a very large dial on his ceiling over head, quite out of the way, and always convenient to observation. The little mirror, if of glass, should be as thin as it is possible to obtain, for the reason that there are two reflecting surfaces to every glass mirror, which each form an independent image of the sun ; and as the two reflective surfaces are not in the same plane, the images will not coincide on the wall, but overlap each other a little, producing an indistinct outline prejudicial to exact observation ; and the more the reflecting surfaces differ from the same plane, the more will the produced images overlap. A metallic surface forms the best mirror ; a bit of polished steel is excellent, if the surface is protected from oxidation, as its reflected image of the sun forms a clear, distinct outline.

Method of Construction.—Place your mirror, which need be no larger than a silver five-cent piece, in a truly horizontal position ; this you can perhaps most conveniently do by observing in it the reflected image of the adjacent corners of the room, or of the window casing or sash bars, or any object within view which has perpendicular lines sufficiently well defined. If your mirror deviates from horizontal, these reflected perpendiculars will not be straight lines, but bent at the surface of the mirror ; but by repeated observations, in various directions, and corresponding changes of level in the mirror, you may get it sufficiently accurate for the purpose.

Having fixed the mirror, you must draw a meridian line, which you can do by suspending a plumb line over the centre of the mirror, which line will cast a shadow on the floor at meridian, and which will be the 12 o'clock hour line ; or you can construct such a line by the process heretofore described. This being done, the meridian line on the floor must be transferred to the ceiling, which may be accomplished by the help of two plumb lines—one over the mirror, the other over the other end of the 12 o'clock line, as at A, Fig. 17, by which means you will have two points



on the ceiling over the meridian line on the floor. Between these two points stretch a line, charged with lamp-black and oil, and snap it (after the manner of a chalk line), and you have permanently the 12 o'clock hour line A C ; make the angle D R P equal to the complement of the latitude of the place (say 36° 30′), which you must do by the aid of a string held, one end at the mirror R, the other at the ceiling, represented by B R, and apply the edge of your quadrant till you find the thread of it cuts the limb at 36° 30′; through that point of the 12 o'clock line (at B) the equinoctial line must pass, which draw at right angles to A D, which is a straight line, as you see in the figure.

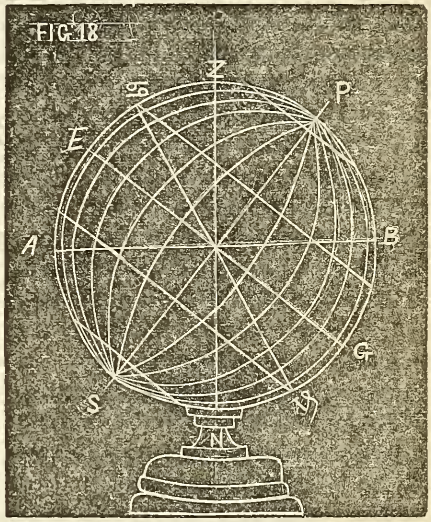
To draw the Hour Lines.—With any convenient opening of the compass, draw the semi-circle R L M, and divide it into 12 equal parts ; but because the centre of the dial does not fall in the room, but out of it in the open air at O, before the hour lines can be drawn you must ascertain the angle that each hour line makes with the 12 o'clock line, and their complements are the angles that they make with the equinoctial. This can be done by calculation ; but as these directions were to be mechanical, you must proceed to draw a horizontal dial for the latitude of the place you are in, as shown at Fig. 17, and with your compasses and line of chords measure the angles that the hour lines make with the meridian, and set them down in a table, as follows. Suppose the lat. be 53° 30′ :

Hours.		Angle with Mer.		Angle with Equinoctial.	
		°	′	°	′
12.		0	0	0	0
1.	11.	12	10	77	50
2.	10.	24	54	65	06
3.	9.	38	47	51	13
4.	8.	54	19	35	41
5.	7.	71	34	18	26
6.		0	0	0	0

Lay your quadrant to the meridian line and make angles upon the ceiling equal to those in the second column of the table ; or you may lay it to the equinoctial line on the ceiling and make the angles for every hour equal to those in the third column of the table ; and by the use of your blackened string, draw the hour lines permanently upon the wall ; or they may be drawn another way, if you think this too tedious. When you have drawn the horizontal dial for your latitude, place the centre of it at the centre of the mirror, and fix a thread at the centre of the dial ; lay the thread straight over every hour of your horizontal dial, fasten it at the other side of the room, and so transfer them to the ceiling as you did the meridian line, by the aid of plumb lines.

We shall give you one more construction which will be space enough devoted to an obsole'e art, and will close what we have to say at prevent on the subject of dialing.

Globe Dial.—This dial, drawn upon a solid or hollow sphere, shows the hour of the day without a stile or gnomon. Procure a sphere, either wood, stone, or metal, which must be fixed upon a pedestal of any kind you choose; then proceed to draw upon it the circles of the sphere, which you can do by the help of a semicircle which just fits the sphere. A B being the horizon, Z N the prime vertical, draw P S, the earth's axis to your latitude ; make Z E equal to P B, and B G equal to A E, and draw E G for the equinoctial; which divide into 24 equal parts, and through those divisions draw the meridians or hour circles, all meeting at the poles. At 23° 29′ from the poles draw the polar circles ; and the same distance north and south of the equinoctial draw the tropics Capricorn and Cancer, and from ♎ to ♑ draw the ecliptic; on which you can, if you choose, place the signs of the Zodiac, beginning at the intersection of the equinoctial and ecliptic, and measure off 30° for Aries, and 30° more for Taurus, and so on for each successive sign 30°.



The hours must be numbered in the equinoctial, placing 12 in the east and west points of the horizon, and 6 in the meridian; because one-half the globe is illuminated, and the edge of illumination shows the hour in two opposite places. On it, if you choose, can be drawn the outline of the principal countries and cities, according to their true longitude, showing what places on the globe are enlightened and what in darkness; where the sun is rising and where setting ; and in fact all the various and interesting problems of the globe. Wires also inserted at the north and south poles will show the hours—north in summer—south in winter.

We see in the *Revue Chronométrique*, published by M. Saunier, Paris, the description of a new equatorial dial so adapted in the manner of putting it up (ball and socket joint) as to popularize it for more general use. Of course, being equatorial, it is drawn on both sides, upper and lower, with the equation table for mean time fixed on the upper dial for the summer months, and on the lower dial for the winter months. It is easily adjusted to the latitude by directing the gnomon to the polar star, and to the meridian by setting it from any correct timepiece.

PATIENCE.

Patience is an element of character most admirably fitted to adorn the watchmaker as well as the Christian gentleman. Few occupations have an equal amount of petty annoyances in their prosecution, and querulous operatives are frequently heard wishing that the famous historic personage who afforded so shining an example of its excellence in his own personal sufferings had been a member of their profession, that they might have seen whether he would not "have fell from grace" under its manifold temptations. We once, in our verdancy, ventured to say that were Job a watchmaker, we were sure the lustre of his fame would have been tarnished by the use of some very improper expletives. No doubt he was very grievously tormented, and that he deserves the full measure of praise bestowed on him; nevertheless, we are not disposed to permit him to enjoy a monopoly of the virtue of patience; others besides him have suffered and borne, but have not been equally fortunate in securing so exquisite a poetical fancy to depict their trials and triumphs. This beautiful virtue assumes so many and diversified forms—each rendered distinctive only by combination with other personal characterists—as to defy classification; and whether we shall succeed in bringing out clearly any special attribute peculiarly adapted to our calling remains to be seen.

It certainly is something different from that form manifested under affliction, which weeps, yet kisses the hand that smites; or that meekly prays for the bitter cup to pass when disease lays its burning palm on the brow, and sets the life blood rushing through the veins at fearful speed; or that, when death robs us of our heart's treasure, and plucks out the very eye of our existence, clasps its hands, and turns its tearful eyes to heaven, saying, "Father, not my will, but Thine be done;" neither is it that physical fortitude which endures the knife and saw without a groan, or permits the bigot's fire to consume the body by hell's own torture, without a sigh, or the movement of a muscle; nor is it the bodily and mental endurance which uncomplainingly labors day and night, in heat or cold, to earn the pittance which links body and soul together; nor yet the calm which settles on the soul, tearless and awful, when calamity, almost too great for endurance, overtakes and crushes.

All these, and more, are forms of patience derived from Christian submission, or constitutional fortitude, and are phases quite different from what we have in contemplation. The quality we speak of is shown in the calm unruffled endurance of *little provocations*—diminutive irritations—which oftener arise from our own neglect or stupidity, and which we cannot blame upon others—than from pure accident; it is a patience which comes from education, and is often exhibited in a marked degree in affairs pertaining to one's calling, without in the least influencing the general character of the person. We have known workmen search for hours without a murmur for a minute article lost, and yet bristle up, "like the fretful porcupine," at the slightest *word* of provocation.

We do not expect in the wide-awake energetic man no sign of anger; such a person would be more than human; to seek to extinguish it entirely is but the bravery of a stoic; but the proper *control* of it, is about our definition; limiting it in degree and duration, constitutes patience. The constant endeavor to do this is a part of the necessary education of the practical workman; and we have found no better way to do this than to meditate on the subject *after* the provocation has ceased. Seneca says: "Anger is like rain, which breaks itself on what it falls." Men must not become wasps and sting themselves. Anger, when uncontrolled, is the unmistakable evidence and accompaniment of *weakness;* consequently, is pardonable in children, diseased, or old and infirm persons; but a strong man in its grasp is from that moment in the power of his adversary, and becomes a fit subject for ridicule. Whosoever cannot possess his soul in patience is at the mercy of circumstances. What can be more ridiculous than a man, perhaps "grave and reverend," standing on tip-toe, on the top of a high stool, stretching himself to his utmost limit to reach a top shelf; suddenly the stool "flips" from under him, and he is sprawling on the floor; instantly angry, dispossessed of his patient soul, he kicks the harmless stool to the further end of the room, and in so doing breaks his leg; in spite of his agony who can help smiling at his folly?

So is he a fit subject for mirth, who, in a sudden gust of wind, becomes the servant instead of the master of—his hat, and follows it as fast as his legs can carry him. No "laugh comes in" when the owner patiently waits for the hat to quit its frolic, and lets "patience have her perfect work;" the man then continues master of the hat.

Our daily lesson in education should be quiet endurance of all momentary irritations; that will always give the man complete mastery of the situation, save him from further injury to himself, and from becoming ridiculous in the eyes of his fellows.

GARLIC JUICE *VS.* MAGNETISM.

We have always deprecated the publication of receipts, processes, or methods that were not well authenticated, and been thoroughly proved. Earlier in life we have been led many a long chase in pursuit of a result said to follow when certain things were done so and so. Now we are a little cautious of wasting time (mostly gone) and money, upon experiments obviously contrary to our experience with the laws of Nature; or even venturing much on statements of processes that did not seem to show any analogy between the means and the end. One of these experiments we have just tried, and are almost ashamed to own it. A long time ago we read in a little pamphlet published in St. Louis for the use and instruction of watchmakers, that garlic juice would extract magnetism from any piece of steel so charged. Not being able to see any possible relation between the means and the result, we concluded it could not be true, and didn't try it; but recently we have received a communication from a valued correspondent on the subject, wherein he describes several experiments going to show that *onion* will do the thing. We were still unbelieving, thinking there must be some error in his observations—some condition which he had overlooked; so we experimented, following his directions as near as possible, and the result verified our expectations. We took a square pivot file which was strongly magnetic, taking careful note of the weight it would sustain, and placed it between the two halves of an onion, fitting it in nicely, and bound them together and watched for the result which was stated would follow in a few minutes. In ten minutes, no result; in twelve, none; none in an hour, and in 24 hours the magnet was as strong as ever. Thinking that the original formula (garlic) might succeed, we tried that; and our tears bore witness to the same signal failure. Wherein our test was erroneous we cannot see; we took the utmost pains, consequently we must be pardoned for remaining incredulous till we have further proof.

THE NEW YORK WATCH COMPANY.

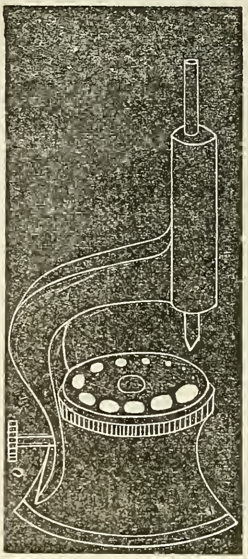
About the first of May last, Mr. Richard Oliver, of No. 11 John street, who had enjoyed a reputation for dealing in fine watches, becoming satisfied that the productions of the above Company would do credit to his reputation, associated with himself Mr. Peter Balen, Jr., and made arrangements for the entire production of the factory. A few weeks afterward the building, together with the heavy machinery, was destroyed by fire. This calamity occurring during working hours, while all the employees were on duty, the greater portion of the tools and small machinery was saved, together with the material in different stages of completion, which enabled them to provide temporary accommodations and go to work again with very little delay; and now, we are happy to say, they have so perfected their arrangements as to be able to meet all demands made upon them for their watches.

Availing themselves of all the past experience of the other factories, they were enabled, at the start, to provide themselves with the best machinery that could be made—their machine shop, in particular, being without a rival in quality. The style of their watches, so far as already produced, is $\frac{3}{4}$ plate, and we consider it in every respect much more desirable than the old full plate movement, though they are making arrangements to produce, in a short time, that style of watch, thereby bringing themselves in direct competition, both in price and quality, with the other companies. The design of the watch is plain and neat, and the work is simple, sound and well finished ; and, having a quick vibration, and a tempered spring, is capable of a very accurate adjustment. We have carried one for several weeks, taken at random out of the stock (and 2d quality), for the purpose of testing their performance, and can say that that one has performed remarkably well, and see no reason why the others should not do as well.

STAKING TOOLS.

EDITOR HOROLOGICAL JOURNAL :

Noticing a description of a new "staking tool" in a late number of your paper, I am induced to write you about one which I have had in use for the past three years, which Mr. Farjeon, of Nassau street, sells. This tool costs but $7, which brings it within reach of all. It is made of the best cast-iron, very much on the style of the old Swiss uprighting tool, having a base of about two inches, and runs up, on a taper, about one and one-half inches, where it has a "*face*" of about one and one-fourth inches across. From the side of this face an arm runs up, in the form of nearly a half circle, and ends with a piece extending upward about two inches, directly over the edge of the "face" of the tool. On this "face" is a *hard*, polished, circular steel plate, which revolves on a *turned* steel pin, passing down through its centre. Through this pin is drilled a hole, nearly at the bottom, and through the back of the tool runs a screw with a *taper point*, which, being forced into the hole in the pin, draws it down and holds the steel plate firmly in its place. This steel plate is full of graduated holes, and any one of these holes is brought directly under the punch by revolving the plate and putting the "*pointed centre*" down into the hole ; then turn up the back screw and the plate is fast. This tool has with it twenty punches, both round and flat faced, with holes in them, ranging from the very finest Swiss pinion up to largest centre pinion. Also there are two solid punches for riveting bushes—one round and one flat faced ; also one for stretching wheels, and one for pushing down a roller perfectly true. There are also four "stubs"



to put in the largest holes, to rivet bushes on, alter the "end shake," and one to rivet a balance with the *rim down*. This tool is one every workman needs, and its price being so low should induce every good workman to order one.

The accompanying drawing will give a good general idea of the appearance of the tool.

E. A. SWEET.

NEW YORK, Sept. 26, 1870.

ANSWERS TO CORRESPONDENTS.

T. G., *Wilmington, Del.*—Asks "Why do the American Watch Co. send their watches into market without having the forks and levers poised? In the three-quarter plate Appleton & Tracy watch, for instance, where everything else in the escapement is beautifully finished, and the geometrical proportions correct, why is this important condition of the lever wanting? Is the necessity of it ignored, or is it omitted through neglect? Will one of the Company please inform us? The fact of having to correct such discrepancies in watches as highly recommended as the one in question, and when in the finished state, is excessively annoying."

We cannot answer for the Company, but

we can say that a watch which makes pretence to such accuracy as to be adjusted to temperature and position, should also be as near perfect in the poise of the pallets as may be ; for there is a possibility of error in change of position where such imperfection exists. Every mechanic and mathematician is aware how rapidly very small but constant increments of time or space accumulate ; the error may be only the infinitesimal part of a vibration of the balance, and it may be much more than that in those watches in which the lever is oblique, or at right angles to a vertical line from the pendant ; yet, in an hour the quantity of these minute errors amounts to 16,000 or 18,000, and in a day is increased to the number of 432,000, a quantity which certainly begins to be appreciable.

Of course there is another side to this question ; some, who are high authority, asserting that unless the want of poise is sufficient, by violent agitation, to unlock the pallets and bring the guard pin in contact with the roller, that the minute additions or diminutions to the momentum of the balance by the lever being *slightly* out of poise, counterbalance each other perfectly.

We are heartily glad of one thing, however, which is, that the trade are becoming critical, and are reasoning, philosophizing, and educating themselves to a higher standard of excellence ; these are indications in a direction that will ultimately compel all watch manufacturers to depend upon the perfection of their products to secure to themselves the confidence of dealers.

G. A. L., *Cal.*—We do not know how the crimson watch hands of commerce are manufactured, but you can produce the desired color by using any lacquer colored to the tint required by dragon's blood, or by aniline color; apply with a soft camel hair pencil. An excellent red lacquer is made of 8 parts (by weight) good alcohol, 1 part dragon's blood, 3 parts Spanish anatto, 4½ parts gum sandarack, 2 parts turpentine. Digest (with frequent shaking) for a week; decant, and filter; must be kept close. In some localities it is difficult to get pure alcohol—and let us say in parenthesis, that the failure of many an experiment and receipt is due to the want of pure material. Common alcohol may be rendered nearly pure by putting a pint in a bottle, which it will fill only about three-fourths full ; add to it half an ounce of hot powdered pearlash or salt of tartar; shake the mixture frequently during half an hour, before which time a considerable sediment, like phlegm, will separate from the spirits, and it will appear along with the undissolved pearlash or salt at the bottom of the bottle. Pour the spirit off into another bottle, being careful to bring none of the sediment with it. To the quantity just poured off add half an ounce of pearlash powdered, and heated as before, and repeat the same treatment. Continue to do this until you obtain little or no sediment. When this is the case an ounce of alum powdered, and made hot, but not burned, must be put into the spirits, and allowed to remain some hours, the bottle being frequently shaken during that time ; after which the spirit, when poured off, will be found equal to the best rectified spirits of wine.

A. F. C., *N. Y.*—It is not necessary to alloy iron castings or coat them with any other metal for the purpose of giving them the appearance of bronze. After having carefully and thoroughly cleaned the article, give it a uniform coating of some vegetable oil ; sweet oil is as good as any, and more readily obtained than most others. Having done this, expose it, in a furnace, to a high temperature, taking care not to carbonize the oil. By this means the casting absorbs the oxygen at the moment when the oil is decomposed, and forms on its surface a thin coating of oxide, which adheres very strongly to the metal. It is susceptible of a high polish, and presents the appearance of a beautiful bronze.

☞ We have received from Mr. E. L. May, of Defiance, Ohio, an illustration of his method of keeping his watch register. His day-book does not differ materially from those in general use by the trade, but he has, in addition, what he calls a ledger, into which are posted, in a very comprehensive manner, the items in the journal, making the ledger very convenient for reference, and showing for the week or month at a glance the amount of his watch-work. The customers, as well as himself, are protected by a system of numbered tickets or checks, which insures safety from loss.

H. P. F., *N. Y.*—Many experiments have been made to try the tenacity of various metals. The results—as measured with a spring balance—we give below : Two wires (No. 23) were used. The weight which broke these wires was—for tin, 7 lbs. ; for lead, 7 lbs. ; for gold, 25 lbs. ; for copper, 30 lbs. ; for silver, 50 lbs. ; for iron, 90 lbs. ; for alloy of lead and tin, 7 lbs. ; for alloy of tin and copper (12 lbs. to 100 of copper), 7 lbs. ; for alloy of copper and tin (12 lbs. to 100 tin), 90 lbs.; for alloy of gold and copper, 75 lbs. ; for alloy of silver and platina, 80 lbs. ; for steel, 200 lbs.

A. L. C., *Phila.*—We hardly know what one you refer to. In the Museum of the St. Petersburg Academy of Sciences there is carefully preserved a watch said to be made by a marvellously inspired Russian peasant. It played two airs, and moved figures, although no larger than an egg. It was a repeater, too, and had a representation of the tomb of Christ, with the Roman sentinels on the watch. On pressing a spring, the stone would roll away from the tomb, the sentinels fall down, the holy women enter the sepulchre, and a chant would be played. This is the only one we know of claimed to be the product of inspiration.

A. S. M., *Mass.*—We know no instrument that will give you the strength of hair-spring necessary for a watch when the weight of balance, and the number of vibrations per minute, are known ; such a contrivance would be exceedingly useful. The only hair-spring gauge in general use is Bottom's.

AMERICAN HOROLOGICAL JOURNAL,

PUBLISHED MONTHLY BY

G. B. MILLER,

229 Broadway, N. Y.,

At $2.50 per Year, payable in advance.

A limited number of Advertisements connected with the Trade, and from reliable Houses, will be received.

☞ MR. J. HERRMANN, 21 *Northampton Square, E. C., London, is our authorized Agent for Great Britain.*

All communications should be addressed,

G. B. MILLER,

P. O. Box 6715, *New York.*

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For October, 1870.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian.	Equation of Time to be Subtracted from Apparent Time.	Equation of Time to be Added to Mean Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M S.	M. S.	S.	H. M. S.
Sat	1	64.36	10 18.72	10 18 86	0.797	12 40 3.86
Su.	2	64.41	10 37.66	10 37.80	0.785	12 44 0.41
M..	3	64.46	10 56.30	10 56.44	0.771	12 47 56.96
Tu.	4	64 51	11 14.64	11 14.78	0.758	12 51 53.51
W.	5	64.56	11 32.67	11 32.81	0.744	12 55 50.07
Th.	6	64.62	11 50.33	11 50 47	0.728	12 59 46.62
Fri.	7	64.68	12 7.61	12 7.75	0.712	13 3 43.17
Sat	8	64.74	12 24.48	12 24.62	0.695	13 7 39.72
Su.	9	64.80	12 40.93	12 41.07	0.677	13 11 36.28
M..	10	64.87	12 56.93	12 57.07	0.659	13 15 32.83
Tu.	11	64.94	13 12.45	13 12.59	0.638	13 19 29.38
W.	12	65 01	13 27.48	13 27.63	0.617	13 23 25.94
Th	13	65.09	13 42.00	13 42.14	0.594	13 27 22.49
Fri.	14	65 17	13 55.98	13 56.11	0.571	13 31 19.04
Sat	15	65.25	14 9.41	14 9 54	0.547	13 35 15.60
Su.	16	65.33	14 22.25	14 22.38	0.523	13 39 12.15
M..	17	65.42	14 34.50	14 34 63	0.498	13 43 8.70
Tu.	18	65 51	14 46.14	14 46.27	0.472	13 47 5.26
W.	19	65 60	14 57.15	14 57.27	0.446	13 51 1.81
Th.	20	65.69	15 7.51	15 7.62	0.419	13 54 58.36
Fri	21	65 79	15 17.22	15 17.32	0 391	13 58 54.92
Sat	22	65.88	15 26 25	15 26 34	0.362	14 2 51.47
Su.	23	65 98	15 34 59	15 34.67	0.333	14 6 48.02
M..	24	66.08	15 42.24	15 42.32	0.304	14 10 44.58
Tu.	25	66 19	15 49.19	15 49.26	0.275	14 14 41.13
W.	26	66 29	15 55.43	15 55 49	0.245	14 18 37.69
Th.	27	66.40	16 0.93	16 0.99	0.214	14 22 34.24
Fri.	28	66.51	16 5 69	16 5.74	0.183	14 26 30.79
Sat	29	66.62	16 9 71	16 9.75	0.152	14 30 27.35
Su.	30	66 73	16 12.97	16 13.01	0.120	14 34 23.90
M..	31	66.84	16 15.47	16 15.50	0.088	14 38 20.46

Mean time of the Semidiameter passing may be found by subtracting 0.18 s. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
☽	First Quarter....................	1 9 19.2
☉	Full Moon........	9 1 42.9
☾	Last Quarter....................	17 6 13.6
●	New Moon......................	24 3 35.7
☽	First Quarter...........	30 20 1.2
		D. H.
☾	Apogee	11 21.5
☾	Perigee	24 16.5

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1

	H. M. S.
Long. Harvard Observatory..............	4 44 29.05
New York City Hall...............	4 56 0.15
Savannah Exchange..............	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception......	8 1 42.64

	APPARENT R. ASCENSION.		APPARENT DECLINATION.	MERID. PASSAGE.
	D.	H. M. S.	° ′ ″	H. M.
Venus.....	1	11 29 28.42	+ 4 51 28.7	22 50.0
Jupiter....	1	5 43 19.72	+22 49 56.1	17 0.6
Saturn. ..	1	17 29 29.26	−22 16 25.6	4 48.7

AMERICAN

Horological Journal.

VOL. II. NEW YORK, NOVEMBER, 1870. No. 5.

CONTENTS.

*** *Address all communications for* HOROLOGICAL JOURNAL *to* G. B. MILLER, *P. O. Box* 6715, *New York City. Publication Office* 229 *Broadway, Room* 19.

INVENTION.

Thousands of vigorous, inventive minds are wearing themselves out planning and devising new combinations, new machines, and new compounds, and fortunes are spent, fond hopes blasted, friends wearied out, and homes made desolate by the fruitless labor of invention ; years of study and costly experiment result, perhaps, in an application for a patent on a really valuable discovery, creditable alike to the inventive talent and the persevering industry of the inventor, but all, alas, too late. When hope is soaring in the sunlight, its wings are suddenly palsied, and the light extinguished, by the information that the child of invention is a hundred or more years old.

This deplorable result, so crushing to the hopes and fortune of the inventor, is no fault of his ; it is simply the result of ignorance of what has been done long previous to his time. Had he been better informed, or shown his first conception to some one better posted as to what had transpired in the world of invention, all these disasters might have been avoided, and the amount of mental labor thus lost turned in a direction where better results might have been obtained. Undoubtedly it is impossible for every inventor to be so well read as to know *all* that has heretofore been discovered. Not even the best read can say that there is no invention of which they are not informed ; but whatever information can be obtained that bears upon the study under pursuit, will be of decided advantage, and may result in averting the provoking result of re-discovering old inventions.

We have seen recently several advances made in the direction of affording assistance to inventors. One is the publication of "507 Mechanical Movements."* Such a work can be eminently useful in two ways : one in showing what has been done, and the other by furnishing to the inventor's hand, ready made, the very devise he desires in some construction he is laboring on. The idea has also been advanced to create a museum of machinery ; not completed machines, which would be impossible, but a working model of all the various devices for producing mechanical effects ; a collection where every known method of applying the principle of the lever is illustrated in working models, every plan for changing linear to rotary motion, every invention for the accumulation of force, every means by which it has been transmitted, or its direction changed, etc., etc. Such a collection of models would be but an alphabet of machinery, from which the inventor could elaborate machines to an extent limited only by his inventive ability, and save his own mind the wear and tear of studying out means to produce such effects as he desired in his proposed constructions.

We have been led into this channel of thought by the multifarious plans constantly brought to our notice for compensating pendulums. Not a week passes that does not bring a new solution of the problem ; very

* Published by Brown, Coombs & Co., office of the "American Artizan," 189 Broadway, New York. Price, One Dollar.

few of them ought to be called *new*—most of them dating back as far as Graham and Elliott, and scarcely any possessing sufficient advantages over old ones to make them desirable. Could we spare the space, we think it would be useful to give a description and drawing of all the known forms, as a guide to investigation; it might save many a man profitless brain-work—mental labor which he could spend in inventive research in paths not already well worn and dusty with previous travel—in research which would have a better prospect of resulting in good to himself and the world.

Escapements, also, seem to have received a very large share of attention; no branch of horological mechanics seems more seductive than this, and the quantity of escapements invented is endless; every one seems *gifted* with the faculty of originating new ones, and there is probably not a single workman in the country but what has had a try at it. An old clockmaker once offered, on a wager, to invent a new escapement every morning before breakfast for a month. Inventions seem *so easy* to some minds; they see no difficulties in the way; everything is clear; a few *principles* adhered to, and the thing is done. Let us see how it works. We will quote from Mr. Nicholson's observations, which are as applicable now as they were in 1798: "We will suppose a very acute theorist, who is not himself a workman, nor in the habit of superintending the practical execution of machinery, to have conceived the notion of some new combination of mechanical powers to produce a determinate effect; and for the sake of perspicuity let us take the example of a machine to cut files. His first conception will be very simple or abstracted. He knows that the notches in a file are cut with a chisel driven by the blows of a hammer by a man whose hands are employed in applying those instruments, while his foot is exerted in holding the file on an anvil by means of a strap. Hence he concludes that it must be a very easy operation to fix the chisel in a machine, and cause it to rise and fall by a lever, while a tilting hammer of the proper size and figure gives the blow. But as his attention becomes fixed, other demands arise, and the subject expands before him. The file must be supported on a bed, or mass of iron, or wood, or lead or other material; it must be fixed, either by screws or wedges, or weights, or some other ready and effectual contrivance, and the file itself, or else the chisel with its apparatus for striking, must be moved through equal determinate spaces during the interval between stroke and stroke, which may be done either by a ratchet-wheel, or other escapement, or by a screw. He must examine all these objects and his stock of means in detail, fix upon such methods as he conceives most deserving of preference, combine, organize, and arrange the whole in his mind, for which purpose solitude, darkness, and no small degree of mental effort will be required; and when this process is considerably advanced he must have recourse to his drawing-board. Measured plans and sections will then show many things which his imagination before disregarded. New arrangements to be made, and unforeseen difficulties to be overcome, will infallibly present themselves. The first conception, or what the world calls invention, required an infinitely small portion of the ability he must now exert.

"We will suppose, however, that he has completed his drawings; still he possesses the form of a machine only; but whether it shall answer his purpose depends on his knowledge of his materials; stone, wood, brass, lead, iron forged or cast, and steel in all its various modifications, are before him. The general process of the workshop, by which firmness, truth, and accuracy alone are to be obtained, and those methods of treatment, chemical as well as mechanical, which the several articles demand, these, and numberless others, which may either lead to success, or by their deficiency expose him to the ignorance or obstinacy of his workmen. If he should find his powers deficient under a prospect so arduous; if he cannot submit to the severe discipline of seeing his plans reversed, and his hopes repeatedly deferred; if unsuccessful experiment should produce anguish, without affording instruction, what then will remain for him to do? Will he embitter his life by directing his incessant efforts, his powers and resources, to a fascinating object in which his difficulties daily increase, or will he make a strong exertion of candor and fortitude which will lead him to abandon it at once?"

There are cases, however, in which the profoundest knowledge of primary principles and previous practice has not saved the inventor years of toil and millions of money; neither is the voyage of invention always plain sailing and calm weather. The poor inventor, however differently he may think, is often not more sorely beset by difficulties than he who has money and mind at unlimited command. Knowledge sometimes gives great advantage to its possessor in the prosecution of invention, and yet it sometimes leads one far astray. Bessemer was a remarkable illustration of this; scientific analysis had shown steel to be a compound of carbon and iron, in proportions which might vary from forty to two hundred per cent. and yet be merchantable steel; and cast or pig iron differed from steel only by containing more carbon; and that malleable or wrought iron was made so by entirely decarbonizing the pig. The inference very naturally arose, that steel should be produced at some point *short* of total decarbonization; and that instead of costing *more* than wrought iron, it ought to cost *less*.

Reasoning upon all these *facts*, Mr. Bessemer assumed that stopping the decarbonizing process at the proper point was *the* thing; and *all* there was to do to effect this desirable change was to stop the decarbonizing process at the proper moment. But, with all his science, he never succeeded in making a pound of merchantable steel. What was the matter? Analysis of his product showed the proper percentage of carbon to form steel, but it was iron still. Failure followed failure, and any man with less means and perseverance would have given up the chase. Still he toiled on, and his researches brought him to the very method that experience had discovered and successfully practised for years, namely, to *wholly* decarbonize the iron and then recarbonize. The first condition he accomplished by the hot blast, and the second by adding a definite quantity of spiegeleisen to supply the carbon necessary for conversion to steel. Had he known in the beginning all that he afterwards found out, years of expensive experience would have been avoided. The facts which are now known to have prevented his success at first are, that the pig iron contained other substances than carbon, which must be eliminated before steel can be produced. Silicon, phosphorus, and sulphur maintain their hold upon iron with the greatest tenacity, and any known process by which they can be separated, will also *completely decarbonize* the iron, which must of course be re-carbonized to produce steel. The books taught only part of the process—practical experience, the rest; but together they show clearly why steel cannot be produced cheaper than iron.

Thus we see the necessity for theory and practice to go hand in hand,—and when the trinity is completed by the addition of money, they together form a foundation on which a superstructure of any extent may be built, which will not only be a glory in itself, but a blessing to the world.

HEAT.

NUMBER FOUR.

INCREASE OF VOLUME IN SUBSTANCES BY HEAT—DO METALS BECOME PERMANENTLY ELONGATED—CHANGE OF THE ZERO POINT IN THERMOMETERS—CONDUCTION AND REFLECTION OF HEAT—FAMILIAR EXAMPLES—HEAT TRANSMITTED THROUGH MERCURY BY CONVECTION—REMARKS ON COMPENSATING PENDULUMS, ETC.

It is a general, though not a universal law, that when a metallic body increases in temperature it also expands in volume, or dilates, and that when it diminishes in temperature its volume contracts, and that when restored to its original temperature it resumes its original volume, or nearly so. Under the same augmentation of heat, different solids expand very differently. Certain crystals, as fluor spar, aragonite, etc., expand more than any of the metals which are frequently marked first; and the rate of the expansion of ice, could it be observed through the same range, is greater than that of any metal between 32° and 212°, being one part in 287. Wood expands chiefly in a direction transverse to its fibres, and very little in length; and hence wood, as well as lucullite (a species of marble found in Egypt), has been used for pendulum rods. The contraction of bodies upon cooling is sometimes not so great as their previous expansion—perhaps it is *never* so great. Heat expands bodies by insinuating itself between the particles of these bodies, forcing them asunder, and causing them to occupy a greater space. Heat, therefore, opposes cohesion. Solids, in which cohesion is strongest, expand the least under the influence of heat; liquids having less cohesion expand more; gases and vapors, in which cohesion is entirely wanting, expand most. Clay may be taken as an exception to heat expanding all solids; it is contracted by baking, and ever afterwards remains so; this is supposed to be owing to a chemical change produced in the clay by heat. It is certain that under peculiar conditions some metals become permanently elongated by repeated heating. The familiar example of the old bars of a fire grate, when they are rigidly fastened at both ends, becoming distorted, as we often see them, as well as another household example of lead pipes conveying hot water, have been found lengthened and thrown into curves after several weeks' use, does in a great measure prove this. Some of our readers would probably notice in No. 11, Vol. I., a correspondent suggests that this permanent elongation of metals through the influence of heat might be the cause of some of the irregularities of pendulums, especially the Harrison one. Whether this permanent elongation of metals takes place in the comparatively small changes of temperature which a pendulum is subjected to, as it sometimes does in metals subjected to a boiling, or approaching to a melting heat, we have not as yet any reliable means of ascertaining, although we have given the subject much attention. We have never observed any case, or heard of any complaint or well authenticated instance, where fine clocks have increased their losing rate in the same ratio as the clocks increased in age, which would be the natural result to be looked for, were the metals which compose the pendulum affected in the above manner; still, the idea we consider is one worthy of the attention of those who are studying this important subject, as it is evident that for the higher class of purposes the very best pendulums have yet to be improved.

The fact of bodies or metals, when exposed to very high temperatures, not resuming their former bulk when cooling, may be attributed to the fact that when they are cooled very suddenly, in most cases their particles have not had time to bring themselves into the condition proper to the reduced temperature, and in consequence the substance is in a state of constraint, and continues so often for a length of time. This is probably the cause of the change of the zero point in a mercurial thermometer, for when such an instrument has been graduated shortly after the filling of the bulb, this point may change in a few years as much as nearly 3° Fahr., but this is believed to be the full limit of the change. When an instrument is made and filled, the bulb is suddenly heated and suddenly cooled, and hence its particles have not had time to approach so near to one another as they would have done if the process of cooling had been very gradual; and had the bulb been laid past and kept for some time before graduation, and also had it been well annealed, the change would have been less; nevertheless, with all this precaution the error may amount in the course of five or six years to several tenths of a degree. Besides this progressive and permanent change, there is also a temporary one produced by heating and suddenly cooling the instrument when in actual use. For example, if a thermometer has, first of all, its freezing point determined by melting ice, then be plunged into boiling water, and suddenly withdrawn, and finally again plunged into the ice water, the freezing point will be found to have changed, and the instrument may read 31.8° and will not recover its true reading till several weeks have elapsed. The same kind of error may be introduced into the barometer, when the system is practised of boiling the mercury in the tube to drive the air out. We have frequently noticed steel articles become sensibly larger after being hardened, and it is well known to all workers in glass and metals that the articles we form from the heated or molten material require to be very carefully and slowly cooled or annealed in order to bring them to their solid state, or their natural density; and thus it appears that time is an important element in the cooling of bodies, and with this reservation it may not perhaps be erroneous to assert that a metallic body heated and *very slowly* cooled will regain its original volume on regaining its original temperature.

Having made some allusion in this article to the question of compensating a pendulum as near as possible to perfection, the present may, perhaps, be a proper time to notice some other points to be considered in connection with this important subject. In last number we noticed how heat was conveyed through metals by conduction. The following table, showing the capacities of several of the metals for conducting heat, is taken from Professor Tyndall's work on Heat, considered as a mode of motion :

Silver	100.	Steel	11.7
Copper	74.	Lead	9.
Gold	53.	Platinum	8.
Brass	24.	German silver	6.
Tin	15.	Bismuth	2.
Iron	12.		

This table differs from many of the older ones published, which up to late years were accepted as correct, in which gold was considered to be the best conductor of heat, and platinum and silver the next in order, being considered very little inferior to gold. However the process by which the authors of this table have reached the above results differed essentially from their predecessors in that line of experiment, and is entirely devoid of any theoretical assumption, being reached by actual experiment with the aid of a small thermo-electric pile, the most delicate and accurate of all known instruments for measuring heat or testing its progress through bodies. As all metals have a certain capacity for conducting heat, so have they for reflecting it under favorable conditions of their surfaces. Highly polished and light colored surfaces reflect best. For instance, fire irons, if brightly polished, will remain comparatively cool, notwithstanding their proximity to the fire, while if rough and unpolished they will become too hot to be touched. Water contained in a burnished silver pitcher can with difficulty be heated, even while placed directly before the fire, while the same amount of water in a rough iron kettle at an equal distance from the fire would speedily be made to boil. Nor is it necessary that the protecting surface should be of any great thickness. The *thinnest coating* of a bright metal reflects heat as perfectly as a *solid metallic plate* of the same metal. A mere covering of gold leaf will enable a person to place his finger within a very short distance of red hot iron or other red hot metal, while the hand would be burned at ten times the distance, if unprotected. If a piece of red hot iron be held over a sheet of paper upon which some letters have been gilded, the uncovered intervals will be scorched while the letters will remain untarnished. If the bulb of a thermometer be covered with tin foil it will remain comparatively unaffected by change of temperature. The polished metallic helmet and cuirass worn by soldiers are cooler than might be imagined, because the polished metal throws off the rays of the sun, and cannot easily be raised to an inconvenient temperature. Taking advantage of these properties for the reflection of heat off metals, Mr. John Gowans, a partner in the firm of Blunt & Co., of this city, has for some time past been coating his pendulums with a thin covering of nickel. This, as our readers are aware, presents a bright whitish surface, susceptible of a very high polish, and consequently presents the most favorable surface for the reflection of the heat from off the pendulum, and has also the additional property of being unaffected by rust should the clock be placed in a situation liable to dampness.

Having every thing in its favor, with no counteracting disadvantage, we hail this as an important step in the right direction towards destroying some of the causes of the many *little* errors that are in *all* pendulums, and that only appear visible in clocks of the very best construction, where the *larger* errors do not exist to drown the small ones.

Another important point in connection with the mercurial pendulum is the capacity of mercury for conducting or conveying heat. We have taken considerable pains to determine exactly the value of the conducting power of mercury. In all the chemical authorities we have at our command, both in the English and French languages, we never meet with mercury in the tables of the thermal conductivity of heat; for, mercury being a liquid, heat is conveyed through its particles by convection, and convection depends upon two things. In the first place it depends on the extent liquids expand under heat; thus, for instance, if a body hardly expanded at all, its convection would be very feeble. In the second place, convection depends on the force of gravity; for were there no gravity there could be no convection. We have no direct means of ascertaining exactly the capacity of mercury for conveying heat; but if we reason from analogy, and assume that the density of metals bear a relation to their powers of conduction, and also that the properties for conducting heat and electricity are nearly the same in all metals, then mercury must be a very good conductor of heat; probably as good as silver or copper. It seems to us that this fact of heat being transmitted by conduction through steel, and by convection through mercury, has an important bearing on the calculations of a mercurial pendulum, and in some measure affects the compensation as regards the *time* each body takes to expand or to contract; and this idea, so far as we are aware, is a new one.

The expansion and contraction of the jar that holds the mercury, and somewhat affects the rise and fall of the mercury column, being difficult to correctly determine, we will conclude the present article by presenting a method by which this object may be accurately obtained, which is also new for this purpose. Take a glass jar of a given size and cleanse it thoroughly, and fill it with mercury, without air specks being in any part of it. The jar will be found to hold, at 32° Fahr., say 10169.3 grains of mercury (about the amount used in a heavy seconds pendulum), while at 212° it only holds 10011.4 grains. Now it is known that the expansion of mercury between 32° and 212° is .018153; that is to say, a quantity of this fluid occupying a given volume equal to unity at 32° will at 212° occupy a volume =1.018153. Hence the weight of mercury occupying a given volume at 212°, will bear to that occupying the same volume at 32°, the proportion of 1: 1.018153; and hence (had the jar not expanded) the weight of mercury filling it at 212° would have been $\frac{10169.3}{1.018153} = 9987.9$ grains. But the glass jar having expanded, it holds 10011.4 grains, or 23.5 grains more than it would have held had there been no expansion. The volume of the expanded jar will therefore bear to that of the same jar at 32°, the ratio of 10011.4 to 9987.9, or of 1.00235 to 1; and hence *the expansion of the jar between* 32° *and* 212° *will be* .00235.

THE LEVER ESCAPEMENT.

NUMBER TWO.

The action of the lever and roller is that action of the mechanism of the lever escapement which communicates to the balance the motion created by the wheel and pallet, as described in the preceding article on this subject. There are many ways of accomplishing this action; but as we intend strictly to adhere to the rule of giving the *principles* of this escapement, for the reasons previously mentioned, we will content ourselves by giving the two most common forms of accomplishing this action, viz.: that having the ruby pin and safety roller in one piece, commonly called the table roller, and that having the ruby pin and safety roller in two pieces, commonly termed double roller. The action of the lever and roller embodies two distinct functions—that of propulsion, and that of unlocking—which will be better understood from the following description:

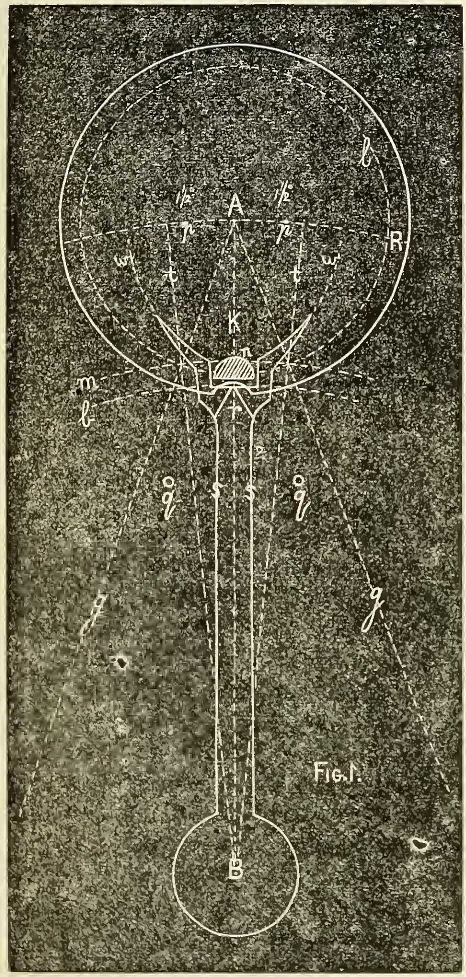
The lever, being solidly joined to the pallet, forming, as it were, one piece, is forced to communicate the impulse derived from the action of the wheel on the pallet to the balance, by means of the ruby pin, acted upon by the slot in the lever. If we suppose the ruby pin to have been carried to the extreme degree of the lifting arc on either side of the lever (that is, if the drawing tooth has already dropped from the driving plane on either arm of the pallet), the balance will then be detached from the other parts of the escapement, and will be free to make its entire arc of vibration, effected by the impulse derived. This is the function of impulsion. The dimensions of the arc of vibration will be comparatively equal to the weight of the balance and the strength of the hair-spring.

When the balance has reached the extreme degree of the arc of vibration, it will be acted upon by the tension of the hair-spring, thereby causing a return vibration of the balance. As soon as the ruby pin touches the slot, the lever, and, necessarily, the pallet along with it, follow the impulse far enough to withdraw the locking face, on which a tooth is resting. The tooth thus released begins its impulse on that arm of the pallet, and which is, of course, communicated to the balance by the lever and the ruby pin. The impulse continues until the tooth has slid across the face of the driving plane, and dropped therefrom on to the other arm of the pallet—which action is continuous. From this it will be seen that the action of the lever and roller is alternately to communicate impulse derived, and to unlock. As the watch is subject to almost continual external motion, it is therefore of the greatest importance to provide a means by which the lever, when at rest, may be kept in position, so that when the return vibration of the balance brings the ruby pin to the place where the connection is to be made, it may not find a vacant place; the lever, meanwhile, being on the opposite side, and the ruby pin, instead of working into the slot, striking the outer edge of the lever, causing the watch to stop, and very likely a breakage of the ruby pin, and giving rise to the expression "overbanked." (From this it will be seen that when the roller is too small, overbanking will result.) The prevention of this is called the safety action, and consists of a perfectly round disk of steel, having a hollow filed in it directly above the ruby pin, and is solidly adjusted to the balance staff; and a pin or abutment on the lever placed immediately above and in the centre of the slot. The action of this is obvious. The lever being at rest on either side, it will remain so by the pin striking the edge of the roller when disturbed by violent external motion, but immediately returning from such position by the action of the "draw," as described in the previous article. The action of the "draw," if not properly controlled, would also bring the lever out of position, but in a contrary manner to that of the safety action, by causing the lever to pass out of reach (for connection) of the ruby pin on a return vibration of the balance *from* the roller. This means of control is termed the "banking" arrangement, and consists of two pins, placed at a proper distance from each other, equally on each side of the lever, so that the lever will be enabled to give the whole amount of impulse derived, and yet not pass out of reach of the ruby pin on its return vibration.

The original lever escapement, as invented by Mudge, had the ruby pin and safety roller composed of two pieces. At one time this was supposed not to be a very good arrangement, consequently the table roller was substituted. Later, however, the original plan was adopted as the best for the purpose designed. The reason why the safety roller and the ruby pin is best in two separate pieces is thus: the safety roller, in this instance, being always one-third the diameter of the ruby roller, is affected far less by external motion than the roller and the ruby pin in one piece, for the safety roller being smaller, the friction occasioned by the safety pin rubbing against the edge of the safety roller, when disturbed by external motion, will be lessened, as the friction is applied at a less distance from the balance centre.

Our task will now be to determine the size of the roller (in both instances), the place for the ruby pin, the size of the lever, etc., etc., for any given distance of centres, considering first the one having the ruby pin and safety roller in one piece.

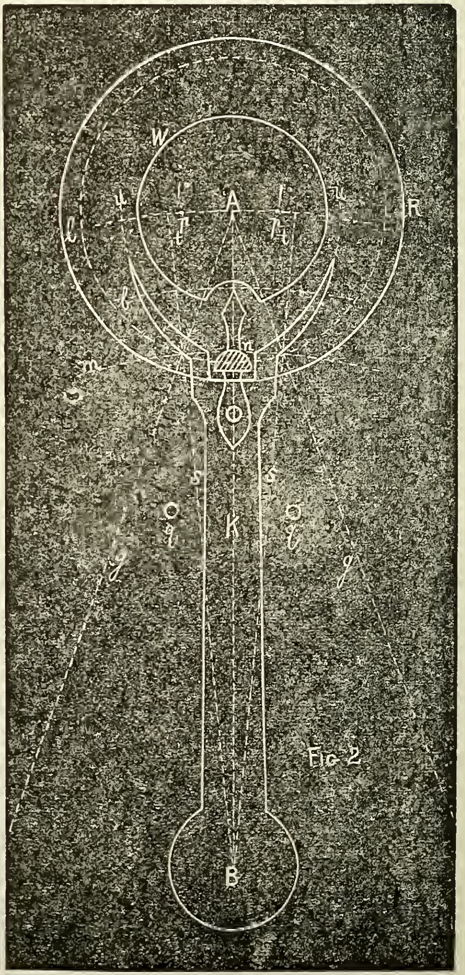
First determine the distance between the centre of lever and centre of balance, increase the dimensions by ten or fifteen times, and connect them by line K, as in Fig. 1; then take $11\frac{1}{2}°$, the whole movement of lever or pallet (as determined in the preceding article), and draw half of this, $5\frac{3}{4}°$, on each side of the line K from the centre of lever B, and mark the lines *t*. Next, determine the lifting angle of the balance, which, in this case, as an example, is 40°, and which proceed to draw from the centre of balance A to 20° each side of the line K, and mark the lines thus drawn *g*; from where the lines *g* cross the lines *t*, draw a circle *l*, which indicates the place for the ruby pin *n*. Next proceed to determine the breadth of the ruby pin, which in all cases must be one-third the space between two teeth of the escape wheel. To determine the working sides of the slot in the lever, draw a curve m from the centre of lever B, so that it will cross the point where the lines t and g, and the circle l, cross each other, which indicate the place where the horns of



the lever u are to be drawn from, and are to be drawn thus: From the centre of lever B mark off the dots p, $1\frac{1}{2}°$ distant from the lines t, and place one leg of the compass on one of these dots, and draw the curve u of the opposite horn, proceeding in like manner with the other horn.

To determine the actual length of the lever, that is from the point or abutment r to the centre B, the hollow in the roller for the passage of the abutment r must be above the ruby pin far enough to allow the latter to sit solidly in its place, and must have a breadth of 10° or 12°, and the point of the abutment r must be 1° or $1\frac{1}{2}°$ distant from the deepest part of the hollow, which we determine by the curve b drawn from the centre of lever B, as shown in the figure, and from the point where the lines t cross the curve b we draw the circle or roller R. Now proceed to determine the place for the banking pins or abutments q, the positions of which are entirely dependent upon the shape of the lever. The easiest way to determine this is to suppose the ruby pin to be carried around to a point where the abutment r will rest on the roller R; in such a position $1\frac{1}{2}°$ or 2° distant (requisite shake) from the outer edge of the lever s will give the proper place for the banking pins or abutments.

We will now consider the lever and roller action, having the ruby pin roller, and safety



roller separate. First, fix upon the distance between the centre of lever and centre of ballance, increase the dimension ten or fifteen times, and mark on paper A and B, connecting them by line K, Fig. 2 ; take the whole movement of the lever (or pallet), $11\frac{1}{2}°$, and draw them from the centre of lever B, $5\frac{3}{4}°$ on each side of link K, and mark *t*. We propose the lifting angles to be 40°, which are drawn from the centre of balance A, 20° on each side of the link K and mark *g;* from the point where the lines *g* cross the lines *t* we draw a circle *l*, which indicates the place for the ruby pin *n*, which must be one-third the space between two teeth of the escape wheel ; then mark off the dots *p*, 1° distant from the lines *t*, on a curve through the balance centre A from the lever centre B. To determine the slot in the lever, draw a curve *m* from the lever centre B, so that it will cross the spot where the lines *t* and *g* and the circle *l* cross each other ; the slot should have a breadth 1° greater than that of the ruby pin (requisite play), and is marked off on the curve *m*, from these points are drawn the curves *u* from an opposite dot *p*, forming the horns of the lever.

We next determine the actual size of the lever—that is, from the lever centre B to the point of the safety pin *n*, thus : the diameter of the safety roller *w* being $\frac{2}{3}$ that of the ruby pin roller R, it will therefore require a hollow of 36° to 38° for the safe passage of the safety pin *r* (the safety roller being smaller and the lever larger); from the point where the lines *t* cross the circle or safety roller *w*, draw from the lever centre B a curve *b ;* the spot where this curve crosses the line K is the place for the point of the safety pin or abutment *r;* the deepest part of the roller must be 1° from the point *r*. The method of determining the proper place of the banking pin *q*, is the same as in Fig. 1. To determine the actual size of each part, it only remains to diminish each part as many times as the original centre distance was increased.

It is deemed unnecessary to give the combination of the action of lever and roller with that of wheel and pallet, as there are so many of these combinations, each differing from the other ; some having the pallets at right angles from, and others in a line with, the lever, while others are placed at some other angle ; but it matters not whether it be at right angles or in a straight line ; the principle is always the same, and can in no way be altered by any angularity of the pallet to the lever. There are many repairers imbued with the idea that the so-called straight line lever is the best, as the best watches with this escapement are planned straight line. This is erroneous, as they are so planned only because it makes an elegant appearance.

CHARLES SPIRO.

ADJUSTMENTS TO POSITIONS, ISOCHRONISM AND COMPENSATION.

NUMBER ONE.

The importance of a thorough apprehension of the principles involved in seeking for the above adjustments, and the interest which is everywhere felt among the trade concerning them, must be the writer's excuse for soliciting the attention of the readers of the JOURNAL.

In reasoning upon these subjects, the theme of articles already published in the columns of the JOURNAL, and particularly in the contributions of Chas. Spiro, for which we would, on behalf of the trade express our grateful acknowledgments, we do not propose to present anything original or new—anything which nobody else knows—but shall simply endeavor to investigate the principles involved in, and to copy and translate from the writings of eminent foreign horologists, and particularly from Prof. Phillips, Jurgensen and others, such data as will contribute to make the subjects clear and intelligible to the minds of those interested in them.

The main principles of the isochronism of the hair-spring have already been clearly set forth by Mr. Spiro, but in our opinion, in order to obtain the bests results of isochronism the adjustment to position ought to precede in the order. There is nothing so necessary to the successful accomplishment of so tedious a work, as logical reasoning. Practical horology is nothing less than a physico-mathematical science, and it becomes necessary for the workman to educate himself to the use of these sciences, if he does not wish to waste much time and talent. Although theoreticaly, and according to Prof. Phillips, the isochronism of a spring can be found without the application of an escapement, yet in practice this would hardly ever be done ; it is much more likely that that adjustment is undertaken only with a watch in a finished state, and when every other part has been carefully brought to as near perfection as possible. The best writers, too, concur in the opinion, that, although by the application of an isochronal hair-spring to the balance any irregularities resulting from unequal friction in different positions could theoretically be entirely overcome, it is nevertheless of the greatest importance that those irregularities should first be removed as nearly as possible by a judicious adjustment to positions. If a lever watch is to be adjusted to positions, one of the first conditions necessary is, that the fork and lever, as well as the escape wheel be perfectly poised. On this point the opinions of all the best writers and most experienced artisans, such as J. H. Martens, M. Grossmann and others, agree ; and in fact in the best movements of foreign manufacture the condition is fulfilled ; but since there is such a great number of watches wanting this condition, and some of them the productions of highly reputable manufacturers, and since even among our own home manufacturers the necessity of establishing the equipoise of the lever in their escapements seems to be partially overlooked, let us investigate the matter a little closer ; and for this purpose we beg leave to draw the attention of the reader for a moment to the principles of the mechanical lever.

The simplest form of a lever is a straight rod, supposed to be inflexible and without weight, resting on a fixed point somewhere in its length, about which it can freely turn, and having two forces applied, one on each of the extremities of the rod. The fixed point on which it rests, and about which it can turn, is called the *fulcrum ;* one of the forces applied to it is called the *power*, and the other the *weight*. The distances of the points of application of the power and weight from the fulcrum are called the *arms* of the lever. If, now, we imagine such a lever in the shape of a beam thirteen feet long, and the fulcrum be a foot from one end, an ounce placed on the long arm will balance a pound (*troy weight*) on the short arm ; and the least additional weight, or the slightest push or pressure on the long arm thus loaded, will make the pound on the short arm move upwards. If, instead of a pound, we place upon the short arm of this lever the long arm of a second lever, whose fulcrum is one foot from its short end, and then place the short arm of this second lever upon the long arm of a third lever, supported by a fulcrum one foot from its end, and each of the three levers is thirteen feet long, then an ounce on the first lever's long arm will balance a weight of one hundred and forty-four pounds on the third lever's short arm. Now, let us apply the principle to the train of a watch ; each of the wheels and pinions of which are nothing more nor less than such levers ; the pivots being the fulcrums, the radii of the pinions the short arms, and the radii of the wheels the long arms, and let us suppose the leverage power of each at equilibrium to be as 1 to 8, and furthermore that the force of the main-spring acting upon the short arm of the first lever (centre-wheel pinion) is as the weight of one pound, then one-eighth of a pound will balance it at the circumference of the centre wheel, $\frac{1}{64}$ at the circumference of the third wheel, $\frac{1}{512}$ at the circumference of the fourth wheel, and $\frac{1}{4096}$, or one grain and $\frac{13}{32}$ of a grain at the circumference of the escape wheel. If now, the lever, together with the fork, should weigh three grains, and this weight be distributed so that two grains should be on one side of its axis and one on the other, it will be apparent that, while the unequal poise could not arrest the motive power, owing to the freedom of the lever on its axis, and the great purchase which it has upon the pallet arms, it would at least occasion very great irregularity in the transmission of it to the balance—in many cases endangering the lockings—and never could such a watch run in all positions alike. One of the consequences of unequal poise in the lever is, that the watch, though the hair-spring may be properly fastened, will always sound as if it were out of beat. We may, by reasoning in this way, not only be able to appreciate the evil consequences of unequal poise in the lever, but also the importance of making them as light as a certain solidity will permit.

But we will suppose a watch perfect in this particular and proceed to investigate the means of adjusting it to position. So far as we know, two theories have been advanced on this subject; the one resting upon the principle of governing the motion of the balance by means of the screws applied as compensating weights, the other upon that of equal friction in all positions. According to the former theory the balance is actually thrown out of poise in this way: when the watch goes fast in a hanging position, one or more of the screws of the balance which are on the top of it when it is in equilibrium and the watch is in a hanging position, is moved a little further out from the centre, which will cause the balance to describe greater arcs of vibrations in that position, and consequently make it go slower. Now it is evident that the advocates of this theory do not suppose an isochronal hair-spring to be in such a watch, and if that is the case the effect of such an operation might be a contrary one, for it might just as well happen that an increase of motion would make it go faster; would the fact of its going faster in a hanging position indicate less friction? and even were this operation to have the desired effect in that position, how would it be if the watch were reversed? At best the practice is a violation of the law of the compensation balance—the perfect equipoise—which is most strongly inculcated, to advocate which no good workman should be guilty of doing. We propose to adjust a watch to position according to principles which shall be independent of, and not interfere with or destroy, any other adjustment in the watch; and that we deem can only be done according to the principles of equal friction.

Ernest Sandoz, in his "Practical Methods of Accurately Adjusting Watches," bases his theory on the same principles, but in his practice he goes equally wrong to effect an increase of friction, by throwing the hair-spring a little out of centre. It probably did not occur to him that he thus destroys an essential condition of the isochronism of the spring.

We know of no better way of adjusting a watch to position than by the pivots of the balance. J. H. Martens gives the following rules for this adjustment, which in the main have already been mentioned by Mr. Spiro, but which we beg leave to repeat:

"1st. The pivots of the balance must have "the least possible diameter which the weight "and size of the balance will permit, must be "well hardened and polished so as to cause "the least possible friction in the jewel holes.

"2nd. Jewels with olive-shaped holes must "be used for the balance, in which the friction "is much smaller than in cylindrical ones.

"3d. The ends of the pivots must be made "almost entirely flat, by means of which the "friction in a horizontal position of the watch "can be made equal to that in a vertical "position.

"4th. It is necessary that the utmost care "be had in fastening the hair-spring to a "proper height from the balance, and its coils "regularly concentric to its axis, in order to "insure perfect freedom in its vibration."

If these four conditions be carefully observed, we will endeavor to show that the adjustment can be accomplished by varying the third.

This theory rests upon producing equal friction in all positions. If, then, we present equal surfaces of the pivots to friction, the object must be attained. The end of the pivot being flat, to know the area of surface it presents to friction, we must measure its diameter and multiply it by 3.14, and we will have the circumference of the pivot, which is also the circumference of the circle of the flat surface of the pivot, the area of which we wish to know. Now, the area of a circle is equal to the circumference, multiplied by half its radius; and if we measure half the radius of the pivot on its length, it is evident that we have, on the circumference of the pivot, the same square area as on the flat end (if the pivots are conical, full or more than twice this length on each must be perfectly cylindrical); this would present an equal surface to friction, as well on the side of the pivot as on the end of it; but when the watch runs in a horizontal position—that is, on the end of the pivot—the flat surface of the pivot rubs against an equal flat surface on the end stone; whereas, when it runs in a vertical one—that is, on the side of the pivot—the same surface, owing to the shape of the pivot hole, only rubs against a single point, and though this is in a measure balanced by two such surfaces, one on each pivot, rubbing thus against points, nevertheless the friction in that position of the watch will be much less than on the end of the pivot, whereby the arcs of vibrations of the balance will be increased.

Now, before attempting to equalize the friction, the balance must be perfectly poised; and to test whether this condition is entirely established in it, it should be laid with its pivots on two upright steels, brought to a knife-edge, perfectly level and polished on top ; on such an apparatus, if a perfect equilibrium is not established in the balance, it will show itself—there being no friction in the rolling of the pivots on these edges—and must be corrected. All the preceding conditions being complied with, and the watch is running, observe the arcs of vibration in both horizontal and vertical position ; if they are greater in the vertical position, it indicates less friction, and this cannot well be increased in that position, or we do not wish to increase it ; we therefore decrease it in the horizontal position by rounding off the ends of the pivots a little; each pivot must thus be separately adjusted, until in all positions the arcs of vibration are the same, which will indicate equal friction n ıll. It will be seen that we may thus approximate isochronism, even without establishing it in the hair-spring, and experience has amply proved to us that a watch thus adjusted will, except under irregular external influences, run in all positions very nearly alike.

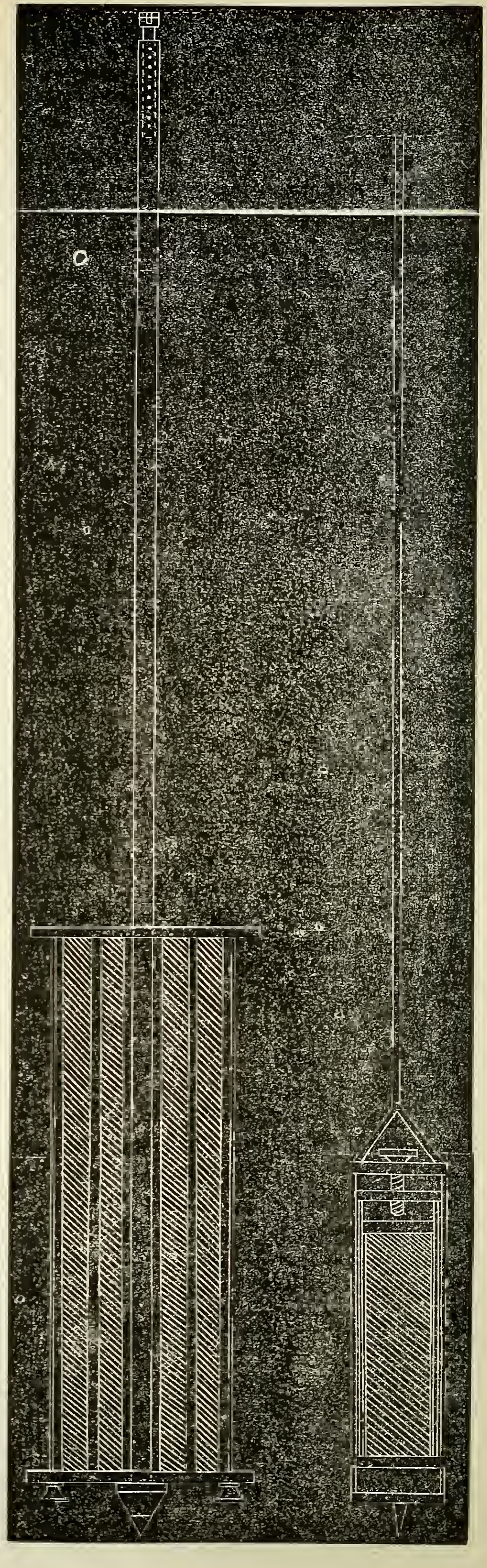
In the next number we purpose giving a translation of Professor Phillip's theory of the terminal curves necessary to establish isochronism.

HOROLOGIST.

MR. GROSSMAN'S MERCURIAL PENDULUM.

We have received from Mr. Grossman the following diagram of his mercurial pendulum, as compared with the Graham pendulum, both being one-sixth the actual size of a seconds pendulum.

He has also promised another article on the subject for the next number of the JOURNAL. We regret to learn that the state of his wife's health is such as to leave no hopes for her recovery, and are sure that he will receive the sympathy of our readers as well as our own.



FILES.

It may not be uninteresting to many of our readers to know something more about files than their use. They are very extensively manufactured at home as well as abroad, and their commercial value is commensurate with their world-wide utility. There is scarcely any branch of manufacture where they are not required ; the humblest occupation can scarcely be continued without using a file of some form.

The varieties of files are almost endless, depending as they do upon the uses they are to be put to. They may vary in length from those we use, say three-quarters of an inch to three feet and more. Watchmakers' files are perhaps as varied in their form and character as those of any other artisan, but they seldom exceed 4 or 5 inches in length. Mathematical instrument makers, gunsmiths, and those whose works are of medium size, employ files from 4 to 14 inches in length. The file is always measured exclusive of the tang, by which the file is fixed in its handle. Generally the lengths of square, round, and triangular files are from 20 to 30 times their greatest width ; broad, flat, and half-round are from 10 to 13 times their width.

Files are distinguished as *taper*, *blunt*, and *parallel*. The taper are the most numerous, their length being made so as to terminate in a point ; the blunt are made nearly parallel, terminating in a square end. In both kinds, however, the section of the file is largest towards the middle, so that the sides are somewhat arched or convex. A few files are made as nearly parallel as possible, and consequently have an equal section throughout ; such are called parallel files ; but even in these it is common to find them a little full in the middle. In almost all taper, blunt, and parallel files the central line is kept as straight as possible. Files used by sculptors and carvers are made curvilinear in their central line, and are called *riflers*.

Files, in other respects the same, may differ in the forms and sizes of their teeth. In the first place, they may be single-cut—that is, a number of ridges are raised straight across the file by one series of straight chisel cuts ; these are called *floats*. In the second place, files are *double-cut*—that is, two series of straight chisel cuts are made across each other, whereby an immense number of points or teeth are raised on the surface of the file ; such double-cutting makes them true files. In the third kind the surface of the steel is dotted over with separate teeth, formed by a pointed chisel or punch, and it is then called a *rasp*. Floats and rasps are made for woods, horn, and other soft material ; files proper for metals and general purposes. The following table gives the general cut of files and the names indicating the cut :

	4 in. long.	6 in. long.	8 in. long.	12 in. long.	16 in. long.	20 in. long.
	Cuts, per in.	Cuts, per in	Cuts, per in.	Cuts, per in.	Cuts, per in.	Cuts, per in.
Rough...	56	52	45	40	28	21
Bastard.........	76	64	56	58	44	34
Smooth........	112	88	72	68	64	56
Superfine........	216	144	112	88	76	64

To give the names and uses for all the various forms would require a volume, and we will stick to the *trade*, as far as possible.

Taper flat files are rectangular in shape, considerably rounded on their edges, and somewhat also in their thickness; hence they are said to be bellied, and are in general use among all classes of mechanics.

Flat or *Hand files* are rectangular in section, parallel in width, and a little taper in thickness.

Cotter files are narrower than hand files, nearly flat on the sides and edges, used for filing grooves for keys or wedges in fixing wheels or shafts.

Pillar files are somewhat narrower and thinner than flat hand files, and usually have one safe (uncut) edge.

Half round are just what the name indicates, and are called *full half* round and *flat half* round.

Triangular are also called three-square, and are usually taper files.

Crossing files, sometimes called double half round, have each face of a different curvature, and are used for filing out the crosses, or arms, in small wheels—the opposite sides of the tool presenting a choice of curvature.

Round files, when taper, are called *rat tail*, and when small, *mouse tail*, from their resemblance to those animals' appendages; when parallel, they are called *joint* files.

Square files are mostly taper, made both with and without a safe side.

Equalling files are usually parallel in width, and always so in thickness; when both sides are safe, they are called *ward* files.

Knife files are usually taper, with one edge thin and the other thick.

Slitting files have both edges thin.

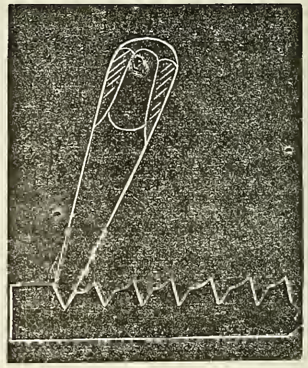
Pivot or *Verge files* are half square; that is, their width is double their thickness, and are subdivided into right and left hand, according to the angle which the edge makes with the side; in neither is it quite a right angle

Potence files, and pillar files, are small flat hand files.

Round-off files are half round, with the flat side cut, and the round side safe, and have a pivot on the end opposite the tang.

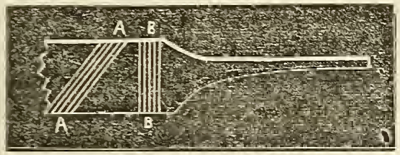
The forging of file blanks is all done by hand labor, the workmen each confining himself to a certain kind of file, in order that by the concentration of his skill and attention he may attain speed and perfection in its manufacture. The rod of steel is raised to a heat, never exceeding blood red, in a coke fire, two persons working together at the same anvil— one called the maker, the other the striker. Three square and a half round are formed in grooved bosses or dies, fixed in the anvil. The forged blanks are carefully annealed to make them soft enough for cutting the teeth. Blanks for common files are softened in an ordinary annealing oven, but the best blanks are protected from the action of the air by being buried in sand contained in an iron box; this is slowly heated to a blood red as in forging. The surfaces of the blanks are next made accurate in form, and clean in surface, by rough filing and grinding; in some cases dead parallel files are planed in a planing machine.

Next comes the cutting. The workman sits astride a low bench (usually stone); in front of him, at one end, is the anvil; the file blank is held on the anvil by means of a leather strap passing over each end of it, and then under the feet of the workman, like stirrups; the hammers weigh from one to six pounds according to the size of the file, and are curiously formed, the handle being so placed as to cause the mass of metal to be pulled toward the workman while making the blow. The chisels are formed of the best steel, and vary with the size of the file; they are broader on the face than the width of the



file, and are only just long enough to be held between the thumb and the forefinger of the left hand. At every blow of the hammer the chisel is made to cut a tooth, and the blows follow one another in such rapid succession that the movement forward of the chisel between each blow is not perceived. When one surface is covered with single cuts, he proceeds, in double-cut files, to add a second row, making them cross the first at a certain angle. When one side is fully cut, he proceeds to cut the other side; but as the teeth just finished would be injured by placing them on the naked anvil, they are protected by interposing a flat piece of alloy of lead and tin, which perfectly preserves the side already formed.

Holtzapffel describes the operation in these terms: "The first cut is made at the point of the file, the chisel is held at a horizontal angle of about 55°, with the central line of the file as at *a a* in the figure, and with a vertical inclination of about 12° from the perpendicular. The blow of the hammer upon the chisel causes the latter to indent and slightly drive forward the steel, thereby throwing up a trifling ridge or *burr;* the chisel is immediately replaced on the blank and slid by the operator until it encounters the ridge previously thrown up, which prevents it slipping further back, and thereby determines the succeeding position of the chisel. The chisel, having been placed in its second position, is again struck with the hammer, each blow, by practice, being given with the same force. The drawing gives an enlarged view of the section of the file and chisel, showing very clearly the formation of the teeth. In making the second cut the chisel is inclined vertically as before, but only about 5° to 10° from the rectangle, as at *bb*.



Before being hardened, the files are drawn through beer grounds, yeast, or some adhesive fluids, and then through common salt mixed with pounded hoof; the object of which is to protect the teeth from direct action of the fire and oxidation by the air ; the fusion of the salt affording an index when the hardening heat is attained ; it is then immediately removed from the fire and plunged into a cistern of cold water. The method of plunging it in the water is of importance ; it is held by the tang with tongs, and immersed slowly or quickly, vertically or obliquely, according to its form ; experience only can teach that method which is most likely to keep the file straight. They are next scoured with brushes dipped in sand and water, then are put in lime water for some hours to get rid of every particle of salt ; they are then thoroughly dried at the fire, rubbed over with olive oil containing turpentine, and are then ready far packing.

The manual dexterity displayed in file-cutting is scarcely excelled in any branch of art. In the great London Exposition, in the Danish department, were displayed a series of cast steel files that were almost fit to be classed among fine art ; one large square file was covered with a series of pictures, representing on one face a view of the city of Copenhagen, on another face the operations of the forge, file cutting, etc.

These effects were entirely produced by the file-cutter's chisel; the effect of shading being given by the various angles of the teeth reflecting the light at different degrees of obliquity. The teeth of a large circular file were cut so as to represent in a spiral going several times around the file, the maker's name, wreaths, date, etc. This file was hollow and contained within it a second hollow file, which in its turn contained ten others, all ornamented in a similar manner, the smallest being not larger than a needle.

Machine-cut files are produced to some extent, but the difficulties attending the use of machines have prevented their serious interference with the hand work. The proper use of the file requires more dexterity than many suppose ; there are very few who can use a large file skilfully without long and tedious practice. A moment's consideration of the subject will show why. Suppose a piece of metal in the vise, an inch in thickness, to be filed square across ; to do this, the file must be drawn and pushed in a perfect plane, which seems easy to do, but on trying it you will find the leverage between the point and handle is constantly changing ; in the beginning of the cutting stroke the handle has all the advantage; at the middle of the stroke each hand, one at each end, are equally balanced; but as the file advances, the point gets the advantage of the long end of the lever ; the consequence of this condition of things is a great tendency to cut away the edge nearest you of the piece upon which you operate. In the last end of the stroke it is almost impossible not to tilt the point of the file downward, so as to cut away the far side of the piece ; consequently the surface filed becomes convex instead of flat. There is also another element of error which comes in ; both arms tend to swing on a curve, or rather on two curves—one centre being at the shoulder, the other at the elbow, and these compound circular motions are difficult to reduce in practice to the necessary straight line. The shapes of files would indicate that the cut would be *concave*, but the workman who can file a surface to *fit the file* is a rarity. By the diagram showing the enlarged view of the file-teeth it will be seen that they cut only in one direction—and the pressure, in using, should be applied only during the forward stroke, and the return stroke with barely sufficient pressure to keep the file in contact with the surface, the "flat" being kept more by the sense of touch than by reasoning or judgment.

To use files economically, the first wear should come upon brass or cast-iron ; when they commence to lose their keen edge, they can then come upon wrought-iron or steel, with almost as sharp a cut as at first ; if the first use be upon iron or steel, they are comparatively valueless for cast-iron or brass afterward. Six inch files, without handles, are no better than three inch ones properly handled ; for one half the file, in the first instance, is used as a handle, and the rear part is valueless, except to hold it by. It is a shiftless, wasteful method to use them thus, and when we see a bench strewn with handleless files, we expect to find a careless, unthrifty workman.

We have seen many receipts for recutting wornout files by acid, but have never succeeded in accomplishing any great good by them. The best way is to take them to a file-cutter, then you have *new* files for old ones, at a trifling expense ; nearly all the principal cities now have such establishments ; certainly every manufacturing place supports one or more of them.

Many small files imported from the Continent are simply iron, case-hardened ; that is, the surface converted into a thin film of steel. Such files are used to a considerable extent by jewellers, for filing gold and such soft metals, and answer a tolerable purpose ; but for a watchmaker to buy such is a waste of money. English files have for years maintained a reputation for superiority, but of late years certain makes of Swiss and French files have proved very excellent, and it would seem that a people who so extensively and skilfully use them ought to be equally successful in their manufacture.

——o——

☞ We have received too late for this number, an article from Mr. J. Herrmann, of London, on the epicycloidal formation of wheel teeth by co-ordinates, but which will be presented to our readers in the December number, and can also promise an article from Mr. Grossmann in the same issue. Mr, Herrmann is doing a very valuable work in giving instructions in mechanical drawing to classes in connection with the Horological Institute, and we only regret that the young men in our own city could not avail themselves of similar opportunities for improvement.

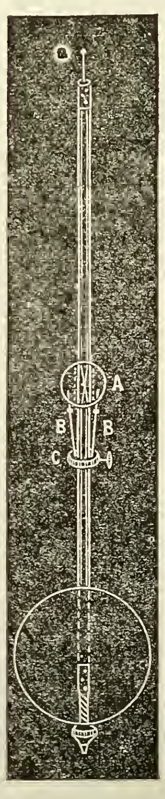
A COMPENSATED WOODEN PENDULUM.

EDITOR HOROLOGICAL JOURNAL:

Even if any of the various pendulums now in use was perfect, there would still be an occasion for discovering one that might be simpler and less expensive.

The Graham pendulum—the best—requires a more costly material than any other, and the Gridiron, while open to the same objection, on account of its construction, is a thing "fearfully and wonderfully made." These two are in general use in this country. The performance of the Graham is excellent, but it is not quite perfect. The performance of the Gridiron, when well made, is only ordinary, while the least defect in its construction is fatal to even ordinary time.

The following description of a pendulum which approximates to the perfection of the Graham, at a merely nominal cost, will be so readily understood that any watchmaker can apply it and test it himself. The principle upon which it is made has been generally followed heretofore in selecting the least expansive material for the rod. The rod in the present case is of soft white pine wood, of course well seasoned and perfectly straight in the grain. The expansion or contraction of this wood lengthwise is absolutely little or nothing. The bob is the common brass shell filled with lead, and is adjusted to time in the ordinary manner. The rod is suspended by a tempered steel spring, which should not be thick enough to hinder its very free vibration, and for a seconds pendulum the working part of the spring need not exceed in length $\frac{5}{8}$ of an inch. The compensation is provided for in the following manner, viz.: A is a brass ball free enough on the pendulum to slide up or down *without touching* the rod ; B B are brass or zinc rods; upon the upper ends of these two rods the ball A is fitted loosely, and is adjusted up or



down by screw nuts traversing the rods. The lower ends of the rods B are fitted into a collet C that is fastened to the pendulum rod by a screw. The compensation ball should be placed nearly in its place on the rod and fastened by the screw in the collet C; it may then be adjusted exactly to compensation by the small nuts on the brass rods B.

The action of the compensation is seen at a glance. As the heat lengthens the pendulum rod and lowers the bob, it also lengthens the rods B and raises the ball A to compensate for the increased length of the pendulum, and so *vice versa*. For a seconds pendulum the ball A may be 2 inches in diameter, and the rods B 6 inches in length. As "comparisons are odious" and provoke controversy, the merits of this rod will be alluded to without comparing them with those of any other.

1st. It is a remarkably correct timekeeper. It has been applied to a great many clocks put up in different parts of the country, principally turret clocks, which are exposed to the changes of temperature more than any other kind of clocks, and has as a general thing performed well. The turret clock in the Military Academy at West Point, manufactured by Mr. Byram, of Sag Harbor, has this compensation, and during a period of seven years its variation from mean time was not over thirty seconds a year for all that time.

2d. It is the simplest of compensation pendulums, and its price is only a little more than the wire pendulum to a Yankee clock.

As every watchmaker wants to have a good regulator, and in many cases is only deterred by the cost, every little improvement, whether it tends to greater excellence or to simplicity of construction, must alike be considered a step in the right direction.

B. F. H.

Sag Harbor, *Oct.*, 1870.

[We perfectly agree with "B. F. H," in regard to the value of wood as a material to be used in the construction of a pendulum rod for a turret clock, or an ordinary watchmaker's regulator, considering it far preferable to most of the patent compensating pendulums that are offered to the trade. We have before heard of the rate of running claimed for the turret clock at West Point, and consider it wonderful, even taking into account the fact that it was under the charge of scientific men during the entire time.]

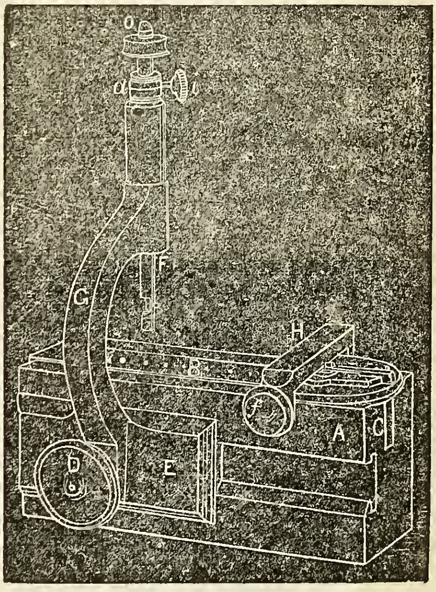
STAKING TOOL.

Editor Horological Journal:

I wish to call your attention to my new patent staking tool, which is almost indispensable for riveting and unriveting wheels, and for rounding and stretching the same. It is also one of the most convenient devices for a freeing-tool, and for finishing bushings; also for closing pivot-holes, and for removing table-roller from balance staffs, and in many instances answers the purpose of a lathe in connection with the bow, besides being adapted to many other purposes that might be named.

Its many advantages will readily be seen from the fact that the drill, punch, or finishing-tool used therewith, have a perfect guide, so that a true and unerring blow may be given, and the work more accurately performed than can possibly be done by hand.

It also forms a true and perfect guide for the drill when the bow is used, and also admits of many attachments being used therewith, such as small anvils and beaks, on which many kinds of work may be done in the most accurate manner.



A represents the block or foundation on which the attachments and adjuncts of my tool are fixed. It is made of any suitable metal, but from experience it has been found that cast-iron, steel, brass, or wrought iron are most suitable. It is rectangular in form, and may be made of any suitable or desired dimensions.

C is a groove, made much deeper than its width, running longitudinally from end to end of the block A.

Over this said groove C, and on the top of the block A, is closely imbedded a tempered cast-steel plate, B, which also runs from end to end of the block A, and spans the groove C.

The surfaces of the block A and steel plate B are planed off evenly, and polished, so as to form a perfect and true surface.

The steel plate B is provided with a series of holes, graduated in a true longitudinal line with the block A, the objects of which are to allow the journal of a watch-wheel to pass down through them, so that the rim or sides of the wheel can be brought flat upon the true plain surface of the plate.

G represents a movable guide, that moves or slides from end to end of the block, by means of a gib, E, fitted and working closely in a dovetail groove, and secured in any desired position by means of a set-screw, D, all these being arranged and located on the side of the block A.

The arm of the guide G leaves the block A in a curve, and is brought around over the top of the centre of the block, at which point the said arm is provided with a perpendicular hole or bore, F, which receives a punch, drill, or other tool required, as seen at O, which represents a drill provided with a grooved wheel, designed to be used with the bow.

This drill is provided with a movable sleeve, *a*, for the purpose of gauging the depth of the drill, which is done by moving the said sleeve up or down, and securing the same in the desired position by means of the set-screw, *i*.

H shows a cross-bar, with flanges or gibs closely fitted over each side of the block A, which serves the purpose of a gauge or guide, and for steadying the work while being done.

This cross-bar is rigidly secured in its position by means of a set-screw, *f*.

The simplicity of this tool, and the many uses to which it is adapted, would readily seem to suggest its mode of operation to any one of ordinary skill. I will, however, state, that to bring the bore or tool to be used directly over the centre of any of the holes in the block, I have a slim centre punch, closely fitting to the bore, which, when the set-screw D is slackened, is introduced into the hole designed to be used, by which means the bore is brought directly over the centre where it can be firmly secured by the set-screw D.

DAN. M. BISSELL.

SHELBURNE FALLS, MASS.

BENZINE AS A SUBSTITUTE FOR ALCOHOL.

EDITOR HOROLOGICAL JOURNAL:

In the 1st Volume of your Journal I read a very useful article on "Watch Cleaning," p. 52. It contains cautions against treating the parts of the lever escapement too much with alcohol, as the jewels might get loose in their shellac fastenings. This makes me wish to point out to your readers a cleaning fluid which seems little known among the watchmakers of your country, viz., *benzine*. It is a stronger dissolvent of all oily or greasy matter than alcohol, but does not attack any resinous substance, and you may, without the slightest fear, leave the escapement for hours and days in it without loosening the jewels. A few moments of immersion in benzine are sufficient for taking away even thick and gummy oil, and any one may satisfy himself by the simple experiment of throwing a small particle of shellac in a bottle with benzine, that it does not dissolve in weeks or months. It would be most useful if repairers might punctually follow the indications given in No. 2, p. 52, only substituting benzine for alcohol. Then many vexations arising from loose jewels would be avoided.

In the same communication I find a statement leading to the belief that the electro-gilding deposited on a coat of crystallic silver is more liable to be brushed off than a gilding made in another way. This is not the case, for the electro-gilding on a dead silvered ground resists brushing just as well as any other gilding. This method, compared to the old one, allows of making the gold coat almost of any thinness, and a great number of Swiss manufacturers have taken advantage of this possibility for economizing gold, and thus the electro-gilding has been discredited in its durability. But if a common-sized watch is coated carefully with about ¼ dollar's worth of gold on a dead silvered ground, it will take some hours brushing with a hard brush before the silver shines through.

SAXON.

——o——

TAPS AND DRILLS.

EDITOR HOROLOGICAL JOURNAL:

I have a word or two to say in regard to fluting very small taps. My method is to make them with a conical shoulder, instead of a square shoulder, as are those which usually accompany finished screws by the gross; in fact, I take the same taps and put them in a spring chuck and turn the shoulder back of the thread to a conical form, as that insures the greatest amount of strength; then I take a common graver and cut a groove from end to end of the thread on the tap, sloping the point of the graver so as to leave one side slightly under-cut in the direction in which the tap is to cut; the other portion of the cut will, of course, slope off so as to give the freeing for chips. I make three such cuts equidistant on the circumference, then harden and temper.

In regard to making and tempering small pivot drills, I use the best English needles, as the steel in those is generally of a superior quality. I file the drill a very little smaller than the hole which I wish to make in the staff or pinion, and then place it in a sloping position on any round surface, and then strike two or three smart blows with a light bench hammer, then cut with a pair of sharp cutting nippers in the centre of the part so hammered, and file up to shape. If for very hard steel, I give a very small angle to both the feeding and cutting angles, about 120° to the feeding angles, and 3° or 4° to the cutting angles. If the point is somewhat thick after this dressing, I rub the flat sides to a point crosswise on an oil-stone slip; I then temper by heating to a bright, cherry red, and plunge into a piece of white wax, such as dentists use for taking impressions, after which I finish the cutting edge on the oil-stone; this will make a drill that will cut smoothly and not so liable to break in the hole as those that are tempered in resin and such materials. For large drills I sometimes use resin to harden the extreme point, but prefer plain water, drawing to a yellow color after hardening. In both large and small drills which are used on softer metals than steel, I give more of a feeding angle, say 80° or 90°, but no more than 3° or 4° of cutting or freeing angle, as all that is necessary is to free the body of the drill, back of the edge, and it will not have so much of a scraping as cutting action. In large drills I make a groove directly above the cutting edge on the face side with a graver or fine file, which will make the drill bite in and cut faster; but on the whole, for anything larger than the pivot drill I prefer the twist drill, as they are always ready.

A. H. CATHCART.

MARSHALL, MICH.

——o——

PINION MEASUREMENTS.

EDITOR HOROLOGICAL JOURNAL:

In several numbers of your valuable monthly I have seen directions for obtaining the correct measurement of pinions, but none of them was based on rule or method, so as to be easily remembered when once impressed on the mind. The following rule will have this advantage, and can be used by any watchmaker who is not in possession of the finer and more accurate, but costly tools, for all practical purposes: Count each tooth and space as three until you equal twice the number of leaves in the pinion; this will be the diameter of the pinion; set your calipers and you have the gauge: Thus:

A pinion	of	5	will require	10	spaces.
"	"	6	"	12	"
"	"	7	"	14	"
"	"	8	"	16	"
"	"	9	"	18	"
"	"	10	"	20	"
"	"	11	"	22	"
"	"	12	"	24	"

J. E.

BOSTON, *Oct.* 25, 1870.

REPAIRING ENGLISH WATCHES.

Editor Horological Journal:

I wish to give a word of advice to your young readers. It often occurs with English lever watches, especially the larger sizes, which have been dropped or roughly used by the wearer, that when the watch is taken down for repairs, the barrel, great wheel, and centre wheel are found running foul of the plate, or of each other, and forthwith the workman gets his universal lathe to work on the plates. Whereas, if the plate pillars, which very likely are loose, were firmly riveted in the first place, and a little attention paid to truing the barrel, the faults would be permanently remedied. Another very important point, and one often overlooked, is to make sure before putting a watch together, that the wheels are quite firm on the pinions. I have known many instances of fine English and Swiss watches stopping or failing to come to time, for no other reason than because the scape wheel was loose on the pinion. This will sometimes occur in cleaning, especially when the wheel is not secured on the pinion direct. American watches generally are well secured against any such fault. Pinions, too, should always be left very clean and smooth; every pivot that looks the least bit ragged should be burnished, and in no case should the workman fail to examine the balance staff pivots; see that they are polished, sufficiently rounded, and long enough to reach the end jewel, with shoulder quite free. The centre wheel should have only enough shake to be free (having too much is a common fault), not only to prevent fouling, but for the better working of the dial wheels and hands. Never pass an English watch that has been running any length of time, without taking the great wheel off the fuzee and seeing that the click work is in good order, clean, and with fresh oil. Never give out a watch unless sure it is in beat, if ever so busy, and take pains to pin the hair spring in true and flat (if a plain one); see that none of the screws in the balance are loose or even unscrewed, unless intended to be so; pass no bad fitting screws, especially important ones, as cock screws, barrel plate and bridge screws, and those used for securing cap jewels. The improved appearance of a watch that has good screws will always compensate for attentions given in that direction. I use a flat block of lead, and a round hammer for riveting pillars. The lead holds them sufficiently and prevents the ends from spreading. Clackner's barrel contractor is a tool that every watchmaker should have for truing main-spring barrels of all kinds. It saves a deal of time.

James W. Pembroke.

Pittsburg, Pa., *Oct.* 20, 1870.

FAIR OF THE AMERICAN INSTITUTE OF NEW YORK.

The Twenty-third Exhibition of works of industry, applied science and art, in connection with this Institute, was opened to the public in this city on September 15th, and is still in progress, visited by thousands daily. Collected within one great building are to be seen the choice works of skill, ingenuity, handicraft and art, in almost every conceivable department of industry peculiar to our country ; but it is a source of regret to us that the Horological Department is not more fully represented—only two of the watch factories making any exhibition of their products, and the immense clock interests of the country are entirely unrepresented.

Watches.—The United States Watch Co., Marion, N. J.—Giles, Wales & Co., 13 Maiden Lane, New York, General Agents—display a fine variety of ladies' and gentlemen's watches, with full and three-quarter plate movements, exposed pallets, straight-line escapements, and stem winders—the Company claiming strength and simplicity as the peculiar feature of the winding mechanism. They exhibit over fifty different styles, many of them in solid nickel, and beautifully damaskeened. Their style of casing is especially worthy of notice, both in design and finish, some of them being very elaborately enamelled, and especially adapted for presentation purposes. Among the ladies' watches was one set with diamonds, valued at $1,800, and one valued at $700. They also exhibit a number of dials with masonic and other emblems, which were very beautifully executed, The New York Watch Co., Springfield, Mass.,—Messrs. Richard Oliver and Baden, No. 11 John Street, New York, General Agents—bring forward a goodly display of stem-winding and key-winding fine watches, complete in gold and silver cases. They also exhibit their movements in various stages of manufacture ; dials, plain and with sunk seconds, are seen in 16 different stages ; dial plates in 5 ; upper plates in 4 ; balance bridge in 6; main-spring band in 7; main-spring in 2; winding arbor in 6 ; centre wheel and pinion in 11 ; 2d wheel and pinion in 11 ; 3d wheel and pinion in 11 ; 'scape wheel and pinion in 11 ; pallets and lever, in a multiplicity of different stages, and compensation balances in 12 ; hair-springs in 4 ; balance roller and staff in 12 ; regulators in 7 ; winding and setting arbor cups in 10 ; ratchet, click, and spring in 14 ; male and female stops in 9 ; and motion wheels, screws, and jewels, in many different processes of manufacture. The escapements of these watches resemble very closely the one used by Jurgensen, and in the arrangement of the movement simplicity predominates; nothing useless is introduced, and they somewhat resemble the superior class of Swiss movements. Several of the movements are in nickel, beautifully damaskeened in various patterns.

Howard and Co., of Broadway, exhibit a very fine case of watches, the production of the American Watch Co., but not for competition, and also a fine display of gold and silver chains.

Clocks.—This department is very meagrely represented, and contains nothing of special merit. James Rodgers, of Liberty street, New York, exhibits a showy clock and case, designed to be fastened up on a wall, probably in some large office or hall. Chas. E. Market, 792 Third avenue, New York, a boy 16 years of age, exhibits a little clock all made by himself at his leisure hours. The clock is covered with glass, and of course the works are exposed, and with boyish simplicity he has two roses on the top of the movement, and a small bird flying between the two, keeping time with the pendulum. The whole is creditably executed, and we hope that it will be an incentive to the young man towards higher efforts, and an example to all our New York, and in fact all our American watchmakers' apprentices, to spend a portion of their leisure hours in such studies.

L. Thorne, Robinson street, New York, exhibits a globe clock. We have not had an opportunity of having it explained to us, or of examining the principle of its construction, and we can only say that it is a small clock under a glass shade, evidently designed to show certain astronomical movements. J. Cohen, 942 Third avenue, exhibits a clock for a watchmaker's or jeweller's window. A clock of similar construction is described at page 202 of the first volume of this Journal.

William H. McNary, Brooklyn, exhibits a clock having no hands. The hours, minutes, and seconds are marked on the edges of revolving cylinders, and the figures show through small holes in the dial plate. Mr. McNary claims, and not without some show of reason, that his system is less liable to mistakes in reading the time than the system of hands pointing to figures, and its simplicity enables any child that knows figures to tell what o'clock it is. We have examined the system by which the cylinders are made revolve, no friction springs are used to keep them steady, and consequently to drag on the clock ; they are arranged perfectly free, and can only move at the proper time. We hope Mr. McNary will, in a short time, make his system more public.

Mr. William H. Horton, Jersey City, N. J., exhibits an adjustable compensation pendulum, or rather he styles it an adjustable compensating regulator, of which Messrs. Terhune & Edwards, 18 Cortlandt street, New York, are agents. This is one of the many modifications of Ellicott's pendulum, and the inventor makes the rather extravagant claim "that it is superior in every respect to any pendulum in use ; that *it is perfect*, etc." As a scientific Journal, we are always ready to acknowledge merit, and assist in its development, but we are opposed to all charlatan ism, and unhesitatingly denounce the distinguishing feature of this pendulum to be a delusion ; and the general workmanship, both in the important fittings, and that which tends to make a good general appearance, to be the very worst in any part of the section it belongs to. We may have occasion to refer to this pendulum in some forthcoming number, and at present can only remark, that no stronger argument is required for the necessity of a purely horological journal, than the fact of this pendulum being placed for competition in an exhibition of the American Institute.

Astronomical and Optical Instruments.—Blunt & Co., 179 Water street, New York, make a fine display of the principal instruments they manufacture, and the only ones of the kind on exhibition. Conspicuous in their case stands a fine transit theodolite. This comprehensive instrument will measure horizontal and vertical angles reading on both circles to 10 seconds of arc, and compass angles can also be measured by it. The axis is perforated for illumination of the cross wires, and having both erect and diagonal eye pieces and astronomical reticule, can be used for celestial observations. The dipleidoscope or meridian instrument they exhibit is a very useful and convenient little instrument, and contains all the accuracy requisite for ordinary purposes. We are informed that Professor B. H. Bull, of the New York University, used one of them in the country during the past summer, and his observations with the dipleidoscope never differed more than a very few seconds from the observations taken with his fine transit erected in the upper part of this city.

T. H. McAllister, 49 Nassau street, New York, exhibits a fine selection of microscopes and microscopic apparatus, and three condensing lenses, and a variety of other articles which appear to be first-class goods, and are tastefully arranged. Miller Brothers, 69 Nassau street, New York, also show microscopes and microscopic apparatus and a variety of lenses. The professional microscope in this case is very fine.

Solid Silver and Plated Goods.—The Exhibition is rich in this department. Tiffany and Co., 550 and 552 Broadway, New York, exhibit a magnificent selection of solid silver presentation plate. The Queen's Challenge Cup, won by the yacht "America," of the New York Yacht Club, in 1851, and lately contested for by the English yacht "Cambria," and still remaining in possession of the New York Yacht Club, is exhibited in their show-case; also the plate presented to the New York Club by Commodore James Ashbury, owner of the "Cambria," and which was won by the "Magic;" also a number of other cups won in yachting contests,—all of the most gorgeous description. We consider the artistic skill and talent of the country in this branch of the business to be concentrated in the goods shown by Messrs. Tiffany & Co.

Reed & Barton, Taunton, Mass., display a fine variety of silver, and silver-plated goods, of elegant and artistic design. Their show-case is very attractive.

Simpson, Hall, Miller & Co., Wallingford, Conn.—Office, 19 John street, New York—exhibit a case of fine silver-plated ware. Elegance and durability are claimed by the exhibitors for their goods.

The Lippiatt Silver Plate and Engraving Co., 10 Maiden Lane, New York—Manufactory at Newark, N. J.—make a fine display of their goods, engraved and chased by their patented steam machinery. These goods are artistic in design, and the pearl satin finish is well executed.

Miscellaneous Articles.—L. L. Smith, 6 Howard street, New York, exhibits a number of miscellaneous articles to show the usefulness and practicability of nickel plating. A ship's binnacle and a steam engine are among the articles exhibited.

The Bradsley Nickel and Manufacturing Co., 74 & 76 Fulton street, Brooklyn, also exhibit specimens of their nickle plating.

M. Bourdon, No. 6 Old Slip, N. Y., exhibits the superiority of Emil Prevost's new liquid chromic acid as a substitute for other liquids in galvanic batteries. The liquid chromic acid is suitable for any description of battery, and recommends itself on the score of superior strength, economy, durability, and evenness of action, and has no odor whatever.

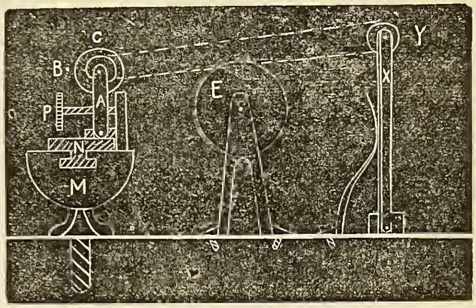
Messrs. L. L. Whitlock & Co., Office 708 Broadway, N. Y., P. O. Box 6775, exhibit one of Whitlock's drop presses for hand or mechanical power, but is especially valuable to jewelry manufacturers who use hand power. It can be worked five times as fast as the common hand drop, and takes but from one-quarter to one-sixth the power to do so. Mr. Whitlock informs us that he has another drop press nearly completed, which he expects will strike a blow equal to one hundred pounds once every minute or oftener, and when once started might be worked by a lady as easily as a sewing machine. Mr. Whitlock lays no claim to *making* or *creating* power ; he simply *saves* and *stores up* the little forces as they accumulate, which is the secret of the results he attains in the extra amount of work done by his machines. We noticed a choice and costly selection of Swiss drawing instruments and materials, exhibited by Keuffel & Esser, 116 Fulton street, and also by J. H. Queen, 5 Dey street, and an assortment of American drawing instruments by Benoit & Wood, 142 Fulton street, New York, completes the list of articles likely to be interesting to our readers. In conclusion, we would make a suggestion to our young friends to emulate Chas. E. Market, and show some little production of their skill at the next Exhibition of the Institute. It need not be an entire watch or clock ; probably a very few have the facilities to make a whole instrument, but all could exhibit some feats of skill in handling the file, polishing a flat surface, using the lathe, and many other difficult manipulations. Doubtless the Institute would give facilities for the exhibition of such articles, which would be a means of developing powers that otherwise may be dormant and probably never see light.

——o——

ANSWERS TO CORRESPONDENTS.

A. H. C., *Marshall, Mich.*—The thing you have to do with your lathe is to fix in or on your swing rest a live mandrel, as described on page 118 of the Journal. You will not need the swinging frame, as there described, because your rest itself is the swing, and can be made to approach the centre of your lathe mandrel by its screw. The only difficulty will be in connecting it by a counter shaft with your lathe pulley in such a manner as to allow the necessary amount of swing to your rest which carries the grinding and polishing mandrel.

We arranged something of the kind for an American lathe, which may give you an idea how to adapt something to your lathe. On the bed of the lathe M we fixed a rest N, to which was attached a swing frame A, carrying a short mandrel and pulley, on the projecting end of which we fixed the cutting and polishing disks *c*, which could be made to approach the lathe centre B, by means of the screw P. The difficulty was to run a band



from the centre shaft to carry the polishing arbor, and yet allow the swinging movement without altering the tension of the band. This we did by placing beyond the counter shaft an upright arm X, carrying a pulley Y, at the top and hinged at the bottom to allow of a swinging motion to correspond with the swing of the frame carrying the grinding disks ; the band was carried completely around the large pulley E on the centre shaft and thence around the little pulley on the arm, which was kept at the proper tension by a spring G, sufficiently strong ; this arrangement, of course, allowed full motion to the swing frame without altering the length of the band.

J. B. M., *Toledo, O.*—One of the earliest escapements applied to stationary time-pieces after the discovery of the pendulum was the anchor, so called from its resemblance to the flukes of an anchor. It is not positively known who invented it ; some attribute the invention to Thomas Mudge, some to Clement. It was claimed as a dead beat, " because the curves upon which the beats were made are arcs of circles of which the anchor pivot is the centre," and was so regarded for more than eighty years, or until Berthoud, in 1763, " gave minute rules by which the anchor escapement invented by Clement, a London clockmaker, in 1861, might be made *recoiling* for small clocks, with the view of rendering the vibrations isochrônal " All authority seems to confirm the opinion that it was *dead beat*, and the name seems to have more reference to the motion (as seen) of the seconds hand, that to any sound it gave ; the hand always in such escapements remains motionless, or dead, till the moment of escaping, just the opposite of the recoil escapement, which was always on the move—restlessly alive. In the endless descriptions of escapements extant, by common consent, all such as permit excursions of the pendulum beyond the impulse plane, without disturbance of the condition of rest in the escape wheels, are called dead beat; no matter what their peculiarity of construction, or by what additional name called, if they possess the property above mentioned they are undoubtedly *dead beat* escapements.

D. B. M., *Texas.*—We have recently seen in a foreign scientific and industrial journal a method described of covering iron or steel with copper, which will, perhaps, be just the thing you require for coating the articles you mention. "First make the article entirely bright by fill, scratch brush, or any of the usual modes. Apply to the surface a coating of cream of tartar, then sprinkle the surface with a saturated solution of sulphate of copper, and rub with a hard brush." The coating of copper deposited on the iron is said to be very even and durable.

E. L. D., *Ohio.*—You cannot make a new hole in the inner end of a clock spring without straightening out the spring and recoiling it, which is very difficult to do unless you have a clock spring reel. "The game is not worth the powder," when springs can be bought so cheaply.

M. O., *Pa.*—The word Horology is derived from the Latin, Horologium, a description of the hours. The French give us Horloge; the Italians, Ora; the Germans, Uhr, and the Greek, ὡρολογιον.

AMERICAN HOROLOGICAL JOURNAL,

PUBLISHED MONTHLY BY

G. B. MILLER,

229 Broadway, N. Y.,

At $2.50 per Year, payable in advance.

A limited number of Advertisements connected with the Trade, and from reliable Houses, will be received.

☞ MR. J. HERRMANN, 21 *Northampton Square, E. C., London, is our authorized Agent for Great Britain.*

All communications should be addressed,

G. B. MILLER,
P. O. Box 6715, New York.

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For November, 1870.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian.	Equation of Time to be Subtracted from Apparent Time.	Equation of Time to be Added to Mean Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M S.	M. S.	S.	H. M. S.
Tu.	1	66.95	16 17.20	16 17.22	0.056	14 42 17.01
W.	2	67 07	16 18.16	16 18.17	0.024	14 46 13.57
Th.	3	67.19	16 18.33	16 18.32	0.009	14 50 10.12
Fri.	4	67.31	16 17.69	16 17.68	0.043	14 54 6.68
Sat	5	67.42	16 16.24	16 16 22	0.077	14 58 3.23
Su.	6	67.54	16 13.98	16 13.95	0.111	15 1 59.79
M..	7	67.66	16 10.88	16 10.84	0.146	15 5 56.34
Tu.	8	67 78	16 6.95	16 6.90	0.181	15 9 52.90
W.	9	67.90	16 2.17	16 2 11	0.216	15 13 49.45
Th.	10	68.02	15 56.55	15 56.48	0.252	15 17 46.01
Fri.	11	68 14	15 50.07	15 49.99	0.288	15 21 42.56
Sat	12	68 26	15 42.73	15 42.65	0.324	15 25 39.12
Su.	13	68 38	15 34.52	15 34 43	0.360	15 29 35.67
M..	14	68.50	15 25.45	15 25 35	0.396	15 33 32.23
Tu.	15	68.61	15 15.51	15 15 40	0.432	15 37 28.79
W.	16	68.73	15 4.71	15 4.59	0.467	15 41 25.34
Th.	17	68.84	14 53.06	14 52.94	0.503	15 45 21.90
Fri	18	68.96	14 40 55	14 40.42	0.538	15 49 18.45
Sat	19	69.07	14 27.20	14 27 06	0.573	15 53 15.01
Su.	20	69.19	14 13.01	14 12.87	0.608	15 57 11.57
M..	21	69.30	13 58.00	13 57.85	0 642	16 1 8.12
Tu.	22	69.41	13 42.18	13 42.03	0.676	16 5 4.68
W.	23	69 52	13 25.56	13 25.40	0.708	16 9 1.23
Th.	24	69.62	13 8.17	13 8.00	0.740	16 12 57.79
Fri.	25	69.73	12 50.01	12 49.84	0.771	16 16 54.35
Sat	26	69.83	12 31.11	12 30.94	0.802	16 20 50.91
Su.	27	69 93	12 11.49	12 11.32	0.832	16 24 47.46
M..	28	70.03	11 51 17	11 51.00	0.861	16 28 44.02
Tu.	29	70.13	11 30 16	11 29.99	0.889	16 32 40.58
W.	30	70.22	11 8 49	11 8 32	0.916	16 36 37.13

Mean time of the Semidiameter passing may be found by subtracting 0.19 s. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

	D.	H.	M.
☉ Full Moon	7	19	31.9
☾ Last Quarter	15	20	58.9
● New Moon	22	13	20 9
☽ First Quarter	29	10	33.0

	D.	H.
☾ Apogee	8	1.5
☾ Perigee	22	4 8

	°	′	″
Latitude of Harvard Observatory	42	22	48.1

	H.	M.	S.
Long. Harvard Observatory	4	44	29.05
New York City Hall	4	56	0.15
Savannah Exchange	5	24	20 572
Hudson, Ohio	5	25	43.20
Cincinnati Observatory	5	37	58.062
Point Conception	8	1	42.64

		APPARENT R. ASCENSION.	APPARENT DECLINATION.	MERID. PASSAGE.
	D.	H. M. S.	° ′ ″	H. M.
Venus	1	13 52 35.43	−10 14 45.5	23 11.1
Jupiter	1	5 42 25.07	+22 50 13.3	14 57.5
Saturn	1	17 39 36.48	+22 27 11.2	2 56.9

AMERICAN

Horological Journal.

Vol. II. NEW YORK, DECEMBER, 1870. No. 6.

CONTENTS.

*** *Address all communications for* Horological Journal *to* G. B. Miller, *P. O. Box* 6715, *New York City. Publication Office* 229 *Broadway, Room* 19.

HEAT.

NUMBER FIVE.

EXPANSION OF SOLIDS—CUBICAL EXPANSION—LINEAR EXPANSION—CONSTRUCTION OF PYROMETERS—EXPANSION OF LIQUIDS—EXPANSION OF AERIFORM FLUIDS, ETC.

In the present number the relation between the temperature and the volume of a substance will be considered. In some cases it is the increase of the volume of a body which we wish to estimate, while in others, as for instance when we are considering a substance such as a bar, of which the length is the important element, it is change of length and not change of volume with which we concern ourselves. The former of these is called *linear*, and the latter *cubical* expansion. To determine the cubical expansion of a solid we may either, first, weigh the substance at different temperatures in a liquid of which the absolute expansion is known, or we may, secondly, enclose it in a glass vessel, the remainder of which is filled with mercury or water ; and if the absolute expansion of either of these liquids is known, that of the glass envelope and of the enclosed solid may be easily determined by mathematical calculation.

We present a table showing the difference between the linear and the cubical expansion of six of the principal metals, and give the names of the observers.

Substance	Mean linear expansion between 32° and 212° Fahr.	Mean cubical expansion between 32° and 212° Fahr.	Observers.
Glass......	.000837	.00254	Lavoisier & Laplace, Roy & Ramsden, Dulong & Petit, Regnault.
Copper....	.001716	.005127	" " Daniell " Kopp.
Lead......	.002882	.0089	" " " Kopp.
Tin	.001959	.0069	" " " "
Zinc......	.002976	.0039	Daniell "
Iron	.001204	.003546	Lavoisier & Laplace, Borda, Dulong and Petit.

From this it will be seen that the cubical expansion is in every case equal to about three times the linear expansion of the same substance. The reason of this relationship between the two follows at once from the fact that when an uncrystallized solid expands, it does so in such a manner that its figure at one temperature is similar to that at another. Universal experience demonstrates the truth of this statement, and it can be very easily shown that, assuming it to be correct, the cubical expansion of a substance will then be as nearly as possible three times as great as its linear expansion.

Several methods of finding the linear expansion of solids have been proposed and adopted by experimentalists. The most common, although probably not the most accurate form is, to place the metal to be operated upon in a horizontal position, a few inches above a table, one end of the metal rigidly attached to a pillar firmly fixed in one end of the table, and the other end of the metal fitting freely into a support fixed at a convenient distance from the first. When heat is applied to the metal its loose end presses against the short arm of a lever whose long arm forms a pointer, which exhibits, by its movements along a graduated circle, any change of length in the metal. Thus, were the metal to expand, the pointer would be pushed upwards ; and were it to contract, the pointer would fall downwards ; and any change in the length of the metal is thus rendered visible exactly in the same manner as watchmakers measure the size of a piece of work on the quadrants constructed for the purpose.

Another plan which admits of great accuracy, and is known as Lavoisier's method, is to place an axis in a horizontal position on the top of two pillars, such as are used for a transit in a permanent observatory. A stout bar is rigidly fixed to this axis, and hangs between the pillars, and is attached to the metal to be operated upon. One end of the axis projects beyond one of the pillars, and carries a telescope pointing to a vertical scale of inches placed at a considerable distance. The action of this instrument will be seen at a glance. When the metal under trial expands or contracts in length, the bar hanging between the pillars will be moved ; consequently the telescope will be moved also, and indicate the different divisions on the vertical scale it is pointing to.

Other most elaborate instruments have been devised for this purpose, but the principles upon which they are founded are either the same as the two already mentioned, or a combination of them both. Wedgewood's pyrometer is an instrument for measuring very high temperatures, and its action depends on the contraction which takes place in baked clay when heated. An air thermometer, however, furnishes a much more accurate means of obtaining the same result, and Breguet's Metallic Thermometer may also be used with great advantage. In some forms of the pyrometer the metal that is being experimented upon is placed in a trough or bath filled with water, and the heat communicated to it by heating the water.

The following table of the linear expansion of solids, has been lately arranged by Professor Balfour Stewart, LL.D. F.R.S., and Superintendent of the Observatory at Kew, England, and exhibits the results obtained by various pyrometers. It is instructive to notice sometimes the coincidence between the determination of different observers, and sometimes the difference between those of the same observer when operating upon different specimens of the same substance.

We suppose that by means of the methods already described a great amount of accuracy of measurement may be obtained, yet there is an uncertainty regarding the real temperature of the experimental bar, and this becomes very great for temperatures above the boiling point of water. In such cases, where a bath is used, it is not only very difficult to keep this at a constant temperature, but it is also very difficult to estimate accurately the temperature by means of a thermometer. This uncertainty with regard to estimation applies still more strongly to higher temperatures ; but for the range between freezing and boiling water, which is that of the foregoing table, it may perhaps be assumed that the determinations are very good. Whence, then, proceed the differences between the results of different observers, and even between those of the same observer when estimating the expansion of different specimens of the same substance. This is probably due to two causes. In the first place, substances which bear the same name are not always of the same chemical composition. Of these, glass may be mentioned as a prominent example ; and accordingly we find the expansion of this substance ranging in the table from .000918 to .000776. Brass, cast-iron, and steel are likewise compounds of which the composition is variable. But besides this, the commercial varieties of those substances which, when pure, are elementary, such as iron, lead, silver, gold, etc., often contain a very appreciable amount of impurity, so that the composition of different specimens is by no means uniform.

Very often, too, a comparatively small impurity causes a very great alteration in some of the properties of a metal. In the next place it ought to be observed that two solids may have precisely the same chemical composition, while yet their molecular condition may be different, owing to a difference in the treatment which they have received. Thus steel, heated and suddenly cooled, is a very different substance from steel which has not been treated in this manner ; and accordingly we find that while steel tempered yellow has for its expansion .0001240, untempered steel has .0010S0. Glass, also, will behave in a different manner, according as it is annealed or unannealed ; and in certain cases it is almost impossible to obtain two bars, although made of precisely the same material, which shall, in all their properties be precisely alike.

Name of Substance.	Length at 212° Fhr. of a rod whose length at 32° = 1.000000.	Name of Observer.
Glass tube without lead (1st piece)	1.000876	Lavoisier and Laplace.
" " (2d piece)	1.000898	" "
" " (3d piece)	1.000918	" "
Glass, English flint	1 000812	" "
" French, with lead	1.000872	" "
" tube	1.000776	Roy and Ramsden.
" solid rod	1.000808	" "
" "	1.000861	Dulong and Petit.
Copper (1st piece)	1.001722	Lavoisier and Laplace.
" (2d piece)	1.001712	" "
"	1.001716	Daniel.
Brass (1st piece)	4 001867	Lavoisier and Laplace.
" (2d piece)	1 001890	" "
" (standard scale)	1.001855	Roy and Ramsden.
" (English plate in a rod five feet long	1.001893	" "
Iron, soft (forged)	1 001220	Lavoisier and Laplace.
" (drawn)	1.001235	" "
Iron, wrought	1.001182	Dulong and Petit.
"	1.001156	Borda.
Steel, untempered (1st piece)	1.001079	Lavoisier and Laplace.
" (2d piece)	1 001080	" "
" tempered, yellow	1.001240	" "
" rod five feet long	1.001145	Roy and Ramsden.
Cast iron (prism length 5 feet)	1 001109	" "
"	1.001072	Daniell.
Lead	1.002848	Lavoisier and Laplace.
"	1.002788	Daniell.
Tin (East Indies)	1.001938	Lavoisier and Laplace.
" (Falmouth)	1 002173	" "
"	1.001767	Daniell.
Silver (fine)	1.001910	Lavoisier and Laplace.
" (standard of Paris)	1.001909	" "
"	1.001951	Daniell.
Gold (de depart)	1 001466	Lavoisier and Laplace.
" (standard of Paris not annealed)	1 001552	" "
" (standard of Paris annealed)	1 001514	" "
"	1.001230	Daniell.
Platinum	1.000884	Dulong and Petit.
"	1.000857	Borda.
Zinc	1.002976	Daniell.

The expansion of metals by heat, and their subsequent contraction, are often employed with great advantage in the arts, and frequently as most efficient mechanical powers. The amount of force which produces these expansions and contractions is enormous, being equal to the mechanical power required to stretch or compress the solids in which they take place, to the same amount. On heating an iron sphere of 12½ inches diameter, from 32° to 212° Fahr., the expansion exerts a force of 60,000 lbs. upon every square inch of its surface, or 30,000,000 lbs. upon the whole sphere. A bar of iron one square inch in section is stretched $\frac{1}{10000}$ part of its length by a ton weight; the same elongation, and an equal amount of force, is exerted by increasing its temperature 16° Fahr. In a range of temperature from winter to summer of 80° a wrought-iron bar 10 inches long will vary in length $\frac{5}{1000}$ of an inch, and will exert a pressure, if its two ends be fastened, of 50 tons upon the square inch.

The immense force of expansion is clearly proved in many notable instances in large works of engineering where iron is largely used as a material of construction. The Southwark Bridge, over the Thames, at London, is constructed of iron, and surmounted by stone, and the arcs rise and fall one inch within the usual range of atmospheric temperature. The Hungerford Chain Suspension Bridge, also over the Thames, has a span of 1,352 feet in length; the height of this chain roadway varies in the hottest day in summer and the coldest day in winter to the extent of eight inches.

The Menai Suspension Bridge weighs 20,000 tons, and this is raised and lowered 14 inches by the change of temperature between winter and summer. The Victoria Bridge, at Montreal, is exposed to great vicissitudes of heat and cold, and it is found that beams of iron, 200 feet in length, are subject to a movement of three inches in the climate of Canada. It would be a curious and instructive calculation for some of our young friends to determine how many pounds less of telegraph wire, or the number of tons less of railroad iron, is required to stretch across this Continent in winter than is required in summer.

Aeriform fluids are greatly expanded by heat, and much more than either solids or liquids, for the same increase of temperature With equal increase of heat they all expand equally. If, therefore, the ratio of expansion for one gas, as oxygen, be known, then the ratio for common air and for all other gases will be known also. The ratio of expansion for all gases has been found to be about $\frac{1}{490}$ of the volume which the gas possessed at 32° for every degree of Fahrenheit's thermometer. This calculation is based upon the experiments of Gay Lussac, who found that 1,000 cubic inches of atmospheric air raised from the freezing point to the boiling point, were expanded so as to make 1,375 cubic inches. It follows, therefore that one cubic inch of atmospheric air at 32° will, if raised to 212°, be expanded to 1.375 cubic inches, and for every additional 180° it will receive a like increase of volume. The ratio of expansion being $\frac{1}{490}$ for 1°, if any volume of air at 32° be raised to the temperature of $32° + 490° = 522°$, it will expand to twice its volume; and if it be raised to a temperature of $32° + (2° \times 490°) = 1{,}012°$, it will be expanded to three times its volume, and so on. Later experiments have slightly altered this ratio, and show that the different gases do not all expand to exactly the same degree for equal increase of heat; the inequality may however be disregarded for all practical purposes. In general the gases and vapors all dilate equally, and to the same degree as atmospheric air.

It is a striking fact, that water at certain temperatures does not obey the usual law of expansion from heat, and contraction from cold. Between 32° and 40°, if water be heated it contracts; if it be cooled it expands. If therefore water at the temperature of 60° be cooled, it will contract till it reaches 40°; and then, if it be cooled to a lower degree than this, it will expand. At 40°, therefore, water is said to possess its maximum density. At the moment of congelation water also undergoes a still further expansion; and this takes place with irresistible power, so that the vessels in which it is confined, if they be full are infallibly broken. This is the cause of the bursting of water-pipes at the approach of winter. This expansion is supposed to be due to the crystallization of the water as it freezes, and to the fact that the crystals which are formed do not lie side by side closely packed together, but cross each other at angles of 60° and 120°, thus leaving large interstices, and the water therefore necessarily occupies more space than it did before. The force with which this expansion takes place is very great, and cannon filled with water and plugged at the muzzle, may readily be burst. In 1784-5 Major Williams, at Quebec, made some experiments upon this subject, in one of which an iron plug three pounds in weight was projected from a bombshell to the distance of 415 feet, and shells one and a half and two inches in thickness were burst by freezing of the water. The Florentine Academicians burst a hollow brass globe having a cavity of only an inch, by freezing the water with which it was filled; and it has been estimated that the expansive power in this case was equal to 27,720 pounds. Water is not the only liquid which expands as it solidifies. The same effect has been observed in a few others, which assume a highly crystalline structure on becoming solid. Melted antimony, bismuth, iron, and zinc, are examples of it. (Mercury is a remarkable instance of the reverse, for when it freezes it suffers a very great contraction.) It is on account of this property that fine castings can be made from iron. The metal, as it cools and solidifies, expands so as to force into the most delicate lines of the mould. Antimony possesses this property in a high degree, and for this reason is mixed with tin and lead to form type metal, and give the mixture the property of expanding into the moulds in which the types are cast. It is because gold and silver do not possess this property, but on the contrary shrink greatly as they cool in the moulds, that coins cannot be made by casting, but require to be stamped.

Liquids expand more for a given increase of heat than solids. Alcohol, on being heated from 32° to 212°, increases in bulk $\frac{1}{9}$; olive oil $\frac{1}{10}$; water $\frac{1}{23}$. Twenty gallons of alcohol measured in January will become twenty-one in July. The cubical expansion of a liquid may be either real or apparent. By apparent expansion is meant the apparent increase of volume of a liquid confined in a vessel which expands, but in a less degree than the liquid which it contains. By real or absolute expansion is meant the true change of volume of the liquid without reference to the containing vessel. One of the various methods employed for this purpose is to fill the bulb of a thermometer, of which the internal volume or capacity is supposed to be known, at the various temperatures of observation. This bulb is attached to a graduated stem, and the internal capacity of each division of this stem is likewise supposed to be known. When this instrument has been filled with the liquid under examination it is exposed to different temperatures, and for each of these the position which the extremity of the liquid occupies in the stem is accurately noted. It is clear that by this means the volume of the liquid for each temperature becomes known, and hence the amount of its real expansion may be easily deduced.

——o——

☞ It is with sincere regret that we learn, through Mr. Geo. E. Wilkin, of Syracuse, of the death of the wife of Mr. Moritz Grossmann, after a long and painful illness of many months. Mr. Grossmann has many admirers in this country who will sympathize with him in his affliction.

SOFT SOLDER.

It is often very convenient, and, in fact, sometimes necessary, to have soft solder which will flow at different degrees of temperature. Many instances occur in which jobs cannot (in the country) be done by a professional jeweller, consequently the watchmaker is expected to do whatever nobody else can; and he must often run the risk of spoiling work by subjecting it to too intense a heat; whereas, if he had a little easy-flowing soft solder, there would be no danger.

From the following table you can easily prepare such as you wish—if only a little of some of the sorts; it will be found convenient:

No. 1.	1 part Tin,	25 Lead—		melts at 580° F.
2.	1 " "	10 "		" " 541
3.	1 " "	5 "		" " 511
4.	1 " "	3 "		" " 482
5.	1 " "	2 "		" " 441
6.	1 " "	1 "		" " 370
7.	1½ " "	1 "		" " 334
8.	2 " "	1 "		" " 340
9.	3 " "	1 "		" " 356
10.	4 " "	1 "		" " 365
11.	5 " "	1 "		" " 378
12.	6 " "	1 "		" " 381
13.	4 " "	4 "	1 pt. Bism'th	320
14.	3 " "	3 "	1 " "	310
15.	2 " "	2 "	1 " "	292
16.	1 " "	1 "	1 " "	254
17.	1 " "	2 "	2 " "	236
18.	5 " "	3 "	3 " "	202

No. 8 is the common tinsmith solder. No. 7 is the most fusible, unless bismuth be added. No. 18 will melt at 122°, by the addition of 3 parts of mercury. The most convenient form for using soft solder is to have it in wire. It is very easy to have it in that form; for when you have it melted in a ladle, in pouring it out on a flat iron or stone you must trail it—that is, draw your ladle along so as to flow out on the stone a thread of metal. With a little practice you cannot but succeed. Any of these alloys will flow with the ordinary soldering fluid.

Another convenience for soft soldering is not as much used as it might be, and would save injury to many a job; that is, a soldering iron, the same as a tinsmith's, only minuter. A piece of copper wire, an inch long and one-fourth inch thick, filed away almost to a point, with a wire handle about 4 inches long, terminated by a bit of wood or cork. In using, heat the copper in the lamp flame by laying it across something, to save time, and when hot enough to melt the solder, touch the end into your pickle, which will brighten it; then touch it to a bit of solder, and it will instantly take it up. Then you can apply it at any point you wish, without heating the balance of the article in hand.

—o—

CONSTRUCTION OF THE ADDENDUM OF A TRAIN WHEEL TOOTH BY CO-ORDINATES.

The formation of the curves of the addendum of a train wheel tooth by sections of the epicycloid is attended with considerable difficulty. In order to get a tooth large enough to form a complete curve, by the ordinary method of mechanical drawings, the space required for the radii of the primitive and generating circles passes much beyond the limits of the general appliances. Hence it follows that there is a great obstacle in the way of many horologists for getting a knowledge of the properties of an epicycloidal tooth.

This difficulty is surmounted by the method of coördinates, by which a tooth of any magnitude is easily constructed, without the necessity of drawing the primitive or generating circle. A reference to Fig. 1 will explain the basis of this method.*

Let a b and a^1 b^1 represent the tooth of a wheel of 60 teeth, terminated at the pitch circle m m^1. Let A be the centre of the primitive or pitch circle (*i. e.*, centre of the wheel), A a its radius; and let n be the centre of the generating circle, and n a its radius, proportioned to the radius of a pinion of 6 leaves, and here representing one leaf in line with the line of centres n A. By a revolution of the pitch circle of 6° the radius n a will rotate through an angle of 60°, and n^3 will then be the position of the centre of the generating circle, and n^3 a^2 the position of the face of the adjacent leaf; here again in line of centres n^3 A. With the centre of generating circle in n, o is a point in the arc o^1 coinciding with a. With the centre in n^1, this point o lies in the arc o o^2; with the centre in n^2 it lies in arc o o^3, and with the centre in n^3 it lies in arc o o^4, its radius forming, with the radius of the pitch circle, the angles o n^1 A, o n^2 A and o n^3 A—these being respectively 20°, 40° and 60°. The generating point o has therefore a triple motion, viz.: it revolves about A, rotates about n, and radiates from A.

The measurement of these motions of the generating point o enables us to determine so many points in the curve as are deemed essential in their relation to fixed points and lines, which lines are called coördinates.

Let a a^1, y^3 y^4, Fig. 2, represent the section of sector equal to the angular measure of a tooth and terminated by the pitch circle and the extremity of the addendum; a a^1 will then equal the width of a tooth measured at the pitch circle, which is taken equal in magnitude to the space; then by finding the magnitude of the parallels, the points o, as the points of intersection, can be determined, and the joining of these points will form the epicycloidal addendum.

Proportions and Definitions for a Drawing.—Make $a\,a^1 = 12$; bisect it and draw the perpendicular m $n = 12.212$. Draw the parallel y^3 y^4, and make n y^3 and n y^4 each $=6.3$; therefore y^3 $y^4 = 12.6$; join y^3 a and y^4 a^1. Draw perpendiculars to a y^3 and a y^4, from o and x; then determine 15 points in the curve a o o o, as follows: Measure off on the lines a x and a^1 x—

1 =	.0022
2 =	.0144
3 =	.0467
4 =	.1038
5 =	.2122
6 =	.3720
7 =	.5662
8 =	.8613
9 =	1.2215
10 =	1.6655
11 =	2 2029
12 =	2 8404
13 =	3.5827
14 =	4.4421
15 =	5.4235

On the lines a y^3 and a^1 y^4 measure off—

1 =	.0610
2 =	.2451
3 =	.5402
4 =	.9714

* The diagrams cannot make any pretence to accuracy, and are only given to illustrate the method set forth.

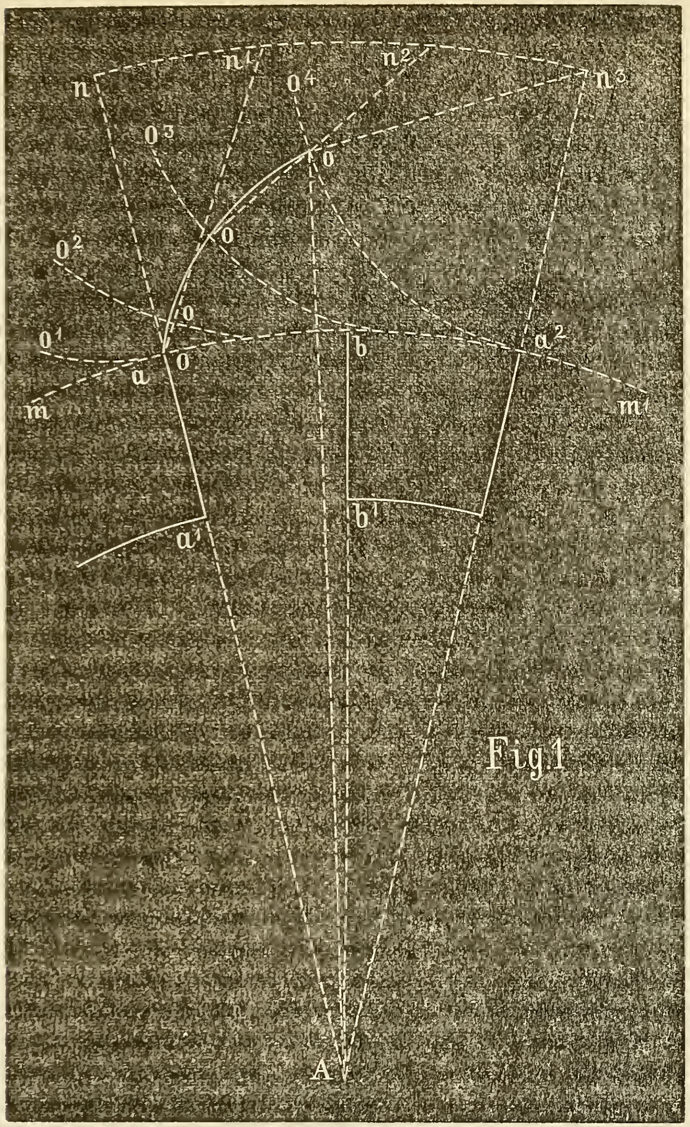

n
n1
o4
n2
n3
o3
o
o
o2
o
o1
o
b
a2
a
m
m1
b1
a1
A

Fig. 1

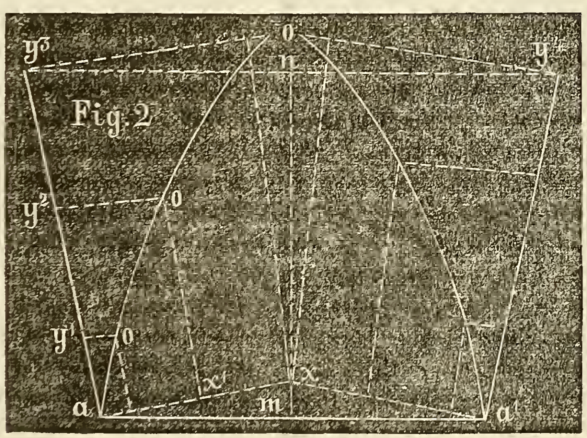

o
y3
n
y4
y2
o
y1
o
x1
x
a
m
a1

Fig. 2

5 =	1.5153
6 =	2.1689
7 =	2.9314
8 =	3.7927
9 =	4.7623
10 =	5.8187
11 =	6.9600
12 =	8.1791
13 =	9.4663
14 =	10.8156
15 =	12.2160

Draw parallels from the points measured off, as indicated in Fig. 2, join the points of their intersection and the curves are complete.

The following formulas will give the coördinates :

Let a = the radius of the primitive circle = to radius of a wheel of 60 teeth; b = the radius of generating circle, = to radius of pinion of 6 leaves ; c = the line of the circle, $d = \angle\ o\ \mathrm{A}\ n^3$ (Fig. 1); then (Fig. 1) point o'

$$x = \sin\,(6^\circ - d)\ (\sec d.\ \overline{c - \cos 60^\circ b})$$

$$y = \left(\cos\,(6^\circ - d)\ (\sec.\ d.\ c - \overline{\cos.\ 60^\circ b})\right) - a$$

Observation.—The practical construction of a perfect epicycloidal tooth by an engine with a curved cutter, which is formed artificially, cannot be demonstrated. My limited knowledge of the wheel cutting engines used in United States watch factories, leads me to suppose that they are of this description. While such is the case, no definite calibre in the pitchings, and *vice versa*, is reliable. I am prepared to say that engines can be constructed which will cut an epicycloidal tooth to mathematical accuracy. The line of centres will then be determined by gauging the wheel, and *vice versa*, instead of using the depthing tool, which is an engine of destruction in the hands of unskilled workmen.

J. HERMANN.

21 NORTHAMPTON SQUARE,
LONDON, *Oct.* 10, 1870.

[There can be no doubt that the subject of the proper curves of the acting faces of the teeth and leaves of wheels and pinions, considered not merely from a theoretical point of view, but in the reduction of scientific theories to actual practice, demands the closest investigation on the part of all mechanicians, whether watchmakers or millwrights, who construct gearing of any description. And although it may not always be possible to impart to wheels and pinions, with mathematical precision, those curves that in theory produce the least possible friction, and consequently the greatest economy of motive power and the minimum of wear, still the mechanic who aims at the best results should, even with limited appliances, endeavor, at any rate, to approximate to that which is scientific, and if he can be guided in his practice by his eye only, in shaping or selecting wheels and pinions, then it is important he should be able to draw on paper the proper form for the teeth and leaves of wheels and pinions of any numbers, that he may thereby educate his eye to a knowledge of the requisite epicycloidal curve. Any gross departure in practice from the true theory in this respect will, in horology, even though every thing else be of the highest order of excellence, produce poor time-keeping, thus defeating the primary object of a timekeeper; in the application of the rack and pinion movement, it will cause an unpleasant jerking and rubbing sensation, and ultimate destruction of the parts ; and in cam movements, such as the lifting of mill stamps, the valve rods of marine engines, and kindred appliances, a heavy jarring, caused by an improper relation between the velocity of the acting part of the cam and the inertia of the corresponding lifted body, is full of ruin to costly machinery at every stroke. We mention these two last movements because the principles that govern their construction are analogous to those of the wheel and pinion.

We are sure our readers will not accuse us of any desire of disparaging their intelligence if we remark that the publication of the foregoing scientific elucidation of a method of delineating the epicycloidal curve of a wheel tooth, which has been kindly furnished to us by the talented teacher of drawing in the British Horological Institute, will be shooting over the heads of a great number, who would be far more interested in some article giving a short cut to success in the repairing line, which is all well enough in its place ; but, on the other hand, we are consoled by the reflection that the list of our readers includes the names of many who thirst after knowledge, and to such we take an especial pleasure in introducing the above-mentioned author and his subject.

Referring to the "Observation" in the closing part of the article, we may say that we quite agree with Mr. Hermann when he says the curve of the tooth of any watch wheel cannot be demonstrated to be epicycloidal, even though it be such. Still, the attempt is made, at least in our watch factories, to produce that curve, and, it is claimed, with success. Whether the pitchings are reliable, and the depths on the whole are good, can be tested by actual experiment in a depthing tool, but if the general satisfaction with which the American watches are regarded, by both wearers and repairers, is any indication of success in the application of sound principles, then it must be conceded that any errors and inaccuracies they may possess, as a class, are not more than are incidental to the manufacture of such minute work by machinery. We hope Mr. Hermann will give our readers the benefit of his views on the construction of an engine for cutting "an epicycloidal tooth to mathematical accuracy."—Ed.]

—o—

ADJUSTMENTS TO POSITIONS, ISOCHRONISM AND COMPENSATION.

NUMBER TWO.

We have, in the first number, on the subject of adjustment to position, endeavored to show that it can be accomplished on the principle of presenting equal surfaces of the pivots of the balance to friction; for, if equal surfaces touch equal surfaces in all positions during the oscillation of the balance, the friction must be equal in all positions; and, if the friction is in all positions the same, the arcs of vibrations of the balance will also be the same in all positions; and since equal arcs of vibrations are performed in equal time, the watch will in all positions run alike.

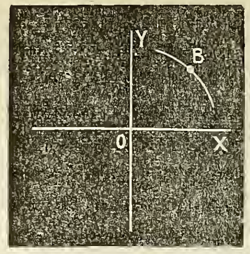
Now, directly from the above reasoning we infer, that if the arcs of vibrations are unequal in different positions, the friction must be unequal; and we are therefore enabled to determine inequality of friction, by observing the arcs of vibrations; and since we know that the lesser friction produces the greater arcs of vibration we also know in which position to remedy the inequality in the friction. We have thus briefly stated our reasoning, for the purpose of contrasting it with the method generally adopted among watchmakers to determine unequal friction, which consists of observing the running of the watch, and then altering the condition of the pivots according to the difference of the time it indicates in different positions during the same number of hours, and on the theory that the watch will go faster under the influence of less friction, and slower when the friction is greater. But we may ask the question, why will it go faster with less friction, and slower with more? If we admit that there is such a thing as a principle of isochronism in the hair-spring under certain conditions, which would cause arcs of vibrations of unequal extent to be performed in the same time, we could not infer that the advocates of this theory supposed such a spring to be in the watch, for, as we have just said, we know that less friction produces greater arcs of vibration. But they say less friction makes the watch go faster; and if such a hair-spring is not supposed to be in the watch, our question is equally unanswerable, for our experience teaches us that, according as circumstances are, greater arcs of vibration may be performed either slower or faster. The fact is, that, as to adjustment to position, the faster or slower running of a watch proves nothing.

But we think we have sufficiently indicated the means of adjusting to position, and will therefore proceed to investigate the next adjustment—that of isochronism. We have promised in our last to furnish a translation of Prof. Phillips's theory, and we know of no better authority on the subject; but as his reasoning is of the very highest order, and the subject necessarily a troublesome one, since the essentially complex form of the hair-spring introduces into the application of the theory of the elasticity some of the most complicated differential equations, it will be difficult for those who are not acquainted with mathematical logic, to follow it throughout; nevertheless it is to be hoped that those who feel a real interest in the subject will be encouraged by the value of it, to study themselves those sciences in order to be able to understand it. It would be difficult to write into plain English all the demonstrations in the higher calculus and trigonometry, but we will endeavor to give such hints, as will nevertheless convey the result of the reasoning to the minds of those who will follow it attentively, although they may not understand the process.

The theory of the isochronism of a cylindrical as well as of a flat hair-spring is here based upon the principle that, during the vibrations of the balance, as well as when it is at rest, the centre of the coils—considering them as circles drawn around the axis of the balance—shall always coincide with the centre of the axis of the balance, and that therefore this shall also be, during arcs of whatever extent of the vibrations of the balance, the centre of gravity of the hair-spring. This he proves can be accomplished by certain terminal curves of the hair-spring, to find which, is the main object of the treatise. He looks upon the question as a mechanical problem, of which the following is the substance: "A hair-spring being attached to a balance, to find the laws of their common movement." In practice we have evidently to take into account secondary details, such as the influence of the oil, friction, etc; nevertheless the solution and rules which shall be developed satisfy the problem as absolutely as the theory of the pendulum does in its application to the measurement of time. He first solves the problem of the equilibrium of the system of the hair-spring and the balance, which we shall now give in his own words, cautioning the reader to keep well in mind the signs used to express certain quantities.

The hair-spring and the balance being in their natural position of equilibrium, we suppose the balance to be made to describe an angle of rotation, a, and we ask what is the amount of coupling necessary to maintain it in this new position against the action of the hair-spring?

In order to solve this problem, we arrange the system under two co-ordinate rectangular axes passing through the centre O of the balance, and one of which also passes through



that extremity of the hair-spring which is fastened. If we consider, in this new position of equilibrium, the balance and hair-spring as forming one solid, the system must be in equilibrium under the action of the coupling applied to the balance, the amount of which, G, is precisely what we wish to determine. Moreover, the centre of the balance being stationary, nothing can hinder it from being considered free, provided we apply at the point O a force equal and contrary to the pressure which it exerts against the sides of the hole. Let us designate by Y and X the components, according to O Y and O X, of the force thus applied at the point O, which point we shall then consider free. B being the position occupied by any point of the hair-spring in the new state of equilibrium, we call x and y its co-ordinates; S the length of the hair-spring, comprised between that point and the end of the hair-spring fastened; L the total length of the hair-spring; M its amount of elasticity; finally, ρ the radius of the curve of the hair-spring at the point B, in the new position of equilibrium, and ρ_0 the radius of the curve at the same point B, in the natural state of the hair-spring, when the amount G is null.

In the new state of equilibrium this would not be disturbed if we solidified the entire portion of the hair-spring comprised between the point B and the extremity engaged in the balance, and we would then have to consider the equilibrium of a solid formed of this portion of the hair-spring together with the balance, and subjected on one part to the coupling G, which acts upon the balance, and to the forces X and Y, on the other hand, to the molecular actions exercised on the section B by the non-solidified portion of the hair-spring. If we transpose to the point B the forces X and Y, as also the coupling G, the resulting coupling must hold in equilibrium the molecular action developed by the non-solidified portion of the spring. Or, if in order to fix our ideas, we suppose that the angle of rotation a be in such a direction that the radius of the curve shall have diminished at the point B, the amount of molecular action is equal to

$$M\left(\frac{1}{\rho}-\frac{1}{\rho_0}\right),$$

and we shall have

$$(1)\quad M\left(\frac{1}{\rho}-\frac{1}{\rho_0}\right)=G+Yx-Xy.$$

This equation is applicable to all points of the hair-spring.

We can, therefore, multiply the two members by ds and integrate for the entire extent of the hair-spring, which will give :

$$(2)\quad M\left(\int\frac{ds}{\rho}-\int\frac{ds}{\rho_0}\right)=G\int ds+Y\int x\,ds-X\int y\,ds.$$

Let us first occupy ourselves with the second member, we have

$$\int ds=L$$

and

$$G\int ds=G\,L$$

Next, if we call x_1 and y_1 the coördinates of the centre of gravity of the hair-spring, it is evident that

$$\int x\,ds=L\,x_1 \text{ and} \int y\,ds=L\,y_1\ ;$$

consequently

$$Y\int x\,ds=Y\,L\,x_1 \text{ and } X\int^1 y\,ds=X\,L\,y_1$$

We pass now to the first member of the equation (2). We see that $\frac{ds}{\rho_0}$ is, for the natural form of the hair-spring, the angle formed by two consecutive normals, and consequently $\int\frac{ds}{\rho_0}$ is nothing else than the angle comprised between the two normal extremes. In the same way $\int\frac{ds}{\rho}$ is the angle between two normal extremes in the new form of the hair-spring ; but where this has passed from the first position to the second, the normal, relative to the extremity fastened, remains invariable in direction, because it is fastened at this point. On the other hand, since the other extremity of the spring is fastened in the collet of the balance at an angle with the circle of the collet, which remains also constant because of its being fastened, the result is, that in passing from the natural position of the hair-spring to the new position of equilibrium, the normal of the spring, at its extremity corresponding to the balance, turns by an angle a.

It follows from what precedes that we have simply :

$$\int\frac{ds}{\rho}-\int\frac{ds}{\rho_0}=a,$$

and equation (2) becomes

$$M\,a=G\,L+L\,(Yx_1-Xy_1).$$

Let us admit, for the present, that the term $L\,(Y\,x_1-X\,y_1)$, which is in the second member, be null or negligible—this point will be fully treated a little further on, in all that concerns it, and the necessary conditions established to prove sufficiently that it is so—then the equation (3) will be reduced to

$$M\,a=G\,L$$

or,

$$(4)\qquad G=\frac{M\,a}{L}$$

which expression is very simple, and shows that the amount of the power of the coupling tending to move the balance is proportional to the angle which the latter has described after leaving the natural position of equilibrium, and which, moreover, gives the amount of this coupling expressed in function of the amount of elasticity and length of the hair-spring.

Henceforth it is easy to find the time of the oscillations of the balance. In effect, if we call A the amount of inertia of the balance, with respect to its axis of rotation, we have, in every instance, observing that the power G acts as a resistance :

$$A\frac{d^2a}{dt^2}=-G$$

or, on account of (4)

$$(5)\qquad A\frac{d^2a}{dt^2}=-\frac{M\,a}{L}$$

I designate by a_0, the angle of motion of the balance which answers to the limit of the oscillation when its swiftness is null, and we have, by multiplying the two members of (5) by $2da$ and integrating :

$$(6)\quad A\frac{d\,a^2}{dt^2}=\frac{M}{L}\left(a_0^2-a^2\right).$$

This expression shows that the angular swiftness of the balance $\frac{da}{dt}$ is indefinitely null when $a = a_0$ or when $a = -a_0$, so that, if it were not for divers passive resistances, it would always vibrate to the same extent to each side from its position of equilibrium.

We draw from equation (6)

$$(7) \quad dt = \sqrt{\frac{AL}{M}} \frac{da}{\sqrt{a_0^2 - a^2}}$$

It is now time to integrate this equation for all the values from $a = -a_0$ to $a = a_0$.

Now

$$\int \frac{da}{\sqrt{a_0^2 - a^2}} = \int \frac{d\frac{a}{a_0}}{\sqrt{1 - \left(\frac{a}{a_0}\right)^2}} = \text{arc sin } \frac{a}{a_0} + \text{constant}$$

then

$$\int_{-a_0}^{a_0} \frac{da}{\sqrt{a_0^2 - a^2}} = \pi,$$

and consequently by designating by T the time of an oscillation, equation (7) gives:

$$(8) \qquad T = \pi \sqrt{\frac{AL}{M}},$$

which simple relation gives the time of the oscillations, and they will be found isochronal whatever may be their extent. The preceding expression (8) is analogous to that which gives the time of the smaller oscillations of the pendulum. We see that the length l of the simple pendulum, which would perform its oscillations in the same time as the balance, would be expressed in the formula

$$(9) \qquad l = L \frac{Ag}{M},$$

As to the further conditions of isochronism, let us take up equation (3) again, in which we have neglected the term $L\ Yx_1 - Xy_1$), and examine under what conditions we can effectively consider it of no value, on which will depend definitively the isochronism of the oscillations and the accuracy of formula (8).

In the first instance this term would always be null if x and y were constantly equal to zero, that is to say, if the centre of gravity of the hair-spring coincided always with the centre of the axis of the balance. From this we infer directly that it is important to give to the coils of the hair-spring a sensibly circular form and concentric to the staff, so that the centre of gravity of the entire spring be on the staff and deviate from it as little as possible during its motion.

In the second instance, the term L $(Yx_1 - Xy_1)$ would vanish yet if the components X and Y were null, and consequently if the pressure of the staff were always null, or if this pressure were always at the centre of gravity of the hair-spring. In fact, in practice this pressure is always null in well-made time-pieces, since—provided the oil has not been neglected—we cannot find the slightest wear of the pivots or their holes, even after many years of running. Nevertheless, we will examine, under all the developments which the subject shall bring forth, the conditions under which we can rigorously and mathematically attain to this end. We shall then see, as a consequence of this analysis, that if, for the flat hair-spring, we can arrive at it but for small oscillations of the balance, on the contrary, for the cylindrical ones we will obtain this result for the greatest as well as for the smallest of vibrations, and that by means of particular theoretical terminal curves and a total length of the spring, which is to be neither too long, nor above all too short.

To this effect we mention, that if X and Y are null or can be entirely neglected, equation (1) gives:

$$\frac{1}{\rho} - \frac{1}{\rho_0} = \frac{G}{M},$$

or because of (4)

$$(10) \qquad \frac{1}{\rho} - \frac{1}{\rho_0} = \frac{a}{L}.$$

It follows from this, that then the tension of the curves is uniform. Thus, if ρ_0 is constant ρ will be the same, *i. e.*, if the coils have the form of the circumferences of circles in their natural state, they will be yet, after their deformation, circumferences of circles, though of a different radius.

Reciprocally to what precedes, if we had always, for all points of the hair-spring $\frac{1}{\rho} - \frac{1}{\rho_0} = \frac{a}{L}$, *i. e.*, the difference $\frac{1}{\rho} - \frac{1}{\rho_0}$ constant, equation (1) shows that we would then forcibly have $Y = o$ and $X = o$, and that consequently equation (4) with its consequences would take place.

We shall, in subsequent numbers, continue to give a digest together with liberal literal translations from the work of M. Phillips, trusting the readers of the Horological Journal may be benefited thereby.

Horologist.

ENGRAVING.

In the first volume of the HOROLOGICAL JOURNAL, was an article on the subject of Engraving, which treated of the process of Etching, and gave an explanation of the geometric lathe, by which dies are engraved, with combinations of lines forming geometric figures. We propose to continue the subject of engraving, and will speak of the work which is done by the hand. Almost all engravings are produced by etching, combined with lines made by the hand. The lines made with the graver without the use of acid, are technically called "dry pointed."

For engraving on steel and copper, a few tools only are necessary. First are the etching points, of which one or two only are necessary. Second, gravers, two or three of which are required, which may be lozenge shaped or square. A scraper and a burnisher are also required.

The etching points are used to trace lines through the varnish on the plate, for the action of the acid. They are also used to make light lines on the plate, when acid is not to be employed. The gravers are used to cut deep and broad lines. The scraper is used to remove any burr of metal raised by the graver in cutting. Also in the kind of engraving called mezzotint, the different shades of tint are scraped out by this tool. The burnisher is used to make the bright lights in mezzotint engraving, and to remove accidental scratches on plates, and in line engravings to erase lines that have been cut too deep.

In mezzotint engravings the plates are prepared by rolling over them in every direction, a small wheel with sharp points, which covers the plates entirely with minute dots, and if printed from, would present a black surface.

When thus prepared the design is traced upon the surface, and the engraver takes the scraper, and scrapes to greater or less depth, according to the tint required. In the highest lights the burnisher is used, as aforesaid. The effects produced by the mezzotint process are very soft. There are no lines, and the different tints shade into each other, with delicate gradations; and this process is also employed in connection with line engravings, with happy results.

"Stippling" is a term employed to denote effects produced by series of dots. When used alone, the gradations of shade are made almost imperceptibly. In all work indicating softness and delicacy, stippling may be employed to advantage. In most representations of statuary stippling is used alone, the absence of lines giving an impression of the surface of the marble. With line engraving stippling is also much used. In most pictures in which human figures are represented the flesh-tints are produced by stippling, sometimes alone, and sometimes combined with delicate lines. Line engraving consists of series of lines side by side, of greater or less depth according to the color required. When series of lines cross other series of lines, the term cross-hatching is used. It may be observed here that the lines are cut into the metal; and to print, the ink is filled into the lines, the surface of the plate being made entirely clean. The plates are then passed under heavy rollers, and an impression is made on paper upon the press. In former times copper was the principal material used for plates, but, as a limited number of impressions could only be made, steel was substituted for copper. It is harder to cut than copper, but is so much more durable that it is generally employed, especially for bank notes. And recently an invention has been made by which copper plates, after being engraved, may be faced with steel, thus increasing their durability.

The introduction and use of steel plates may be claimed as American. About a quarter of a century ago, Jacob Perkins invented a method of hardening steel after it was engraved. By bank-note establishments this method is extensively employed to obtain duplicates of designs. A design is engraved with the finest skill and beauty; rollers of softened steel are prepared and passed over this finely engraved plate, receiving a sharp impression in relief. These rollers are then hardened, and are dies, from which may be made as many impressions as are required. A large steel plate is softened and a number of impressions are made from the die on it. It is then hardened and ready for printing.

To digress a little, we will state that the bank notes of the United States are the finest in use in the world. The present bank of England notes are printed from an electrotype surface, and an indifferent quality of paper.

The notes of the Bank of France are also printed from an electrotype surface, though in a much neater and more elegant manner than the Bank of England.

Bank notes require vignette or picture engraving, letter engraving, and geometric engraving by machines. The pictures or vignettes are usually executed in lines ; stippling and mezzotint not being sufficiently durable.

It is customary for engravers to confine themselves to special departments of art. An engraver of pictures rarely cuts letters ; and a letter engraver seldom can engrave pictures. There is also much work that comes within the province of the letter engraver ; scroll-work and other ornamental designs are within the scope of this department. Heretofore we have been speaking of engravings from which impressions are made. But the letter engraver finds a large field for the exercise of his talents in engraving upon plate and jewelry. All lettering is done on silver and gold, in the same manner as on copper or steel. In another paper, we will take up this department of the art, including ornamentation and enchasing.

——o——

HAIR-SPRING GAUGE.

Editor Horological Journal :

Noticing in the October number of the Journal, your answer to A. S. M., of Mass., I write you respecting a gauge for hair-springs, which I find the most convenient and best adapted to the wants of the watch repairer, of any tool I have seen for this purpose. I have used Bottom's hair-spring gauge for several years, until I found this instrument. I refer to the Micrometer, illustrated on page No. 329, Horological Journal. The instrument I use is a Swiss-made tool, somewhat different in construction from your illustration, but, in principle, identical. It cost $6.50 or $7.00. I find it a perfect tool for measuring pivots, hair-springs, or any small article of which it is desirable to know the exact dimensions. Jewel holes can also be measured by putting a round broach into the hole, and measuring the broach. In measuring hair-springs, both the width and thickness can be got, the same as in gauging main-springs by Dennison's gauge. It can probably be purchased of any tool and material dealer in New York; and it is worth much more than its price to any watch repairer who wishes to do work with precision.

I have no doubt that by a series of measurements, carefully conducted, a table may be formed of sizes of springs, weight of balances, and numbers of vibrations, by which any repairer may know to a certainty the size of hair-spring required, when the other conditions are found. E. E. Rawson.

Barton, Vt.

——o——

TRANSIT INSTRUMENTS.

Editor Horological Journal :

Among the letters we have received this month expressing the satisfaction with which the writers have used our Patent Improved Transits, were the following, which are a fair sample of general approval. We enclose them for publication, believing your readers will be interested in testimony confirming the reputation of these instruments for absolute accuracy.

Helena, Montana Territory,
Nov. 10th, 1870.

Messrs. John Bliss & Co. :

Gentlemen,—In relation to the Transit Instrument purchased of you last spring, I am pleased to state that during the past thirty years I have depended on my own observations for the purpose of keeping correct time in which period I have been familiar with nearly all kinds of instruments used for like purpose, and I have never used any with greater ease and satisfaction than your watchmaker's transit. Under your printed instructions, at my first attempt I placed in proper position, and recent verifications determine its constant accuracy. This mode of observation is made easy by the application of your splendidly finished and constructed prism ; magnifying the field of view with such distinctness enables the operator to mark the meridian line to the fraction of a second. I must say I like the instrument very much. It is ornamental in the show-case, easy to use, and as correct as the most costly instrument. I would not change it for any other time-taking instrument, and without hesitation I recommend it, particularly for watchmakers' use. Yours truly,

CHARLES RUMLEY,
Watchmaker and Jeweller.

ASHTABULA, OHIO, *Nov.* 12*th*, 1870.

MESSRS. JOHN BLISS & CO.:

GENTLEMEN,—If the Transit could not be bought for less than twice the money I paid for it, I would not be without it, after even the short acquaintance I have had. I enclose for your inspection my last observation, taken alone. Respectfully yours,

GEO. W. DICKINSON.

SALEM, MASS., *Nov.* 5*th*, 1870.

MESSRS. JOHN BLISS & CO.:

GENTLEMEN,—After a thorough test of the Transit Instrument I bought of you in Oct., 1868, I find it all you represented it to be—if anything, beyond my expectations. I would most cheerfully recommend it to all in want of such. Yours truly,

W. H. KEHEW.

—o—

WORN RIMS.

EDITOR HOROLOGICAL JOURNAL:

It is a great annoyance to watch-wearers to have the rim of hunting cases so worn by the friction of the springs that they will not close tight, or perhaps not stay closed at all. This trouble can be frequently remedied by undercutting the rim at such an angle that the spring will draw the case tight. I have always found it difficult to do this neatly with a graver, or other hand tool. I now use, for this purpose, the ordinary steel ratchet wheel, taken from the material box, mounted on the lathe as a cutting burr. A wheel should be selected with very fine teeth; and if not hard, it should be hardened, the same as any other cutting tool, and mounted on the live spindle in the most convenient manner.

This burr will cut and finish a square hole in a main-spring so narrow as to be difficult to punch, besides saving the risk of breaking small files in finishing the hole; the spring to be cut should be bent backwards, so that the hole will not be cut too long. It will also cut solder from the grooves in spectacles after mending, and do a hundred other little things that no file will do.

I noticed some time since, in your paper, an item about the use of the potato for protecting stones, enamel, chasing, and engraving from the effects of heat, in hard soldering. That was the process taught me in my apprenticeship, and that I followed until lately; then I heard of another way, which is cleaner, and absolutely sure to effect the object, if carefully done : The part to be protected should be well covered with a thick paste of whiting and water.

This may be new to some, as it was to me a year ago, and will prove to all who try it a valuable process. B. F. H.

SAG HARBOR, L. I.

—o—

LIGHT.

In reply to numerous inquiries and suggestions in regard to this subject, we perhaps cannot do our readers a greater kindness, than to lay before them the remarks of Mr. John Tyndall, of London.

GENERAL CONSIDERATIONS—RECTILINEAR PROPAGATION OF LIGHT.

The ancients supposed light to be produced and vision excited by something emitted from the eye. The moderns hold vision to be excited by something that strikes the eye from without. What that something is we shall consider more closely subsequently.

Luminous bodies are independent sources of light. They generate it and emit it, and do not receive their light from other bodies. The sun, a star, a candle-flame, are examples.

Illuminated bodies are such as receive the light by which they are seen from luminous bodies. A house, a tree, a man, are examples. Such bodies scatter in all directions the light which they receive ; this light reaches the eye, and through its action the illuminated bodies are rendered visible.

All illuminated bodies scatter or reflect light, and they are distinguished from each other by the excess or *defect* of light which they send to the eye. A white cloud in a dark-blue firmament is distinguished by its excess of light; a dark pine-tree projected against the same cloud is distinguished through its defect of light.

Look at any point of a visible object. The light comes from that point in straight lines to the eye. The lines of light, or *rays*, as they are called, that reach the pupil form a *cone*, with the pupil for a base, and with the point for an apex. The point is always seen at the place where the rays which form the surface of this cone intersect each other, or, as we shall learn immediately, where they *seem* to intersect each other.

Light, it has just been said, moves in straight lines; you see a luminous object by means of the rays which it sends to the eye, but you cannot see round a corner. A small obstacle that intercepts the view of a visible point is always in the straight line between the eye and the point. In a dark room let a small hole be made in a window shutter, an let the sun shine through the hole. A narrow luminous beam will mark its course on the dust of the room, and the track of the beam will be perfectly straight.

Imagine the aperture to diminish in size until the beam passing through it and marking itself upon the dust of the room shall dwindle to a mere line in thickness. In this condition the beam is what we call a *ray* of light.

FORMATION OF IMAGES THROUGH SMALL APERTURES.

Instead of permitting the *direct sunlight* to enter the room by the small aperture, let the light from some body illuminated by the sun—a tree, a house, a man, for example—be permitted to enter. Let this light be received upon a white screen placed in the dark room. Every visible point of the object sends a straight ray of light through the aperture. The ray carries with it the color of the point from which it issues, and imprints that color upon the screen. The sum total of the rays falling thus upon the screen produces an *inverted* image of the object. The image is inverted because the rays *cross* each other at the aperture.

Experimental Illustration.—Place a lighted candle in a small camera with a small orifice in one of its sides, or a large one covered by tinfoil. Prick the tinfoil with a needle; the inverted image of the flame will immediately appear upon a screen placed to receive it. By approaching the camera to the screen, or the screen to the camera, the size of the image is diminished; by augmenting the distance between them, the size of the image is increased.

The boundary of the image is formed by drawing from every point of the outline of the object straight lines through the aperture, and producing these lines until they cut the screen. This could not be the case if the straight lines and the light rays were not coincident.

Some bodies have the power of permitting light to pass freely through them; they are *transparent* bodies. Others have the power of rapidly quenching the light that enters them; they are *opaque* bodies. There is no such thing as perfect transparency or perfect opacity. The purest glass and crystal quench some rays; the most opaque metal, if thin enough, permits some rays to pass through it. The redness of the London sun in smoky weather is due to the partial transparency of soot for the red light. Pure water at great depths is blue; it quenches more or less the red rays. Ice when seen in large masses in the glaciers of the Alps is blue also.

SHADOWS.

As a consequence of the rectilinear motion of light, opaque bodies cast shadows. If the source of light be a *point*, the shadow is sharply defined; if the source be a luminous *surface*, the perfect shadow is fringed by an imperfect shadow called a *penumbra*.

When light emanates from a point, the shadow of a sphere placed in the light is a *divergent* cone sharply defined.

When light emanates from a luminous globe, the perfect shadow of a sphere equal to the globe in size will be a *cylinder*; it will be bordered by a penumbra.

If the luminous sphere be the larger of the two, the perfect shadow will be a *convergent cone;* it will be surrounded by a penumbra. This is the character of the shadows cast by the earth and moon in space; for the sun is a sphere larger than either the earth or the moon.

To an eye placed in the true conical shadow of the moon, the sun is totally eclipsed ; to an eye in the penumbra, the sun appears horned ; while to an eye placed beyond the apex of the conical shadow and within the space enclosed by the surface of the cone produced, the eclipse is *annular*. All these eclipses are actually seen from time to time from the earth's surface.

The influence of magnitude may be experimentally illustrated by means of a batswing or fishtail flame ; or by a flat oil or paraffine flame. Holding an opaque rod between the flame and a white screen, the shadow is sharp when the *edge* of the flame is turned towards the rod. When the broad surface of the flame is pointed to the rod, the real shadow is fringed by a penumbra.

As the distance from the screen increases, the penumbra encroaches more and more upon the perfect shadow, and finally obliterates it.

It is the angular magnitude of the sun that destroys the sharpness of solar shadows. In sunlight, for example, the shadow of a hair is sensibly washed away at a few inches distance from the surface on which it falls. The electric light, on the contrary, emanating as it does from small carbon points, casts a defined shadow of a hair upon a screen many feet distant.

ENFEEBLEMENT OF LIGHT BY DISTANCE—LAW OF INVERSE SQUARES.

Light diminishes in intensity as we recede from the source of light. If the luminous source be a *point*, the intensity diminishes *as the square of the distance increases*. Calling the quantity of light falling upon a given surface at the distance of a foot or a yard—1, the quantity falling on it at a distance of 2 feet or 2 yards is $\frac{1}{4}$, at a distance of 3 feet or 3 yards it is $\frac{1}{9}$, at a distance of 10 feet or 10 yards it would be $\frac{1}{100}$, and so on. This is the meaning of the law of inverse squares as applied to light.

Experimental Illustrations. — Place your source of light, which may be a candle-flame—though the law is in strictness true only for *points*—at a distance say of 9 feet from a white screen. Hold a square of pasteboard, or some other suitable material, at a distance of $2\frac{1}{4}$ feet from the flame, or $\frac{1}{4}$th of the distance of the screen. The square casts a shadow upon the screen.

Assure yourself that the area of this shadow is sixteen times that of the square which casts it ; a student of Euclid will see in a moment that this must be the case, and those who are not geometers can readily satisfy themselves by actual measurement. Dividing, for example, each side of a square sheet of paper into four equal parts, and folding the sheet at the opposite points of division, a small square is obtained $\frac{1}{16}$th of the area of the large one. Let this small square, or one equal to it, be your shadow-casting body. Held at $2\frac{1}{4}$ feet from the flame, its shadow upon the screen 9 feet distant will be exactly covered by the entire sheet of paper. When therefore the small square is removed, the light that fell upon it is diffused over sixteen times the area on the screen ; it is therefose diluted to $\frac{1}{16}$th of its former intensity. That is to say, by augmenting the distance four-fold we diminish the light sixteen-fold.

Make the same experiment by placing a square at the distance of 3 feet from the source of light and 6 from the screen. The shadow now cast by the square will have nine times the area of the square itself ; hence the light falling on the square is diffused over nine times the surface upon the screen. It is therefore reduced to $\frac{1}{9}$ of its intensity. That is to say, by trebling the distance from the source of light we diminish the light ninefold.

Make the same experiment at a distance of $4\frac{1}{2}$ feet from the source. The shadow here will be four times the area of the shadow-casting square, and the light diffused over the greater square will be reduced to $\frac{1}{4}$th of its former intensity. Thus, by doubling the distance from the source of light we reduce the intensity of the light four-fold.

Instead of beginning with the distance of $2\frac{1}{4}$ feet from the source, we might have begun with a distance of 1 foot. The area of the shadow in this case would be eighty-one times that of the square which casts it ; proving that at 9 feet distance the intensity of the light is $\frac{1}{81}$ of what it is at 1 foot distance.

Thus when the distances are

1, 2, 3, 4, 5, 6, 7, 8, 9, etc.,

the relative intensities are

$$1, \tfrac{1}{4}, \tfrac{1}{9}, \tfrac{1}{16}, \tfrac{1}{25}, \tfrac{1}{36}, \tfrac{1}{49}, \tfrac{1}{64}, \tfrac{1}{81}, \text{etc.}$$

This is the numerical expression of the law of inverse squares.

PHOTOMETRY, OR THE MEASUREMENT OF LIGHT.

The law just established enables us to compare one light with another, and to express by numbers their relative illuminating powers.

The more intense a light, the darker is the shadow which it casts; in other words, the greater is the contrast between the illuminated and unilluminated surface.

Place an upright rod in front of a white screen and a candle flame at some distance behind the rod, the rod casts a shadow upon the screen.

Place a second flame by the side of the first, a second shadow is cast, and it is easy to arrange matters so that the shadows shall be close to each other, thus offering themselves for easy comparison to the eye. If when the lights are at the same distance from the screen the two shadows are equally dark, then the two lights have the same illuminating power.

But if one of the shadows be darker than the other, it is because its corresponding light is brighter than the other. Remove the brighter light farther from the screen, the shadows gradually approximate in depth, and at length the eye can perceive no difference between them. The shadow corresponding to each light is now illuminated by the other light, and if the shadows are equal it is because the quantities of light cast by both upon the screen are equal.

Measure the distances of the two lights from the screen, and square these distances. The two squares will express the relative illuminating powers of the two lights. Supposing one distance to be 3 feet and the other 5, the relative illuminating powers are as 9 to 25.

BRIGHTNESS.

But if light diminishes so rapidly with the distance—if, for example, the light of a candle at the distance of a yard is 100 times more intense than at the distance of 10 yards—how is it that on looking at lights in churches or theatres, or in large rooms, or at our street lamps, a light 10 yards off appears almost, if not quite, as bright as one close at hand?

To answer this question I must anticipate matters so far as to say that at the back of the eye is a screen, woven of nerve filaments, named the retina; and that when we see a light distinctly, its image is formed upon this screen. This point will be fully developed when we come to treat of the eye. Now the sense of external brightness depends upon the brightness of this internal retinal image, and not upon its size. As we retreat from a light, its image upon the retina becomes smaller, and it is easy to prove that the diminution follows the law of inverse squares; that at a double distance the area of the retinal image is reduced to one-fourth, at a treble distance to one-ninth, and so on. The concentration of light accompanying this decrease of magnitude exactly atones for the diminution due to distance; hence, if the air be clear, the light, within wide variations of distance, appears equally bright to the observer.

If an eye could be placed behind the retina, the augmentation or diminution of the image, with the decrease or increase of distance, might be actually ob erved. An exceedingly simple apparatus enables us to illustrate this point. Take a pasteboard or tin tube, three or four inches wide and three or four inches long, and cover one end of it with a sheet of tinfoil, and the other end with tracing paper, or ordinary letter paper wetted with oil or turpentine. Prick the tinfoil with a needle, and turn the aperture towards a candle-flame. An inverted image of the flame will be seen on the translucent paper screen by the eye behind it. As you approach the flame the image becomes larger, as you recede from the flame the image becomes smaller; but the *brightness* remains throughout the same. It is so with the image upon the retina.

If a sunbeam be permitted to enter a room through a small aperture, the spot of light formed on a distant screen will be *round*, whatever be the shape of the aperture; this curious effect is due to the angular magnitude of the sun. Were the sun a *point*, the light spot would be accurately of the same shape as the aperture. Supposing, then, the aperture to be square, every point of light round the sun's periphery sends a small square to the screen. These small squares are ranged round a circle corresponding to the periphery of the sun; through their blending and overlapping they produce a rounded outline. The spots of light which fall through the apertures of a tree's foliage on the ground are rounded for the same reason.

LIGHT REQUIRES TIME TO PASS THROUGH SPACE.

This was proved in 1675 and 1676 by an eminent Dane, named Olaf Rœmer, who was then engaged with Cassini in Paris in observing the eclipses of Jupiter's moons. The planet, whose distance from the sun is 475,693,000 miles, has four satellites. We are now only concerned with the one nearest to the planet. Rœmer watched this moon, saw it move round in front of the planet, pass to the other side of it, and then plunge into Jupiter's shadow, behaving like a lamp suddenly extinguished; at the other edge of the shadow he saw it reappear like a lamp suddenly lighted. The moon thus acted the part of a signal light to the astronomer, which enabled him to tell exactly its time of revolution. The period between two successive lightings up of the lunar lamp gave this time. It was found to be 42 hours, 28 minutes, and 35 seconds.

This observation was so accurate, that having determined the moment when the moon emerged from the shadow, the moment of its hundredth appearance could also be determined. In fact it would be 100 times 42 hours, 28 minutes, 35 seconds, from the first observation.

Rœmer's first observation was made when the earth was in the part of its orbit nearest Jupiter. About six months afterwards, when the little moon ought to make its appearance for the hundredth time, it was found unpunctual, being fully 15 minutes behind its calculated time. Its appearance, moreover, had been growing gradually later, as the earth retreated towards the part of its orbit most distant from Jupiter.

Rœmer reasoned thus:—"Had I been able to remain at the other side of the earth's orbit, the moon might have appeared always at the proper instant; an observer placed there would probably have seen the moon 15 minutes ago, the retardation in my case being due to the fact that the light requires 15 minutes to travel from the place where my first observation was made to my present position."

This flash of genius was immediately succeeded by another. "If the surmise be correct," Rœmer reasoned, "then as I approach Jupiter along the other side of the earth's orbit, the retardation ought to become gradually less, and when I reach the place of my first observation there ought to be no retardation at all." He found this to be the case, and thus proved not only that light required time to pass through space, but also determined its rate of propagation.

The velocity of light as determined by Rœmer is 192,500 miles in a second.

THE ABERRATION OF LIGHT.

The astounding velocity assigned to light by the observations of Rœmer received the most striking confirmation from the English astronomer Bradley, in the year 1723. In Kew Gardens to the present hour there is a sundial to mark the spot where Bradley discovered the aberration of light.

If we move quickly through a rain-shower which falls vertically downwards, the drops will no longer seem to fall vertically, but will appear to meet us. A similar deflection of the stellar rays by the motion of the earth in its orbit is called the *aberration of light.*

Knowing the speed at which we move through a vertical rain-shower, and knowing the angle at which the rain-drops appear to descend, we can readily calculate the velocity of the falling drops of rain. So likewise, knowing the velocity of the earth in its orbit, and the deflection of the rays of light produced by the earth's motion, we can immediately calculate the velocity of light.

The velocity of light, as determined by Bradley, is 191,515 miles per second—a most striking agreement with the result of Rœmer.

This velocity has also been determined by experiments over terrestrial distances. M. Fizeau found it thus to be 194,677 miles a second, while the later experiments of M. Foucault made it 185,177 miles a second.

"A cannon ball," says Sir John Herschel, "would require seventeen years to reach the sun, yet light travels over the same space in eight minutes. The swiftest bird, at its utmost speed, would require nearly three weeks to meke the tour of the earth. Light performs the same distance in much less time than is necessary for a single stroke of its wing; yet its rapidity is but commensurate with the distance it has to travel. It is demonstrable that light cannot reach our system from the nearest of the fixed stars in less than five years, and telescopes disclose to us objects probably many times more remote."

We shall give from time to time further extracts on this and kindred subjects, from the same author, as every one dealing in optical goods should become familiar with it.

——o——

ANSWERS TO CORRESPONDENTS.

W. L. M., *Mass.*—Tradition points to Egypt as the birthplace of Alchemy; and the probable etymology of the name is that which connects it with the most ancient and native name of Egypt—*Chemi*. It is to the Arabs (from whom Europe got the name and the art) that we owe the prefix *Al*. Chemia was a generic term, embracing all common operations, like the decocting ordinary drugs; but the grand operation of transmuting was Al-chemia—the chemistry of chemistries.

Caligula instituted experiments for producing gold out of sulphuret of arsenic. Diocletian ordered all works on Alchemy to be burned; for multitudes of worthless books on this art were appearing, ascribed to famous names of antiquity, like Democritus, Pythagoras, and even to Hermes Trismegistus, the father of the art. Later the Arabs took up the art, and it flourished during the Caliphates of the Abbosides; and the earliest work of this school, written by Gebir—*Summa Perfectionis* (Summit of Perfection)—is the oldest known treatise on Chemistry in the world. It is a text-book of all then known and believed. They had long precipitated, sublimed and coagulated chemical substances, and worked with gold and mercury, salts and acids, and were familiar with a long range of what are now called chemicals. Gebir taught that there are three elemental chemicals, viz.: Mercury, Sulphur and Arsenic; and these, by their potent and penetrating qualities, fascinated their minds. They saw mercury dissolve gold, the most incorruptible of matters, as water dissolves sugar; and a stick of sulphur presented to hot iron penetrated it like a spirit, and made it run down in a shower of solid drops—a new and remarkable substance, possessing qualities belonging neither to sulphur nor iron. Thus they toiled, making many mixtures. Their creed was transmutation; their method blind groping; yet they found many new bodies and invented many a useful process.

Finding its way through Spain into Europe, it speedily was entangled with the fantastic subtleties of scholastic philosophers. In the middle ages it was the monks who chiefly occupied themselves with it, and Pope John XXII. delighted in it, though his successor forbade it. Roger Bacon and Albertus Magnus were the earliest writers on the subject; but the first was the greatest man in the school. Strongly condemning magic and necromancy, he believed in the convertibility of inferior metals into gold; and he sought even more than gold—the Elixir of Life. Like Gebir, he believed that gold, dissolved in nitro-hydrochloric acid (*aqua-regia*), was this desired Elixir, and urged it on the attention of Pope Nicholas IV., and doubtless took much of it himself. Magnus was thoroughly acquainted with the chemistry of his times; he regarded water as nearer the soul of Nature, the radical source of all things. Thomas Aquinas also wrote on the subject, and was the first to use the word Amalgam. Raymond Lully, another great name in the annals of Alchemy, first introduced the use of symbols into Chemistry. Valentine was also celebrated among the craft, and first introduced Antimony into medical use. He inferred the Philosopher's stone must be a compound of salt, sulphur and mercury, so pure that its projection on the baser metals should work them into a state of greater purity, till finally they should be silver and gold. His practical knowledge was so great he was ranked as the founder of Analytical Chemistry. But in Paracelsus Alchemy culminated. He held, with Valentine, that the elements of compound bodies were salts, sulphur, and mercury, representing respectively earth, air, and water—fire being regarded as imponderable. But these again were representative; all matter was reducible under some one of these typical forms; every thing was either one of these forms, or was, like the metals, a compound. There was one element common to the four—a fifth essence—an unknown and only true element, of which the four genuine principles were nothing but diminutive forms. In short, he believed there was but one elementary matter; but what it was no one knew. This prime element he considered the universal solvent which all sought; to express which he introduced the word *alcahest*.

After Paracelsus' time the Alchemists were divided into two classes. The first was composed of men of diligence and sense, who devoted themselves to the discovery of new compounds; practical and observant of facts, the legitimate ancestors of the positive chemists of the era of Lavoiser. The other class took up the visionary, fantastical side of older Alchemy, carrying it to an extent before unknown. Their language is mystical metaphor. The seven metals correspond with the seven planets, the seven cosmical angels, and the seven openings of the head—the eyes, ears, nostrils, and mouth. Silver was Diana; Gold, Apollo; Iron, Mars; Tin, Jupiter; Lead, Saturn. They talked of the ascent of black eagles, of lily brides; the escape of red lions from the embraces of Diana; their object being merely to disguise a formula for a chemical operation. It was long regarded as a pure art, vouchsafed to man by the kindness of Providence, and was the favorite study of the clergy; hence many mediæval churches contain alchemical symbols. The Blue Lion and the Green Lion, the Red Man and the White Woman, the Toad, the Crow, the Dragon and the Panther, Crucibles and Stars, were blended with the legends of Saints and Martyrs. Westminster Abbey, many of whose Abbots were notable Alchemists, is still adorned with many of the emblems of occult science. The magical Pentalpha is still visible in the western windows of the southern aisle, and the celestial orbs and spheres are figured deep in the pavement before the altar.

It is interesting to observe that the leading tenets in the Alchemists' creed, viz., the transmutation of other metals into gold and silver—a doctrine which once it was thought modern chemistry had utterly exploded—receives not a little countenance from facts every day coming up. The multitude of phenomena known to chemists under the name of Allotropy, are leading prominent chemists more and more to the opinion that many substances hitherto considered chemically distinct, are only the same substance under some different condition of its component molecules; and that the number of really distinct elements may be very few indeed. A series of experiments recently performed seem to indicate that silver is capable of transmutation into another metal, possessing some of the properties and characteristics of gold. The question of the age then is—as of all past ages—what is the interior nature of all these elements? No analytical power can move one of these elements from its propriety. Let synthesis be tried, if analysis has failed. It is in the highest degree probable that all the metals are equidistant from simplicity, and all equally compound, if there be any truth in the unanimous testimony of chemical analogy. Could we but discover the secret of one of these tantalizing elements, we should know it of all. Boundle s fields would then await the explorer.

F. E. B., *Catlettsburg, Ky.*—From India, that land of gems, came the first diamond of commerce. The most precious among the many gems for which that fair tropical land is famed. The territory of Nizam—or sometimes called Golconda, after its most powerful fortress—produced the finest stones. But a few centuries exhausted mines in which, for untold ages, the pure carbon had been crystallizing into the limpid jewel. More eagerly than the alchemist, bent over his crucible to discover the magic stone, and as vainly, have scientific men sought to wrest this secret from the bosom of the earth. Only in four shapes are diamonds cut: the brilliant, the rose, the table, and the briolette. These last two styles are not now used, and are only seen in some of the girdle diamonds of "the beautiful Austrian." The diamonds of the "Queen's necklace" were mostly of the rose form, so rarely seen in America; *i. e.*, flat on the under surface, and cut into innumerable facets on the top.

The "Koh-i-noor" (Mountain of Light) was once part of the aigret of the god Kirschun; but the poor, powerless god was unable to keep it, for a wild Delhi chieftain took it, to grace his tiara of eagle's feathers. From chief to chief it passed, till to Aurunzebe it occurred that it would be no worse for cutting and polishing; but the unskilful workman cut it down from 793 to 186 carats. Aurunzebe wished to repay him in kind by cutting him down also, commencing at his head. From this "exceeding great reward" he escaped only by instant flight. Soon after, Nadir Shah stole it; and from his descendants it was forced by Achmet, who, in his turn, was obliged to resign it to Runjeet Singh; from whom it was taken by the British troops, and presented to her Most Gracious Majesty, Victoria, of England. Dissatisfied with its form, which was irregular and uncouth, she caused it to be re-cut; thus reducing it to 106 carats.

The "Mattan Diamond," three times the size of the Koh-i-noor, yet remains with the Rajah of Mattan, and caused a bloody civil war, of more than twenty years' duration, for its possession. It is pear-shaped, and of unspeakable brilliancy. Many nations have wished to gain it; but, believing the fortunes of his race depend on retaining it, he refuses all negotiations for it. The "Orloff" is a yellow diamond, and is universally conceded to be the finest diamond in the civilized world. Once the eye of the Indian Polyphemus, it was most zealously guarded by the priests of the Temple. To obtain it a wily Frenchman became a Pagan; and rising, by slow degrees, to the dignity of the priesthood, became, finally, the most devoted worshipper of the bright-eyed god. Unawed by its supposed divinity, he achieved the purpose of his life, and stole the stone; and thus, pre-eminent among the jewels of the earth, it adorned the crown of the Northern Semiramis, where it yet remains. There, too, we find the red and the green diamond, of exquisite lustre and colors. The "Polar Star" vies with them in brightness, contrasting its limpid purity with their deep hues.

The "Pitt Diamond" (an heir-loom of the Orleans branch), is one of the crown jewels of France, and was stolen during the Revolution. The thief, not being a crowned head, was unable "read his title clear to it," and so returned it. The first Napoleon wore it on the hilt of his sword. This stone, of 51 carats, presented to the (late) Empress, by her husband, the third Napoleon, is rendered even more precious by bearing on its spotless surface the name of the most beautiful owner, *Eugenie.*

The "Sancy Diamond," though only 53½ carats in weight, ranks high among these stones, by reason of its exquisite and unusual beauty. Every step of its history is written in blood. Though preserved for centuries in the Burgundian family, in some of the fierce mediæval wars it was torn from the body of the dying duke, and brought to the King of Portugal; thence the Baron Sancy bought it to send, as became so loyal a courtier, to his king. The messenger who bore this princely treasure was slain by robbers, but not before he swallowed the diamond. Removed, uninjured, from his dead body, it reached James the Second; thence it remained among the French crown jewels till the Revolution. Misfortune attends it; for Napoleon regained it, only to sell it to Prince Demidoff; from whose hands it passed to the Earl of Westmeath, and now awaits future transitions among the possessions of the late Sir Jametsee Jejeibhoy.

The "Shah" is among the Russian crown jewels, and is a parallelogram, weighing 86 carats. It has inscribed on it the name of the Persian fire god, in whose temple and to whose shrine it was consecrated.

The "Florentine," like the "Sancy," belonged to the Duke of Burgundy. Taken from him by a soldier, after his death on the battle field, it reached Pope Julius Second. From him the Emperor of Austria obtained it, and it is among his crown jewels. Of 139½ carats, it is not quite flawless, which decreases greatly its value. With it is the blue "Hope" diamond. Of this rare color there were two; but one was stolen from the crown of France, and lost. Thus Austria claims the *only* true blue.

One of the finest diamonds of modern times is in the hands of the Castors, of Amsterdam, the famous diamond cutters.

We know of no ring made from a diamond, except the one worn by the favorite wife of Abdallah, and which was once in the circlet of the beautiful Empress Fastrada, beloved of Charlemagne, and to which is ascribed magic power.

By referring to No. 7, Vol. I. of the Journal, you will obtain the information you desire, in regard to cutting the diamond.

In India, the hard rock crystal is called the unripe, and the perfect gem the ripe diamond; thus classing it in the vegetable kingdom. In the middle ages Europeans thought it an animal. Perhaps you have read the story of the lady who kept in her casket two rare rose diamonds; and, on taking them from their seclusion, found, snugly between them, a smaller stone; and her delight increased on finding, a few months later, another; the loving jewels thus replenishing her treasury as well as the earth. This is as well authenticated as other mediæval legends, and bears equal inherent evidence of truth!

M. P., *Pine Bluff, Ark.*—To charge the needle of a surveyor's compass: Remove the brass centre cap, lay the needle on its side, and place over it a strip of soft sheet-iron a little longer and wider than the needle. Bring the ends of a horseshoe-magnet in contact with the upper surface of the short iron strip, with the north end of the magnet towards the south end of the needle. Rub the magnet back and forth while keeping it upright, at the same time firmly holding down the ends of the iron strip. The strokes should not be much, if any, longer than the needle. End the rubbing by bringing the magnet to the centre, and suddenly remove it by drawing it sideways, at right angles to the line of the needle and strip. Turn the needle on the other side and repeat the operation. A dozen strokes of a one or two pound magnet, in good order, will saturate the needle with all the magnetism that can be put into it by any p ocess. The charging magnet to be in good order should be able to sustain not less than its own weight It will be noticed that in the above operation the magnet does not touch the needle. After the needle is charged avoid touching it to any iron or steel. Sharpen and finely finish the spindle on which the needle turns, and see that there is not the least appearance of a pit mark where the spindle comes in contact with the cap.

Place the needle on the spindle and allow it to settle, noting the exact point to which it becomes pointed. Cause it to vibrate, and see if it settles again at the same point. If not, there is something wrong either in the contact of the spindle and cap, or in the magnetism, which must be sought and corrected.

For filling engraving, a good quality of black sealing wax is best; if for metal, heat hot enough to melt the wax, which rub on till entirely filled and covered; if for wood, ivory or pearl, rub it in with a hot iron, taking care in either case not to burn the wax. Grind off with pumice stone and water assisted with finely pulverized pumice stone.

John Seller's gravers are considered as good as any.

L. F., *Flemington, N. J.*—A pendulum, suitable for the clock you mention, like that described on page 112, Vol. II., of the Journal, would cost you, all complete, about $5. The compensation could only be adjusted after the pendulum is applied to the clock, and only then by careful experiments. But why not make one yourself? Instead of 43 inches, the length of your present pendulum, make it 40 inches, which is better, and increase the weight of the bob from 25 oz. until the clock keeps time. Make your rod round, of soft white pine about ⅜ inch diameter, and varnish with shellac; fit a ferule on each end to hold the spring and screw; also fit a ferule *over* the rod for the crutch to work on, and alter the crutch to the thickness of the rod. For the pendulum spring, take a piece of music box spring about 1½ inches long, cover the ends that are to remain thick with shellac, applied with a lamp, and immerse the spring in a mixture of about equal parts of nitric acid and water for a few minutes, or until the part exposed to the acid is nearly thin enough; wash it clean, and grind out all the acid marks with an oil-stone slip. Make the compensation as described heretofore and you will find no trouble in adjusting it. It only requires time and patience. If you do not wish to spend the time to make it, address B. F. Hope, Sag Harbor, N. Y.

You *can* alter your breguet spring to make the watch go slower if there is any to *let out;* and of course you can take it up to increase the rate ; but if the spring is in good shape it should never be disturbed, but bring to time by adding to or diminishir g the weight of the balance.

AMERICAN HOROLOGICAL JOURNAL,
PUBLISHED MONTHLY BY
G. B. MILLER,
229 Broadway, N. Y.,
At $2.50 per Year, payable in advance.

A limited number of Advertisements connected with the Trade, and from reliable Houses, will be received.

☞ MR. J. HERRMANN, 21 *Northampton Square, E. C., London, is our authorized Agent for Great Britain.*

All communications should be addressed,
G. B. MILLER,
P. O. Box 6715, *New York.*

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For December, 1870.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian.	Equation of Time to be Subtracted from / Added to Apparent Time.	Equation of Time to be Added to / Subtracted from Mean Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	M. S.	S.	H. M. S.
Th.	1	70.31	10 46 18	10 46.01	0.942	16 40 33.69
Fri	2	70.39	10 23 25	10 23 08	0.967	16 44 30.25
Sat	3	70.47	9 59 72	9 59.55	0.991	16 48 26.81
Su.	4	70 55	9 35.60	9 35.44	1.015	16 52 23.36
M.	5	70.63	9 10.95	9 10.79	1.038	16 56 19.92
Tu.	6	70.70	8 45.76	8 45.60	1.060	17 0 16.48
W.	7	70.77	8 20.03	8 19.88	1.081	17 4 13.04
Th.	8	70 84	7 53.81	7 53.67	1 101	17 8 9.59
Fri	9	70.90	7 27.15	7 27.01	1.120	17 12 6.15
Sat	10	70.96	7 0.05	6 59.91	1.138	17 16 2.71
Su.	11	71.01	6 32.52	6 32.39	1.155	17 19 59.27
M..	12	71.06	6 4.57	6 4.46	1.171	17 23 55.82
Tu.	13	71.10	5 36.28	5 36 17	1.186	17 27 52.38
W.	14	71.14	5 7.64	5 7.54	1.199	17 31 48.94
Th.	15	71 18	4 38 70	4 38.61	1.211	17 35 45.50
Fri.	16	71.21	4 9.50	4 9.41	1.221	17 39 42.05
Sat	17	71.24	3 40.07	3 39 99	1.230	17 43 38.61
Su.	18	71 26	3 10.43	3 10.36	1.238	17 47 35.17
M..	19	71.28	2 40.63	2 40.57	1.244	17 51 31.73
Tu.	20	71 29	2 10 69	2 10.64	1.249	17 55 28.29
W.	21	71.30	1 40.65	1 40 61	1.252	17 59 24.85
Th.	22	71.30	1 10.56	1 10 53	1.253	18 3 21.40
Fri.	23	71.30	0 40.46	0 40 45	1.252	18 7 17.96
Sat	24	71 29	0 10.39	0 10.40	1.250	18 11 14.52
Su.	25	71.28	0 19.61	0 19.59	1.246	18 15 11.08
M..	26	71.27	0 49.51	0 49.49	1.241	18 19 7.63
Tu.	27	71.25	1 19.27	1 19.24	1.235	18 23 4.19
W.	28	71.22	1 48 85	1 48 81	1.227	18 27 0.75
Th.	29	71.20	2 18.22	2 18.17	1.218	18 30 57.31
Fri	30	71.17	2 47.34	2 47.28	1.207	18 34 53.87
Sat	31	71.13	3 16.19	3 16.12	1.195	18 38 50.42

Mean time of the Semidiameter passing may be found by subtracting 0.19 s. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON

		D. H. M.
☺	Full Moon	7 14 39.1
☾	Last Quarter	15 9 10.9
●	New Moon	22 0 18.8
☽	First Quarter	29 4 38.1
		D. H.
☾	Apogee	5 3.3
☾	Perigee	20 15 9

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1

	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

		APPARENT R. ASCENSION.	APPARENT DECLINATION.	MERID. PASSAGE.
	D.	H. M. S.	° ′ ″	H. M.
Venus	1	16 22 55.32	−21 19 11.1	23 43.7
Jupiter	1	5 29 36.68	+22 45 6.1	12 46.6
Saturn	1	17 53 12.50	−22 34 57.6	1 12.4

AMERICAN

Horological Journal.

Vol. II. NEW YORK, JANUARY, 1871. No. 7.

CONTENTS.

*** *Address all communications for* Horological Journal *to* G. B. Miller, *P. O. Box* 6715, *New York City. Publication Office* 229 *Broadway, Room* 19.

ESSAY

ON THE

CONSTRUCTION OF A SIMPLE AND MECHANICALLY PERFECT WATCH.

BY MORRITZ GROSSMANN.

INTRODUCTION.

The construction of a good watch is undoubtedly one of the most complicated problems in the whole range of practical mechanics. The small dimensions not only, but also the absolute necessity of confining the whole mechanism to a space of a certain shape, which must not be transgressed nor altered, together with the claims to mechanical perfection and exterior elegance, are difficulties which may not be encountered in the same degree by any other branch of engineering.

The ingenuity and skill of the practical horologists have nevertheless contrived many different constructions of watch movements, and especially in Switzerland, that old centre of watch manufacturing, there exists an incredible variety of designs, more or less happily adapted to their purpose. In reviewing so many different expressions of the same fundamental idea, the attentive observer will not fail to arrive at the conclusion that a great part of these different patterns have been invented in order to produce something novel and original, or to suit some taste or fashion. Some of them, indeed, make an impression as though a watch were a fancy article, and not a scientific instrument.

This was certainly one of the chief motives which caused the Board of Trade of Geneva to open a competition for the study of a simple and normal movement. Being impressed with the usefulness of a clear treatment of this matter, and having become practically acquainted with the manufacturing systems of Switzerland, England, France, and Germany, I resolved to enter into this competition; and I had the satisfaction to see that my reflections on the subject were favorably judged and approved by the jurors.

At the request of the editor of the American Horological Journal, I have translated this Essay, originally written in French, into English, at the same time revising and correcting it carefully, and adding some additional remarks especially referring to English watches. I am well aware that watch manufacturing in the United States is carried on in an altogether different way from what it is anywhere else. The excessive cost of skilled hand labor has led to an extended employment of mechanical appliances, and it is really gratifying to learn what amount of skill and sagacity has been developed in the construction of automatic and self-measuring little machines.

The system of perfect identity of the parts of the movement is certainly very commendable, and affords great facilities in manufacturing large quantities. It has already been adopted in Paris and Geneva, and the possibility of maintaining this identity within certain limits is no longer doubtful. Still it seems to me that this system ought not to be extended to the manufacturing of the escapement, which, in carefully made watches, ought always to be treated as an individual—especially the lever escapement. The horizontal escapement, on the contrary, would admit much better an identic treatment.

Watch manufacturing in Switzerland is organized in a very different way from what it is in the United States. In Switzerland a number of comparatively small establishments get up the movements — that is, the frames, wheels and pinions, barrels and click-work. The watch manufacturer orders or buys them, and gets the casing, motion work, escapement and finishing done. The leading principles in the construction of the movements are better not inquired into, as they seem to be governed by the taste of the customers rather than by mechanical science. This organization gives rise to great irregularities and inconveniences in manufacturing, which has caused several houses of importance, especially in Geneva, to create a complete manufacture of movements for their own wants in inclosed localities, much in the same way as it is now done in the watch factories of the United States.

The English way of manufacturing presents nearly the same general feature, so far as the movements are concerned ; but the completion of these latter is much more dispersed over all the country, and at almost every place there are watchmakers who, besides attending to their repairing business, do more or less in the manufacturing line ; so that comparatively few pure manufacturers, in the Swiss style, will be found in that country. This system has the decided advantage of fostering the taste for new work, and of affording facilities to those desiring to carry out any scheme of a new escapement, etc. On the other hand it puts the manufacturer of movements rather out of the reach of his customers' influence and wishes, and this, together with other circumstances, must account for many astonishing imperfections in the getting up of movements. Many English manufacturers are aware of them, but not able to enforce their views to the movement makers. In the last decade one or two of these latter have begun to work on the system of identity, but I have not heard anything as to their success.

The English, Swiss and French manufacturers of movements are exhibiting one common inconvenience, viz.: the want of a generally acknowledged working standard, and of adequate measuring instruments. In France and Switzerland the horological population hold with uncommon tenacity to the antiquated measuring system based upon the "*Pied de roi*" (the King's foot), though neither of these countries has a king. This system, in total inharmony with the political institutions, with the monetary and measuring systems of those countries, and with the daily social practice, is entirely impracticable for calculation and intercomparison, and not very appropriate to the dimensions of watch-work, and ought to be abolished and replaced by the metric system. If I am correctly informed, this latter has been introduced in the factories of the Geneva establishments above mentioned.

The English manufacturers are working upon the unit of the English inch — still more unfit for watch work than the Paris ligne ; but the majority of special parts are classified by their makers in arbitrary sizes without any reliable standard, and without any guarantee that a certain size of one maker is uniform with the equally numbered size of another maker. The disadvantage of such a state of things could not fail to strike the observation of the thinking horologists there; and in fact the inconveniences arising from it are rendered much more perceptible from the fact that watch manufacturing is spread all over the United Kingdom, while the movements and materials are only made in the Lancashire district. Thus, the London manufacturer has to get his movements — wheels, pinions, hands, etc., etc. — from a distance of at least one hundred and fifty miles, and it is easy to understand that it requires a good deal of practice to do this without frequent mistakes, owing to the want of a generally acknowledged standard of measuring.

This caused the British Horological Institute to issue a circular in 1861, by which information was asked about a good and practical universal measuring system; and it was expressly stated that the suggestions to be made should in no way be bound to the actual English standard of measuring. I forwarded a detailed description of the method and instruments in use here in Glashütte for employing the metric system. This was published two years afterwards, and warmly recommended by the special committee appointed for the gauge and measuring question. No other communication was published afterwards, except an eccentric gauge, which, by its nature, admitted no connection with any standard, and so concluded that no one had sent another suggestion. Nevertheless, the opinion of the committee has found no followers, and English watch-work is, up to the present day, measured by inches and their fractions.

In my Treatise on the Detached Lever Escapement,* I expressed my opinions on the matter in detail, and tried to prove the perfect applicability of the metric system to watch-work, and the calculation of its dimensions and proportions.

It is very much to be regretted that the watch factories of the United States had not at once introduced the metric measurement, which affords so great facilities ; and it might have been very easily done, because everything had to be created anew, and because these factories form, as it were, each a world for itself.

The Swiss watch manufacturers have complicated their task in a very unnecessary way by creating a great variety of sizes of movements. Their regular sizes begin at 10 lignes and go up to 21 lignes, thus giving twelve sizes. But a too great readiness to meet the most minute exactions of their customers, has led them so far as to have even sizes by half lignes. The English watches have also about seven regular sizes. This I think too many, and a gradation by 1 ligne (about 2.5 mill.) is finer than required to meet even the most pronounced taste. If five sizes were adopted, differing by 3 mill. from each other, the manufacturing would be very much simplified. The sizes then would be 34, 37, 40, 43 and 46 mill., and would embrace the whole range from 15 to 21 lignes. Watches smaller than 15 lignes, or 34 mill., ought not to be made.

The factories of the United States have not made so much concession to the difference of taste of the public. So far as I know of, they make chiefly two sizes of watches, one for gentlemen and one for ladies. Most likely the equalizing and levelling character of the republican institutions of that country has assisted them in doing so, and much to the advantage and convenience of the trade, I am sure.

To these introductory remarks I will merely add that, for establishing the proportions of the parts of movements, I think it the best way to find their relation to the diameter of the pillar-plate in as simple fractions as it can be done.

According to my opinion, the question : *What caliper is the best for the cheap production of a simple but mechanically perfect and sound watch movement?* can best be answered by studying the designs already employed, as to their relative merits, and by choosing the most commendable of them ; or, if the actual methods do not seem convenient, by creating a new one.

CHAPTER I.

THE FRAME.

1. This part must be the beginning, because the way in which it is made influences most essentially the physiognomy of the movement, the arrangement of its organs, and even the shape of the case. A watch, as well as any other machine constituted mainly by rotating parts, requires a frame for sustaining both ends of each moving axis ; and this frame has to fulfil the same general mechanical requirements as in any other machine.

2. On looking over the frames, as they are made in the different manufactories, we may distinguish three different modes of construction:

The full plate movement.

The three-quarter plate movement.

The movement with cocks—or skeleton movement.

We will, in the first place, have to compare these three systems for the purpose of choosing the one offering the greatest advantages for the fabrication, and the best conditions for the solidity and good service of the watch.

3. The movement with cocks is almost exclusively adopted in the Swiss manufacturing, and it must be acknowledged that it is, more than any other one, calculated to exhibit the mechanism of the watch favorably to the eye,

* To be had of Mr. Chas. Wm. Schumann, 44 Nassau street, New York.

and give a rich look to the movement. At the same time it is of a more complicated nature, and it can not be manufactured or finished for the same price and in the same time of a full or three-quarter plate movement. The same observation applies to the taking to pieces and putting together; and it is not unlikely that the workmen employed in the manufacturing, as well as the repairers, would protest against this system if, instead of being sanctified by the practice of a rather long period, it were to be introduced now.

4. The frame, with cocks, of a horizontal watch requires ten to eleven screws for the cocks only, and sixteen steady pins; the frame of a three-quarter plate movement only seven screws and six steady pins. Thus, the adjustment of the three pillars balances itself by the adjustment of three to four screws and nine to ten steady pins; an undeniable advantage in favor of the three-quarter plate movement, when cheap and quick manufacturing is kept in view. Besides, there are four cocks to be made instead of the upper plate, and especially the consideration of the shaping and finishing of these numerous parts, which shows an essential economy in favor of the three-quarter plate.

In repairing, the same inconveniences prevail; the number of the separate parts is too great in the movement with cocks, which occasions necessarily a loss of time in the operations of taking to pieces and putting together.

5. The stability of the depths, together with the vertical position of the pinions, is endangered by each bending of a steady pin in the frame with cocks. It is for all these reasons, that some of the best Swiss manufacturers have dispensed with the cock of the third wheel by annexing the hole for this wheel to the centre wheel cock, because this depth, being the highest above the level of the pillar plate, might suffer most from the last-mentioned danger. With this course of ideas, it is only surprising that the same reasons have not at once led to a more radical change of system.

6. It may be asserted as a merit of the movement with cocks, that it affords more facility in taking out certain parts; *i. e.*, the barrel, in case of a broken spring, or a piece of the click-work, or stop-work in disorder. But even this little advantage does no really exist, because, for taking out the barrel, if the hole in the plate for this latter is not too wide, or if the steady pins of the barrel cock are rather long, the centre wheel must be taken off first, and for doing this; if the spaces are limited, it is often required to lift also the cock of the third wheel. Then there are four screws to be unscrewed, instead of the three of the three-quarter plate. Thus there remains the more sightly exposition of the train as the only advantage of the movement with cocks.

7. The three-quarter plate movement is very rarely made in Switzerland; but so much the more in England, where, for about twenty years, it has obtained a pronounced preference in place of the old full-plate design. It secures the relative position and vertical standing of the moving axes better than the Swiss system, and requires a less number of pieces, and less time and trouble in repairing, still leaving sufficient facility in taking out the parts of the escapement.

8. The arrangement of the train in these two kinds of frames is, however, exactly the same; so that any three-quarter plate movement might be transformed into one with cocks by merely taking off the pillars and upper plate, and substituting them by cocks for each moving axis.

9. The full-plate movement, on the contrary, admits and even requires a quite different arrangement of the train. It is the most ancient of all frames in watch-work, and has been always in great favor in England. This kind of frame has also been generally adopted by the watch factories of the United States.

10. It affords the possibility of making the balance of greater diameter than in any of the other frames; but this is an argument of no great importance, because it has long since been ascertained that an excessively large balance, approaching more to the effect of a fly, is not commendable for a good time-keeper. Most likely it was the reduction of the size of balances which caused the English makers to adopt the three-quarter plate movement.

11. The full-plate frame allows of a much easier and more spacious arrangement of the

train, and especially in fusee movements the wheels and pinions can be made larger than in a hree-quarter plate frame, which is certainly an advantage. But on the other side, for having a main-spring of the same breadth, the full-plate movement requires a considerably greater height of frame and case. This was tolerable at the period when the taste required a case with strongly convex backs, but the fashion of our days insists upon having the backs flat, or nearly so, and this caused the necessity of abandoning the full-plate system, lest the cases should have too disproportionate a height.

12. The full-plate movement is undeniably the most simple ; it can be executed with two cocks only (those of the balance), and with an economy which no other system affords to the same degree.

13. The taking to pieces and putting together of a full-plate watch has inconveniences which can only be found supportable by a long practice with this kind of movement. The pottance which carries the lower balance pivot must necesarily overlap the extremity of the fork, or the rim of the escape wheel in case of a horizontal watch, and the workman who takes down the upper plate without the necessary precaution, will invariably break the lower pivot of the pallet-staff, or of the escape pinion in the horizontal watch. This happens very often to repairers who take English watches to pieces without attentively considering their arrangement. In fact, to avoid an accident of that kind, the movement must be put together and taken to pieces on the upper plate, which is a very inconvenient method, especially in fusee movements, where the tension of the main-spring must be adjusted anew after each taking down.

It is true that all these objections might be easily eliminated by dispensing with the pottance, and setting the lower balance hole in the pillar plate. But an arrangement of this kind would not offer the same certitude of position and end shake of the balance staff.

14. The examining of the escapement, also, in a full-plate movement cannot be made with the same ease as in a movement otherwise arranged. Likewise it is impossible to make alterations on the escapement, or to clean it, or give it fresh oil, without taking the whole movement to pieces.

15. Having thus balanced the merits and inconveniences of these three systems of movements, it will not be difficult to draw the conclusion, *that for the watches of our period the full-plate movement is not admissible; and that from the two other arrangements remaining, the three-quarter movement is preferable for its greater solidity and economy in the execution.*

16. A little saving in the practical execution might be attained by omitting the two lower bridges. The plate then would only be turned out a trifle on the dial side, just to make up for any unevenness of the dial. The place for the barrel and motion work, and even for the lever escapement, can easily be provided by circular sinks made on the lathe.

In the same way a little advantage in the execution of a three-quarter plate frame would result from omitting the pillar, and making the upper plate of sufficient thickness to screw it directly to the lower plate, securing it in position by three good steady pins. For flat watches this method is to be recommended, as it gives additional solidity. The room for the moving parts must be hollowed out on the lathe. Watches in thin gold cases, thus made with two solid plates, would appear more weighty than they would with plates of common thickness. The setting of the jewels is not so convenient as when it is done in the bridges, but with properly arranged tools there is no difficulty in setting them directly into the plate.

17. The pillars ought not to be placed close to the periphery of the upper plate. On the contrary, they will better meet their purpose if put a little more inside, because the plates cannot be so easily deflected in screwing down when the shoulder of the pillar is not quite correct and square. The two pillars near the barrel ought to be so placed that a straight line from the one to the other comes as near as possible to the barrel centre. The barrel is the reservoir of the moving force, and, therefore, the frame must be so arranged that it possesses the greatest strength at this part.

18. There is no absolute mechanical necessity for giving a certain thickness to the plates

of the frame, but the pillar plate ought to be sufficiently thick to afford a safe hold for good strong screws, and to contain the pallet and escape wheel so as to be a trifle below the surface of the plate. The upper plate ought contain the centre wheel in its countersink flush with the inner surface of the plate; and, besides, a solid bearing for the upper pivot of the centre pinion should be left.

According to these necessities, it will be a good proportion to make the pillar plate of a three-quarter plate or skeleton movement 0.06 of its diameter. The upper plate ought to be about 0.035 of the same diameter. These proportions, of course, apply only to watches of a mean height (say 0.16, or about one-sixth of their diameter); a flat watch, having a weaker main-spring, and consequently less strain on the frame, and less pressure on the centre pinion, can bear a reduction of these thicknesses.

19. The material of which the frame is to be made is also worthy of consideration. A certain degree of elasticity and hardness are required for the purpose; besides it ought to offer the least frictional resistance to the movement of the pivots, and oppose the greatest durability to the wear resulting from this motion.

20. For this last reason steel is out of question here. Besides, it could not possibly be protected against rusting, and magnetism might endanger the rate of such a watch in a most serious way. Still, I will remark here, that I had an opportunity of observing for many years a good watch, constructed by a German maker before jewel holes were at convenient reach. He had, for obtaining greater durability, screwed steel bushings into the plates for all the pivots, the escapement included, and these steel holes, well hardened and polished, showed almost no wear at all after more than fifty years performance, and kept the oil remarkably well.

21. Brass answers fully all the requirements of a good watch frame, if by sufficient rolling or hammering it is brought to its greatest hardness and density. Hammering is preferable to rolling, if possible, because this latter process stretches the metal — an effect which is not sought for, and which, at the same time, does anything but improve he quality of the material. Small rollers stretch the material more than large ones. I have made a rather tedious series of experiments in order to find out the best way of obtaining the greatest possible density of brass. For this purpose I constructed a small tilt hammer of about 3 lbs. weight, striking five to six blows in a second, and adjustable to perfect parallelism with its anvil. I found that a strip of brass worked with it did not show the slightest increase in breadth and length—a proof that the considerable amount of mechanical work bestowed upon it had gone exclusively in the useful direction. By comparing I found a strip of 1 millim. thickness, reduced to 0.9 millim. by this vertical hammering, to equal in elasticity a strip of 3.0 millim. reduced by rolling to the same thickness. This latter was stretched out to $2\frac{1}{2}$ times its former length.

Thus it is clearly to be seen that the work done by the rollers is mostly expended in stretching the metal — and that only a small fraction of it serves the real purpose. This stretching is a source of great injury to the solidity of the metal, not only because it produces fissures at the edges of the strips, but also because it multiplies the size of the smallest defects (flaws or holes) in the metal to double and triple their size, while vertical compression will rather mend them. I could not continue my experiments on a larger scale, because this little tilt hammer was the maximum of what a man can drive with a foot-wheel, and I had no machine power at my disposal. But the result obtained led me to the conclusion that the method generally used for attaining the necessary density and elasticity of brass, is altogether wrong. I should prefer to stamp out the rough plates and other parts with punch and die from the common hard rolled sheet brass to be bought in any shop, allowing about 10 per cent. extra thickness for the reduction by the vertical blow. Then each part ought to be put on a flat anvil and submitted to the powerful blow of a falling block, adjusted exactly parallel to the face of the anvil. Such a method would offer another advantage, of making the two faces of the blank piece quite smooth and level, so that it would not require so much to be taken away as when prepared in the usual way.

22. The plates of English watches are, as a rule, very soft, owing o a bad practice of the gilders in exposing them to a high degree of heat ; I do not know for what reason, for it requires no proof that a very good gilding can be effected without heating at all. Their upper plates, too, are generally too thin, and especially with the screwed jewels, the screw heads of which are sunk into the plate ; they give very much trouble to the repairer, owing to the very small amount of stock left for the screw threads in that soft metal.

23. For some years there has been an increasing demand for the so-called *nickel movements*. These are made of *German silver*, and that incorrect denomination is derived from nickel, one of the chief constituents of this alloy. There can be no doubt that German silver is a first rate material for watch-work, from its elasticity and hardness, and I refer the reader for further particulars about this matter to the comparative experiments published in my "Essay on the Detached Lever Escapement," Chapter XIV. A nicely polished and grained German silver movement is certainly a handsome looking article, and its surface resists remarkably well all atmospheric influences, while brass needs to be protected by gilding. Still, when touched in a careless way with perspiring hands, it gets very ugly black stains, and in this particular it is inferior to gilt brass.

In all other points, German silver offers no advantage over brass ; and it must be said that it is very injurious to the eyes of those who have constantly to work at finishing those bright polished movements. Brass, at any rate, if well prepared, is so nearly equal in physical qualities to German silver, that the demand for this latter as a material for watch movements may be considered a mere matter of taste.

[In wishing our patrons a Happy New Year we take pleasure in presenting them with the first chapter of Mr. Grossmann's Essay, read before the Board of Trade of Geneva, and now for the first time published. It is unnecessary to say that it will be a work of great interest and benefit to the trade, as every intelligent horologist is already aware that no man now living is considered better authority in both practical and scientific horology then Mr. Grossmann. It is to be presumed that the majority of our readers are already familiar with his Treatise on the Lever Escapement, but such as are not we would advise that they at once procure a copy.

For the benefit of our foreign readers, we would state that in the American Watch Factories the parts are not interchangeable to that degree that might be inferred from Mr. Grossmann's remark, but that every escapement "is treated as an individual," to a certain extent, as are also the other parts requiring a fine adjustment. In the manufacture of arms it is possible to have the gauges so perfect that the parts are so nearly perfectly identical that a thousand muskets may be taken to pieces, and then the parts be taken promiscuously and put together again. The same results are obtained in the manufacture of sewing machines, and many other articles; but that will probably never be the case in the manufacture of fine watches.

We are under obligations for very many flattering and encouraging letters approving our course during the past (which modesty, as well as want of space, forbids publishing), and shall use our best endeavors to merit the good opinion of our friends in the future. In a private letter Mr. Grossmann remarks that he finds many valuable suggestions in the articles from the correspondents of the Journal, and we hope to be the recipient of still more favors from that source, as there are but few workmen that are not capable of giving information on some particular point.

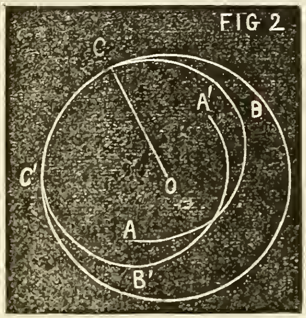
If there *are* any of our patrons who have forgotten to forward their subscriptions for the current volume, we would suggest that it would be acceptable as soon as the state of their finances will admit of it.]

ADJUSTMENTS TO POSITIONS, ISOCHRONISM AND COMPENSATION.

NUMBER THREE.

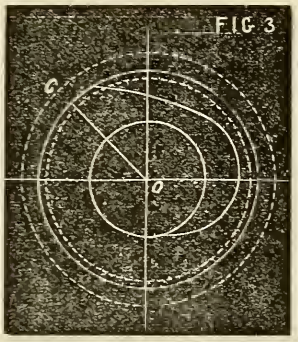
We will now examine under what circumstances and conditions we can look upon the difference $\frac{1}{\rho}-\frac{1}{\rho_0}$ as constant for the entire extent of the hair-spring.

Suppose, first, that the coils be equal and concentric circles, as is the case in the cylindrical hair-spring. Let A B C (Fig. 2) be the



curve which commences the hair-spring ; A being the end fastened, C the point of conjunction of the curve and the circle of the first coil, meeting it at a tangent. At the other extremity the hair-spring terminates by an equal and symmetrical curve, the end of which, A′, corresponds to A, and is fastened in the collet of the balance. Now the problem is this : see whether we can, for all the values, between which the angle a varies, deform the hair-spring according to the law $\frac{1}{\rho}-\frac{1}{\rho_0}=\frac{a}{L}$ in such a way that the conditions relative to its extremities be fulfilled—that is, that the point A and its tangent be invariable, and that its opposite A′ shall always be on the circle of the collet, meeting it at a given and constant angle. From this moment we may safely conclude that whatever may be the form of the terminal curves, the condition is very nearly fulfilled—since during the general deformation of the hair-spring, the point C is very little displaced, as also the normal C O, on which the centre of the first conference is placed; and since all the coils assume equal and concentric circles during the deformation, the point C′, where the curve C′ B′ A′ leaves the coil, will be very little off the primitive circumference of the coils; and the form of C′ B′ A′, having itself varied very little during the deformation, the extremity A′ will meet the circumference of the collet at very nearly the angle given. We are, then, safe to conclude that, in general practice, the pressure, the components of which are X and Y, is relatively very small, and as the coördinates of the centre of gravity are also generally infinitely small, the result is, that the quantity Yx_1-Xy_1 of the equation (3) is negligible in the presence of the power G; that consequently the isochronism is, if not perfect, at least very closely approximated, and that the duration of the oscillations of the balance are expressed in formula (8).

Up to this time, we have given pretty much a literal translation of the theory of Professor Phillips' work, because the preceding embraces all the fundamental principles upon which his subsequent reasoning is based, so that the student may be able to verify for himself the accuracy of the results; but we shall now deviate from this course, and endeavor to give the leading features of the work, in plainer language, at least where such a proceeding is possible. We have said, in the preceding article, that the theory of the isochronism is here based upon the principle that, during arcs of vibrations of the balance, of whatever extent, the centre of the coils of the hair-spring, as well as the centre of gravity of the same, shall always coincide with the centre of the axis of the balance. To accomplish this result, the hair-spring must be adjusted so that during its movements it will be deformed according to the law $\frac{1}{\rho}-\frac{1}{\rho_0}=\frac{a}{L}$, to establish which was the leading object of the preceding arguments. Now, if the reader has attentively followed the reasoning, he will understand that this expresses a proportionality between the angle of motion and the length of the hair-spring, which shall remain the same though the radii of the coils of the hair-spring vary during its deformation. The principle of this deformation (Fig. 3) will illustrate where the white circle represents the coils of the spring in their state of equilibrium, and the dotted ones the position of the same after the deformation has taken place—all concentring at the centre O, which is the centre also of the axis of the balance, and consequently also the centre of gravity of the spring. By a very difficult chain of reasoning, the author



of the work has discovered the means of causing the hair-spring to vibrate according to this law, and these means consist in certain fixed terminal curves, according to which the ends of the hair-spring must be shaped. We will not occupy ourselves with the translation of all the mathematical formulas and demonstrations evolved, but simply give the results of the reasoning, in plain English. As before stated, it is the object of the author to find the means of keeping the centre of gravity of the entire hair-spring on the centre of the axis of the balance, and that, during all angular motions of the balance; to effect this, the curves themselves must have their centre of gravity on the axis of the balance. The conditions of these curves are as follows:

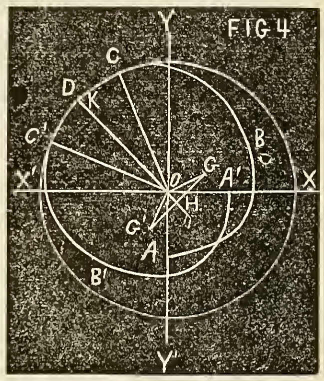
1st. The ends A A′ of the hair-spring (Fig. 4) must be fastened at half the radius of the primitive circles of the coils of the spring, and the curves must describe arcs of from 180° to 270° around the point O.

2d. The centre of gravity of each of the curves must be on the perpendicular D O, let fall through the centre O to the line C O (Fig. 5), (which will presently be explained).

3d. The distance of this centre of gravity of the curve to the centre of the coils must be equal to $\frac{\rho_0^2}{l}$; ρ_0^2 being the square of the radius of the primitive circle of the coils and l the length of the curve; that is, it must be equal to a third proportional to the radius of the coils and the length of the curve.

These properties, the author goes on to say, not only fulfil the conditions of the centre of gravity above expressed, but it also happens that by reason of these same curves, the term neglected in the second member of equation (3) becomes, if it may be so expressed, a quantity infinitely small of the second order, on the one side because the components X and Y are infinitely small, and further because the same is true with respect to the coördinates of the centre of gravity of the hair-spring.

To show that the centre of gravity of these curves coincides with the centre of the coils, let ABC (Fig. 4) represent one of the curves,



of which A is the end fastened, and let A′B′C′ represent the other curve, of which the end A′ is fastened in the collet. The figure supposes the state of the hair-spring as it is before any deformation takes place. Let COC′=β, β being any angle whatever. We can look upon the hair-spring as forming two distinct parts: the first composed of any whole number of coils commencing and ending at the point C, the centre of gravity of which is in O ; the second, comprising the two curves and the arc CDC′, the centre of gravity of which we wish to seek. Now, if G and G′ are respectively the centres of gravity of the two terminal curves, which are, as we know, equal and symetrical, the centre of gravity of the two is at the point H, in the middle of the line GG′. Moreover, if the angles COG and C′OG′ are right angles, the line OH, bisecting GOG′, prolongated to D, also bisects COC′, and passes consequently through the centre of gravity K, of the arc CDC′, from which it follows that the angle OGH is equal to the angle COK, or to $\frac{1}{2}\beta$. If now, we call M the weight of the two terminal curves with respect to the point O, and M′ that of the arc CDC′, with respect to the same point we have :

$$M = 2l \times OH = 2l \times OG \sin \tfrac{1}{2}\beta$$

or, $$M = 2\rho_0^2 \sin \tfrac{1}{2}\beta.$$

On the other side, by virtue of the law which gives the centre of gravity of an arc of a circle, we have :

$$M' = \rho_0^2 \times \text{corde } CC'$$

or, $$M' = 2\rho_0^2 \sin \tfrac{1}{2}\beta,$$

from which results that

$$M = M'$$

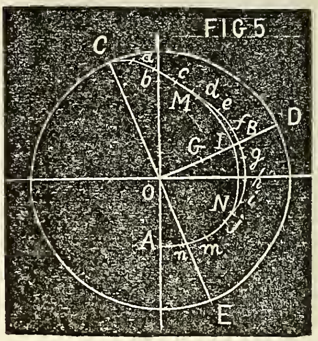
and that consequently the centre of gravity of the two terminal curves together, and that of the arc C D C′, is at the point O, which is also the centre of gravity of the entire spring. It is to be remarked that this consequence is independent of the magnitude of the angle β, or of the interval which separates the points C and C′.

The author further proves that this coincidence of the centres of gravity takes place not only in the primitive state of the hair-spring, but that it is also a consequence of the invariability of the centre of gravity of the coils, whatever may be the extent of the angle of rotation of the balance. Thus the terminal curves, indicated by this theory, produce the isochronism by satisfying the two conditions, to annul all pressure against the axis of the balance, and to place the centre of gravity of the entire hair-spring on this axis, and that, too—which is important to be mentioned—whatever may be the relative positions of the two curves, one above the other.

Moreover, they also possess the properties of causing certain perturbations to disappear, which are detrimental to the isochronism or its preservation; they thus realize the free hair-spring, that from which the balance suffers no pressure, and by which the friction and its variability, on account of the thickening of the oil, is reduced to its minimum.

All the preceding properties of the curves subsist, whatever may be the angular space which, in the construction of the spring, separate its two ends. There is in this angle, or what is the same thing, in the total length of the hair-spring, an element by means of which we may reach the closest possible approximation to isochronism, by making it longer or shorter.

In tracing these curves graphically, the author proceeds in the following way: he supposes that the point A (Fig. 5) at which the end of the curve is to be fastened be at half the radius of the primitive circle of the coils and that the point C, where the curve is to



leave the coils, be fixed at any angle of between 180° to 270° of arc from A around the centre O. Draw radius O C, and another O D, perpendicular to the first. (The drawing must be made on an enlarged scale; the most convenient may be twenty or thirty times the real size of the hair-spring.)

Now, a curve is to be found which shall have its centre of gravity on this last line O D. To this effect we may trace a first curve A B C, approximately correct, but meeting the coils at C at a tangent; we then divide this curve into equal parts, ten or twelve, for example, *Ca, ab, bc, cd*, etc., the last of which, An, shall be the only one generally a little smaller than the others. We then mark the centre of gravity of each of these parts, considering them as small straight lines, or, as the case may be, as small arcs of a circle; we then measure the distances of each of these centres of gravity from the line O D, modifying the one relative to An by multiplying it by the ratio of An to the common length of all the other arcs. With this modification, it is to happen that the sum of the distances of the centres of gravity which are on one side of O D shall be equal to the sum of the distances of those on the other side of O D. If this condition is not fulfilled, it will be easy to modify one or the other portion of the curve in such a manner as to arrive at the desired result. This first point established, we have yet to satisfy the second condition, viz., that the distance O G of the centre of gravity to the centre of the coils be equal to $\frac{\rho_0^2}{l}$, ρ_0 being the radius of the coils, and l the length of the curve A B C. Now in order to obtain the distance of the centre of gravity of the curve from the centre O, we measure the distances of the centres of gravity of all the little arcs *Ca*, *ab*, *bc*, etc., from the line C O E, again modifying the one in relation to A*n* by multiplying it by the ratio of A*n* to the lengths of the other little arcs. We then take the algebraical sum of all these distances, regarding as positive those which are on the right of C E, *i. e.*, on the same side as B, and as negative those which are on the other side; we then multiply this sum by the length common to the elements *Ca*, *ab*, *bc*, etc., and divide the product by the length of the curve A B C. The quotient, which will give the distance O G, shall then be equal to $\frac{\rho_0^2}{l}$. Should this equality not take place, it will be easy to modify the curve in such a manner as to arrive at it, all the while satisfying the first condition.

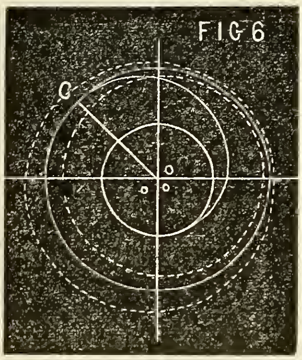
In fact, suppose, in order to fix this idea in the student's mind, that the distance O G thus obtained be greater than $\frac{\rho_0^2}{l}$, we can take on one side and the other of the point B two arcs B M and B N, such that their centre of gravity be on O D, which could be easily verified, and substitute for the arc M B N an interior one M I N, the centre of gravity of which is also on O D, but the sum of the distances of which from the line C E will be evidently less. It is clear that in this way we would very soon arrive at the desired results. We can next reduce the curve to its real size by a like curve traced around the centre of the coils.

As for the flat hair-spring the preceding laws cannot be established except, as we have already mentioned, for very small vibrations of the balance, since it is evident that it cannot be constructed so, that during angular motions of the balance of whatever extent, the centre of gravity of the spring shall remain on the centre of the axis of the balance. If the laws of the theory of Prof. Phillips are true, and they are unquestionably proved to be so, any attempt at obtaining isochronism in the flat hair-spring would seem to be a vain waste of time and talents, and indeed most of the theories advanced on this subject by workmen are mere blind ideas, utterly undemonstrable on the ground of any rule or law.

Different is it with those flat springs the outside coil of which is brought back again nearer the centre, called Breguet springs. In these all the laws applicable to the cylindrical ones can be established; indeed the author proves abundantly that it is in no respect inferior to the cylindrical spring, provided the coil brought back again to the centre be curved so as to fulfil the conditions established with respect to the centre of gravity of the curve. In addition to this, it is of the greatest importance that the flat spring, called "Breguet spring," should be as long as possible and coiled very closely, for then it will deform itself less during the vibrations of the balance, open and shut more concentrically to the axis, and therefore tend less to press the pivots of the balance against the sides of the holes; this is otherwise well known, and the necessity of it abundantly proved by all writers on the subject.

Retrospect.—We have seen by equation (4) that the power necessary to hold the balance in equilibrium against the action of the hair-spring is proportionate to the angle which the balance has described;—we shall add to this a number of tables of experiments by which the author has abundantly proved this relation—and we have in this equation the amount G expressed in the amount of elasticity of the hair-spring, from which it results that the angle of motion of the balance is always proportionate to the length and elasticity of the hair-spring, or *vice versa.* Directly from these principles, and introducing the amount of inertia A of the balance, formula (8) has been deduced expressing the duration of the oscillations of the balance, which is here shown to be proportionate to the square root of the length of the hair-spring;—a table of experiments of the author's will be added, showing the manner in which these durations of the oscillations vary with the length of the springs. In order to make these vibrations of the balance isochronal, it has been shown necessary that the hair-spring during its motions be deformed according to the law $\frac{1}{\rho}-\frac{1}{\rho_0}=\frac{\alpha}{L}$, which law we have illustrated by

Fig. 3; for an illustration of the non-existence of this law in the hair-spring and its consequences, we add Fig. 6, where the white circle again indicates the coils of the spring in their primitive position, but where the



radii of the circles of the coils vary unequally according to the angle of motion, and with respect to the centre of the axis of the balance, as represented by the dotted circles. The means of establishing this law in the spring the author has discovered in certain terminal curves, the conditions and finding of which are shown and illustrated by Figs. 4 and 5.

It would be impossible to prove to the uninitiated all the reasons, the whys and the wherefores of these results, so that they should be able to grasp it ; to do this it would be necessary to teach them all the branches of mathematical science, the highest not excepted; but it is to be hoped that those at least who are desirous of learning to work correctly and according to sound principles will be benefited, inasmuch as it will stimulate them to research. We may mention that a complete translation of the entire work of Prof. Phillips on the hair-spring, combined with explanations and references, is proposed by the writer of this, should it be found likely to recompense him for the cost and labor. Those who would think it of sufficient interest to possess such a work may indicate it to the editor of the Journal.

The following tables contain experiments made with a view to test the influence of theoretical curves as to the isochronism of the vibrations. In these experiments an elastic balance has been used weighing nearly one milligramme, by means of which the force necessary to maintain the balance at certain angles from its primitive position of equilibrium, has been measured, and the law of the proportionality between force and the angle of motion tested and proved. The tables will explain themselves.

First Experiment.—Hair-spring with theoretically curved extremes, but having only 7¼ coils.

Angles.	Force in Grammes.	Loss of Angle by permanent Deformation.	Force reduced to 22½° by the proportion of the angles.
Degrees.	Grammes.	Degrees.	Grammes.
22½	1 542	0.	1.542
45	3.084	0.	1.542
67½	4.620	0 1	1.5423
90	6 150	0.166	1.5404
135	9.222	0.2	1.5393
180	12.305	0.26	1.5404
225	15.360	0.35	1.5384
270	18.440	0.6	1.5401

It may be seen by the fourth column that the proportionality is as nearly perfect as possible, and yet it must be remembered that the spring had but 7¼ coils, and that there was some slight friction.

The second experiment has been made with a spring a little longer but having extreme curves made far from combining any theoretical conditions.

Second Experiment.—Spring with 8 coils, curves not theoretical.

Angles.	Force in Grammes.	Loss of Angle by permanent deformation.	Force reduced to the Proportion of 22½°.
Degrees.	Grammes.	Degreess.	Gramms.
22½	1 500	0.	1.500
45	2 983	0.	1.4915
67½	4 461	0.	1.4870
90	5.930	0.5	1.4833
135	8 875	0.15	1.4808
180	11.815	0.20	1.4823
225	14 807	0.27	1.4825
270	17.820	0.50	1.4878

It will suffice to compare the 4th column of this table with the preceding experiment to see at once that the law of the proportionality is much less perfect in this.

The next two experiments were made with hair-springs of but 4 coils, made of steel which was not very homogeneous. The terminal curves of one were made theoretically, those of the other not.

Third Experiment.—Spring with 4 coils—

steel not very homogeneous—with theoretically made curves.

Angles.	Force in Grammes.	Loss of Angle by permanent Deformation.	Force reduced to the Proportion of 22½°.
Degrees.	Grammes.	Degrees.	Grammes.
22½	1.542	0.3	1.5628
45	3.092	0.4	1.5600
90	6.215	0.5	1 5624
180	12.472	0.6	1 5642
270	18.581	2.2	1.5611

We see that the proportionality is yet very nearly perfect.

Fourth Experiment.—Spring with 4 coils—steel not very homogeneous—with terminal curves not made theoretically.

Angles.	Force in Grammes.	Loss of Angle by permanent Deformation.	Force reduced to the Proportion of 22½°.
Degrces.	Grammes.	Degrces.	Grammes.
22½	1.569	0.1	1.5760
45	3.150	0.2	1 5820
90	6 271	0.4	1 5747
180	12.475	0.6	1.5646
270	18.780	0.9	1.5703

We see that notwithstanding the bad quality of steel, and the small number of coils, the preceding spring gives very nearly the proportionality, while the last one is very far from doing so.

The following four experiments were made with the hair-springs of the first and the second experiments ; but they are interesting in as much as, the friction having been diminished, the spring with theoretical curves still showed great advantage over the other.

Fifth Experiment.—Spring of the first experiment with theoretical curves, with the friction of the balance diminished.

Angles.	Force in Grammes.	Loss of Angle by permanent Deformation.	Force reduced to the proportion of 22½°.
Degrees.	Grammes.	Degrees.	Grammes.
22½	1.538	0	1.5380
45	3.076	0	5380
67½	4.611	0.05	1 5381
90	6.132	0.25	1.5375
135	9.219	0.17	1.5384
180	12.286	0 40	1 5390
225	15.366	0.37	1.5390
270	18.470	0.45	1.5387

We see that the proportionality is very close.

Sixth Experiment.—Spring of the second experiment—curves not theoretical—but with the balance of the fifth experiment.

Angles.	Force in Grammes.	Loss of Angle by Permanent Deformation.	Force reduced to the proportion of 22½°.
Degrees.	Grammes.	Degrees.	Grammes.
22½	1 500	0.	1.5000
45	3 002	0 05	1 5027
67½	4.489	0.	1.4963
90	5.967	0.05	1.4926
135	8 938	0 05	1 4902
180	11.906	0 125	1.4893
225	14 866	0.23	1 4881
270	17.872	0.25	1.4907

We see the proportionality is much less approximated here, than in the preceding experiment.

Seventh Experiment.—Spring of the first experiment—theoretical curves—but with a smaller balance, and the friction very much reduced.

Angles.	Force in Grammes.	Loss of Angle by permanent Deformation.	Force reduced to the proportion of 22½°
Degrees.	Grammes.	Degrees.	Grammes.
22½	1 565	0	1.5650
45	3 130	0	1.5650
67½	4.692	0.05	1.5651
90	6.261	0	1 5652
135	9.381	0.143	1.5652
180	12 500	0.333	1.5654
225	15 640	0.10	1.5647
270	18.757	0.20	1 5643

Eighth Experiment.—Spring of the second experiment—curves not theoretical—but with the balance of the seventh experiment.

Angles.	Force.	Loss of Angle by permanent Deformation.	Force reduced to the proportion of 22½°.
Degrees.	Grammes.	Degrees.	Grammes.
22½	1 507	0 05	1.5103
45	3.024	0.10	1.5153
67½	4 538	0.10	1.5149
90	6.055	0.143	1.5161
135	9.073	0 25	1.5150
180	12.106	0.333	1.5160
225	15.146	0 5	1.5180
270	18.198	0.5	1.5193

We see that the spring of the seventh experiment has still considerable advantage over that of the eighth.

It has been shown that the duration of the oscillations of the balance is proportionate to the square root of the length of the hair-spring. The following table will permit us to see at once the manner in which the duration varies with the length of the hair-spring.

Table showing the proportion of the number of vibrations of the balance in a given time, to the different lengths of a hair-spring.

Proportion of the lengths of a hair-spring.	Proportion of the number of vibrations of the balance in a given time.	Proportion of the lengths of a hair-spring.	Proportion of the number of vibrations of the balance in a given time.
0.99	1.0050	0.59	1.3019
0.98	1.0101	0.58	1.3133
0.97	1.0153	0.57	1.3245
0.96	1.0206	0.56	1.3363
0.95	1.0260	0 55	1.3484
0.94	1.0314	0.54	1.3608
0.93	1.0370	0.53	1.3736
0.92	1.0426	0.52	1.3867
0.91	1.0483	0.51	1.4003
0.90	1.0541	0.50	1.4142
0.89	1.0600	0.49	1.4286
0.88	1.0660	0.48	1.4434
0 87	1.0721	0.47	1.4587
0.86	1.0783	0.46	1.4744
0.85	1 0846	0 45	1.4907
0.84	1.0911	0.44	1 5076
0.83	1 0977	0.43	1.5250
0.82	1.1043	0.42	1.5430
0.81	1.1111	0 41	1.5618
0.80	1.1180	0.40	1.5811
0.79	1 1251	0.39	1.6013
0.78	1.1323	0.38	1.6222
0.77	1.1396	0.37	1.6440
0.76	1.1471	0.36	1.6667
0.75	1.1547	0.35	1.6903
0.74	1.1625	0 34	1 7150
0.73	1.1704	0.33	1 7408
0.72	1.1785	0.32	1.7677
0.71	1 1868	0.31	1.7960
0.70	1.1952	0.30	1 8257
0.69	1.2038	0.29	1 8570
0 68	1.2127	0.28	1.8898
0.67	1 2217	0.27	1 9245
0.66	1.2309	0.26	1.9612
0.65	1.2403	0.25	2.0000
0.64	1.2500	0.24	2.0412
0.63	1.2599	0.23	2 0851
0 62	1.2700	0 22	2.1320
0.61	1.2803	0.21	2.1822
0.60	1.2910	0.20	2.2361

HOROLOGIST.

———o———

ENGRAVING ON JEWELRY AND PLATE.

For lettering upon jewelry and plate it is necessary to have thirty or forty gravers—several being required similar in shape to those used by engravers on wood or steel. These tools are straight on the bottom, the width making the different degrees of fineness; but for gold or silver ware that is hollowed the straight tool cannot be used; it is necessary that the points of the gravers turn upwards. In several tools the points may be turned up sufficiently by grinding the tool on an oil-stone, but in others the tool is bent upwards, as much as required, before it is hardened—the face being made as in other gravers. By "face," we mean the end of the tool that is ground on the oil-stone to sharpen it. An oil-stone for sharpening tools is, of course, essential, and must be of fine quality, and sweet oil is the best for using on it.

A stand, with an arm to hold a magnifying glass, is required; the arm having a joint in it, with a screw, which permits the glass to be placed on any required plane. Pads or cushions of several sizes are required—some being little more than two inches across—and are used singly or together, one on top of another. They are also stuffed to different degrees of hardness; some being so soft that the article to be engraved may be indented into it.

To hold the various articles in place, several small adjuncts are necessary. For holding knives, spoons, etc., small clamps are required; these are made of wood, and are about four inches high, and at the top about two inches in diameter—one diameter, however, being greater than the other—the shape of the top being a flattened circle. This clamp is divided in halves, slightly hollowed inside, and joined together by a hinge at the bottom. At the opening on the top the wood is grooved to make a rest for the fork, spoon, or other article to which it may be applied. The top, with its groove, is capped with brass, and narrow slips of leather or metal are laid into the groove, according to the thickness of the plate placed in it—it being essential that the surface to be engraved shall be level with the top of the clamp.

Half way from the bottom to the top a screw permits the top to be opened to the proper width for the article to be placed in the rest, and holding it firmly while being engraved. When rings are engraved on the outside, they are slipped on smooth sticks, which are tapered to fit different sizes of rings. To engrave inside, the engraver holds the ring in his fingers, resting it on the cushion. Napkin rings, pencils, heads of canes, cardcases, etc., are also held by the fingers. To hold a thin plate of metal in place blocks of wood are used, small tacks at the edges of the plate keeping it in place. A steel burnisher is required by the silver engraver, also a set of mathematical drawing tools, and hones, covered with buff leather, to remove the finger marks from the surface of the metal.

To prepare an article for engraving, the engraver dims the surface with candle grease, which he applies with his fingers, a very slight quantity being sufficient.

To rule straight lines on a flat surface, a small, thin steel rule is used. This is rectangular in shape, with a rectangular opening, leaving on one side and the ends a third of an inch of metal; on the other side two-thirds of an inch is left. To rule lines on a circular surface, as for instance a cup, or round napkin ring, a pencil-holder is fastened at right angles to a short rod of steel, which the engraver holds between his fingers at the edge of the article, and turning it carefully makes his lines parallel with the top. We have seen a rod which was adjusted with a flexible joint and screw, which enabled the engraver to set his pencil at whatever angle he might require for the article on which he was at work. This is especially serviceable for the inside of silver ware, such as a cake basket. The "pencil" used is made of boxwood, pointed, and although its point will trace lines on the dimmed surface, it will not scratch the metal. Formerly steel points were used, and where the lines traced were guide lines, it was necessary, after the lettering was done, to remove them with the burnisher. The boxwood point, it may be seen, is a great improvement.

The engraver also uses these boxwood pencils to sketch out the letters he desires to engrave; then, according to the shape of the article, he selects a suitable graver for the lettering. When requisite that a set of spoons, knives, etc., shall be marked alike, one article is engraved with the letters selected; after which the surface is spread with a coat of candle grease, which is carefully filled into the lettering, and the superfluous grease is removed from the face of the article, leaving the letters filled. A piece of dampened woven letter paper is then laid over the lettering, and, with a burnisher, an impression of the edge of the article is rubbed on the paper, which serves for a guide to place the paper on every article in the same position. A second piece of paper is laid on, and the burnisher is rubbed over the lettering till an impression in grease is printed on the paper. This impression is now ready to trace upon the gold or silver as many copies as are required. At first a slight pressure with the fingers is sufficient to make a trace upon the surface of the metal; afterwards the burnisher is required. One of these impressions will usually trace two dozen articles. The proper gravers are selected, and the letters cut in this tracing—the hair lines and the broad lines being cut at different degrees of depth. It is usual to prepare in the copy from which the tracing is made only the body of the letter; the ornamental dots and points being added to each duplicate by the engraver—eye-practice giving him precision in this respect. After the article is engraved it is wiped clean with chamois skin, no trace of the grease remaining.

Shades and screens for the protecting of the eyes are adjusted according to the exigencies of the place in which the engraver is obliged to work; it being generally conceded that a north exposure gives a clearer, steadier light than any other, but shades may be adjusted so that any exposure may be used. The rule should be, to have sufficient light on the work to see well, but a glare should be avoided. It is important that the light fall on the work and the eyes be shaded. Attention in this respect will enable the engraver to see better, and not wear out his eyes.

In ornamental engraving many of the tools used are similar to those used by letter engravers on steel, or flat silver surfaces; technically, by the ornamental engraver, they are called "line gravers." But to perform most of the ornamental engraving tools are required with fine lines cut into the bottom of the tool, and when held steadily on the plate a series of fine lines are cut, known as shading. Some of these tools make only two lines, and others make three, four, five, or six; they are generally straight on the bottom, and, in engraving, the hand is held high, so that the point of the tool touches the plate, the left hand moving it as the design requires. At present the ornamentation in vogue is called "bright work," and is produced by holding the tool as aforesaid, and wriggling it in short, rapid turns, the left hand turning the article. When this wriggling is done rapidly the wave effect produced on the lines cut is almost imperceptible to the naked eye. The lines made by this method are so delicate that the light falls on them in such a manner that it makes the design look white on the tinted back-ground of gold or silver, and a large variety of ornamental leaves, scrolls, etc., may be executed with these tools.

For figures, animals, scrolls in outline, etc., the line gravers are best adapted. Many designs employ the several kinds of tools, which are sharpened on an oil-stone, the same as other gravers, but for "bright work" it is necessary that they be polished upon a block of wood covered with rouge and oil, which imparts a polish to the tool that enables the engraver to cut his work with great brilliancy and beauty of effect. The ornamental engraver preserves proofs of his works on paper, the same as steel-plate engravers, which are used to trace the design again when required.

An original design is drawn on paper, which is then perforated with a fine needle and laid upon the article to be engraved; pumice powder is then beat upon the paper, the design being traced on the plate in fine dots. To preserve a *fac-simile* of the engraving on a flat surface, printers' ink is rubbed into the lines, the surface being wiped clean in the same manner that a steel plate is prepared for printing; but a silver salver or cake basket cannot be made to pass through a printing press; so, to get an impression from them, some plaster of Paris is wet with water to the consistency of batter and poured over the whole article. It is allowed to become set and dry, and being then removed from the silver ware, a perfect representation, in black, of the design is printed on a white surface.

This department of ornamental engraving sometimes is classed under the head of enchasing, but is properly called engraving, because the tools and manipulation are those of the engraver, rather than of the enchaser.

METALS.

It may be somewhat of interest to part of our readers, and possibly of advantage to others, to know something of the various metals in existence. A volume would not suffice to give the history, properties, modifications, and known relations of them all, and we can give space to no more than a meagre outline.

Of all the elementary substances—that is, substances whose constituent parts (if they are not simples) have not yet been resolved—the metals form far the most numerous class, and their importance in the useful arts is equal to their extent. They are diffused universally and very equally through the earth's crust; some are rare, others are extremely abundant; some of the most importance in the metallic state, others in combination with oxygen, sulphur, phosphorus, or whatever else. Their properties are so numerous that we must refer to a few of them only, under their respective heads. There are certain properties in which all metals agree; they all have metallic lustre; they are all good conductors of heat and electricity, and are electro-positive; that is, when a metallic compound is decomposed by the electric current, the metal is given off at the cathode or negative pole.

The most striking property of the metals is their lustre, which serves to distinguish them from the non-metallic elements. This lustre is evident, whether the metals be in masses or in fragments; even when in fine dust it can be made evident by means of an agate burnisher. The lustre seems to depend on the opacity of the metals, and on the facility with which they take a polish, more or less perfect; hence they are adapted eminently to reflect light, since their opacity prevents the transmission, and their polish the absorption of luminous rays. There are, however, a few exceptions to the perfect opacity of metals, for gold leaf transmits green rays, and leaf of the alloy of gold and silver transmits blue rays.

The colors of the metals are various. Copper and titanium are red, bismuth is pinkish, gold is yellow, and all the others possess a certain degree of uniformity, ranging from the pure white of silver to the bluish-grey tint of lead. The metals differ so much in their densities that while potassium is lighter than water, platinum is twenty-one times heavier than that fluid.

The following table gives the specific gravities of the more common and well known metals :

Platinum	20.98	Iron	7.79
Gold	19.26	Molybdenum	7.40
Tungsten	17.60	Tin	7.29
Mercury	13.57	Zinc	6.86+
Palladium	11.30+	Manganese	6 85
Lead	11.35	Antimony	6.70
Silver	10 47	Tellurium	6 11
Bismuth	9.82	Arsenic	5.88
Uranium	9.00	Titanium	5 30
Copper	8.89	Aluminium	2.00
Cadmium	8.60	Magnesium	1.70
Cobalt	8.54	Sodium	0.972
Nickel	8.28	Potassium	0.865

All these metals differ in hardness as much as they differ in density; for while some are very hard, others can be scratched by the thumb-nail, or even moulded, like wax, between the fingers. The following table shows the relative degrees of hardness of some of them :

Titanium, Manganese—harder than steel.

Platinum, Palladium, Copper, Gold, Silver, Tellurium, Bismuth, Cadmium, Tin—scratched by Calc. spar.

Chromium, Rhodium—scratch glass.

Nickel, Cobalt, Iron, Antimony, Zinc—scratched by glass.

Lead—scratched by the nail.

Potassium, Sodium—soft as wax.

Mercury—liquid at ordinary temperature.

All the metals are supposed to have the property of assuming the crystalline form; but it is not always easy to place them under conditions favorable to their doing so. Many of them occur in nature, in what is called the native state, in a crystalline form, particularly gold, silver, copper, and bismuth ; some crystallize when reduced to a fluid state and allowed to cool slowly. When a solid crust has formed on the surface, if the fluid metal be poured out from within, the interior of the crust will be found lined with crystals. Crystals of antimony, lead, and tin, may be obtained in this way, but not so easily as with bismuth—larger masses of metal and slower cooling being required. In iron foundries crystals of that metal have been found in the midst of large masses, which have been allowed to cool slowly.

Some metals are precipitated in a crystalline form from a solution of their salts by another metal; a strip of zinc, in a solution of acetate of lead, precipitates the lead in feathery crystals; silver is thus deposited by mercury, and gold from an ethereal solution by a stick of phosphorus. Electric currents of feeble intensity produce crystals from metallic solutions, and it may be owing to this action within the earth's crust, that many of the metals are found in a native crystaline form.

Metals are more or less valuable in the arts in proportion to their ductility and malleability, which permits them to be drawn into wire, and beaten or pressed into thin leaves. The following list is arranged in the order of malleability:

Gold,	Zinc,
Silver,	Iron,
Copper,	Nickel,
Tin,	Palladium,
Cadmium,	Potassium,
Platinum,	Sodium.
Lead,	

The ductility of the metals does not follow the order of their malleability, as the following table will show:

Gold,	Zinc,
Silver,	Tin,
Platinum,	Lead,
Iron,	Palladium,
Nickel,	Cadmium.
Copper,	

The ductility of metals depends upon their tenacity, or power of resisting the tension necessary to apply to them in forcing them through the holes of the draw plate, which is simply applying sufficient force to cause the particles of metal to *flow* in front of the plate, as has been shown clearly in one of the earlier numbers of the JOURNAL.

Silver can be drawn into wire $\frac{1}{500}$ of an inch in diameter, and by enveloping an ingot of gold with silver previous to drawing, a single grain of gold may be drawn into a wire 550 feet long; this wire is covered with silver, which may be removed by dilute nitric acid, leaving the enclosed gold wire only the $\frac{1}{5000}$ of an inch in diameter. Platinum has been drawn in this manner to the $\frac{1}{30000}$ of an inch in diameter.

The tenacity of metals is the power which they possess of resisting tension without breaking. It varies with the different metals, and the following table will show their relative tenacity as compared among themselves. The following weights are sustained by wires 0.787 of a line in diameter.

Iron	249.250 lbs.	Gold	150.753 lbs.
Copper	302.278 "	Zinc	109.540 "
Platinum	274.320 "	Tin	34.630 "
Silver	187.237 "	Lead	27.621 "

The tenacity varies greatly in the same metal, with its purity and its method of preparation, it being much diminished by annealing. A soft iron wire which sustained a weight of 26 lbs., after annealing broke with a weight of only 12 lbs., and one of copper which sustained 22 lbs. before annealing, was broken by 9 lbs. after being annealed. The process of annealing seems to have removed the particles to a greater distance from each other, thus diminishing the cohesive attraction between the particles by just so much as the annealing has separated them.

The conducting powers of the metals are as various as their other qualities, and their examination properly comes in the series of articles on heat which we are now publishing, as does also their fusibility. Some of the metals, if slightly elevated in temperature, particularly by friction, evolve an odor which is quite perceptible to sensitive organs of smell. We have known persons who could detect a plated article by the frictional odor of the enclosed base metal.

Copper, iron, and tin are especially noticeable for this quality of odor, and also for their metallic *taste*.

The harder metals are also elastic, and consequently more or less sonorous, but these qualities are more conspicuous in alloys which are formed by certain combinations of metals with each other. This subject of the alloy of metals is one of the most important of their properties, and in its ramifications and uses embraces every department of art; and is, in fact, as fascinating to some minds as the subject of perpetual motion to others. We do think, and must say, that it is one of the branches of metallurgy, which has been too much and too long neglected; a few dozen metallic alloys are all that science (or accident) has contributed to the useful arts, while the chemical metallic combinations are numbered by thousands. Modern science is yearly adding to the list of known metals, but how few useful combinations of them are ever heard of. Were one-tenth of the thought, labor, and money spent upon alloys, that is spent upon *useless* mechanical invention, we doubt not but that very surprising and useful results would be brought to light. No scientific reasoning on the resultant of the combination of two metals, can prove truthful; nothing short of actual experiment can be relied upon. Who would have dreamed that the combination of two metals as soft as tin and copper, would produce so hard a compound as speculum metal? And it is as surprising that the sweet and limpid glycerine, combined with nitric acid, should form that truly fearful combination—*Nitro-glycerine.* We hope to see the day when the combinations of metals with metals shall be as fully developed as are now their combinations with the non-metallic elements. We shall hereafter speak further on this subject of alloys.

The combinations of the simple metals with the non-metallic simples, form the basis of compounds which are infinite, and in most of these combinations the metallic characteristics are lost sight of. In all the oxides, chlorides, sulphides, etc., etc., the metallic peculiarities disappear, and with many of the compounds the highest chemical skill is required to eliminate the metallic base. It is this tenacity with which they cling to their affinities that renders their separation so difficult; and it is only by the persevering skill of the chemist that the new metals are being slowly but constantly divorced from their firm attachments.

—o—

☞ Good oil is essential to the correct performance of a watch, and parties using Kelley's oil will require to exercise caution in its purchase, as a spurious article has been thrown on the market.

TRAVELLING OPTICIANS.

EDITOR HOROLOGICAL JOURNAL:

There is no profession or branch of trade that can claim freedom from charlatans and impostors, and outside of the medical profession I know of none that feel the baneful influence of these unprincipled scoundrels more than do the jewellers and opticians. It is not to be supposed that charlatanry can be put down as long as unprincipled men and a gullible public exist; but if those who can, will exert themselves in the proper direction when the occasion offers, they can most effectually bring some of these impostors to grief. I wish to direct the attention of your readers to a class of men who travel about the country calling themselves "Opticians." As nearly every watchmaker or jeweller who has a store keeps spectacles, even if he is not a regular optician, they will undoubtedly be interested in this subject to a greater or less extent. I will first state that it is a well established fact that no physician of character or standing in his profession, or the community in which he lives, ever travels about the country seeking patients; the moment that he does so, he proves his incapacity to do what he claims that he can and will do. If any one of these travelling doctors could do what they *say* they can do, instead of seeking patients first in one place then another, they would have a thousand times more than they could attend to even if they were located on the top of one of the Rocky Mountains. Now, the science of medicine and that of optics are closely allied, and all these opticians claim to cure diseases of the eye; *i. e.*, they are oculists as well as opticians, or as some of them advertise themselves "Optical Oculists." And the remarks that I have made about travelling physicians are equally applicable to travelling "Oculists."

An Oculist is one who understands the anatomy of the eye, can determine the character of any abnormal condition of the same, either congenital or that caused by accident or disease, and can cure such cases as are curable, or devise means to counteract some of these abnormal conditions to a greater or less extent. An Optician is one who makes or sells optical goods, and who ought to have a pretty thorough knowledge of the science of optics, especially if he expects to succeed in his business, or do justice to his customers. Of course an oculist must fully understand the science of optics, the laws of the refraction and reflection of light. Now, every man who keeps spectacles for sale ought to know something about optics, so as to be able to select such glasses as are suitable, and of the proper focus, for the great majority of his customers; for very few men can select the proper glasses for themselves without the aid of some one who is competent to assist them. Now, if every watchmaker throughout the country would only inform himself on this subject, he would not only be able to do justice to his customers, but could protect them from the travelling so-called opticians. I have never yet heard of a single travelling optician who was anything but a humbug. They are usually men who have a great deal of assurance, and are what are called "sharp fellows." They make use of a great many high-sounding words, talk very learnedly about the peculiarities of the eye, and create the impression upon the minds of those who are ignorant of the subject that this particular "Professor" is the only man in the world, or at least the only one that *travels* (they all denounce each other as humbugs) who is qualified to select spectacles for the afflicted, and in fact the only man who has spectacles that are fit to be worn, which are "adjusted to the eye upon principles entirely his own, which have never been known to fail." They usually claim to have factories in Europe, or are professors in some eye hospital, or something of the kind, and all claim to make their own spectacles; and it seems the more and bigger lies they can tell, the more readily they are believed.

I have never yet failed to run these chaps off when they have come into my section. As soon as one of these "Professors" arrives he usually advertises very extensively. I do the same, and state that I will test spectacles for anybody free of charge (as the spectacles sold by these fellows, are nearly always sold for pebbles, and are in reality nothing but glass). I also give the price of pebble and other spectacles in steel, silver, and gold frames—what they are sold for by resident opticians, etc. I make my advertisement as conspicuous as the "celebrated opticians," and tell nothing but the truth, and put in plenty of local. They cannot stand exposure, and if the attention of the public is only called to these chaps, by some one who can show them up, their occupation is gone in that place. Every one of these men that I have exposed, has threatened to whip me (so I have been told); but they never tried it on.

The smartest and sharpest travelling optician that I ever saw paid us a visit not long ago. He came with four or five large trunks, and a very large stock of spectacles, and gave out that he would remain a month. That was the length of time he staid in each place that he visited, and he would usually take in from $2,000 to $6,000 in that short time. As he charged from $10.00 to $15.00 a pair for steel frame spectacles, and $30.00 a pair for gold frames, the profits can be easily calculated. He secured the parlor of the hotel for his show and salesroom, displayed his goods to the best advantage, had some large pieces of glass, also of rock crystal, and his optomiter, etc., all arranged to attract attention. He then procured a carriage, and personally called to see the principal doctors and preachers, and gave each a pressing invitation to call and see his spectacles, instruments, etc. ; at a certain hour they did so, and the "Prof." gave each a pair of spectacles, explaining the marvellous good qualities of the same, and denouncing *all* others to be injurious to the eye,—exhibited a diploma that he claimed to have received from some medical college in Europe, spoke very learnedly and fluently of the different diseases of the eye, and then requested these gentlemen to sign some of his printed certificates, which went on to say, that "Prof. —— was the most scientific optician and oculist that they had ever seen ; that *he made his spectacles* on truly scientific principles, so much better than any others they had ever seen,"etc., etc. In every place but this the M. D.s and D. D.s would sign the certificates, which the "Prof." would put in the paper as part of his advertisement. This would be done before he would offer a single pair for sale. Now when the community saw the names of these learned and good men, whom they knew to be honest gentlemen, appended to these certificates, the effect would be magical ; everybody who used spectacles fairly flocked to this man's room, and exchanged their "ducats" for spectacles. Now you will ask, why did these physicians and others sign these certificates if the man was a humbug? Simply because there is not one physician in fifty that knows comparatively anything about the eye. If they have a patient who is afflicted with some disease of that organ, which is seldom the case, other than some simple case of inflammation or something of that kind, they send him to some one who makes a specialty of that class of diseases, and consequently he signs the certificate through ignorance ; or in other words *he* is imposed upon. I had seen this man's advertisement before he came here, and as soon as he came I called the attention of our physicians to what other physicians had certified to. They immediately saw the point, and said that they could not see how any Dr. could certify that the "Prof." made his own spectacles, and upon scientific principles, etc., when they had not *seen* him make them ; in other words, they could not vouch for the accuracy of what a perfect stranger would say about himself, and more especially when he did not have a single certificate from any oculist or optician in this country, which explains why the physicians of this place did not sign the certificates. They called on the gentleman with their eyes open. The next morning my advertisement appeared, giving the price of spectacles, etc., etc. ; that day the "Prof." said that he "did not think he had been treated properly, and as the place was so small he would leave ; but would be back again soon." Now if he could have met with the same reception in every city that he visited, his career would have been short ; for he did not sell a single pair of spectacles during his stay here. There is no doubt but what this man would have swindled our community out of at least $3,000, if I had held my tongue. Now let every watchmaker devote some of his spare time to the study of optics, and then get "Wells on Long, Short and Weak Sight," published by Lindsay & Blackiston, Philadelphia. JAS. FRICKER.

AMERICUS, GA.

LIGHT.*

NUMBER TWO.

THE REFLECTION OF LIGHT (CATOPTRICS)—PLANE MIRRORS.

When light passes from one optical medium to another, a portion of it is always turned back or reflected.

Light is *regularly* reflected by a polished surface; but if the surface be not polished the light is *irregularly* reflected or scattered. Thus a piece of ordinary drawing-paper will scatter a beam of light that falls upon it so as to illuminate a room. A plane mirror receiving the sunbeam will reflect it in a definite direction, and illuminate intensely a small portion of the room. If the polish of the mirror were perfect it would be invisible—we should simply see in it the images of other objects; if the room were without dust particles, the beam passing through the air would also be invisible. It is the light scattered by the mirror and by the particles suspended in the air which renders them visible.

A ray of light striking as a perpendicular against a reflecting surface is reflected back along the perpendicular; it simply retraces its own course. If it strike the surface obliquely, it is reflected obliquely. Draw a perpendicular to the surface at the point where the ray strikes it; the angle enclosed between the *direct* ray and this perpendicular is called the angle of incidence. The angle enclosed by the *reflected* ray and the perpendicular is called the angle of reflection. It is a fundamental law of optics that *the angle of incidence is equal to the angle of reflection.*

VERIFICATION OF THE LAW OF REFLECTION.

Fill a basin with water to the brim, the water being blackened by a little ink. Let a small plummet—a small lead bullet, for example—suspended by a thread, hang into the water. The water is to be our horizontal mirror, and the plumb-line our perpendicular. Let the plummet hang from the centre of a horizontal scale, with inches marked upon it right and left from the point of suspension, which is to be the zero of the scale. A lighted candle is to be placed on one side of the plumb-line, the observer's eye being at the other.

* Extracts from Prof. Tyndall's lectures on Light.

The question to be solved is this:—How is the ray which strikes the liquid surface at the foot of the plumb-line reflected? Moving the candle along the scale, so that the tip of its flame shall stand opposite different numbers, it is found that, to see the reflected tip of the flame *in the direction of the foot of the plumb-line,* the line of vision must cut the scale as far on the one side of that line as the candle is on the other. In other words, the ray reflected from the foot of the perpendicular cuts the scale accurately at the candle's distance on the other side of the perpendicular. From this it immediately follows that the angle of incidence is equal to the angle of reflection.

With an artificial horizon of this kind, and employing a theodolite to take the necessary angles, the law has been established with the most rigid accuracy. The angle of elevation to a star being taken by the instrument, the telescope is then pointed downwards to the image of the star reflected from the artificial horizon. It is always found that the direct and reflected rays enclose equal angles with the horizontal axis of the telescope, the reflected ray being as far below the horizontal axis as the direct ray is above it. On account of the star's distance the ray which strikes the reflecting surface is parallel with the ray which reaches the telescope directly, and from this follows, by a brief but rigid demonstration, the law above enunciated.

The path described by the direct and reflected rays is the shortest possible. When the reflecting surface is roughened, rays from different points, more or less distant from each other, reach the eye. Thus, a breeze crisping the surface of the Thames or Serpentine sends to the eye, instead of single images of the lamps upon their margin, pillars of light. Blowing upon our basin of water, we also convert the reflected light of our candle into a luminous column. Light is reflected with different energy by different substances. At a perpendicular incidence, only 18 rays out of every 1000 are reflected by water, 25 rays per 1000 by glass, while 666 per 1000 are reflected by mercury.

When the rays strike obliquely, a greater amount of light than that stated in 60 is reflected by water and glass. Thus, at an incidence of 40°, water reflects 22 rays ; at 60°, 65 rays ; at 80°, 333 rays ; and at $89\frac{1}{2}$° (almost grazing the surface) it reflects 721 rays out of every 1000. This is as much as mercury reflects at the same incidence. The augmentation of the light reflected as the obliquity of incidence is increased, may be illustrated by our basin of water. Hold the candle so that its rays enclose a large angle with the liquid surface, and notice the brightness of its image. Lower both the candle and the eye until the direct and reflected rays as nearly as possible graze the liquid surface ; the image of the flame is now much brighter than before.

Reflection from Looking-glasses.—Various instructive experiments with a looking-glass may here be performed and understood.

Note first when a candle is placed between the glass and the eye, so that a line from the eye through the candle is perpendicular to the glass, that *one* well-defined image of the candle only is seen. Let the eye now be moved so as to receive an oblique reflection ; the image is no longer single, a series of images at first partially overlapping each other being seen. By rendering the incidence sufficiently oblique, these images, if the glass be sufficiently thick, may be completely separated from each other.

The first image of the series arises from the reflection of the light from the anterior surface of the glass. The second image, which is usually much the brightest, arises from reflection at the silvered surface of the glass. At large incidences, as we have just learned, metallic reflection far transcends that from glass. The other images of the series are produced by the reverberation of the light from surface to surface of the glass. At every return from the silvered surface a portion of the light quits the glass and reaches the eye, forming an image ; a portion is also sent back to the silvered surface, where it is again reflected. Part of this reflected beam also reaches the eye and yields another image. This process continues; the quantity of light reaching the eye growing gradually less, and, as a consequence, the successive images growing dimmer, until finally they become too dim to be visible.

A very instructive experiment illustrative of the augmentation of the reflection from glass, through augmented obliquity, may here be made. Causing the candle and the eye to approach the looking-glass, the first image becomes gradually brighter ; and you end by rendering the image reflected from the glass brighter, more luminous, than that reflected from the metal. Irregularities in the reflection from looking-glasses often show themselves ; but with a good glass—and there are few glasses so defective as not to possess, at all events, some good portions—the succession of images is that here indicated.

Position and Character of Images in Plane Mirrors.—The image in a plane mirror appears as far behind the mirror as the object is in front of it. This follows immediately from the law which announces the equality of the angles of incidence and reflection. Draw a line representing the section of a plane mirror ; place a point in front of it. Rays issue from that point, are reflected from the mirror and strike the pupil of the eye. The pupil is the base of a cone of such rays. Produce the rays backward ; they will intersect behind the mirror, and the point will be seen *as if* it existed at the place of intersection. The place of intersection is easily proved to be as far behind the mirror as the point is in front of it.

Exercises in determining the positions of images in a plane mirror, the positions of the objects being given, are here desirable. The image is always found by simply letting fall a perpendicular from each point of the object, and producing it behind the mirror, so as to make the part behind equal to the part in front. We thus learn that the image is of the same size and shape as the object, agreeing with it in all respects save one—the image is a *lateral inversion* of the object.

This inversion enables us, by means of a mirror, to read writing written backward, as if it were written in the usual way. Compositors arrange their type in this backward fashion, the type being reversed by the process of printing. A looking-glass enables us to read the type as the printed page.

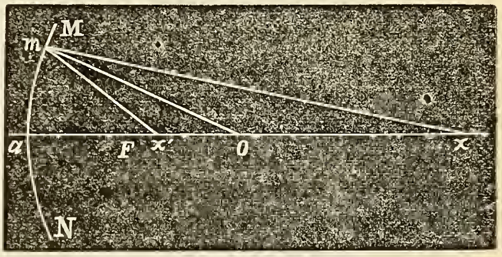
Lateral inversion comes into play when we look at our own faces in a glass. The right cheek of the object, for example, is the left cheek of the image ; the right hand of the object the left hand of the image, etc. The hair parted on the left in the object is seen parted to the right of the image, etc. A plane mirror half the height of an object gives an image which embraces the whole height. This is readily deduced from what has gone before. If a plane mirror be caused to move parallel with itself, the motion of an image in the mirror moves with twice its rapidity. The same is true of a *rotating* mirror ; when a plane mirror is caused to rotate, the angle described by the image is twice that described by the mirror. In a mirror inclined at an angle of 45° to the horizon, the image of an erect object appears horizontal, while the image of a horizontal object appears erect.

An object placed between two mirrors enclosing an angle yields a number of images depending upon the angle enclosed by the mirrors. The smaller the angle, the greater is the number of images. To find the number of images, divide 360° by the number of degrees in the angle enclosed by the two mirrors; the quotient, if a whole number, will be the number of images, plus one, or it will include the images and the object. The construction of the kaleidoscope depends on this. When the angle becomes 0—in other words, when the mirrors are parallel—the number of images is infinite. Practically, however, we see between parallel mirrors a long succession of images, which become gradually feebler, and finally cease to be sensible to the eye.

REFLECTION FROM CURVED SURFACES ; CONCAVE MIRRORS.

It has been already stated and illustrated that light moves in straight lines, which receive the name of rays. Such rays may be either divergent, parallel, or convergent. Rays issuing from terrestrial points are necessarily divergent. Rays from the sun or stars are, in consequence of the immense distances of these objects, sensibly parallel. By suitably reflecting them, we can render the rays from terrestrial sources either parallel or convergent. This is done by means of *concave* mirrors. In its reflection from such mirrors. light obeys the law already enunciated for plane mirrors. The angle of incidence is equal to the angle of reflection.

Let M N be a very small portion of the circumference of a circle with its centre at O. Let the line *a x*, passing through the centre, cut the arc M N into two equal parts at *a*. Then imagine the curve M N twirled round *a x* as a fixed axis ; the curve would describe part of a spherical surface. Suppose the surface turned towards *x* to be silvered over, we should then have a concave spherical reflector ; and we have now to understand the action of this reflector upon light.



The line *a x* is the principal axis of the mirror. All rays from a point placed at the centre O strike the surface of the mirror as perpendiculars, and after reflection return to O. A luminous point placed on the axis beyond O, say at *x*, throws a divergent cone of rays upon the mirror. These rays are rendered convergent on reflection, and they intersect each other at some point on the axis between the centre O and the mirror. In every case the direct and the reflected rays (*x m* and *m x*, for example) enclose equal angles with the radius (O *m*) drawn to the point of incidence. Supposing *x* to be exceedingly distant, say as far away as the sun from the small mirror—or, more correctly, supposing it to be *infinitely* distant,—then the rays falling upon the mirror will be *parallel.* After reflection such rays intersect each other, *at a point midway between the mirror and its centre.* This point, which is marked F in the figure, is the *principal focus* of the mirror ; that is to say, the principal focus is the focus of *parallel rays.* The distance between the surface of the mirror and its principal focus is called the *focal distance.*

In optics, the position of an object and of its image are always exchangeable. If a luminous point be placed in the principal focus, the rays from it will, after reflection, be parallel. If the point be placed anywhere between the principal focus and the centre O, the rays after reflection will cut the axis at some point beyond the centre. If the point be placed between the principal focus F and the mirror, the rays after reflection will be *divergent*—they will not intersect at all—there will be no *real* focus. But if these divergent rays be produced backwards, they will intersect *behind* the mirror, and form there what is called a *virtual* or imaginary focus.

—o—

ANSWERS TO CORRESPONDENTS.

A. F. T.—There is no fixed place for the compensation on the pendulum described on page 112, Vol. II., Horological Journal. The object of the set screw in the collet C is to allow the compensation to be placed in such a position on the rod as may be found proper by experiments; and the nuts traversing the rods B are used to adjust it more accurately than can be done by moving the collet. Fasten the collet at about one-third the length of the rod from the lower end and try it in the clock; if the clock gains as the temperature decreases, lower the compensation ball, or raise it if the clock loses. Be careful to alter it according to the rate of the clock; if the rate is large alter it by using the set screw in the collet, but if the rate is small use the nuts on the rods.

AMERICAN HOROLOGICAL JOURNAL,

PUBLISHED MONTHLY BY

G. B. MILLER,

229 Broadway, N. Y.,

At $2.50 per Year, payable in advance.

A limited number of Advertisements connected with the Trade, and from reliable Houses, will be received.

☞ Mr. J. Herrmann, 21 *Northampton Square, E. C., London, is our authorized Agent for Great Britain.*

All communications should be addressed,

G. B. MILLER,
P. O. Box 6715, New York.

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For January, 1871.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian.	Equation of Time to be Added to Apparent Time.	Equation of Time to be Subtracted from Mean Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	M. S.	S.	H. M. S.
Su.	1	71.09	3 44.73	3 44 65	1.182	18 42 46.98
M.	2	71.04	4 12.92	4 12.83	1.167	18 46 43.54
Tu.	3	70.99	4 40.74	4 40.65	1.151	18 50 40.10
W.	4	70 94	5 8.17	5 8.07	1.134	18 54 36.66
Th.	5	70.88	5 35.18	5 35 08	1.116	18 58 33.21
Fri.	6	70.82	6 1.73	6 1.62	1.097	19 2 29.77
Sat	7	70.75	6 27.81	6 27.70	1.077	19 6 26.33
Su.	8	70.68	6 53.42	6 53.30	1.057	19 10 22.89
M..	9	70.61	7 18.52	7 18.40	1.035	19 14 19.44
Tu.	10	70.54	7 43.07	7 42.94	1.012	19 18 16.00
W.	11	70.46	8 7.06	8 6.93	0.988	19 22 12.56
Th.	12	70.38	8 30.49	8 30.35	0.964	19 26 9.12
Fri.	13	70.30	8 53.32	8 53.18	0.939	19 30 5.67
Sat	14	70.21	9 15.52	9 15 38	0.913	19 34 2.23
Su.	15	70.12	9 37.09	9 36.95	0.886	19 37 58.79
M..	16	70.02	9 58.03	9 57.89	0.858	19 41 55.34
Tu.	17	69 92	10 18.27	10 18.13	0.829	19 45 51.90
W.	18	69.82	10 37.81	10 37.67	0.800	19 49 48.46
Th.	19	69.72	10 56.64	10 56.50	0 771	19 53 45.02
Fri.	20	69.62	11 14.74	11 14.60	0.740	19 57 41.57
Sat	21	69 52	11 32.08	11 31 94	0.708	20 1 38.13
Su.	22	69.41	11 48.66	11 48 52	0.676	20 5 34.69
M..	23	69 30	12 4.47	12 4.34	0.643	20 9 31.24
Tu.	24	69.19	12 19.48	12 19.35	0.610	20 13 27.80
W.	25	69.08	12 33.68	12 33.56	0.576	20 17 24.35
Th.	26	68.97	12 47.06	12 46.94	0.541	20 21 20.91
Fri.	27	68.86	12 59.61	12 59.49	0.506	20 25 17.47
Sat	28	68 75	13 11 33	13 11.22	0.471	20 29 14.02
Su.	29	68.63	13 22.20	13 22.10	0.436	20 33 10.58
M.	30	68.51	13 32.24	13 32.15	0.401	20 37 7.13
Tu.	31	68 40	13 41.44	13 41.35	0.366	20 41 3.69

Mean time of the Semidiameter passing may be found by subtracting 0.19 s. from the sidereal time.

The Semidiameter for moan noon may be assumed the samo as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
☉	Full Moon	6 9 23.6
☾	Last Quarter	13 18 57.0
●	New Moon	20 12 31 8
☽	First Quarter	28 1 14.4
		D. H.
☾	Apogee	1 16.5
☾	Perigee	17 18 2
☾	Apogee	19 12.0

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1

	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20 572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

		APPARENT R. ASCENSION.	APPARENT DECLINATION.	MERID. PASSAGE.
	D.	H. M. S.	° ′ ″	H. M.
Venus	1	19 12 0.90	−23 20 30.3	0 29.3
Jupiter	1	5 11 58.57	+22 33 6.6	10 27.3
Saturn	1	18 8 56.13	−22 36 49.7	23 22.8

AMERICAN

Horological Journal.

Vol. II. NEW YORK, FEBRUARY, 1871. No. 8.

CONTENTS.

*** *Address all communications for* Horological Journal *to* G. B. Miller, *P. O. Box* 6715, *New York City. Publication Office* 229 *Broadway, Room* 19.

☞ The second instalment of Mr. Grossmann's essay failed to reach us in time for this number. Of course, at this season of the year, ocean steamers are liable to delays, and we must accept the inevitable with the best grace possible. Probably before the close of the month we shall receive the entire work, and then there will be no further interruptions.

In the present number we also commence an original essay on the Pendulum as applied to the Measurement of Time, to which we invite the careful attention of our readers. In the series of articles on Heat, which will be closed in the April issue, will be collected a mass of facts which will prove of value to every workman, no matter what his experience may have been.

Having given some extracts from Prof. Tyndall's lecture on Light, bringing the subject down to the consideration of lenses, next month we shall describe the method of grinding, as practised in this country, together with some remarks on the proper selection of lenses for the eye. Several "Answers" are crowded out this month. In reply to a query from A. F. T., we propose to give an article on Pinions in a short time.

THE PENDULUM

AS APPLIED TO THE

MEASUREMENT OF TIME.

NUMBER ONE.

INTRODUCTION—TERRESTRIAL GRAVITY.

Of the many machines or instruments of precision that are in general use for private or for public purposes, there are probably none where so much misconception exists, or lack of knowledge of first principles is displayed, as in those instruments commonly constructed for the measurement of time; and all those acquainted with the subject, and who have had an opportunity of observing, can confirm that this misconception or ignorance is not confined to the general public, but is developed in a large degree throughout the trade, or among those tradesmen whose business it is to repair or sell such instruments. If we take the subject of the pendulum for instance, it is surprising how many there are who, in the exercise of their inventive faculties to provide a means of overcoming the difficult question of compensation, exhibit so much want of fundamental knowledge of the subject, and often create greater errors than they suppose to have cured. The periodical literature of the day frequently contains diagrams and correspondence on the question which abundantly prove this assertion.

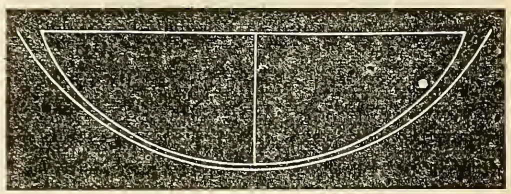
Perhaps, on the part of the workmen, this may be in some measure a result of the growing tendency of the age to concentrate special manufactures in certain localities, and also to the extensive system of subdividing labor, now generally adopted ; although productive of such good results, unquestionably it places the young watch and clock makers under greater difficulties to find suitable opportunities to master all the intricacies of their profession than was experienced a generation ago.

The scientific, or, more correctly, the pseudo-scientific world is also teeming with misconceptions on this subject. In a work newly published on the chemical forces, the author, talking about the Harrison pendulum, says: "This pendulum gained the reward of £20,000, offered by the British Government for a pendulum that did not lose more than the fraction of a second in a year, and enabled the longitude to be determined within thirty miles." It is seldom one sees so many false ideas condensed into so few lines. Probably this statement had its origin in the fact that about the end of the last century Mr. Harrisson received such a reward for a portable time-keeper that could be used on shipboard for the purpose of finding a ship's longitude on the ocean to within thirty miles; but a time-keeper that would not vary more than the fraction of a second in a year would enable the longitude to be determined at any time to the small fraction of a mile instead of thirty miles. Our nautical friends would find a pendulum ill suited for finding longitude at sea, and if writers on any subject connected with chemical forces, or chemical physics, and many other persons besides, were less credulous, and reflected a little, they have ability enough soon to discover that such a result was at that time, and even at the present day, altogether beyond the power of human skill to accomplish. In order that such a result should be reached, the pendulum—assuming it to be a seconds one—would require to vibrate precisely 31,535,999 and a fraction times in 365 days; and the fraction of a second that is lost must be subtracted in an equal ratio from the 31,536,000 seconds that make up the year, regularly and in equal proportion, from second to second, from hour to hour, and from day to day, during the 365 days that constitute our year, and that, too, amidst all the physical changes that are continually going on within and around the clock, although it may be placed in the best situation possible to be obtained.

Time-keepers may be considered to consist of two distinct orders. Those that are portable, like watches, for example, that have their motion imparted to them by a spring, and regulated by a balance and spring, or, as it were, impelled and regulated by an opposition of artificial forces; and those that are stationary, like clocks, and are propelled by weights, and regulated by the oscillations of a pendulum, or, in fact, regulated by the natural force of gravitation. To this question of measuring time by the natural force of gravitation, we propose to devote our attention, and investigate the many questions that bear upon the subject, from the simple or ideal pendulum to the compound and compensated one, and the difficulties to be overcome in obtaining a perfect compensation. Although a pendulous body, by the isochronism of its oscillations, furnishes a means of dividing time into equal portions, it could obviously be of little use until some method was devised of continuing the motion of the pendulum, and registrating the number of its vibrations. This mechanism, technically known as the escapement, we propose also to consider in the relation it bears to the pendulum itself, and illustrate the effects that the various forms of escapements have on the isochronal properties of the pendulum, and point out where their action in some cases partly serves for compensation in a plain pendulum, and in other cases tends to make the question of adjusting a compensated one a matter of contradiction and difficulty. Although it be our object to discuss fully the intricate questions connected with the highest class of clock-work, we will omit, at least for the present, taking any notice of the various systems of striking the hours, or the multitudinous automatic contrivances sometimes attached to clocks for various purposes, which, although they often show great ingenuity of construction, bear no relation to the principle that governs the motion of the clock itself, but in all cases tend to destroy the accuracy of its performance, except where Bond's escapement is used.

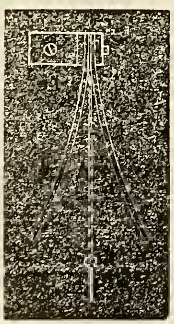
The pendulum is a most important instrument to the scientific world. It is applied to determine the relative force of gravity at different points on the earth's surface, and to determine its shape. It is also from the pendulum that the British standard yard measure is deduced; but its most important application has been to the measurement of time. It is a question of some doubt as to who was the exact individual that first conceived the idea to measure time by the oscillations of a pendulum. The Italians claim the honor for one of their countrymen, but there are records to show that long before the days of Galileo the ancient Asiatic astronomers measured the duration of transits and eclipses by counting the vibrations of a pendulum ; and to show that this was practicable, we notice that in modern times European and American astronomers have used pendulums in this manner for certain temporary operations in the field. Prof. Winlock, of Harvard College, Cambridge, had a pendulum applied without any clock-work attached to it, to break the circuit of the electrical apparatus that was fitted up in Kentucky to observe the duration of the total eclipse of the sun that was visible in some parts of North America in 1869 ; and if we are not mistaken, the same was used by the party sent to Spain by the United States Government, to observe the total eclipse of the sun lately seen from the south of Europe.

Galileo was the first who formally announced, in his work on mechanics and motion, which was published in the year 1639, the isochronal property of oscillating bodies suspended by strings of the same length ; and it has been said that he actually applied a pendulum to a clock, for the purpose of observing eclipses and determining longitudes ; but as there is no proof existing to corroborate the assertion, the fact may be considered doubtful. Sanctorius, in his *Commentary on Avicenna*, describes an instrument to which he had applied a pendulum in 1612. Richard Harris is said to have constructed, in 1641, a pendulum clock in London for St. Paul's Church, Covent Garden. Vincenzo Galilei, a son of Galileo, is stated, on the authority of the *Academy del Cimento*, to have applied the pendulum in 1649. It was applied by Huyghens in 1656, and by Hooke, for whom the invention has been claimed, about 1670. But to whomsoever the merit may belong of having first made the application, Huyghens is unquestionably the first that, in his *Horologium Oscillatoreum*, explained the theory of the pendulum ; and on this account, perhaps, the invention of the pendulum clock has been usually ascribed to him. After demonstrating the true theory of the pendulum, Huyghens's next object was to devise a means of causing a pendulum to vibrate in such a manner that its centre of oscillation would describe the arc of a cycloid. The diagram before us exhibits a



cycloidal and a circular curve, and the point to the right represents the centre of oscillation of an imaginary pendulum. The result Huyghens sought was, that, after this point had passed the perpendicular line, it should be gradually raised up in a certain degree as it ascended the circular curve ; yet although this cycloidal curve is the true curve a simple pendulum should describe in its oscillations, to make them isochronous it it has been found impossible to carry it out in practice with any beneficial result.

Many of our readers will have noticed old clocks, mostly in buhl cases and of French construction, having the verge and crown wheel escapement, and a very light pendulum suspended from a thread ; on each side of which thread are placed two pieces of curved brass, which represent part of the evolute of a cycloid. As the pendulum moves, the thread touches the brass curves and raises the ball, or, in fact, it raises the whole of the pendulum up, and approximately causes the centre of oscillation to describe a cycloid. This was the plan by which Huyghens sought to obviate one of the irregularities in clocks having large vibrations ; still, the varying impulse the pendulum receives on its descent, imparted to it from the crown wheel through the verge, and the variation of resistance it has to encounter from the recoil of the crown wheel on its ascent, makes the cycloidal curve of no practical value could it be carried out,



and it is now abandoned by all men of experience.

The pendulums of all clocks of modern construction do not vibrate in an arc large enough to show any perceptible difference between the circular and cycloidal curve; yet we sometimes meet with a certain class of tradesmen whose knowledge of their business amounts to nothing more than a foggy superstition, and who are possessed of many *secrets* they carefully treasure up, pretend to adjust a pendulum and make it isochronal by manipulating the pendulum spring, or causing it to work between two curves of a peculiar shape, and which is nothing more than attempting to put in practice what Huyghens abandoned 200 years ago; and Huyghens himself shows that the error of the hundredth of an inch in the form of the cycloidal curve described by the pendulum ball, causes greater irregularity than if the pendulum described an arc of 10° or 12° on each side of the point of rest, in a circle.

As we go deeper into our subject, we shall demonstrate the causes of irregularity in the higher class of clocks, whether these irregularities arise from the varying influences of the mechanism or escapement on the pendulum, or from heat, cold, the varying pressure of the atmosphere, magnetic influences, or other causes. Some of these we may propose a means of obviating, and those that we cannot get rid of, we shall, on the principle of "what kills also cures," try to use for the purpose of obtaining the desired end.

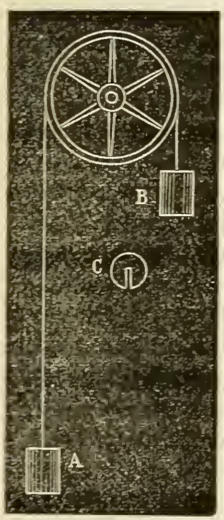
Although we have stated that the cycloid, so far as it relates to the pendulum, has been discarded in practical horology, nevertheless a knowledge of this curve, and also of the inclined plane, and the laws that govern falling bodies, is requisite in order fully to understand the question before us, and previous to going into the practical part of our subject, we shall briefly, and in plain language, describe the various phenomena connected with each of these subjects.

Terrestrial Gravity.—Universal experience demonstrates that all heavy bodies, when unsupported, fall towards the surface of the earth. The direction of their motion may be ascertained by a plumb line, and it is found to be always perpendicular to the level surface of the earth, or, more correctly, the surface of stagnant water. But the earth is very nearly spherical, and a line perpendicular to the surface of a sphere must pass through its centre; hence the direction of a body moving, in consequence of the force of terrestrial gravity, is toward the centre of the earth.

As the attraction of the earth acts equally and independently on all the particles composing a body, it is clear that they must all fall with equal velocities. It makes no difference whether the several particles fall singly, or whether they fall compactly together in the form of a large or a small body. If ten or a hundred leaden balls be disengaged together, they will fall at the same time, and if they be moulded into one ball of great magnitude, it will still fall in the same time. Hence, all bodies under the influence of gravity *alone*, must fall with equal velocities.

Previous to the time of Galileo, philosophers maintained that the velocity of a falling body was in proportion to its weight; and that if two bodies of unequal weights were let fall from an elevation at the same moment, the heavier would reach the ground as much sooner than the lighter as its weight exceeded it. In other words, a body weighing two pounds would fall in half the time that would be required by a body weighing one pound. Galileo, on the contrary, asserted that the velocity of a falling body is independent of its weight and not affected by it. The dispute running high, and the opinion of the public being generally averse to the views of Galileo, he challenged his opponents to test the matter by public experiment. The challenge was accepted, and the celebrated leaning tower of Pisa agreed upon as the place of trial. In the presence of a large concourse of citizens, two balls were selected, one having exactly twice the weight of the other. The two were then dropped from the summit of the tower at the same moment, and, in exact accordance with the assertions of Galileo, they both struck the ground at the same instant.

As all bodies, when left without support, fall from all heights to which they may be carried, it may be inferred that gravity acts upon them during the whole time of their descent, and is therefore a regularly accelerating force. This might also be inferred from the fact, which is easily rendered sensible, that bodies which fall from a greater height arrive at the earth with a greater velocity. If we let an apple fall from off a table on the floor, it will not be injured; but, if we let the same apple fall from the top window of a high house on to the pavement beneath, the apple will be smashed to pieces. But the best method of showing, experimentally, that gravity is a uniformly accelerating force, is by an apparatus known as Atwood's machine. This consists of a pulley, the axis of which turns on friction rollers, and having a groove in its edge to receive a string. Over the wheel a fine silken cord is stretched, to the ends of which are attached



two equal weights, A and B. In this state the weights counterbalance each other, and no motion ensues; but if we add the small weight C to the weight B, so as to give it a preponderance, the loaded weight will immediately begin to descend. The motion which now takes place is exactly of the same kind with that of a body descending freely; and by this method, the properties of uniformly accelerated motion are experimently shown to hold true in the descent of falling bodies. If the additional load be such as will carry the weight to which C is added through a space of one foot in the first second of time, it will carry it through four feet in two seconds, through nine in three seconds, and so on. A proof is therefore afforded by this means that terrestrial gravity is a uniformly accelerating force.

There are some familiar facts which seem to be opposed to this law. When we let go a feather, and a mass of lead, the one floats in the air, and the other falls to the ground very rapidly. But in this case, the operation of gravity is modified by the resistance of the air; the feather floats because the air opposes its descent, and it cannot overcome the resistance offered. But if we place a mass of lead and a feather in the exhausted receiver of an air-pump, and liberate them at the same instant, they will fall in equal periods of time.

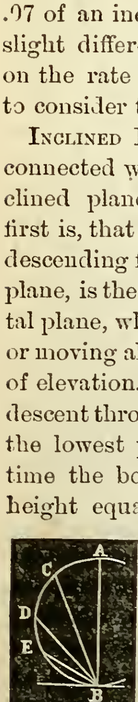
Having ascertained the law according to which gravity acts on bodies, the next question is to determine its absolute intensity, or the velocity which it communicates to a body falling freely in a given time. In the latitude of the city of New York, a body falling from a height will fall a small fraction less than 16 feet in the first second of time, three times that distance in the second, five times in the third, seven in the fourth; the spaces passed over in each second increasing as the odd numbers 1, 3, 5, 7, 9, 11, etc. On account of the rapidity of the descent of heavy bodies, their velocity cannot be determined by direct experiment; nor could Atwood's machine be employed for the purpose with sufficient certainty. The only mode by which an accurate result can be obtained is by measuring the length of a pendulum which makes a certain number of oscillations in a given time. Now the length of a pendulum vibrating seconds of mean solar time in New York, *in vacuo*, and reduced to the level of the sea, has been determined to be 39.10120 inches; and by a system of mathematical reasoning, which at present is unnecessary to be given, it is deduced from the length of this pendulum that a body will fall about 16 feet during the first second of its descent; which is somewhat less than in London, and more than in Trinidad. From experiments made with the greatest care, it appears that the extreme amount of variation in the gravitating force between the equator and the poles is one part in 194 of the whole quantity; that is to say, any body which, at the equator, weighs 194 pounds, if transported to the poles would weigh 195 pounds. The difference of gravitation, therefore, at the equator and the poles is expressed by the fraction 1-194th.

The following table we have prepared to show the direct influence the varying force of gravity has on pendulums designed to vibrate seconds at the level of the sea, at various points along the Atlantic coast of America, and from the equator to 45° north, which is the highest latitude populous cities have yet been built on this continent. The measurement is to the nearest hundredth of an inch, which is near enough for the clockmaker's purpose previous to his making the final adjustments. This table may be interesting and useful to our readers residing in any of the places mentioned, or in those of corresponding latitudes. In localities slightly above the level of the sea there will be no perceptible variation from the table ; but in very high elevations an allowance must be made for the variation of the force of gravity above the level of the sea. Capt. Kater's experiments, determining the length of a seconds pendulum in the latitude of London to be 39.13929, is the basis on which the table has been constructed.

Mouth of the Amazon river, Brazil......	39 01	inches.
Trinidad, West Indies..................	39.02	"
Southern part of Cuba..................	39.04	"
Havana, Cuba...........................	39.05	"
New Orleans............................	39 07	"
Cape Hatteras..........................	39,08	"
New York City..........................	39.10	"
Montreal...............................	39.12	"

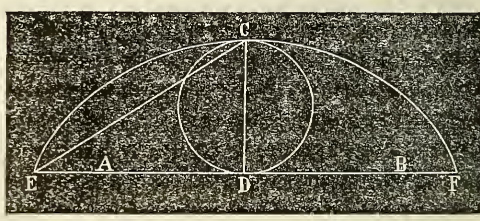
The difference in the length of a pendulum vibrating seconds at the level of the sea in any part of the United States, from the most southern part of Louisiana to the northern boundary of Minnesota, is not more than the .07 of an inch. Yet the result of even that slight difference will show a marked change on the rate of the pendulum, when we come to consider that part of the subject.

Inclined Plane.—There are two properties connected with the motion of bodies on inclined planes, which we must notice. The first is, that the velocity acquired by a body in descending from any elevation to a horizontal plane, is the same when it reaches the horizontal plane, whether falling freely in the vertical, or moving along an inclined plane at any angle of elevation. The second is, that the times of descent through all chords of the same circle to the lowest point, are equal, and equal to the time the body would take to fall through a height equal to the diameter of the circle.

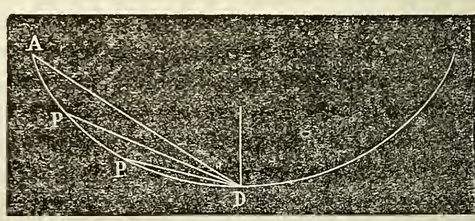


Thus : Let A B be the diameter of a circle, and C B, D B, and E B, chords of a circle. The time a heavy body would consume in falling vertically through the diameter is the same as that in which it would roll down the incline plane C B, D B, or E B—in other words, bodies placed at A, C, D, and E, and abandoned at the same instant to the action of gravity, would arrive at B at the same time. In these proportions it is supposed, of course, that there is no resistance from friction.

Cycloid.—If a circle roll along a straight line, any point in the plane of the circle will generate a curve which is called a cycloid.



Thus, if we take the straight line A B, and the circle C D, and roll the circle backwards and forwards along the straight line A B, a point in the edge of the circle C D will describe the cycloidal curve E C F. To be more familiar, a wheel with a point projecting from the side of it at the extreme edge, if rolled along a work-bench, the projecting point will describe a cycloidal curve on the wall. This curve has many curious and valuable properties. The line A B is called the base of the cycloid, and is equal to the circumference of the generating circle C D, and the distance from C to E is the distance the point of suspension of a pendulum ought to be to fit into the cycloid. If a heavy body descend by the force of gravity in an inverted cycloid, the velocity which it acquires is exactly proportionable to the length of the cycloidal arcs P P D; so that, from whatever



point, P P, it may begin to fall, it will arrive at the lowest point, D, in precisely the same time. If a body has to descend by the force of gravity from the point A to another point, D, not in the same vertical, it will accomplish the passage in less time by describing the cycloid A P P D than by moving in the straight line A D, or in any other path whatever.

HEAT.

NUMBER SIX.

STEEL—ITS MODES OF MANUFACTURE—CAST STEEL—INDIAN WOOTZ—ANNEALING METALS—ANNEALING STEEL ENGRAVERS' PLATES, GOLD, SILVER, BRASS, ETC., WITHOUT CHANGE OF COLOR—THEORY OF ANNEALING.

We have now arrived at the point to consider the practical application and effects of heat in the multitudinous processes required in connection with the different branches of our various professions.

The art of annealing, hardening, and tempering steel, constitutes, probably, one of the most delicate, curious, and useful branches connected with the mechanic arts. At first sight it appears sufficiently simple when, by heating a piece of steel to redness, and plunging it into cold water, it becomes hard ; on a closer inspection, however, the mind will soon discover that many operations and contrivances require to be carried into effect by the operator in order to become efficient in the art, or be distinguished for skill and promptitude in execution. A slight knowledge of the processes will also discover that a certain amount of patient perseverance is required—an amount of which few who have been brought up at the desk, or behind the counter, can form the slightest idea. But we have not set out with the object to discourage the young practitioner, but rather to encourage, and smooth for him the path many have found so rough, but which we have always endeavored to explore without entertaining a sentiment of its hardship; and we would advise all young men who are just starting in life to go and do likewise.

Steel is a compound of iron and carbon—sometimes formed from wrought iron by heating the wrought iron in contact with carbon, and sometimes formed from cast iron by depriving the cast iron of all impurities, except a small portion of carbon. The proportions of iron and carbon vary in the different qualities of steel; but in that ordinarily used the carbon rarely exceeds two per cent., and for some purposes it is as low as one per cent. Good ordinary tool steel contains about one and a-half per cent. of carbon. Previous to the introduction of Mr. Bessemer's method of producing steel direct from the cast iron without the intermediate operation of rendering it malleable, the most common mode of manufacturing steel was by the process called cementation. The furnace in which iron is cemented and converted into steel has the form of a large oven, constructed so as to form in the interior of the oven two large and long cases, commonly called troughs or pots, and built of good fire-stone or fire-brick. Into each of these pots layers of the purest malleable iron bars and layers of powdered charcoal are packed horizontally, one upon the other, to a proper height and quantity, according to the size of the pots, leaving room every way in the pots for the expansion of the metal when it becomes heated. A hole is left in the end of one of the pots, and three or four bars are left in such a manner that they can be drawn out at any period of the process and examined. After the packing of the pots is completed, the tops are covered with a bed of sand or clay in order to confine the carbon and exclude the atmospheric air. All the open spaces of the furnace are then closed, the fire is kindled, and the flame passes between, under, and around these pots on every side, and the whole is raised to a considerable intensity of heat, which is kept up for eight or ten days, according to the degree of hardness required. On the fifth or sixth day a test bar is drawn out of the converting pot for the purpose of judging whether the iron is at its proper heat, and to test the progress of the carbonization. At this period of the process the film of iron is generally distinguished in the centre of the bar, and the fire is generally kept up for a day or two longer in order that the iron may absorb more carbon. If, again, upon the trial of a bar, the cementation has extended to the centre, or, in other words, if the bars of iron have absorbed the carbonaceous principle to their innermost centre, the whole substance is converted into steel, and the work is complete. By this process carbon, probably in the state of vapor, penetrates and combines with the iron, which is thus converted into steel.

Iron prepared by this process is called blistered steel; and when bars of blistered steel are heated, and drawn out into smaller bars by means of the hammer, it acquires the name of tilted steel. Spring steel is the blister steel simply heated and rolled; and German or shear steel is produced by cutting the bars of blistered steel into convenient lengths, and piling and welding them together by means of a steam hammer. The bars, after being welded and drawn out, are again cut to convenient lengths, piled and welded, and again drawn out into bars. It is then called double shear steel, according to the extent of the process of conversion. Shear steel breaks with a finer fracture, is tougher, and capable of receiving a finer and firmer edge and a higher polish than blister or spring steel, and when well prepared is not much inferior to cast steel. Shear steel is very extensively used for those kinds of tools and pieces of work composed of steel and iron.

Cast steel is made from fragments of the blister steel of the steel works. The process is nearly a hundred years old, but it still remains in principle unaltered. This method is to take the blister steel, converted into a certain degree of hardness, break it into pieces of convenient length, and place it in crucibles made of the most refractory fire clay, which are placed in furnaces similar to those used by brass founders. The furnaces are furnished with covers and chimney to increase the draught of air, and the crucibles are furnished with lids of clay to exclude the atmospheric air. The furnaces containing the crucibles are filled with coke, and for the perfect fusion of the steel, the most intense heat is kept up for two or three hours. When the steel is thoroughly melted it is poured into ingot moulds of the shape and size required, and the ingots of steel, once only crude iron, but changed by chemical action into cast steel, are taken to the forge or rolling mill and prepared for the market into bars or plates, as may be required. Cast steel is the most uniform in quality, the hardest and most reliable steel for cutting tools and all delicate mechanism.

What is termed Peruvian or Indian steel has for its base a material known in commerce as *wootz.* It is manufactured, and is marketable throughout the East Indies as a metal suited to the production of cutting instruments of a superior quality, but of which metal the method of manufacture remains but imperfectly known to European and American workmen. The Indian account of wootz-making is the following: "Pieces of forged iron are enclosed in a crucible with wood, and heated together in a furnace; the fire is urged by three or more bellows peculiar to the country, and thus the wood is charred, the iron fused, and at the same time converted into steel. The metal is suffered to crystallize in the crucible, and in this state it is exported." When wootz is submitted to a second and more perfect fusion, it improves so much as scarcely to be recognized; it is fit for the finest of purposes, and is said to be infinitely superior to the best English cast steel, but whether the superior properties arise from the mode of manufacture, or from the materials used, we are unable to say.

Almost every one has heard of the famous Damascus steel; though in fact, little besides the name, and a vague notion that it is made in some parts of the Levant, appears to be known about it. Some authors assert that it comes from Golconda, in the East Indies, where, they add, a method of tempering with alum, which the Europeans have hitherto been unable to imitate, was invented. It is moreover asserted that the real Damascus blades emit a fragrant odor on being bent, and while they bent like a switch, were of so stern a temper that they would cut through iron without injury to the edge. The composition of the material formerly so celebrated as the steel of Damascus has given rise to many investigations with a view to imitate it, but as yet with only partial success. Silver, platinum, rhodium, gold, nickel, copper, and even tin, have an affinity for steel sufficiently strong to make them combine chemically with it, and they have all been used as an alloy for various special purposes, which our limits prevent us for the present from describing.

Annealing is a process used in the manufacture of metals, and also in glass-making. In glass-making it consists in placing the articles, whilst hot, in a kind of oven or furnace, where they are suffered to cool gradually. They would otherwise be too brittle for use. The difference between annealed and unannealed glass, with respect to brittleness, is very remarkable.

When an unannealed glass vessel is broken, it often flies into small pieces, with a violence seemingly very unproportioned to the stroke it has received. In general it is in greater danger of breaking from a very slight stroke than from one of very considerable force. A vessel will often resist the effects of a pistol bullet dropt into it from the height of three or four feet, yet a grain of sand falling into it will make it burst into small fragments. This takes place sometimes immediately on dropping the sand into it; but often the vessel will stand for several minutes after, seemingly secure, and then, without any new injury, it will fly into pieces. If the vessel be very thin, it does not break in this manner, but seems to possess all the properties of annealed glass. Glass is one of those bodies which increase in bulk when passing from a fluid to a solid state. When it is allowed to crystallize regularly, the particles are so arranged that it has a fibrous texture. It is elastic, and susceptible of long continued vibrations; but when a mass of melted glass is suddenly exposed to the cold, the surface crystallizes and forms a solid shell round the interior fluid parts. This prevents them from expanding when they become solid, and therefore they have not the opportunity of a regular crystallization, but are compressed together with little mutual cohesion; on the contrary they press outward to occupy more space, but are prevented by the external crust. By the process of annealing, glass is kept for some time in a state approaching to fluidity; the heat increases the bulk of the crystallized part, and renders it so soft that the internal parts have the opportunity of expanding and forming a regular crystallization.

In the manufactures in which the malleable metals are employed, annealing is used to soften a metal after it has been rendered hard by the hammer, and also to soften cast iron, which is rendered very hard and brittle by rapid cooling. In the manufacture of steel articles which are formed by the hammer, and require to be filed or otherwise treated, and in which softness and flexibility are essential to the change, annealing is absolutely necessary. Annealing is not less necessary in the drawing of wire, whether iron, copper, brass, silver, or gold. The operation of draw ng soon gives the wire a degree of hardness and elasticity which, if not removed from time to time by annealing, would prevent the extension of the wire, and render it extremely brittle; and the same operation is also necessary in rolling or flattening those metals which are in a cold state, such as brass, silver, gold, etc. The methods often employed for annealing iron and steel are very injurious, and materially injure the latter when it is to be used for any important or delicate purpose. After the articles have been formed into shape they are sometimes placed on an open fire, slowly raised to a red heat, and then allowed as gradually to cool. By this method the surface of the steel will be found considerably scaled, from the action of the oxygen of the atmosphere. When it is remembered that steel consists of iron joined to carbon, it will be evident that the steel immediately under the scaly oxide will be deprived of its carbon, which has been carried off by the attraction of the oxygen, and in consequence will lose the property of acquiring that degree of hardness necessary. Nothing, therefore, can be more obvious than that steel should be annealed in close vessels, to prevent that effect. For this purpose the pieces should be in a trough or recess made of soap-stone or fire-brick, and stratified with ashes or clean sand, and finally covered with a thick covering of the same; but if the size of the vessel be small it may be covered with its own materials.

This oven or trough must now be heated by the flame of a furnace passing under and around it, till the whole is of a red heat, and then it must be suffered to cool without letting in the air. The articles so treated will be much softer than by the other method, and the surface, instead of becoming scaled, will have acquired a metallic whiteness from the presence of a quantity of carbonaceous matter contained in the ashes in which they were imbedded. They will become so flexible, also, as to allow them to bend considerably without breaking, which is very far from being the case before the operation.

Wire, especially that of iron and steel, should be treated in a similar way when it is annealed. The wire used for some purposes requires to be soft, and is sold in that state. If the wire, after finishing, when it is bright and clean, were to be annealed in contact with oxygen, it would not only lose all its lustre and smoothness, but much of its tenacity. The process above mentioned will therefore be particularly necessary in annealing finished wire, as well as softening it from time to time during the drawing. Copper and brass suffer much less than iron and steel from annealing in an open fire, and they do not require to be heated above a low red heat; if, however, the lustre is to be preserved a close vessel is desirable.

In casting minute pieces of pig iron, which is generally done in damp sand, the metal possesses the property of steel to such a degree as to assume, by its rapid cooling, a degree of hardness equal to hardened steel; at the same time the articles are so brittle as to break on falling on the ground. When, however, these goods are treated in the way above directed, they acquire a degree of softness which renders them penetrable to the file, and at the same time capable of bending. In this state they are much less tenacious than steel, but still so much so as sometimes to be sold in the form of cutlery and other household utensils.

Less than a certain amount of heat will fail to make steel hard, but on the contrary will *soften it;* and sometimes this effect is useful. For instance, suppose a piece of steel is too hard to be dressed by the file, or cut with the turning tool, and time will not permit of its being softened in a box with charcoal powder; the steel may be heated to a cherry red heat in an open fire, then drawn out of the fire and allowed to cool down till the red heat is not visible by daylight, but can be seen in a dark place behind the forge; then to be plunged at this heat into cold water, and allowed to remain in the water until quite cool. When taken out it will be found to be much softer, and will yield to the file or the turning tool readily. Instead of pure water, some use a mixture of soap and water with good results.

The change which metals undergo by annealing is not yet thoroughly understood. Most of the malleable metals are susceptible of two distinct forms; one called the crystalline form, which they assume by slow cooling, and the other the fibrous, which is acquired by hammering or rolling. When this, however, is carried beyond a certain point, the metal becomes so hard that it is not capable of being bent without breaking. All the malleable metals in the ingot, or in their cast state, are brittle and exhibit a crystalline fracture. By hammering or rolling they become more tenacious, break with difficulty, and exhibit what is called a fibrous fracture. At the same time they become stiffer and more elastic, but they lose the latter properties by annealing, but become more malleable.

If the annealing, however, be long continued the malleability diminishes, and they have again a crystalline fracture. Zinc, when drawn into wire, becomes very flexible, and possesses a degree of tenacity not inferior to that of copper; but if it be kept in boiling water for a length of time it will assume its original brittleness, and show a crystalline appearance when broken. This proves that the particles of metal can change their arrangement without losing their solid form; which is still further confirmed by the fact that brass wire loses its tenacity by exposure to the fumes of acids, and even by the presence of a damp atmosphere. Those parts of the brass work in a turret clock that have been much exposed to an impure atmosphere will be found in the same condition, and the manufacturers of common pins are obliged to keep their wire in a dry atmosphere, or immersed in water. If the wire be first moistened and then exposed to the air, it will assume the brittle state much sooner. This is not caused by the moisture, but by the action of the air on the moistened surfaces.

The process of softening or decarbonizing steel suitable for the steel engraver, has always been one of difficulty; and we will conclude the subject of annealing by giving the methods practised by two celebrated British and American steel engravers. Mr. Jacob Perkins, an ingenious New England artist, conducted the decarbonizing process by enclosing the plate of cast steel, properly shaped, in a cast-iron box, filled about the plate to the thickness of about half an inch, with oxide of iron, or rusty iron filings, and in this state the box was luted close, and placed in a regular fire, where it was kept at a red heat during from three to twelve days. Generally about nine days he found sufficient to decarbonize a plate five-eighths of an inch in thickness.

Mr. Charles Warren, a celebrated English engraver, also enclosed his plates in a cast-iron box, but covered them up with a mixture of iron turnings and pounded oyster shells, and placed the box for only a few hours in a furnace as hot as it could be and not melt the cast iron. But a Mr. Hughes, a pupil of Mr. Warren's, found that the steel was not always sufficiently and uniformly soft (particularly for the purpose of engraving in mezzotinto), and imagined that those occasional defects were owing to a deficiency of heat in the cementing process; accordingly, he substituted a case of refractory clay for the cast-iron one, and, applying a considerable higher heat than the cast-iron box would have endured without melting, was enabled to obtain plates so soft that they might be bent over the knee.

——o——

MEASURING HAIR-SPRINGS.

Editor Horological Journal:

I am inclined to find a little fault with Mr. Rawson's idea for the measurement of the strength of hair-springs. His use of the micrometer for the purpose, I think, must give results quite unreliable. In the first place, no spring wire is homogeneous in its composition, and consequently cannot be uniform in its temper. In the article on Heat, in the same number, the practical impossibility of getting a bar of metal entirely uniform in its molecular constitution, is given as the reason for the want of exact uniformity in the result of the experiments there described. The same unreliability must exist in spring wire, and I cannot possibly conceive how linear measurement can give any indication of such a fault.

Secondly, the linear measurement of a spring will be the same precisely, whether the spring be soft-tempered or hard; but the *action* as a spring depends eminently on these qualities. Thirdly, the effective force of a spiral is so modified by the closeness of the coils, as well as by the total length of the spring, that any external measurement will fail to give a very sure guide to its elastic force. It is on this elastic force that watch springers depend for determining the proper point at which the hair spring should be pinned in the stud, to give the balance the requisite number of vibrations per minute; for, by lengthening or shortening the spring, as held by the tweezers, and counting the vibrations of the balances, this point can be determined with great exactness.

This system of adjustment depends for its success wholly on the elasticity of the spring—not on its width or thickness; of course these elements enter into and help to make up that force, but the *temper*, which is also an important ingredient, will most certainly elude the measurement of even a microscopic micrometer. For these reasons I think any instrument for determining this force should be based in its principles upon the absolute test of that quality in each individual spring.

For some time I have had in use one of Bissell's Staking tools, and cannot refrain from speaking of it with pleasure. It is very well made, and admirably adapted to the purpose. I think it can be used very conveniently as a tool for stretching the teeth of wheels. The wheel, of course, cannot be centred by the pivots, but can be either from the arbor or from the circle of the pinion leaves which will answer every purpose, as the teeth are afterward rounded up in the round-up tool with the pivots as centres. I think Mr. Bissell, will make it more useful, if he can afford to add to the number of punches, two or three, for the purpose I have named; or, if that is too much, let him leave out the drill stock, and give these punches in its place. I think most workmen would prefer that change. Altering the depthing in the very common jewelled Swiss watches must very often be done or the watch will not even go. And there is no ready way to do except to enlarge or diminish the size of the wheels which can speedily be done (and neatly) with a stretching punch and a rounding-up tool.

R. Cowles.

Cleveland.

ABSTRACT OF RATES OF CHRONOMETERS ON TRIAL

Name of Maker.	No.	Address of Maker.	Construction of Balance.
M. F. Dent.......	25334	33 Cockspur street, London.	(No information received.)
Chittenden	779	10 Wilton rd., Hackney, Lond.	Auxiliary as in former years.
Reid and Sons	1491	41 Grey street, Newcastle.	Auxiliary acting in cold.
Lowry............	1656	66 High street, Belfast.	Auxiliary compensation.
Kingston	5321	13 High street, Ramsgate.	Auxiliary acting in cold.
C. Frodsham	3345	84 Strand, London.	(No information received.)
E. Dent & Co.....	3092	61 Strand, London.	Dent's patent balance.
Glover	354	4 Swinton street London.	Auxiliary compensation.
McGregor & Co...	4173	38 Clyde Place, Glasgow.	Poole's auxiliary.
F. Fletcher.......	2921	148 Leadenhall street, London	Auxiliary compensation.
J. B. Fletcher....	2969	148 Leadenhall street, London.	Auxiliary compensation.
Shepherd & Son...	1737	53 Leadenhall street, London.	Auxiliary compensation.
Parkinson & Bouts	1147	59 Gracechurch street, London.	Auxiliary to balance, acting in extremes.
Gowland	2711	178 High street, W. Sunderland	Auxiliary compensation.
C. Frodsham	3364	84 Strand, London.	(No information received.)
Lister & Sons	635	12 Mosley street, Newcastle.	Poole's auxiliary.
McGregor & Co ...	4172	38 Clyde Place, Glasgow.	Auxiliary compensation.
Davison	1671	6 Side, Newcastle.	Auxiliary compensation.
Penlington	1799	3 St. George's Crescent, Liverp.	Auxiliary compensation balance.
J. Fletcher.......	2679	148 Leadenhall street, London.	Auxiliary compensation.
Roskell & Co......	$\frac{1789}{69734}$	21 Church street, Liverpool.	Kullberg's double rim balance, without auxiliary
Dobbie	4323	24 Clyde Place, Glasgow.	Ordinary compound balance, Poole's auxiliary.
Hennessy.........	1613	5 Wind street, Swansea.	Auxiliary compensation.
Reid & Sons.....	1492	41 Grey street, Newcastle.	Auxiliary acting in all temperatures.
Weichert	2215	112 Rothsay Terrace, Cardiff.	Ordinary balance, with original auxiliary.
Shepherd & Son...	1723	53 Leadenhall street, London.	Auxiliary compensation.
Webb	5550	4 Pullen's Row, Islington.	Auxiliary acting in all temperatures.
Lister & Sons.....	636	12 Mosley street, Newcastle.	Poole's auxiliary.
Eiffe	562	Amersham, Buckinghamshire.	Improved application to the pendulum spring.
Eiffe, Jun........	100	Amersham, Buckinghamshire.	Patent balance: unassisted figure.
D. Reid..........	1870	41 Grey street, Newcastle.	Auxiliary balance.
Webb	5552	4 Pullen's Row, Islington.	Auxiliary acting in all temperatures.
Whiffin...........	350	41 Barnsbury road, London.	Auxiliary compensation.
Eiffe	299	Amersham, Buckinghamshire.	Improved application to the pendulum spring.
Gowland	1279	178 High street, W. Sunderland	Ordinary balance with auxiliary.
Thicthener	1000	324 Goswell road, London.	Double locking detent and bi-conical timing spring: plain balance.

The sign + indicates that the rate is gaining.
† During these weeks the Chronometers were placed in the chamber of a stove heated by jets of gas. The gas flames are exterior to the chamber, into which none of the injurious products of combustion can enter.
Eiffe 299 is a pocket Chronometer; Eiffe 562 is an eight-days; all the rest are two-days performers.
The ratings commenced January 15th, and ended August 6th, so that the duration of the trials was 29 weeks.

We present above a table called an "Abstract of the principal changes of rates of Chronometers on trial for purchase by the Board of Admiralty, at the Royal Observatory, Greenwich, 1870." In addition, we have thought it would interest our readers to give some explanation of the nature of these trials, the causes of the failures that disappoint so many of the competitors, and a general review of the trials of the last thirty years.

The test prescribed for these chronometers is about as severe as well can be, and not transcend the limits of reasonable requirement. The Board of Admiralty does not require that chronometers purchased by them shall be limited to any particular size, style, or manner of construction, nor that they shall possess any special property in their adjustments. *Uniformity of performance*, being the desired result of the various adjustments bestowed on chronometers for the purpose of producing time-keeping qualities, is alone the qualification sought for, and the test administered in the Greenwich Observatory is well

AT THE ROYAL OBSERVATORY, GREENWICH, 1870.

Least Weekly Sum.	In what Temperature.	Greatest Weekly Sum.	In what Temperature.	Difference between the Greatest and Least.	Greatest Difference between one Week and the next.	Extremes of Temperature.
s	Degrees Fahrenheit.	s	Degrees Fahrenheit.	s	s	
− 5.3	71 to 92†	+ 0.2	41 to 51	5.5	3.8	35−66
− 1.7	do.	+ 7.0	33 to 38	8.7	5 3	do.
− 13.0	67 to 77	+ 0.5	72 to 90†	12.5	5.1	63−87
− 9.5	62 to 69	+ 3.5	51 to 58	13.0	6.0	62−72
− 6.1	40 to 51	+ 7.1	68 to 72	13.2	6.5	43−73
+ 4.5	do.	+ 20.3	67 to 77	15.8	5.7	63−87
+ 6.1	63 to 84†	+ 21.8	35 to 48	15.1	6.3	55−84
− 17.6	38 to 43	− 1.1	56 to 69	16.5	5.8	48—35
− 13.5	85 to 95†	0.0	41 to 51	13.5	7.5	43−73
− 1.3	63 to 84†	+ 12.9	67 to 77	14.2	7.2	95−62
− 2.0	33 to 38	+ 15.8	51 to 58	17.8	5 8	48−33
− 13.5	55 to 73†	+ 2.4	69 to 87†	15.9	6.9	63−50
− 9.0	71 to 92†	+ 4.0	41 to 51	13.0	9.2	55−84
− 5.8	63 to 84†	+ 7.0	51 to 58	12.8	9.4	35−66
− 6.5	33 to 38	+ 10.7	72 to 90†	17.2	7.5	76−96
− 21.3	52 to 63	− 7.7	68 to 72	13.6	9.3	92−52
− 16.5	56 to 71	− 0 5	72 to 90	16.0	8.8	63−90
− 1.0	33 to 38	+ 21.2	67 to 77	22.2	6.6	95−62
− 17.5	40 to 51	− 0.6	50 to 57	16.9	9.9	38−48
− 6.7	do.	+ 9.0	43 to 49	15.7	11.1	51−38
− 9.3	68 to 72	+ 9.3	71 to 92†	18.6	10.4	95−62
− 10.3	81 to 96†	+ 9.0	33 to 38	19.3	11.1	35−66
− 6.0	33 to 38	+ 12.5	67 to 77	18.5	11.6	63−87
− 2.7	40 to 51	+ 18.7	85 to 95†	21.4	11.7	95−62
− 4.5	33 to 38	+ 28.5	68 to 72	33.0	7.0	43−73
− 0.4	do.	+ 21.0	62 to 69	21.4	13.2	do.
− 28.9	68 to 75	− 5.8	35 to 48	23.1	13.5	92−52
− 23.0	43 to 51	− 0.2	68 to 77	22.8	16.5	43−73
− 28.0	71 to 92†	− 6.1	55 to 73†	21.9	17.0	71−92
− 42.5	33 to 38	− 14.8	62 to 69	27.7	14.2	95−62
− 12.7	43 to 51	+ 26.6	68 to 72	39.3	10.4	do.
− 26.4	56 to 69	+ 2.4	38 to 48	28.8	17.4	50−58
− 15.3	43 to 51	+ 33 6	68 to 72	48 9	12.1	43−73
− 24.0	33 to 38	+ 23.5	69 to 87†	56 5	33.0	68−77
− 14.3	41 to 66	+ 44.0	85 to 95†	58.3	38.3	35−66
+ 6.6	72 to 90†	+ 72.2	68 to 72	65.6	37.3	48−33

The Chronometers are placed in order of merit, their respective positions being determined solely by consideration of the irregularities of rate exhibited in the Table above.

* The Chronometer Eiffe 299 (pocket) accidentally ran down on February 6; the rate for the week February 5 to 12 is therefore wanting, and, consequently, the position of the Chronometer in the Tables is not necessarily correct.

calculated to develop any defect in this particular.

Chronometer makers or dealers are permitted to deposit in the Greenwich Observatory, in charge of the Astronomer Royal, who is the sole arbiter in the decisions made, each a limited number of marine time-keepers on trial for purchase by the Board of Admiralty. The trial usually begins early in January, and continues about twenty-nine weeks. During the cold weather they are exposed to the greatest degree of natural cold possible in that climate ; at other times to medium temperatures, while a portion of the period they are placed in an oven in which the heat is created artificially, but rarely exceeding 100° Fahr. It is designed to test them in all the degrees of temperature within the range mentioned. At the end of each week the gain or loss is noted, together with the maximum and minimum readings of the thermometer. These weekly limits of temperature do not, however, necessarily indicate the *average*, to ascertain which, recourse is had to a chronometrical thermometer, having the balance so constructed that its rate undergoes great changes by small variations of temperature, and its gain or loss during any period, therefore, showing the average temperature, but expressed in seconds of time instead of degrees of the thermometer.

A table is first prepared, showing the running of the chronometers for each successive week; that is, *in the order of time.* During the early part of the trial the temperature is purposely raised from one extreme to the other; then the trial continues through all the medium temperatures, and in the latter part of the term the temperature is considerably raised; while in the last month it is allowed to fall again as low as the natural condition of the atmosphere at that season will admit. A second table is prepared in which the rates of the chronometers for each week is shown *in the order of temperature*, which shows more readily what the general and particular effect has been in each case, by the gradual increase of temperature. A third table is then prepared, being an abstract of the first two, and the one we publish, showing for each chronometer in what week it made its "least weekly sum," and in an adjoining column, in what week its "greatest weekly sum" occurred. Another column shows the "difference between the greatest and least," and in the next column is shown the "greatest difference between one week and the next." The rule for classifying the chronometers is as follows:

Multiply the amount in the column headed "greatest difference between one week and the next" by 2, and add the amount in the column headed "difference between the greatest and the least," and the *trial number* is obtained. Obviously, the less the trial number, the higher the chronometer stands in the order of excellence; and it is in this manner, solely, that the standing is determined. When the trial is terminated, the Board of Admiralty selects for purchase a certain number of those that stand highest on the list, according to the needs of the service, and instructs the Astronomer Royal to offer the respective owners certain prices for them, considerably higher than could be obtained in the ordinary course of trade; so that the price paid is in the nature of a prize. Of course, what is most prized, is the honor of heading the list, and the approval of the Admiralty.

In the manufacture of chronometers, after the highest degree of excellence is secured in the purely mechanical construction, and, as far as the eye can perceive, each part is well adapted to the exercise of its function, and bears a proper relation to every other part, three difficulties arise to defeat the prime object for which they are designed, viz., uniformity of performance. These defects are, *acceleration of the rate*, *imperfect compensation*, and *a want of isochronism.*

Acceleration of rate is due to an inherent property in a new balance spring, generally believed to be found in greater degree in springs of high temper. There is considerable difference of opinion among horologists as to the reason for this defect, which shows itself in a steadily increasing rate, lasting from a few weeks to several years. Eventually the difficulty ceases to exist, and it is claimed that those chronometers which possess this property when new, generally become the most steady when the acceleration ceases; but, at all events, they appear none the worse for having passed through the ripening process. Acceleration cannot be remedied by putting in soft balance springs, as that produces a worse defect, found in irregular performance. The writer is certain that the spring should be highly tempered, and that this should not *necessarily* cause any material acceleration of the rate, nor, if it does, should it continue through any considerable length of time.

Our readers will have noticed nearly all the chronometers entered at Greenwich for trial in the year 1870, were described as having some sort of auxiliary compensation; and the same remark applies to every year since 1850, at which time the Board of Admiralty began to publish with the annual report a description of any peculiarity of escapement or balance. It is a well ascertained fact that most chronometers with the ordinary construction of balance, when adjusted to maintain the same rate in extreme temperatures, say 30° and 100°, go considerably faster in the mean temperature, or 70°, or what is the same thing, whatever the rate of such a chronometer in 70°, it goes slower in either extreme; and this quantity varies from a small fraction of a second to six seconds, in some cases, per day. It rarely happens that chronometers with ordinary balances have the contrary property of losing in the mean temperature, and when they do, in very slight degree. Without attempting to go into the reasons for this interesting fact, it is enough for our present purpose to point out that, during the last twenty years, certainly, the English makers have been impressed with the importance of overcoming this difficulty in the compensation. Several years since, Mr. Charles Frodsham publicly said in effect that the man who could invent a balance having all the good qualities of that ordinarily used, and none of the unstable properties of the auxiliary compensation or others of similar design, and which should remedy this one defect, "ought to have a golden feather put in his cap." Although there have been nearly as many inventions to remedy this defect in the compensation as there have been competitors for the highest honors at Greenwich, yet the problem does not appear positively to have been solved.

The effect of a proper isochronal adjustment is shown in the maintenance of a uniform rate under varying motive power. If, therefore, this adjustment is not perfect, inasmuch as chronometers usually in such cases go faster with a decrease of power, there is a tendency to gain, as the oil thickens. This defect is not developed to any great extent in a short trial of twenty-nine weeks. Yet it probably, in some cases, contributes to failure, as some kinds of oil may slightly change in fluidity with variations of temperature, thus causing fluctuations in the extent of the arcs of vibration.

The late Mr. John Poole, of London, was probably the best of the English makers. The workmanship on his chronometers was of the highest order, in addition to which his springing was of superior merit; but undoubtedly much of his success was due to what he called his auxiliary, though as it was merely a check acting in cold, we never could see just why this name was given to it. His work was very popular with the trade, and many dealers purchased his chronometers, having their names put on the dials, and entered them at these trials, but whatever credit they gained was due to Mr. Poole, rather than those whose names they bore. It is only fair to the other competitors to say that his make stood the best chance of being first on the list, as there were sometimes as many as twelve entered in one year by parties who had purchased them from him. Poole's auxiliary was constructed by securing on the outside of the rim of the balance, at the point opposite the end of the arm, a small cock, made concentric with the centre of the balance, and parallel to the circular rim. Through the end most distant from the arm a set screw passed which nearly touched the rim in medium temperatures. The chronometer was then adjusted to go the same in high and medium temperatures, which threw all the error of compensation on the side of the adjustment for cold, that is, it lost exceedingly in cold. By the aid of the set-screw, this was remedied, until it corresponded with the adjustment for other temperatures. Probably most of the auxiliaries are on this principle: Dent's, Hartnup's, and Kullberg's balances are on the principle of flat rims, instead of upright, and the arms as well as the rims are laminated. Excepting Poole's, these balances, or any others with auxiliaries, are seldom seen in the chronometers manufactured for ordinary trade, and the use of them is mainly confined to those instruments made expressly for the Admiralty trials.

Some of the auxiliaries are constructed to act only in heat. We notice, in 1867, that Webb entered one such, and in all the temperatures up to 81° it was of unusual excellence; but at that point the auxiliary began to act, and so overdid the matter in the temperatures between 81° and 95° that it caused it to rank the fifty-first in the list. It is a curious circumstance that the renowned maker, Jurgensen, never succeeded in rising higher than thirty-first in the list, which perhaps was due to the fact that he clung tenaciously to a gold balance spring, of the merits of which he wrote considerably.

We close this article by adding a table, compiled from the annual reports of trials of chronometers at Greenwich since 1840, showing the names of the successful competitors and the years in which they respectively stood first in the list. The names are arranged in the order of merit, according to the trial number given by the formula mentioned. An inspection will show that the highest honors have not been monopolized by any particular maker, although Poole heads the list five times, Molyneux three times, and Kullberg, Loseby, Lawson, P. Birchall, and Fletcher twice each. It is worthy of note that since 1850 two only of the chronometers had balances of "ordinary construction," and they had the peculiarity of a "slight alteration."

Year.	Maker.	Trial Number.
1870	M. F. Dent	13.1
1863	J. B Fletcher	14.0
1867	Sewill	16 2
1868	P. Birchall	16.5
1847	E. J. Massey	16.6
1869	J. B. Fletcher	17.3
1852	Poole	17.6
1854	Poole	17.6
1848	Loseby	17.9
1864	Kullberg	18.6
1865	Webb	18.7
1859	Campbell	19.0
1866	McGregor	19.0
1842	Molyneux	19.2
1840	Molyneux	20.0
1845	Poole	21.0
1843	Molyneux	21 3
1850	Loseby	22 1
*1862	Simpson & Roberts	22.3
1844	Appleton	23.3
1841	Litherland, Davies & Co.	23.7
†1861	McGregor	24.5
1860	P. Birchall	25.3
1858	Blackie	26.7
1846	Hutton	26.9
1853	Lawson	30.2
1855	Lawson	30.2
1849	Eiffe	33.8
†1856	J. Muirhead	36.7
1857	Hornby	38.5
1851	Lister & Son	39.6

———o———

METALS AND ALLOYS.

Chemistry has made us acquainted with about forty-three different metals, of which not more than twelve are of general use in the industrial arts. These are iron, copper, lead, tin, zinc, mercury, gold, silver, platinum, arsenic, antimony, and bismuth. In this limited list platinum is always employed in a pure state, although an alloy of platinum and lead, in definite proportions, is now known to exist, and is being experimented upon. Iron, copper, lead, tin, zinc, gold, and silver are all very extensively employed in their pure state; but when hardness is required an *alloy* is used, which is a mixture of two or more metals. This is not a strict definition of alloy, for mercury unites readily with most metals, and all the compounds so formed are called *amalgams*. What necessity there is for this distinction we cannot see, but universal custom has given to all the alloys of mercury the name of amalgams.

Although the number of useful metals is so limited, the number of alloys may be indefinitely extended; probably two or three hundred alloys are known, but not more than about sixty have been studied with care. An alloy may be regarded as a new metal, since its properties may be quite different from, and perhaps generally do not much resemble either of its component metals. Metallic compounds, like the chemical, often produce unexpected results ; and if the metallic mixture was only a mechanical one, the resultant would be anticipated to be a mean of the metals so mixed; but as the alloys have totally different properties from their originals, we must conclude that, at least in many instances, the combination is chemical, not mechanical.

The power of forming alloys is highly valuable to the manufacturer, as it enables him to create a new metal adapted to such wants as the continually advancing state of his art requires. As illustration of the idea, take type-metal. Printers required types ; the harder metals, iron and copper, were too hard—cutting the paper ; the softer, tin and lead, were too soft—battering down by the necessary pressure ; but a combination of two or three metals was the very thing. An alloy of one part antimony with three or four of lead, gave the proper mean, partaking of the character of both originals, and varying as the quantities were varied.

As an example of chemical combination we may take an alloy of tin and copper—both soft, flexible, and ductile; but nine parts copper and one of tin makes a tough, rigid metal, used in casting ordnance, and called gun-metal. It admits of neither rolling nor drawing, and, by increasing the proportion of the softer metal, tin, the hardness of the alloy is increased. One-sixth of tin produces the maximum degree of hardness ; one-fourth of tin produces the highly sonorous *bell-metal ;* two parts of copper and one

* Made by Kullberg. † Made by Poole.

of tin produces an alloy so hard that it cannot be cut with steel tools, and when struck with a hammer, or even suddenly heated, it flies in pieces like glass, and presents a highly crystalline structure. It retains no trace of the red color of copper, being quite white, and is susceptible of such an exquisite polish, not very easily tarnished, that it is used for mirrors, and is called *speculum metal.*

Alloys may be varied by the introduction of several metals. Brass, for example, is an alloy of copper and zinc ; but the best brass for turning at the lathe is made by the addition of a small quantity of lead, which, however, renders it unfit for hammering. In forming alloys on a large scale, the metals, while fluid, strongly tend to separate according to their specific gravity, the heavier going to the bottom ; and where this difference is considerable, they require constant stirring till cold, and then breaking up and re-melting ; even then it is sometimes difficult to form a bar entirely homogeneous throughout. In most alloys of three or more metals it is best to combine them first in pairs, and then fuse these pairs together. When the component parts of an alloy are separately fused and mingled together, ~reat heat is evolved ; thus showing the chemical character of the union.

The specific gravity of an alloy is seldom the mean of its constituents. In some cases there is an increase, and in others a diminution of density. The following table, prepared by Thenard, shows clearly this peculiarity:

Increased Density.	*Decreased Density.*
Gold and Zinc.	Gold and Silver.
Gold and Tin.	Gold and Iron.
Gold and Bismuth.	Gold and Lead.
Gold and Antimony.	Gold and Copper.
Gold and Cobalt.	Gold and Iridium.
Silver and Zinc.	Gold and Nickel.
Silver and Tin.	Silver and Copper.
Silver and Lead.	Copper and Lead.
Silver and Bismuth.	Iron and Bismuth.
Silver and Antimony.	Iron and Antimony.
Copper and Zinc.	Iron and Lead.
Copper and Tin.	Tin and Lead.
Copper and Palladium.	Tin and Palladium.
Copper and Bismuth.	Tin and Antimony.
Copper and Antimony.	Nickel and Arsenic.
Lead and Bismuth.	Zinc and Antimony.
Lead and Antimony.	
Platinum and Molybdenum.	
Palladium and Bismuth.	

Alloys conduct heat and electricity less perfectly than the pure metals of which they are composed, and are generally less ductile than the more ductile of their constituents. When formed by nearly equal proportions, there are as many ductile as brittle alloys ; but when one of the metals of an alloy greatly predominates, it is usually ductile. By combining ductile metals with brittle ones, brittle alloys are usually formed, if the brittle metal predominates. All alloys of brittle metals are themselves brittle.

Lead, tin, or zinc, when alloyed with the less fusible metals—copper, gold, and silver—produce alloys less malleable when cold than the superior metals, and, when heated barely to redness, fly in pieces under the hammer. Hence brass, gun-metal, etc., when hot, require cautious treatment.

The strength or cohesion of alloys is generally greatly superior to that of their constituents. The relative weights required to sunder a bar one inch square of each of the following alloys is given in the following tables from *Muschenbroek's Investigations :*

Strength of Alloys.

10 Copper	—1 Tin	32,093	lbs.
8 "	1 "	36,088	"
6 "	1 "	44,071	"
4 "	1 "	35,739	"
2 "	1 "	1,017	"
1 "	1 "	725	"

Strength of the Cast Metals of which these Alloys were Composed.

Barbary Copper	22,570	lbs.
Japan "	20,272	"
English Block Tin	6,650	"
" " "	5,322	"
Banca " "	3,679	"
Malacca " "	3,211	"

These results show that theory and practice agree in assigning the proportion of six to one as the strongest alloy. In the following alloys, which are the strongest of their respective groups, the tin is always four times the quantity of the other metal ; and they all confirm the remarkable fact, that alloys for the most part have a greater degree of cohesion than the stronger of their constituents.

Strength of Alloys.

4 English tin,	1 Lead	10,607	lbs.
4 Banca tin,	1 Antimony,	13,480	"
4 Banca tin,	1 Bismuth,	16,692	"
4 English tin,	1 Zinc,	10,258	"
4 English tin,	1 Antimony,	11,323	"

Strength of their Constituent Cast Metals.

Lead,	885	lbs.
Antimony,	1,060	"
Zinc,	2,689	"
Bismuth,	3,008	"
Tin,	2,211 to 6,660	"

All the metals, even the most refractory, which can scarcely be fused in a crucible at the greatest heat of a furnace, melt down with ease when surrounded by more fusible ones. Thus nickel is nearly as difficult of fusion as iron, but it is usefully employed with copper in forming German silver, to which it gives whiteness and hardness. Platinum is a very refractory metal, yet it combines so readily with zinc, tin, and arsenic, that it is dangerous to heat one of those metals in a platinum spoon, for an alloy would probably be formed and the spoon spoiled.

This peculiarity fully explains the result which often occurs by the unskilful use of the blow-pipe. Any attempt to hard-solder gold or silver to which the smallest particle of lead, tin, zinc, or other easily fusible metal is attached, "eats up," as the workmen say, the gold or silver—that is, the superior metal, being in the presence of an easily fused one, commences to flow, and forms with the softer one an alloy which is exceedingly brittle and hard; when intense heat is used, it sometimes becomes so hard as to resist the file.

As we do not propose to give a treatise on metallurgy, only so far as of interest to the trade, and as not one simple metal enters into the construction of either clocks or watches, we shall be obliged to treat principally of alloys, the primary metals being spoken of only in their connection with them.

Alloys are, without exception, more fusible than their constituent metals; the fusing point of an alloy being generally lower than that of the *less* fusible metal in its composition. An alloy, very remarkable for its easy fusibility, is formed of 8 parts bismuth, 5 of lead, and 3 of tin, and fuses at about 200°. And yet, if we *calculate* the fusing point by multiplying the mean of the fusing points into their mass, we get 520° as the fusing point.

$$\frac{8 \times 500 + 5 \times 600 + 3 \times 422}{16} = 520^\circ.$$

Safety plugs for steam-boilers are made by combining these metals in such proportions as to be fusible at a given temperature, and inserted in the hole in the boiler, and when the temperature arrives at the given degree, the plug is fused, giving escape to the steam, and relief to the pressure in the boiler. Sir Isaac Newton is said to be the discoverer of this fusible alloy. An alloy of antimony and iron can be set on fire by the action of a file. The alloy of chromium and lead will spontaneously ignite in the open air if the temperature be slightly raised. In forming an alloy it is often necessary to protect one or both the metals from the action of the atmosphere. Thus in combining lead and tin, resin or grease is usually put on the surface of the melted metals. In alloys formed of two metals, one of which is oxidizable and the other not, the first may be converted into an oxide, and the other retain its metallic state. By this method silver is separated from lead, and some of our native leads are sent to Europe for teatment by this method, the silver obtained making the transaction commercially profitable.

——o——

HINTS TO REPAIRERS.

In the practice of watch repairing there are many little appliances, and certain methods of performing various little jobs of work, the object of which is, in some instances, to save time and labor, and in others to impart a more perfect finish to the work. These little "secrets" (don't misunderstand the term), which to the accomplished workman would seem too insignificant to mention, would be more prized by the unskilled artisan than the most elaborate scientific essay on any subject connected with the manufacture of watches. To the workman whose occupation is that of a repairer only, any little assistance in the direction of saving time or labor is eagerly welcomed.

A trouble much experienced by unskilled workmen, after replacing a broken cylinder or staff, is to find the proper place for the hair-spring stud in order to effect the proper beat. They manage to find it, it is true, but only after the expenditure of much time and labor, pushing the collet hither and thither until the proper "beat" is effected. In the case of a cylinder much time may be saved by putting the balance-wheel and bridge in position, being careful to screw down the bridge firmly to prevent shaking—a trouble often experienced with worn watches; the balance is then moved to such a position that a tooth of the escape-wheel rests on one of the impulse arms of the cylinder, it being immaterial which, and the point on the balance exactly opposite the stud hole will be the proper place for the hair-spring stud.

In a lever escapement the proper place for the stud is found by placing the balance in such a position that the ruby pins stand directly in the centre, between the two banking pins or abutments, and the point on the balance exactly underneath or opposite the stud hole is the proper place for the hair-spring stud. This brings a tooth of the escape-wheel on one of the impulse planes of the pallet, which is the proper position. In general, the lever or cylinder escapement must be so adjusted that, when power is applied (wound), it will start of itself, without being shaken to bring it into action. In the Duplex escapement the proper place for the stud may be found by placing the balance in such a position that a long tooth of the escape-wheel rests on the duplex roller, exactly between the slot and impulse pallet; the point on the balance-wheel exactly opposite the stud hole in the bridge being the proper place for the stud. The impulse jewel, when in action, should be 5° in front of the impulse tooth before receiving the impulse. The diameter of the duplex roller should be one-fourth the space between two long teeth of the escape-wheel. In the case of a chronometer escapement, the proper place for the stud is found by placing the balance in such a position that the gold spring is exactly between the impulse and unlocking jewels; in such a position the point on the balance directly opposite the stud hole is the proper place for the stud. The impulse jewel, when in action, should be 5° in front of the tooth before receiving the impulse. The chronometer and duplex escapements, unlike the lever and cylinder, require to be put in position to perform. This arises from the nature of the escapement. To underturn the face of a pinion, staff, etc., nicely, should be an object of solicitude to every repairer, as it gives a beautiful appearance to the finished work; but to some workmen underturning presents many difficulties. The easiest manner of accomplishing this is by constructing a graver whose face, when ground, presents the shape of an acute cone, and which must be well hardened and tempered. The graver is then held in the position as if a point were to be turned in the direction of the underturning, which will effect the desired result. Care must be taken not to press the graver too hard against the object to be turned, as the point of the graver (the essential part) would be in danger of breaking, but should be held gently, yet firm. After grinding any graver it should be polished by rubbing it across a piece of chamois leather, stretched on a piece of wood, and impregnated with rouge. Any metal (unless it be too hard), especially brass, on being turned with a graver thus prepared, presents the part turned with the appearance of having been polished.

It is very often necessary for the repairer to replace a hair-spring, and although this is not a very difficult job, it generally occupies the unskilled workman the greater portion of the day. By observing the following directions any workman will be enabled, with a little practice, to adjust a hair-spring suitable to the watch in the space of a quarter of an hour: First, ascertain the number of vibrations the balance makes in a minute, by counting the wheel teeth and pinion leaves, as explained on page 19, current volume. Generally, Swiss watches beat 300, English 240, and American either 300 or 270 per minute; secondly, select a spring whose outer coil lies naturally in the regulator pins at the same time that the inner coil is opposite the cock jewel, and temporarily fasten it to the balance staff with wax, and pin the outer coil into the stud, and place the balance thus into position. Wind the watch one turn, and allow it to vibrate exactly a minute, as indicated by a good regulator. Should the number of beats the balance makes in this minute coincide with the number of beats the watch ought properly to make, as before determined, then the spring is one well adapted to the watch; but should it lose or gain vibrations in the minute indicated by the regulator, it proves the spring to be either too weak or too strong, and must be replaced by one suitable. It is not always necessary to change a spring should the difference be slight, as it may be regulated by giving greater length to, or shortening the length of, the hair-spring.

Charles Spiro.

LIGHT.*

NUMBER THREE.

Before proceeding further, it is necessary that these simple details should be thoroughly mastered. Given the position of a point in the axis of a concave mirror, no difficulty must be experienced in finding the position of the image of that point, nor in determining whether the focus is *virtual* or *real*. It will thus become evident that while a point moves from an infinite distance to the centre of a spherical mirror, the image of that point moves only over the distance between the principal focus and the centre. Conversely, it will be seen that during the passage of a luminous point from the centre to the principal focus, the image of the point moves from the centre to an infinite distance. The point and its image occupy what are called *conjugate foci*. If the last note be understood, it will be seen that the conjugate foci move in opposite directions, and that they coincide at the centre of the mirror. If, instead of a point, an object of sensible dimensions be placed beyond the centre of the mirror, an *inverted* image of the object *diminished* in size will be formed between the centre and the principal focus.

If the object be placed between the centre and the principal focus, an inverted and *magnified* image of the object will be formed beyond the centre. The positions of the image and its object are, it will be remembered, convertible. In the two cases mentioned in the preceding paragraph, the image is formed in the air in *front* of the mirror. It is a *real* image. But if the object be placed between the principal focus and the mirror, an *erect* and magnified image of the object is seen behind the mirror. The image is here *virtual*. The rays enter the eye *as if* they came from an object behind the mirror. It is plain that the images seen in a common looking-glass are all virtual images.

It is now to be noted that what has been here stated regarding the gathering of rays to a *single focus* by a spherical mirror is only true when the mirror forms a small fraction of the spherical surface. Even then it is only practically, not strictly and theoretically, true.

CAUSTICS BY REFLECTION (CATACAUSTICS).

When a large fraction of the spherical surface is employed as a mirror, the rays are not all collected to a point; their intersections, on the contrary, form a luminous *surface*, which in optics is called a *caustic* (German, Brennflache). The interior surface of a common drinking-glass is a curved reflector. Let the glass be nearly filled with milk, and a lighted candle placed beside it; a caustic curve will be drawn upon the surface of the milk. A carefully bent hoop, silvered within, also shows the caustic very beautifully. The focus of a spherical mirror is the *cusp* of its caustic.

Aberration.—The deviation of any ray from this cusp is called the *aberration* of the ray. The inability of a spherical mirror to collect all the rays falling upon it to a single point is called the *spherical aberration* of the mirror.

Real images, as already stated, are formed in the air in front of a concave mirror, and they may be seen in the air by an eye placed among the divergent rays beyond the image. If an opaque screen, say of thick paper, intersect the image, it is projected on the screen and is seen *in all positions* by an eye placed in front of the screen. If the screen be semi-transparent, say of ground glass or tracing-paper, the image is seen by an eye placed either in front of the screen or behind it. The images in phantasmagoria are thus formed.

Concave spherical surfaces are usually employed as burning-mirrors. By condensing the sunbeams with a mirror 3 feet in diameter and of 2 feet focal distance, very powerful effects may be obtained. At the focus, water is rapidly boiled, and combustible bodies are immediately set on fire. Thick paper bursts into flame with explosive violence, and a plank is pierced as with a hot iron.

CONVEX MIRRORS.

In the case of a *convex* spherical mirror the positions of its foci and of its images are found as in the case of a concave mirror. But all the foci and all the images of a convex mirror are virtual. Thus to find the principal focus you draw parallel rays, which, on

* Extracts from Prof. Tyndall's lectures on Light.

reflection, enclose angles with the radii equal to those enclosed by the direct rays. The reflected rays are here *divergent*; but on being produced backwards, they intersect at the principal focus *behind the mirror.*

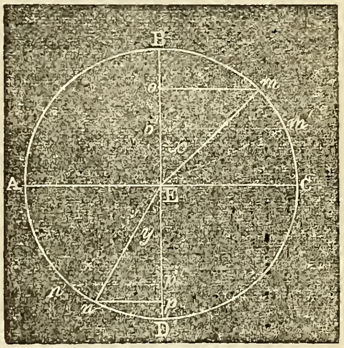
The drawing of *two* lines suffices to fix the position of the image of any point of an object either in concave or convex spherical mirrors. A ray drawn from the point through the centre of the mirror will be reflected through the centre; a ray drawn parallel to the axis of the mirror will, after reflection, pass, or its production will pass, through the principal focus. The intersection of these two reflected rays determines the position of the image of the point. Applying this construction to objects of sensible magnitude, it follows that the image of an object in a convex mirror is always *erect* and *diminished.*

If the mirror be *parabolic* instead of spherical, all parallel rays falling upon the mirror are collected to a point at its focus; conversely, a luminous point placed at the focus sends forth parallel rays; there is no aberration. If the mirror be *elliptical*, all rays emitted from one of the foci of the ellipsoid are collected together at the other. Parabolic reflectors are employed in light-houses, where it is an object to send a powerful beam, consisting of rays as nearly as possible parallel, far out to sea. In this case the centre of the flame is placed in the focus of the mirror; but, inasmuch as the flame is of sensible magnitude, and not a mere point, the rays of the reflected beam are not accurately parallel.

THE REFRACTION OF LIGHT (DIOPTRICS).

We have hitherto confined our attention to the portion of a beam of light which rebounds from the reflecting surface. But, in general, a portion of the beam also *enters* the reflecting substance, being rapidly quenched when the substance is opaque, and freely *transmitted* when the substance is transparent. Thus in the case of water, when the incidence is perpendicular, all the rays are transmitted, save the 18 referred to as being reflected. That is to say, 982 out of every 1,000 rays enter the water and pass through it. So likewise in the case of mercury, mentioned in the same note; 334 out of every 1,000 rays falling on the mercury at a perpendicular incidence, enter the metal and are quenched at a minute depth beneath its surface.

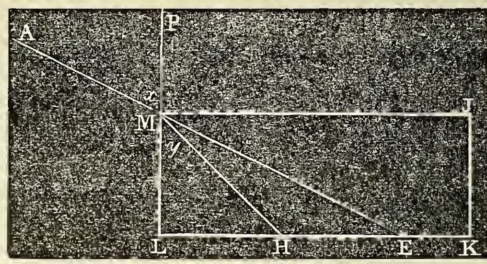
We have now to consider that portion of the luminous beam which enters the reflecting substance, taking, as an illustrative case, the passage from air into water. If the beam fall upon the water as a perpendicular, it pursues a straight course through the water; if the incidence be oblique, the direction of the beam is changed at the point where it



enters the water. This bending of the beam is called *refraction.* Its amount is different in different substances. The refraction of light obeys a perfectly rigid law which must be clearly understood. Let A B C D, Fig. 2, be the section of a cylindrical vessel which is half filled with water, its surface being A C. E is the centre of the circular section of the cylinder, and B D is a perpendicular to the surface at E. Let the cylindrical envelope of the vessel be opaque, say of brass or tin, and let an aperture be imagined in it at B, through which a narrow light-beam passes to the point E. The beam will pursue a straight course to D without turning to the right or to the left. Let the aperture be imagined at *m*, the beam striking the surface of the water at E *obliquely.* Its course on entering the liquid will be changed; it will pursue the track E *n*. Draw the line *m o* perpendicular to B D, and also the line *n p* perpendicular to the same B D. It is always found that *m o* divided by *n p is a constant quantity*, no matter what may be the angle at which the ray enters the water. The angle marked x above the surface is called the angle of incidence; the angle at y below the surface is called the angle of refraction; and if we regard the radius of the circle A B C D as unity or 1, the line *m o* will be the *sine* of the angle of incidence; while the line $n\ p$ will be the *sine* of the angle of refraction. Hence the all-important optical law—*The sine of the angle of incidence divided by the sine of the angle of refraction is a constant quantity.* However these angles may vary in size, this bond of relationship is never severed. If one of them be lessened or augmented, the other must diminish or increase, so as to obey this law. Thus, if the incidence be along the dotted line m' E, the refraction will be along the line E n', but the ratio of $m'\ o'$ to $n'\ p'$ will be precisely the same as that of $m\ o$ to $n\ p$. The constant quantity here referred to is called *the index of refraction.*

One word more is necessary to the full comprehension of the term sine, and of the experimental demonstration of the law of refraction. When one number is divided by another, the quotient is called the *ratio* of the one number to the other. Thus 1 divided by 2 is $\frac{1}{2}$, and this is the ratio of 1 to 2. Thus also 2 divided by 1 is 2, and this is the ratio of 2 to 1. In like manner 12 divided by 3 is 4, and this is the ratio of 12 to 3. Conversely, 3 divided by 12 is $\frac{1}{4}$, and this is the ration of 3 to 12. In a right-angled triangle the ratio of any size to the hypothenuse is found by dividing that side by the hypothenuse. *The ratio is the sine of the angle opposite to the side*, however large or small the triangle may be. Thus in Fig. 2 the sine of the angle x in the right-angled triangle E $o\ m$, is really the ratio of the line $o\ m$ to the hypothenuse E m; it would be expressed in a fractional form thus, $\frac{o\ m}{E\ m}$. In like manner, the sine of y is the ratio of the line $n\ p$ to the hypothenuse E n, and would be expressed in a fractional form thus, $\frac{n\ p}{E\ n}$. These fractions are the sines of the respective angles, whatever be the length of the line E m or E n. In the particular case above referred to, where these lines are considered as units, the fractions $\frac{m\ o}{1}$ and $\frac{n\ p}{1}$, or, in other words, $m\ o$ and $n\ p$ become, as stated, the sines of the respective angles. We are now prepared to understand a simple but rigid demonstration of the law of refraction.

M L J K is a cell with parallel glass sides and one opaque end, M L. The light of a candle placed at A falls into the vessel, the



end M L casting a shadow which reaches to the point E. Fill the vessel with water—the shadow retreats to H through the refraction of the light at the point where it enters the water. The angle enclosed between M E and M L is equal to the angle of incidence x, and in accordance with the definition given in 120, $\frac{L\ E}{M\ E}$ is its sine; while $\frac{L\ H}{M\ H}$ is the sine of the angle of refraction, y. All these lines can be either measured or calculated. If they be thus determined, and if the division be actually made, it will always be found that the two quotients $\frac{L\ E}{M\ E}$ and $\frac{L\ H}{M\ H}$ stand in a constant ratio to each other, whatever the angle may be at which the light from A strikes the surface of the liquid. This ratio in the case of water is $\frac{4}{3}$, or, expressed in decimals, 1.333. When the light passes from air into water, the refracted ray is bent *towards* the perpendicular. This is generally, but not always, the case when the light passes from a rarer to a denser medium. The principle of reversibility which runs through the whole of optics finds illustration here. When the ray passes from water to air it is bent *from* the perpendicular; it accurately reverses its course. If instead of water we employed vinegar, the ratio would be 1.344; with brandy it would be 1.360; with rectified spirit of wine, 1.372; with oil of almonds or with olive oil, 1.470; with spirit of turpentine, 1.605; with oil of aniseed, 1.538; with oil of bitter almonds, 1.471; with bisulphide of carbon, 1.678; with phosphorus, 2.24. These numbers express the indices of refraction of the various substances mentioned; all of them refract the light more powerfully than water, and it is worthy of remark that all of them, except vinegar are *combustible* substances.

It was the observation on the part of Newton, that, having regard to their density, "unctuous substances" as a general rule refracted light powerfully, coupled with the fact that the index of refraction of the diamond reached, according to his measurements, so high a figure as 2.439, that caused him to foresee the possible combustible nature of the diamond. The bold prophecy of Newton has been fulfilled, the combustion of a diamond being one of the commonest experiments of modern chemistry. It is here worth noting that the refraction by spirit of turpentine is greater than that by water, though the density of the spirit is to that of the water as 874 is to 1,000. A ray passing obliquely from the spirit of turpentine into water is bent *from* the perpendicular, though it passes from a rarer to a denser medium; while a ray passing from water into the spirit of turpentine is bent *towards* the perpendicular, though it passes from a denser to a rarer medium. Hence the necessity of the words "not always," employed in 123.

If a ray of light pass through a refracting plate with parallel surfaces, or through any nunber of plates with parallel surfaces on regaining the medium from which it started, its original direction is restored. This follows from the principle of reversibility already referred to. In passing through a refracting body, or through any number of refracting bodies, the light accomplishes its transit in the *minimum of time*. That is to say, given the velocity of light in the various media, the path chosen by the ray, or, in other words, the path which its refraction imposes upon the ray, enables it to perform its journey in the most rapid manner possible. Refraction always causes water to appear shallower, or a transparent plate of any kind thinner, than it really is. The lifting up of the lower surface of a glass cube, through this cause, is very remarkable.

To understand why the water appears shallower, fix your attention on a point at its bottom, and suppose the line of vision from that point to the eye to be perpendicular to the surface of the water. Of all rays issuing from the point, the perpendicular one alone reaches the eye without refraction. Those close to the perpendicular, on emerging from the water, have their divergence augmented by refraction. Producing these divergent rays backwards, they intersect at a point above the real bottom, and at this point the bottom will be seen. The apparent shallowness is augmented by looking obliquely into the water. In consequence of this apparent rise of the bottom, a straight stick thrust into water is bent at the surface *from* the perpendicular. Note the difference between the deportment of the stick and of a luminous beam. The beam on entering the water is bent *towards* the perpendicular. This apparent lifting of the bottom when water is poured into a basin brings into sight an object at the bottom of the basin which is unseen when the basin is empty.

——o——

ANSWERS TO CORRESPONDENTS.

P. G., *Mass.*, inquires, with some anxiety, whether the eyes of a watchmaker are not liable to injury by the constant and intense use of them in his occupation. We think not. Observations among the fraternity in this respect have convinced us — and we think the observation of all will confirm the opinion — that the eyes of watchmakers will compare favorably with any class of mechanics or tradesmen in durability; indeed, if there be any difference, their eyes are better.

The injury to eyes is not usually done by *intense* use of them, but by *tiresome* use. With a watchmaker, for a moment or two—or at farthest for five minutes—he may apply them intensely; then they are relieved from strain by a look out of the window, across the shop, at a customer, or whatever else, and become rested. But let them be fixed — set, as it were, to a given focal distance, as in reading, sewing, writing, or any occupation that confines them for hours to that one distance — and they will become painful, and demand relief, which, if denied, will sooner or later tell upon their healthy condition. The use of an eye-glass for years should, if injurious, show that injury by some difference in the two eyes; but facts show no such difference, although the glass may have been used on one eye only for very many years. P. G.

need have no misgivings about the failure of his sight from any such cause.

G. M. H., *N. Y.*—The instrument of which you send a drawing is by no means new, being found in all the tool stores, and known as an inside caliper.

Your use of it is new, but we cannot see in what way it will be very beneficial; as we understand your description, you only get the distance between the shoulders of the pinion or staff, and that measurement is seldom lost, for pinions very rarely break. If the pivot breaks you still have the shoulder left, and your tool would be useless. A staff never breaks, only the pivots; and your caliper will not give you the length of the required pivot. If the points of your instrument were small enough to go through the jewel hole and rest against the end stone, they would be too delicate to handle with safety.

H. E. W., *Richfield Springs.*—Much of the Etruscan jewelry is made so exceedingly thin as to be almost destroyed by the process of coloring. No quality finer than 14 carat can be used for such a purpose, the coloring being done by eating away, chemically, the alloy from the surface, leaving only the fine gold; and as this takes effect on both surfaces, when very thin, there is no solid metal left for strength, and consequently the article is exceedingly fragile.

When such goods are hard-soldered the color cannot be restored except by gilding, coloring it by the battery process; sometimes in cases of exigency, when soft-soldering must be resorted to, a temporary color can be applied by painting the discolored part with shell gold.

AMERICAN HOROLOGICAL JOURNAL,

PUBLISHED MONTHLY BY

G. B. MILLER,

229 Broadway, N. Y.,

At $2.50 per Year, payable in advance.

A limited number of Advertisements connected with the Trade, and from reliable Houses, will be received.

☞ MR. J. HERRMANN, 21 *Northampton Square, E. C., London, is our authorized Agent for Great Britain.*

All communications should be addressed,

G. B. MILLER,

P. O. Box 6715, *New York.*

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For February, 1871.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian.	Equation of Time to be Added to Apparent Time.	Equation of Time to be Subtracted from Mean Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	M. S.	S.	H. M. S.
W.	1	68.28	13 49 81	13 49 73	0.332	20 45 0.24
Th.	2	68.17	13 57.33	13 57 26	0.297	20 48 56.80
Fri.	3	68.05	14 4.02	14 3 96	0.262	20 52 53.36
Sat	4	67.94	14 9.89	14 9 84	0.227	20 56 49.91
Su.	5	67 82	14 14.94	14 14 89	0.193	21 0 46.47
M..	6	67.71	14 19.17	14 19 13	0.159	21 4 43.02
Tu.	7	67.59	14 22.60	14 22.57	0.126	21 8 39.58
W.	8	67 48	14 25.25	14 25.23	0.094	21 12 36.13
Th.	9	67 36	14 27.12	14 27.10	0.062	21 16 32.69
Fri	10	67.25	14 28.21	14 28.20	0.030	21 20 29.24
Sat	11	67.14	14 28.53	14 28 53	0.001	21 24 25.80
Su.	12	67 03	14 28.11	14 28.12	0.032	21 28 22.35
M..	13	66 92	14 26.95	14 26.97	0.063	21 32 18.90
Tu.	14	66 81	14 25 06	14 25.08	0.093	21 36 15.46
W.	15	66.71	14 22.45	14 22 48	0.123	21 40 12.01
Th.	16	66 61	14 19.12	14 19.16	0.153	21 44 8.57
Fri.	17	66.51	14 15.10	14 15.14	0.182	21 48 5.12
Sat	18	66 41	14 10.37	14 10.42	0.211	21 52 1.67
Su.	19	66.31	14 4 95	14 5.00	0.239	21 55 58.23
M..	20	66 21	13 58.85	13 58.92	0.267	21 59 54.78
Tu.	21	66.12	13 52.09	13 52 16	0.294	22 3 51.34
W.	22	66.02	13 44 68	13 44 76	0.321	22 7 47.89
Th.	23	65.93	13 36.64	13 36.73	0.348	22 11 44.44
Fri	24	65.84	13 27.96	13 28.05	0.375	22 15 41.00
Sat	25	65.76	13 18.66	13 18.75	0.400	22 19 37 55
Su.	26	65.68	13 8.76	13 8.86	0.424	22 23 34.10
M.	27	65 60	12 58.28	12 58.37	0.448	22 27 80.66
Tu.	28	65.52	12 47.21	12 47 32	0.471	22 31 27.21

Mean time of the Semidiameter passing may be found by subtracting 0.19 s. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D	H.	M.
☉	Full Moon	5	2	2.0
☾	Last Quarter	12	3	0.4
●	New Moon	19	1	49 0
☽	First Quarter	26	22	38.3

		D.	H.
☾	Perigee	13	7 1
☾	Apogee	26	9.2

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1

	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

	D.	APPARENT R. ASCENSION. H. M. S.	APPARENT DECLINATION. ° ′ ″	MERID. PASSAGE. H. M.
Venus	1	21 52 45.81	−14 28 8.4	1 7.8
Jupiter	1	5 1 26 14	+22 25 46.2	8 15.2
Saturn	1	18 23 53.72	−22 32 8.3	21 35.7

AMERICAN

Horological Journal.

VOL. II. NEW YORK, MARCH, 1871. No. 9.

CONTENTS.

*** *Address all communications for* Horological Journal *to* G. B. Miller, *P. O. Box* 6715, *New York City. Publication Office* 229 *Broadway, Room* 19.

ESSAY

ON THE

CONSTRUCTION OF A SIMPLE AND MECHANICALLY PERFECT WATCH.

BY MORRITZ GROSSMANN.

CHAPTER II.

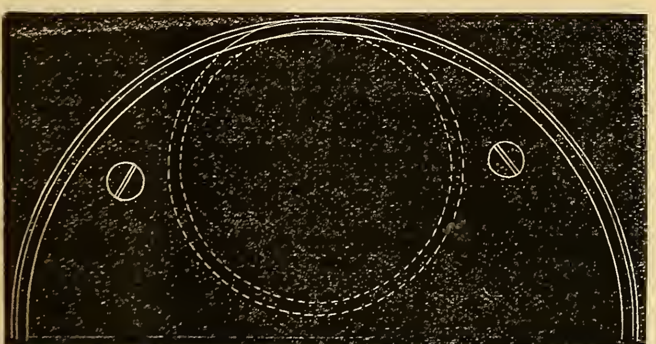
THE BARREL AND MAIN-SPRING.

24. An attentive consideration of the way in which this element of the watch is executed by the modern horological manufacturers will result in the conviction that the care which is due to an object of such importance has not been bestowed upon it. This fact is the more surprising, as a great number of cheap lever watches are produced in our day, with escapements so badly made that they can only be brought to a tolerable vibration by an excess of motive power.

25. In arranging the barrel of a watch, the manufacturer ought to be thoroughly penetrated with the principle that the height and diameter granted for a watch should determine the breadth and thickness of the main-spring. It is of the utmost importance to make the barrel as high and wide as the dimensions of the watch will allow of. For this purpose it will prove a good proportion to multiply the outer diameter of the pillar plate by the fraction 0.47. This will be the diameter of a barrel wheel as large as the size of the watch will admit (Fig. 1A). It is even possible to go a little beyond this limit, by placing the toothed part of the barrel a little lower than it is commonly done, in order to lodge this largest part of the barrel in the hollow space of the middle rim of the case, where there is always space enough, especially in hunting cases, if the case springs are properly placed (Fig. 1B). In this case, the diameter of the plate may be multiplied by 0.485, for attaining the diameter of the barrel.

26. The height of the barrel in a three-quarter plate movement ought to be the sum of the height of the pillars and the thickness of the pillar plate, after subtracting only a sufficient space for the free movement between the top and bottom of the barrel and the frame plates, and the necessary thickness of the bearing for the lower end of the barrel arbor.

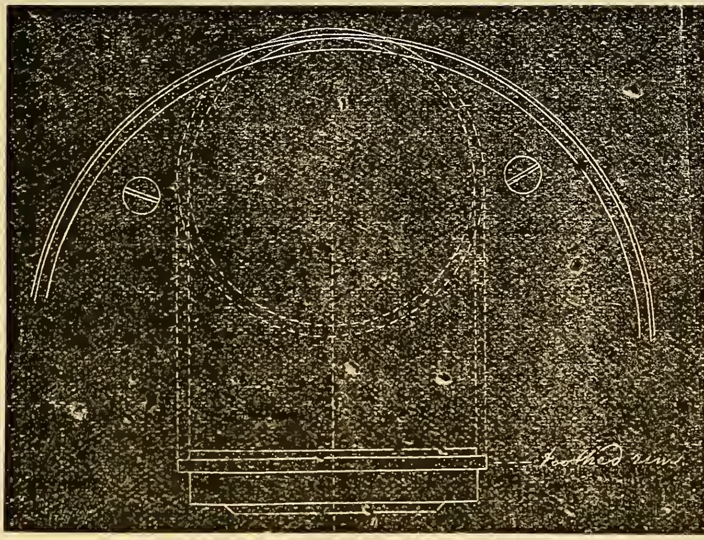
Fig. 1A.



27. It will be easily understood that a watch, the escapement and depths of which are imperfect, and made in a careless way, will require a powerful main-spring, while in a carefully made watch, the judicious utilizing

of space in the barrel will allow of employing a long and thin main-spring, which, by its

Fig. 1b.



suppleness, is less liable to accident, and, by the number of turns it makes in the barrel, affords the advantageous resource of selecting the middle turns of the development of the spring for the daily march of the movement, and thus to obtain a greater uniformity of motive power.

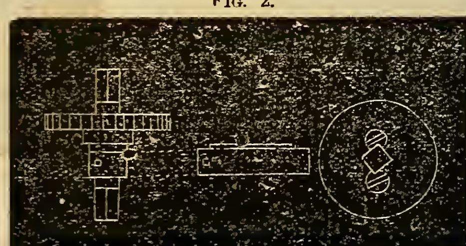
28. It will also be found advisable to reduce the breadth of the toothed rim of the barrel as nearly as possible to the amount required for the length of the teeth. There are many watches, the barrels of which, already too small in diameter, have also the toothed rim of an excessive breadth, so that much of the space due to the spring is entirely lost. It is quite obvious that a barrel of that kind causes a double loss of power. Not only must the spring be thinner and weaker than it might otherwise be, but also the inner radius of the barrel, which is the lever of power, is shortened; while the radius of the toothed part, which is the lever of resistance, is the same. The same consideration indicates also, that the sides of the barrel ought only to have the thickness required for fastening a solid hook.

29. If all the proportions of the barrel are as they ought to be, a spring of the thickness of $\frac{1}{30}$ of the inner diameter of the barrel will be quite sufficient to produce a lively vibration in a watch with escapement and depths a little carefully made. Such a spring, if the centre of the arbor is one-third of the inner diameter of the barrel, has a development of more than six turns, of which the middle ones may be selected for the daily march of the watch.

30. The way in which to construct the barrel arbor shows a vast difference between the various manufacturing countries. I do not hesitate a single moment to disapprove the system in general use in the Swiss watches. In the greatest part of them the lower end of the arbor has no bearing and support at all, and the barrel is maintained in its place by the ratchet, which is made out of the solid of the arbor. This system shows clearly that the preference which it enjoys is merely due to a blind routine. It offers neither economy of time in the manufacturing and in the repairing, nor a better distribution of room for flat watches; besides, it is inferior in the point of solidity and durability. In all watches, in those of careful make as well as in those of lower class work, the barrel arbor ought to be supported at both ends by solid bearings; in the former for the sake of greater solidity, and in the latter, also, for that of cheaper manufacturing.

31. There are two modes of executing these free standing barrel arbors. One of them has the ratchet forming part of the arbor itself (Fig. 2), sunk from the upper side into

Fig. 2.

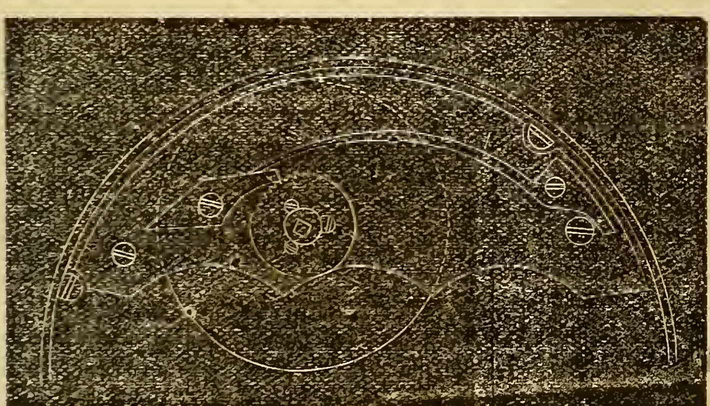


the barrel bridge, and is held in its place by a cap with three or four screws. These screws, having hardly more than three or four threads in the substance of the bridge, are the only means of securing the stability of the receptacle of the moving power in the watch. Every repairer will know, from oft-repeated experience, that this adjustment is an inexhaustible source of trouble, and that the inner face of the cap or the bottom of the sink are subject to rapid wear by the daily winding, if it has been neglected to oil the frictional surfaces. The consequence of this wear is an excess of shake of the ratchet and of the whole barrel. Any defect of this kind is a very serious one, because the barrel and centre-wheel, the two largest moving parts of the train, have, by necessity, their surfaces very close to each other.

32. With the other mode of execution, the ratchet is screwed with three screws on to the shoulder formed at the part of the arbor just above the barrel (Fig. 3).

This system is still worse from the point of durability. There are only two small annular surfaces which constitute the hold of the barrel. The shoulder of the arbor, as well as the edge of the ratchet, wear away gradually the upper and lower side of the bridge, and the screws slacken their hold by the numerous little jerks of the click when winding the watch. Besides, the ratchet is subject to defects in hardening, and by the three holes and sinks for the screws rather close to the edge. In both these cases the core of the barrel arbor is a separate piece, screwed on the arbor, or adjusted on it and held in its place by a pin through both parts. The finger of the stop-work is secured to the end of the arbor by a pin through this latter.

Fig. 3.



33. The most advantageous way, both for the manufacturing and repairing, as well as for the durability and good service, is to make the barrel arbor with two pivots, supported each by a bearing. An arbor of this kind is very easy to execute. The ratchet must be fitted on the square of the arbor, which is easier to achieve than the adjustment of the core of the Swiss arbors. There is no necessity of perforating the lower end of the arbor in order to secure the stop-finger in its place, which is attained by the lower bridge of the barrel.

A barrel of this nature is much easier to take to pieces and to put together than a Swiss one. It requires merely taking off the cover of the barrel, and all is done; while with the other one the pin of the stop-finger must be taken off, and after opening the barrel, the pin joining the core to the arbor must be drawn out or the core screwed off, before the parts can be cleaned, or a new spring put in, and afterwards all these arrangements have to be got together again.

34. In a frame, the pillar plate of which was hollowed only 0.2 or 0.3 mill. at the dial side, this space would suffice for containing a thin steel bridge for maintaining the lower pivot of the arbor. The same space would be necessitated for receiving in a solid way the pin for the stop-finger, if we do not wish to create that unfortunate state of many flat watches, in which it is hardly possible to draw out and put in that pin without splitting the end of the arbor. Thus it will be seen that there is not even an economy of space to be obtained by this system.

CHAPTER III.

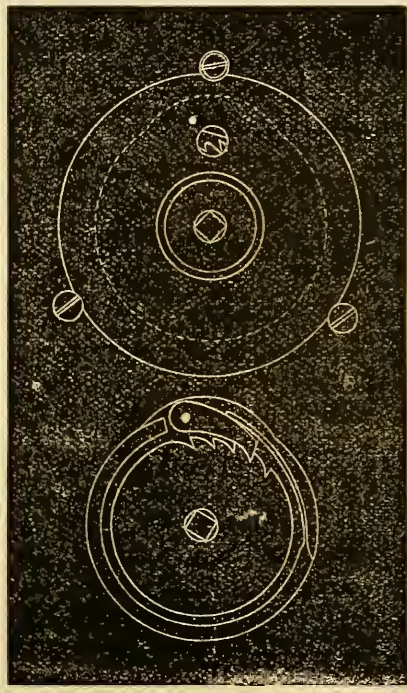
THE CLICK WORK.

35. The click is a necessary adjunct of the barrel and main-spring, its purpose being to prevent the retrograde motion of the arbor when the winding action ceases. This function being rather out of connection with all the other parts of the movement, it cannot be

a matter of surprise to see the click-work executed in a great variety of different ways, all attaining the same purpose with more or less ease in the execution, and with different degrees of elegance in appearance.

36. If simplicity and easy execution are required—especially if the click-work is to be sunk into the upper plate—it seems that the round adjustments deserve the preference. The most simple click-work of that kind would consist in the ratchet and click-spring; the latter of circular form, and surrounding the ratchet with only the necessary interval for free movement—both parts to be adjusted in a sink in the upper plate (Fig. 4). The

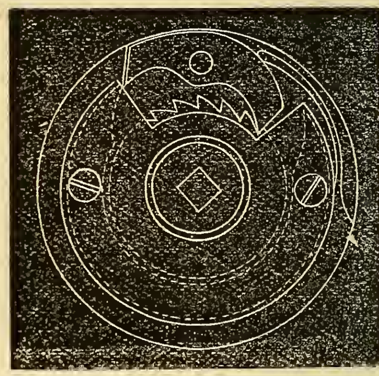
Fig. 4.



click ought to move on a stud left in the sink, or between two pivots. The whole arrangement would be covered and held in its place by a cap screwed on the plate, and perhaps sunk into it a trifle, just in order to centre it easier. A small hole through the cap, at a proper place, would be useful for lifting the click out of action when it is required to let the spring down. It would hardly be possible to have a click-work more simple and cheap of execution, and still quite reliable, than this one.

37. For watches, in the execution of which a greater degree of elegance is wished for, the click and click-spring may be exposed by leaving a small annular space round the sink that contains the ratchet, on which space the cap is screwed. The spring is lodged into a circular sink outside this space, so that it is only covered a very little by the cap, in order to be secured to its place (Fig. 5). The

Fig. 5.



thinner acting part of the spring may easily be formed in an eccentric chuck on the lathe.

38. It would be a simplification of the click-work to form the click at the acting end of the spring, but the click and spring are much exposed to break, and in such a case the replacing of the piece would be a greater trouble (Figs. 6 and 7).

Fig. 6.

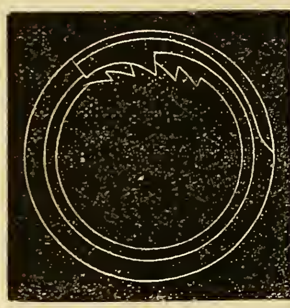


Fig. 7.

39. The material of which the click-work ought to be made is hardened and well tempered steel, at least for the ratchet and click. The spring might as well be made of another metal of sufficient elasticity, but steel is generally preferred, for the more lively appearance which its polished surface gives to the movement.

CHAPTER IV.

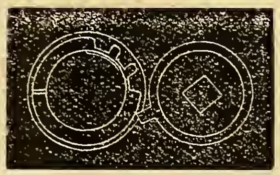
THE STOP-WORK.

40. The last of the accessories of the moving power is the mechanism regulating the amount of tension to apply to the spring in winding it, and the range of development of this latter to be employed for the daily march of the watch. This part, of all others, is the most open to controversy as to the best mode of attaining its purpose ; and as to the way of its execution there is a great variety, from its total omission to the rather complicated and ingenious stop-works of some Swiss and French watches.

41. When we attempt to establish the relative merits of those different constructions, there is an important feature which may guide our judgment. This is the friction ; and all stop-works whose parts move under the control of a frictional resistance, may be objected to; because friction, however slight it may be, if it can be avoided, is a useless loss of power. Besides, in all the stop-works of this kind, it is a tooth or finger only, which, by butting against the full part of the stop-wheel, puts an end to the winding. This tooth or finger is liable to break under the strain it may be subjected to by the careless way in which many people wind their watches.

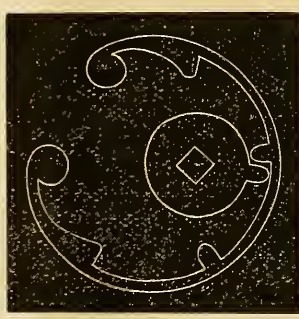
42. The most common of these frictional stop-works, though not often seen in watch-work, has a wheel in which only three or four teeth are cut, and all the rest of the periphery left full. This wheel is screwed, with a stop-screw, to the plate, and the end of the barrel arbor carries a finger or tooth gearing into it, and moving one tooth of it at each revolution of the arbor. At the beginning and end of the winding range the tooth butts against the full part of the wheel's circumference, and prevents further motion of the arbor. It is evident that during all the time between two passages of the tooth the stop-wheel is without any control whatever, and might move round its axis by any external shocks if the freedom of its motion was not checked by a stiffening spring, causing sufficient friction. Sometimes the stop-wheel is reduced to a narrow rim, and is open at the place opposite the teeth, so that it is sprung on a little undercut stud spared from the substance of the barrel cover, thus gaining its hold without any screw or spring (Fig. 8).

Fig. 8.



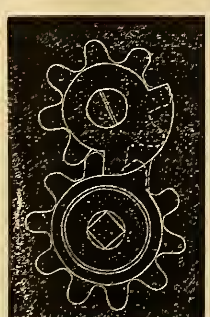
43. To the same class belongs a kind of stop-work, forming, as it were, an inward gear. A concentric annular groove is cut into the barrel cover, a little undercut at its outer edge. This groove holds an annular spring, in the inner edge of which some teeth are cut in which the stop-finger is to gear, and to limit the winding by coming into contact with the plain part of the spring. The friction of this latter in its groove prevents any untimely movement. It is obvious that this arrangement is liable to the same objections as the former one (Fig. 9).

Fig. 9.



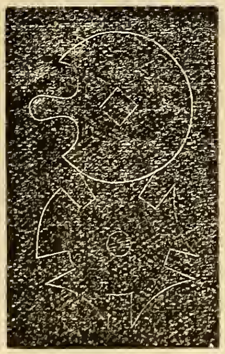
44. Of the other class of stop-works, operating without friction, we mention a very judicious arrangement frequently met with in the better class of Swiss and French watches of about fifty years of age. It consists of two small toothed wheels gearing into each other; the one on the barrel arbor having some teeth more than the other one, so that the same teeth of both wheels meet only after a certain number of turns allowed for the winding. Both the wheels have on their upper side, fastened in a solid way, a stop-piece of steel, and these two stop-pieces, when meeting, stop the motion by butting in a right angle (Fig. 10). The mechanical perfection, and the reliability of this stop-work is beyond any doubt; and it only has the drawback that it requires an additional height for the stop-pieces placed

Fig. 10.



over the two wheels, and it is easy to find that by the same quantity the breadth of the main-spring must be restrained.

Fig. 11



45. The stop-work with the cross of Malta (Fig. 11) is the most in use for watch-work, and deserves this preference. It is too well known to require a description. It is true that the careless way in which this stop-work is often executed, in the lower classes of watches, is a source of trouble and disappointment, both to the wearers of the watches and to the repairers. It must be well understood that the Malta stop-work does not allow any meanness or neglect in its execution; but, well executed, it has a solidity up to any proof. With a judiciously arranged set of tools there is no great difficulty in manufacturing it in an irreproachable way.

46. Still, the stop-work, however well it is made, is only an unavoidable evil, because it complicates the mechanism, and makes it more liable to disorders and failures of various kinds, and lastly, because it takes away a part of the place which otherwise might have served to increase the breadth of the main-spring.

For these reasons it is no wonder that the question has been earnestly considered, whether it would be possible to dispense entirely with the stop-work, without compromising the solidity or the steady rate of a watch, and without exposing the main-spring to any disproportionate strain. This question requires a careful study, for the advantages to be obtained from the suppression of the stop-work are of considerable importance. Thus it will only be necessary to investigate whether these advantages are not outweighed by some grave inconveniences.

47. The omission of the stop-work has been tried in a manifold way. It is more than twenty years since that a spring was employed for this purpose, to the outer end of which was riveted a piece of the same spring, of a length equal to about one-third of the inner diameter of the barrel. This piece was fixed backward in the direction of the spring, and its free end was resting against the hook in the barrel of the ordinary shape. This arrangement allows the spring to be coiled up to its outermost extremity, and the short piece riveted to it will then rest in an oblique direction against the hook, and prevent any further winding. (Fig. 12.)

Fig. 12.

This system is superior to the simple omission of the stop-work, because it preserves the spring much more against breaking; but it does not protect the other parts of the movement from the sudden strains resulting from inconsiderate winding; a fault, though, which may be urged against any of the kinds of stop-work hitherto referred to.

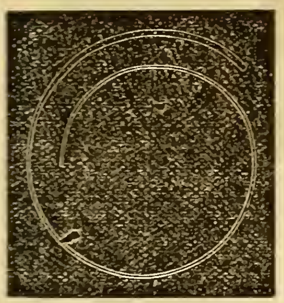
This arrangement looks rather primitive, but it ought not to be totally rejected. I was desirous of obtaining a correct idea of its merits, and constructed, about sixteen years ago, two small ladies' watches, which had to be very flat, with barrels of this kind. These watches have been kept in constant use by persons in my immediate neighborhood, and thus I have had them under constant observation all this time ; they gave satisfaction as to the rate of going, and none of the springs have been broken at the present time.

I recently saw some watches of American origin, the barrels of which were arranged in quite a similar way, with the only difference that the piece riveted to the end of the spring had two pivots at its free end, the one of which moved in a hole through the bottom of the barrel, and the other in the same way was held in the barrel cover.

48. Some years ago a system was invented by which the weak points of the one just mentioned are avoided, and the stop-work entirely dispensed with. These are the *free springs* of Mr. A. Philippe. An examination of their advantages, and of the objections raised against them, will not be out of place here.

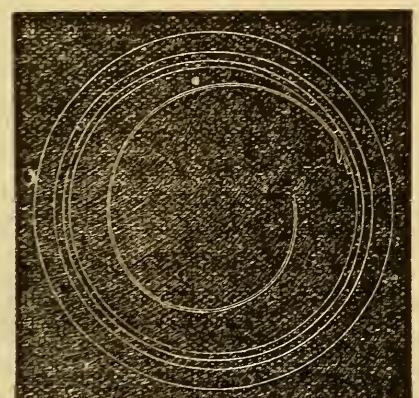
These free springs are made or arranged in such a way as to take their hold in the barrel without the usual hook, merely by the greater tension and strength of their outer coil, which, for this purpose, is of about double the thickness of the acting part of the spring. The relative thicknesses of these two parts must be kept in such proportion that the outer coil, always keeping a frictional hold in the barrel, follows the winding movement, but only when the spring has attained a certain maximum of tension. Thus, any tension of the spring beyond this maximum is rendered impossible, if the winding is continued ever so long (Fig. 13).

Fig. 13.



49. The springs of this kind have been, and may be executed, in two different ways. According to the one, the thicker part is a part of the spring itself; while the other way consists in adding to a spring of the usual kind a separate piece of greater strength, equalling in length the inner periphery of the barrel, and forming, as it were, an elastic bridle for the main-spring, which is attached to it by a hook (Fig. 14). The effect of the two dispositions, of course, is the same.

Fig. 14.



50. It is not easy to pronounce briefly an opinion for or against the free spring; for, judging equitably its merits, we have to consider its drawbacks and the objections raised against it by watchmakers and repairers, and balance them against the advantages it promises. These latter are:

1. Greater height of barrel, allowing to employ for a watch of the same size a broader and thinner main-spring, which is consequently less exposed to accidents, and gives a more uniform traction.

2. Economy in the manufacturing of the barrel. This advantage is, however, in a degree absorbed by the higher price of the free spring, but this price will be considerably reduced if the free spring should become a regular article of trade.

3. Complete elimination of all derangements of the watch, resulting from defects or disorders of the stop-work.

4. Protection of the movement against all injury arising from inconsiderate and rough winding.

5. Lengthened period of daily march with once winding, because the free springs generally are made so as to admit a tension of six turns or more.

These advantages, especially those from 3 to 5, are of great importance, and especially the one No. 4 has not yet been so much appreciated as it ought to be.

51. The drawbacks of the free spring are the following:

1. The absence of distinct perception, marking the end of the winding operation. This objection can be removed by cutting three or four vertical grooves into the inner cylindrical surface of the barrel, and by giving the end of the spring a slight bend outward, so that it penetrates a little into one of these grooves. If the maximum of tension of the spring is attained, the end of the spring will no more be arrested by the hold in the groove, and slips into the next one, thereby giving an easily audible click, which is a warning that the winding is completed. This sudden little motion is at the same time perceptible to the touch.

2. The great inequality of traction, which must necessarily exist between the two extremities of the development of the spring. This objection seems to be a serious one at first sight, because the watch, if not regularly wound, will continue to go till the tension of the spring is almost exhausted; and it cannot be doubted that in the last hours of expiring march, the watch may show some alteration of rate as compared with the rate it keeps when regularly wound. But every one

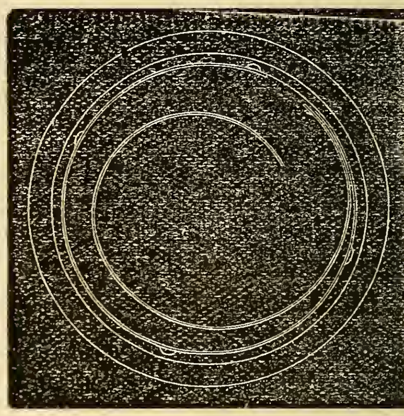
will admit that no watch can be expected to perform in an irreproachable way if it is subjected to such careless treatment; besides, let me ask, what would be the consequences of a neglect in winding a watch provided with the stop-work? It would lead to a total stopping of the watch—a rather disagreeable occurrence, especially when travelling; and it is precisely under exceptional circumstances that the winding is most likely to be forgotten. In such a case, the owner of a watch with the free spring would have to acknowledge it as an advantage that his watch maintains its march, if even with a deviation of some minutes, which, however, would be hardly possible with a good watch, even under such uncommon circumstances.

52. Thus, the two principal objections against the free spring are completely attenuated. But there are several practical difficulties which make most watchmakers averse to its employment. This is chiefly the inconvenience of being obliged to keep an assortment of free springs, besides the stock of common springs for cases of breakage, and the higher price of the free springs adds to the weight of this argument. Springs of the common kind, on the contrary, are cheap and easy to procure.

These circumstances made me reflect whether there was not some means of enjoying the incontestable advantages of the free spring, without resigning the facility of replacing a broken spring of the usual system. I think I have found out a remedy; at least one available in a case of need. I take a common spring of suitable breadth and thickness for the barrel, and I break off a piece of the outer end and corresponding in length with the interior periphery of the barrel. Out of the end of this piece I form a hook to which the spring is hooked in the common way, so that the detached piece extends backward in the direction of the length of the spring (Fig. 15).

This arrangement has the effect that the pressure of this piece against the inside of the barrel increases with the tension of the spring, while with Philippe's arrangement, the traction of the spring diminishes the friction of the outer turn; and this is the reason why this latter contrivance requires the detached pieces stronger than the spring itself. In the modification just mentioned, a piece of the

Fig. 15.



main spring itself is sufficient, and its resistance may be increased by the grooves in the barrel, and by a projection punched at the end of the piece, and lessened by shortening the same. I think a spring arranged in this way would soon make friends, because it offers all the advantages of the free spring, without its difficulties for the practical repairer. At any rate, it offers the means of providing a watch, in which a free spring is broken, with a new spring in suitable conditions, from the ordinary stock of springs on hand.

——o——

CORRECTION.

Editor Horological Journal:

Kindly permit me to correct the reading of my communication of December last.

Page 127, Fig. 1—n^1 A and n^2 A should be joined by dotted lines, indicating the line of centres, viz: centre of formation and generating circles.

Then page 126, column the second, line third, it should read thus: . . . . its radius forming, with the line of centre, the angles $o\ n^1$ A, $o\ n^2$ A, $o\ n^3$ A.

Also, page 128, column first, formula, fourth line, it should read thus:

$c =$ line of centres,

that being the term employed.

Yours, &c.

J. Herrmann.

HEAT.

NUMBER SEVEN.

HARDENING OF STEEL—VARIOUS METHODS OF APPLYING THE HEAT—VARIOUS METHODS OF COOLING—PRECAUTIONS AGAINST CRACKING—CAUSES OF STEEL BECOMING HARD—STEEL LARGER WHEN HARD — VARIOUS METHODS OF TEMPERING — VARIOUS METHODS OF COLORING AND BLUING—THE OIL BATH, SAND BATH, MERCURY BATH, ETC.

We have now to consider the important process of hardening steel, and the changes produced thereby. It is not requisite that the hardener should be a chemist, but some slight acquaintance with chemistry, or of the action of substances upon each other, will be extremely serviceable to him. To be unqualified in this respect will be laboring in the dark; a successful result may often be obtained, but it will be very imperfectly known how it happened, and it will afford no valuable instruction for the future. There are too many who entertain the opinion that they have nothing to learn, and in effect say, that having served an apprenticeship to their business they know everything. These we do not attempt to convince, but the prudent artisan, whose first care is generally to provide himself with tools adapted to his labors, we would ask to improve his knowledge of the nature of the materials from which they are made ; the proper choice and management of which constitutes the first step towards success in mechanical pursuits.

The degree of heat necessary to harden steel differs with the different kinds. The best kinds only require a low red heat—the lowest heat necessary to effect the desired purpose being the most advantageous, and to impart to it an extra portion of heat must partly destroy its most valuable properties, and for this misfortune there is no remedy; for if cast steel is overheated it becomes brittle, and can never be restored to its original quality; therefore it will be quite incapable of sustaining a cutting edge, but will chip or crumble away when applied to the work. There are various ways of applying heat to articles when they require to be hardened. The methods to be adopted will, of course, depend upon the shape and size of the articles, also upon the quantity required to be operated upon at the same time; for in some instances a large quantity can be heated and hardened as expeditiously as a single article. Sometimes it is requisite to heat the articles in the midst of the fuel of a hollow fire; at others it is necessary to heat them in an open fire; and sometimes it is desirable to enclose and surround them with carbon in a sheet-iron box, and heat the whole in a hollow fire, or a suitable furnace; and in some instances it is more convenient to heat them in red hot lead. A more uniform degree of heat can be given to some articles by heating them in red hot lead than by any other means. A gas flame, or the flame of a candle, or a spirit lamp, is very convenient for heating small articles, and some articles may be sufficiently heated by placing them between the red hot jaws of a pair of tongs. Sometimes it is necessary to insert a piece of iron pipe in the midst of the ignited fuel of the fire, and then place the articles in the pipe; clock pinions, and long, small arbors and broaches being generally hardened in this manner. All bright articles, which are made of steel, and require to be hardened, are the better for being heated previous to immersion in contact with carbon. To supply carbon to the surface of steel articles, they may be enclosed in a sheet-iron box, and surrounded on all sides with either wood or animal charcoal; the whole will require to be placed in a furnace, or hollow fire, and heated to redness; but if the hardener be unacquainted with the conducting power of the charcoal he will be apt to draw the box out of the fire too soon. To make sure, all the articles should be examined or tested in some way to see that they are at the proper heat before they are immersed in the water.

It is obvious that the colder the water the more effectually it hardens the steel; and the more especially when the steel is immersed suddenly, and a rapid movement given to it whilst it is becoming cool; but when fresh cold water is used there is always great danger of the steel cracking. The softer the water is, the less is the liability of the steel to crack; and water at a temperature of 60° is said to be the most favorable to hardening without the risk of cracking. When steel is required to be extremely hard, it may be quenched in mercury; but it is obvious that this fluid can only be used on a small scale. Brinish liquids, or water charged with common salt, produce rather more hardness than plain water. We remember a few years ago we had occasion to make a small drill very hard. It was in the hottest of the summer months, and we quenched the drill in what we supposed to be a glass of water that was convenient. The drill proved to be much harder than when quenched in oil, as we had previously done, and bored through several pieces of thin hard steel without materially dulling the edge, and was the cause of much remark among those who witnessed the operation. It turned out, however, that what we supposed to be pure water was in reality *lemonade*, which the workmen had been drinking, and to this cause we attributed the extra hardness of the drill. Ever since then lemonade has been used for such purposes when it can conveniently be had, and that too with the very best results. All kinds of small springs may be advantageously hardened in oil, or pure soft water, with a small quantity of oil floating on the top. Oil or tallow appears to give a certain amount of toughness to steel in hardening which is not attained by any other method or liquid.

It may not be generally known that the hardening of steel does not necessarily depend on the immersion of the metal in a liquid of any kind, but may be effected equally as well by the application of cold; as, for instance, watchmakers harden very small drills by suddenly drawing them through the air after being heated; or when we leave a thin piece of red-hot steel between a large hammer and the face of an anvil, the steel becomes as hard as when quenched in a liquid. Before putting any article in the fire to heat, before hardening, it is necessary to examine the shape in order to know which way it will require to be immersed in the water so as to lessen the risk of its cracking or bending; every kind of article requiring to be dipped in a particular way, according to its shape. For instance, if there be a stout part and a thin part in the article, the stoutest part should always enter the water first, as it causes the steel to cool more uniformly, and lessens the risk of fracture; because if the thinnest part of the article be allowed to enter first it will become cool much sooner than the stout part; and the stout part contracts, by the loss of heat, after the thin part is fixed; the thin part, in its then hard and brittle state, cannot give, consequently it breaks; or, if it does not break at the time of hardening, it is held in such a state of tension or strain that it is ready to break when applied to the work.

Drills and all kinds of tools and work that are only hardened at the ends, and which are only partially dipped into the water, should never be held still when they are becoming cold; but should, after they are dipped to the required depth, have a sudden vertical or other movement given to them. When the water cools them across in a straight line, it causes the hardened part to have a tendency to tear from the soft part; but whether the steel breaks asunder or not, or whether there are signs of fracture or not, this tearing of the particles from each other when the hardening terminates in a strict line, must always, with highly carbonized steel, more or less take place, when it is known that hardened steel occupies more space than soft steel, and that the density of the steel is different in the two states. It is pretty generally known to those who are much employed in the process of hardening steel, and to those in the habit of fitting up various kinds of steel work requiring great nicety, that the hardening of steel often increases its dimensions; so much so, that pieces of work fitted in a soft state will not fit when hardened, and the workman has to resort to the process of grinding to make the work fit. Some explanation of this phenomenon is given in No. 4 of these articles, under the head of permanent elongation of metals, and change of the zero point in thermometers.

Many theories upon the cause of steel becoming hard by the process of heating and suddenly cooling it, have been formed. It is believed by some that the hardness of steel is caused by the compression of the whole of the particles into a denser state; and in confirmation of this, they say that steel always looks closer and finer in the grain after being hardened. Now, if this was the only cause of steel becoming hard, how is it that the steel gets larger in dimensions? It is quite reasonable to suppose, if the particles of the hardened parts of the steel are removed to a greater distance from each other, that the steel would look considerabley more open and coarser in the grain; and consequently it may be inquired if it is not the compression of the whole of the particles into a denser state that is the cause of steel looking closer in its texture after hardening. The answer is, if we accept the theory that it is the crystallization of the carbon which causes the hardness in the steel, that the carbon expands in the act of crystallization in a similar manner that water expands by extreme cold in crystallizing into ice, and fills up every pore or crevice, and gives the steel the appearance of being closer and more solid.

Such is a slight sketch of the causes that lead to the hardening of steel, and although much more might be said, we do not think it to be necessary to entangle the reader with a lot of theories on the subject, although it may be necessary for his amusement, and for the exercise of sound judgment, to occasionally glance at them in treating fully the purely mechanical operations.

The tempering of steel, after being hardened, is also of the greatest importance. Large articles are usually tempered by applying heat to them till their surfaces present a certain color, according to the degree of hardness required; but when a large number of small articles are required to be tempered, it will be too slow a process to temper them by color, and a more expeditious method must be adopted. A very convenient way of uniformly heating a large quantity of small articles at once, no matter how irregular their shape, providing the heat is not applied too suddenly, is to put them into a suitable iron or copper vessel, with as much tallow or cold oil as will just cover them, and then to place the whole over a small fire, and slowly heat the oil until a sufficient heat is given to the articles for the temper required.

It may perhaps be well to remind the young beginner that the temperature of the oil may be raised to 600° of heat, or rather more, and consequently any temperature below a red heat may be given to the articles by the heated oil. Certain degrees of temperature may be estimated by the following circumstances: When the oil is observed to smoke, it indicates the same temperature as a straw color, and if measured by a thermometer, will be about 450°. When the smoke becomes more abundant, and of a darker color, it indicates a temper equal to a brown, and the oil will measure 500° by the thermometer. If the heat be continued so that the oil will yield a black smoke, and still more abundant, this will denote a purple temper, and the oil will contain about 530° of heat. The next degree of heat may be known by the oil taking fire, if a piece of lighted paper be presented to it, but yet not so hot as to burn when the lighted paper is withdrawn. The temperature of the oil at this stage will be about 580°. The next degree of heat may be known by the oil taking fire and continuing to burn. This is the temper best suited for most kinds of springs, and is the temper clockmakers use mostly for pinions and arbors. Any single article, to save trouble of heating in a vessel, may be smeared over with oil and held over a clear fire, or over a piece of hot iron, or a candle, or flame of almost any kind, when there is no smoke. It formerly was a common, and also a very good custom, to harden small drills and taps in the flame of a candle with a blow pipe, quench them in the grease of the candle, and burn off the grease till the desired temper was attained.

Although the above method is a reliable process for tempering steel articles equally throughout, however irregular may be their shape, still it is often required, in fine work, to temper the articles so as to leave the color visible and regular on the surface; and also it is often required to give soft articles a blue or other color by way of ornament. Certain articles can thus be colored by skilfully holding them over a hot iron, or spirit lamp; but when the articles are of irregular shape, it becomes very difficult to impart a regular color to them in this manner. The sand bath is frequently used for this purpose, and, in the hands of skilful operators, good results are obtained; but a neater and more reliable method has been introduced, and which we have ourselves used with great success; and we recommend it to all who require to blue irregular-shaped pieces of work.

The following experiment is simple, and clearly exhibits and illustrates this manner of tempering: Let a plate of steel, finely polished, be so laid as to float on the surface of a bath of mercury, in which plunge the bulb of a thermometer 600° Fahr. No change of color will be visible on the steel until the mercury has risen to 430°, and then it will be so faint as only to be perceptible by comparison with a plate that has not been heated. At 450° the color will be a fine pale straw, which, as the heat increases, will become deeper, and successive changes will take place until it be heated up to the boiling point of mercury, which degree of heat can be attained with a good argand gas burner.

Such is a review of the effects of heat in hardening and softening metals. Further practical directions might easily be multiplied, but the necessity for much further minuteness of detail upon most of the processes will be removed by a little observation, experience, and perseverance, which we wish all our young friends to cultivate. Those who postpone perseverance by satisfying themselves with the hope that length of practice will perfect them, will in the end regret their delusion, and may ineffectually try to recover their loss, when habitual languor, and other injurious habits, have rendered the mind averse to observe, and the hand unable to perform.

——o——

BRASS ALLOYS.

We shall continue the subject of metals in the condition of alloys, somewhat in the order of their importance in our art.

Brass being more largely demanded in our constructions will claim the first consideration. No metal, either simple or compound, iron excepted, enters so largely into mechanical construction as brass. Scarcely any machine, large or small, is completed without some demand being made on this useful alloy of copper and zinc.

Copper, one of its constituents, was known to the ancients, and derived its name from the island of Cyprus, where it was first wrought by the Greeks. Before the discovery of malleable iron it was the chief ingredient in the manufacture of domestic utensils and instruments of war. Copper is largely met with in the metallic state, but still more largely in combination with the metalloids, oxygen, sulphur, and arsenic. The sulphurets are the chief source of supply for commercial demands. Copper is very malleable and ductile, and may be drawn into fine wire or beaten in thin leaves—its tenacity being only inferior to iron. It has a peculiar taste, and by friction evolves an odor peculiar to itself and somewhat disagreeable ; at a white heat it passes off in vapor, which, in the open air, burns with a green flame. At ordinary temperatures this metal does not oxidize in dry air, but quickly changes in moist air; it then becoming covered with a strong adherent coat of carbonate of copper. Heated to redness in the air, copper becomes oxidized—a black scale covering its surface. Dilute sulphuric or muriatic acid scarcely acts upon it, but dilute nitric acid dissolves it readily. Sulphate of copper, or "blue vitriol," is the most important salt of copper ; it occurs in large blue crystals, which are soluble in four parts cold or two of boiling water. This salt is the source of several blue and green colors used by dyers and calico printers, and in some kinds of writing ink. Ink of this character has the inconvenience that in writing with steel pens metallic copper is precipitated on the steel, and clogs the pen. This salt is also a powerful preservator of animal substances, which when imbued with it and dried become unaltered.

Zinc, the other constituent of brass, is first mentioned as a distinct metal by Paracelsus, but it appears to have been known in China and in India from an early period. It has a bluish, white color, and its recent fracture presents a brilliant crystalline surface. It is somewhat brittle at ordinary temperatures, but when heated to between 212° and 300° it becomes malleable and ductile, and may be rolled or hammered out without fracture, and what is remarkable, retains its malleability when cold. The sheet-zinc of commerce is made in this way. If the heat be increased to about 450° the metal again becomes brittle, and may be reduced to powder. At a bright red heat zinc boils and volatilizes, and if air be admitted burns with a vivid, whitish blue light, generating the oxide, a white, flocculent matter, called flour of zinc, or philosopher's wool.

Chloride of zinc combines with sal-ammoniac to form double salts. Zinc dissolved in hydrochloric acid, with an equivalent of sal-ammoniac added, is useful in tinning and soft-soldering copper, iron, etc.

The term brass is usually applied to the yellow alloy of copper with about half its weight of zinc, commonly called *yellow brass;* but copper with about one-ninth its weight of tin is the brass of which ordnance are cast, called gun metal; and similar alloys used for the *brasses* or bearings of machinery are called *hard* brass, and when employed for statues, medals, and articles of virtu, are called *bronzes.* We shall confine ourselves, in this article, to the alloy of copper and zinc only; the harder alloys being almost entirely foreign to our trade. In the language of the foundry, a pound of copper is taken as the standard in speaking of proportions. Yellow brass, they will tell you, is 6 to 8 oz. of zinc; meaning 6 to 8 oz. of zinc to the pound of copper. In the following list of alloys the numbers at the beginning of each paragraph denote the ounces of zinc to every pound of copper.

$\frac{1}{8}$ to $\frac{1}{2}$ oz. is added to copper which is to be cast, for in its pure state it is difficult to get pure copper to make sound castings. The compound is frequently made by adding 4 oz. of brass to every 2 or 3 pounds of copper.

1 to $1\frac{1}{4}$ oz. forms gilding metal for common jewelry. The common formula is 4 parts copper to one of calamine brass, or 1 lb. copper with 6 oz. brass.

3 oz.—Red sheet brass, or $5\frac{1}{2}$ copper and 1 zinc.

3 to 4 oz.—Bath metal, pinchbeck, Maunheim gold, oroide, or whatever else for a name the gullible public will swallow. It resembles inferior jeweller's gold alloyed with copper; some contains a little tin.

6 oz.—This brass will bear soldering. Bristol brass is said to be of this proportion.

8 oz.—Ordinary brass; less adapted to soldering than 6 oz., as it is more fusible. This is a brass patented in 1781 by Emerson. It is the common ingot brass, made by simple fusion of the two metals.

9 oz.—This is one of the extremes of Muntz's patent sheathing.

$10\frac{2}{3}$ oz.—Is Muntz's metal; or 40 zinc, 60 copper. The patentee's statement is that any proportion between the extremes of 50 zinc and 50 copper, and 37 zinc and 63 copper, will roll and work at the red heat, but 40 to 60 is preferred. The metal is cast into ingots, heated to a red heat, into ship's bolts and other fastenings, rolled into sheathing, etc.

12 oz.—Spelter solder for copper and iron is sometimes made in this proportion; for brass work the metals are usually mixed in equal parts.

12 oz.—Pale yellow, suitable for dipping in acids.

16 oz.—Soft spelter solder, fit for ordinary brass work. About 14 lbs. of each are melted together and poured into an ingot mould with cross ribs, which indent it into squares of about 2 lbs. weight. Much of the zinc is lost in fusing and casting, so that the ultimate proportion is less than 16 oz.

The lumps are afterwards heated nearly to redness on a charcoal fire, and are quickly broken up in an iron mortar. If the heat be too great, the solder forms into a cake, or coarse lumps, and becomes tarnished. At a proper heat it becomes nearly granulated; is passed through a sieve and remains a bright yellow color; $16\frac{1}{2}$ oz. is Hamilton's and Parker's mosaic gold, which is dark colored when first cast, but after dipping assumes a beautiful golden tint; when cooled and broken, the yellowness disappears. The best proportions are about $16\frac{1}{4}$ to 17 oz. to the pound.

32 oz., or 2 zinc to 1 copper.—A bluish white brittle alloy, so crystalline that it may be pounded cold in a mortar.

128 oz., or 2 oz. copper to every pound of zinc.—A hard crystalline metal, differing but little from zinc, but more tenacious. It is sometimes used for polishing taps.

The alloys from 8 to 16 oz. are extensively used for dipping, as in the various brass articles used for furniture; the metal being first annealed before it is scoured or cleaned, or the acids, lacquers, or bronzes applied. The ordinary range of good yellow brass, that files and turns well, is from $4\frac{1}{2}$ to 9 oz; with additional zinc it becomes harder and more crystalline, and with less, more tenacious. Up to 8 or 10 oz. the alloys maintain their malleability and ductility. The red color of copper merges into that of yellow brass at 4 to 5 oz., and remains but little altered up to 8 or 10 oz ; after this it becomes whiter.

Owing to the very volatile and inflammable nature of zinc in the furnace, these proportions must not be strictly taken, for whatever weight of the two constituents be put in the crucible there will always be a rapid, and, to a certain extent, uncontrollable waste of zinc.

The native ore (carbonate) of zinc, called *Calamine* is not infrequently used for the manufacture of glass. For this purpose the native Calamine is broken and ground in a mill; after being calcined, the galena (lead ore) contained in it is separated by washing; it is then mixed with about $\frac{1}{4}$ part of charcoal, the mixture put into large cylindrical crucibles, with alternate layers of copper, cut in small pieces, or in the form of shot ; powdered charcoal is then covered over the whole, and a cover luted on, and placed in the furnace—the zinc of the carbonate uniting with the copper, without assuming, apparently, the metallic form. We are largely indebted to Mr. Holtzapffel in his work on "Mechanical Manipulations" for the details of a number of interesting experiments for the best methods of forming alloys of copper and zinc. "The zinc was added to the copper in various ways ; namely in solid lumps, thin sheets hammered into balls, poured in when melted in an iron ladle, and all these both while the crucible was in the fire and after its removal from the same. The surface of the copper was in some cases covered with broken glass, or charcoal, and in others uncovered, but all to no purpose ; as from $\frac{1}{8}$ to $\frac{1}{2}$ the zinc was consumed with most vexatious brilliancy, according to the modes of treatment ; and these methods were therefore abandoned as hopeless. I was the more diverted from the above attempts, from the well-known fact that the greatest loss always occurs in the first mixing of the two metals, and which the founder in general is anxious to avoid. Thus, when a very small quantity of zinc is required, as for so-called copper castings, about 1 oz. of brass are added to every 2 or 3 lbs. of copper. And in ordinary work a pot of brass, weighing 40 lbs., is made up of 10, 20, or 30 lbs. of old brass, and $\frac{2}{3}$ of the remainder of copper. These are first melted. A short time before pouring, the $\frac{1}{3}$ of the new metal, or zinc, is plunged in when the temperature of the mass is such that it just avoids sticking to the iron rod with which it is stirred." In forming an alloy of 2.75 copper with 1 zinc, the proportions of which require to be very carefully preserved, that alloy was found to expand equally with the speculum metal to which it had to be soldered. Lord Rosse found that by employing a furnace deeper than usual, and covering the metal with a layer of charcoal powder 2 inches thick, the loss was reduced to the minimum, and almost exactly the 180th each casting.

Yellow brass may, by rolling, have imparted to it a good degree of elasticity, and has, to some small extent, been used for the springs of clocks; such springs after a time lose their elasticity and remain coiled. This is probably owing to the fact, that the zinc, which is a component part of the brass, has a perpetual *inclination* to assume its normal crystalline condition, and this tendency undoubtedly is the cause of the "rotting" of brass when exposed to acid fumes, or even a damp atmosphere for a considerable time. When kept perfectly dry, or protected by a coat of gilding, the fibrous condition imparted to cast brass by rolling, drawing, or hammering, undergoes no perceptible change. For almost every purpose in our art, brass is required to be quite hard, which hardness is best imparted to it by hammering. In rolled brass the particles seem to elude compression, in some considerable degree, by *flowing* in front of the pressure rollers, in the same manner that water is forced out of the fabric by a clothes-wringer—the metal being more elongated than compressed.

On the contrary, in hammering, the metal seems to be driven down upon itself, compressing and hardening the part directly beneath the hammer; the repetition of the strokes forcing the hardened particles downward into the softer metal below, and so on till the whole mass may be very closely driven together without very much enlarging its area; slight, oft-repeated strokes, with a planishing (flat-faced) hammer, will best produce the maximum hardness.

LIGHT.

NUMBER FOUR.

UPON the refraction of light is based the whole science of optics, and the construction of lenses. A lens is a portion of a refracting substance which is bounded by curved surfaces ; if the surface be spherical the lens is called a spherical lens. Lenses are divided into two classes, one of which renders parallel rays convergent, the other of which renders such rays divergent. Each class comprises three kinds of lenses, which are named as follows:

CONVERGING LENSES.

1. Double convex, with both surfaces convex.
2. Plano-convex, with one surface plane, the other convex.
3. Concavo-convex (meniscus), with a concave and convex surface, the convex being the most strongly curved.

DIVERGING LENSES.

1. Double concave, with both surfaces concave.
2. Plano-concave, with one surface plane, the other concave.
3. Convexo-concave, with a convex and concave surface, the concave surface being the most strongly curved.

A straight line drawn through the centre of the lines, and perpendicular to its two surfaces is the principal axis of the lens. A luminous beam falling on a convex lens, parallel to the axis, has its constituent rays brought to intersection at a point in the axis behind the lens. This point is the principal focus of the lens, and this principal focus is the focus of parallel rays.

If a luminous point be placed in the focus of a convex lens, the rays from it will pass out on the opposite side as parallel rays. If the luminous point approach the lens, the rays will pass out on the opposite side, till divergent. Producing them backward they will intersect on that side of the lens on which stands the luminous point. The focus here is *virtual*. A body of sensible magnitude placed between the focus and the lens would have a virtual image. When an obj ct of sensible dimensions is placed anywhere beyond the principal focus, a real image of the object will be formed in the air behind the lens. The image may be either greater or less than the object in size, but the image will always be *inverted*. The position of the image and the object are, as before, convertible. In the case of concave lenses the images are always virtual.

A spherical lens is incompetent to bring all the rays that fall upon it to the same focus. The rays that pass through the lens near its circumference are more refracted than those which pass through the central portions, and they intersect earlier. Where perfect definition is required it is therefore usual, though at the expense of illumination, to make use of the central rays only. This difference of focal distance between the central and circumferential rays, is called the *spherical aberration* of the lens. A lens so curved as to bring all the rays to the same focus—is called *aplanatic;* a spherical lens cannot be rendered aplanatic. As in the case of spherical mirrors, spherical lenses have their caustic curves (diacaustics) formed by the intersection of the refracted rays.

VISION AND THE EYE.

The eye is a compound lens, consisting of three principal parts: the *aqueous humor*, the *crystalline lens*, and the *vitreous humor*. The aqueous humor is held in front of the eye by the *cornea*, a transparent horny capsule, resembling a watch-glass in shape. Behind the aqueous humor, and immediately in front of the crystalline lens, is the *iris*, which surrounds the *pupil;* then follows the lens and the vitreous humor, which last constitutes the main body of the eye. The average diameter of the human eye is 10.9 lines.* Where the optic nerve enters the eye from behind, it divides into a series of filaments, which are woven together to form the *retina*, a delicate net-work of nerve tissue spread as a screen at the back of the eye. The retina rests upon a black pigment, which reduces to a minimum all internal reflection. By means of the iris the size of the pupil may be made to vary within certain limits. When the light is feeble the pupil expands, when it is intense the pupil contracts; thus the

* A line is one-twelfth of an inch.

quantity of light admitted to the eye is, to some extent regulated, the pupil also diminishes slightly when the eye is fixed upon a near object, and expands when fixed upon a distant one. The pupil appears black, partly because of the internal coating, but mainly for another reason. Could we illuminate the retina, and see at the same time the illuminated spot, the pupil would appear bright; but the principle of reversibility, so often spoke of here, comes into play; the light of the illuminated spot in returning outward retraces its steps and finally falls upon the source of illumination. Hence to receive the returning rays, the observer's eye ought to be placed between the source and the retina; but in this position it would cut off the illumination. If the light be thrown into the eye by a mirror pierced with a small orifice, or with a small portion of the silvering removed, then the eye of the observer placed behind the mirror, and looking through the orifice, may see the illuminated retina. The pupil under these circumstances glows like a live coal. This is the principle of the *ophthalmoscope*, an instrument by which the interior of the eye may be examined, and its condition in health or disease noted. In the case of albinos, or of white rabbits, the black pigment is absent and the pupil is seen red, by the light which passes through the *sclerotica*, or white of the eye; when this light is cut off the pupil appears black. In some animals, in place of the black pigment, is a reflecting membrane, the *tapetum*. It is the light reflected by the *tapetum* which causes a cat's eye to shine in partial darkness. The light in this case is not internal, for if the darkness be *total* the cat's eye will not shine. The photographer's camera is but an enlarged eye, the ground glass upon which the inverted image is received taking the place of the retina in that organ. For perfectly distinct vision it is necessary that the image upon the retina should be perfectly defined; in other words, that the rays from every point of the object looked at should converge to a point on the retina.

THE PUNCTUM CAECUM.

The spot where the optic nerve enters the eye, and from which it ramifies to form the net-work of the retina, is insensible to the action of light. An object whose image falls upon that spot is not seen. The image of the moon, a clock dial, or a human face, may be caused to fall upon this "blind spot," in which case the object is not visible. This can be illustrated by laying two white wafers on black paper, or two black ones on white paper, with an interval of 3 inches between them. Bring the right eye at a height of 10 or 11 inches exactly over the left hand wafer, so that the line joining the two eyes shall be parallel to the line joining the two wafers. Closing the left eye, and looking steadily with the right at the left-hand wafer, the right-hand one ceases to be visible. In this position, the image falls upon the "blind spot" of the right eye. If the eye be turned in the least degree to the right or left, or if the distance between it and the paper be augmented or diminished, the wafer is immediately seen.

Preserving these proportions as to size and distance, objects of far greater dimensions than the wafer may have their images thrown upon the blind spot and be obliterated. The eye is by no means a perfect optical instrument. It suffers from spherical observation; a scattered luminosity, more or less strong, always surrounding the defined images of luminous objects upon the retina. By this luminosity the image of the object is sensibly increased in size; but with ordinary illumination the scattered light is too feeble to be noticed. When, however, bodies are intensely illuminated, more especially when the bodies are small, so that a slight extension of their images upon the retina becomes noticeable, such bodies appear larger than they really are. Thus the crescent moon seems to belong to a larger sphere than the dimmer map of the satellite which it seems to clasp. This augmentation of the true size of the optical image is called irradiation. Almost every eye contains bodies, more or less opaque, distributed through its humors. The so-called *muscæ volitantes* are of this character; so are the black dots, snake-like lines, beads, and rings, which are strikingly visible in many eyes. Were the area of the pupil contracted to a point, such bodies might produce considerable annoyance; but because of the width of the pupil, the shadows which these small bodies would otherwise cast upon the retina are practically obliterated, except when they are very near the back of the eye.

It is only necessary to look at the firmament through a pin-hole to give these shadows greater definition on the retina.

If the letters of a book, held at some distance from the eye, be looked at through a gauze veil placed near the eye, it will be found that when the letters are seen distinctly the veil is seen indistinctly; conversely, if the veil is seen distinctly, the letters will be dimly seen. This demonstrates that the images of objects, at different distances from the eye, cannot be defined at the same time upon the retina. Were the eye a rigid mass, like a glass lens, incapable of change of form, distinct vision would only be possible at one particular distance. We know, however, that the eye does possess a power of adjustment for different distances. This adjustment is effected, not by pushing the front of the eye backward or forward, but by changing the curvature of the crystalline lens. The image of a candle reflected from the front or rear surface of this lens, is seen to diminish when the eye changes as from distant to near vision, thus proving the curvature of the lens to be greater for near than for distant vision. The principal refraction endured by the rays of light in passing through the eye occurs at the surface of the cornea when the passage is from air to a much denser medium. The refraction at the cornea alone would cause the rays to intersect at a point nearly half an inch behind the retina. The convergence is augmented by the crystalline lens, which brings the point of intersection forward to the retina itself. A line drawn through the centre of the cornea, and the centre of the whole eye to the retina, is called the axis of the eye. The length of the axis, even in youth, is sometimes too small; in other words, the retina is too near the cornea, so that the refracting part of the organ is unable to converge the rays to a point upon the retina. In old age also the refracting surfaces of the eye are slightly flattened, and thus rendered incompetent to refract the rays sufficiently. In both cases the images would be formed behind the retina, instead of upon it, and hence the vision is indistinct. A slight defect of this kind is remedied by holding the object at a distance from the eye, so as to lessen the divergence of the rays. When this defect is considerable, a convex lens placed in front of the eye helps to produce the necessary convergence. This is the use of spectacles.

The axis of the eye is sometimes too long, or the curvature of the refracting surfaces may be too great; in either case, the rays entering the pupil are converged so as to intersect before reaching the retina. This defect is remedied by holding the object very near the eye so as to increase the divergence of the rays, or by interposing before the eye a concave lens, which produces the necessary divergence, thus throwing back the point of intersection to the retina. The eye is not adjusted at the same time for equally distant horizontal and vertical objects. The distance of distinct vision is greater for horizontal lines than for vertical ones. Draw with ink two lines at right angles to each other, one vertical and one horizontal; one of them is seen distinctly black and sharp, the other appears indistinctly, as if drawn with lighter ink. Adjust the eye for the latter line, and the former will then appear indistinct. This difference in the curvature of the eye in two directions may sometimes become so great as to render the application of cylindrical lenses necessary for its correction.

These, and other imperfections of the eye, make the subject of the selection of spectacles a matter of no small moment. Wells, in his treatise on this subject, says: "I have no hesitation in saying, that the empirical, haphazard plan of selection generally employed by opticians, is too frequently attended by the worst consequences; and that eyes are often permanently injured, which might, by skilful treatment, have been preserved for years. For this reason I must strongly urge upon medical men the necessity, not only of examining the state of the eyes, and ascertaining the nature of the affection, but of going even a step farther than this, and determining with accuracy the number of the required lens. For this purpose they must possess a case of trial glasses, containing a complete assortment of concave, convex, and cylindrical lenses, glasses of corresponding number being kept by the optician, and give the patient a prescription for spectacles. By doing so the patient is assured of being furnished with suitable and proper glasses."

MANUFACTURE OF LENSES.

The almost universal necessity for spectacle lenses, of every variety of curvature suited to the endless diversity of defects to which the eye is subject, opens a large field to commercial enterprise. Probably no form of lens comes into more general use than those particularly designed for spectacles, and the immense quantities used would astonish those not somewhat familiar with the business. Almost the whole supply was derived from Europe until recently, none being manufactured here, except a few of the finer kinds, for astronomical and optical instruments. These, commanding almost any price, could be profitably made by hand labor; but the smaller and cheap spectacle eyes were obliged to wait for the advent of machinery. We know of no lenses manufactured by machinery in this country except at the establishment of Messrs. Surdam & White, Harlem Building, New York. English or French plate-glass, entirely free from tint of blue, green, or yellow, when viewed through its edge, is used for these lenses, first being broken up into small squares of a size suitable for the eyes of spectacles. The first rough grinding is done in cast-iron forms, or basins, varying in size according to the focus desired. Shallow concave disks, of 20 inches diameter, are used for the lenses of long focus, and diminishing in size and increasing in depth, as the focus is to be shorter; the smallest, of perhaps 6 inches diameter, being used for a focus of 2 or 3 inches. Fitting into these concaves are segments of iron spheres of curvature exactly corresponding. These segments are given a peculiar circular and horizontal motion by an eccentric finger attached to a vertical rotating spindle placed over each of these grinding mills, and actuated by a band and pulley from a common shaft.

The convex surface of this cast-iron grinder is then thickly coated with soft pitch, into which are pressed as many of the little squares of glass as will cover its whole surface, and is then inverted into its cast-iron concave, while the pitch is yet soft and yielding—the whole mass taking the exact curvature of the matrix. When the pitch becomes hard the eccentric finger is attached, the band slips on the pulley, and the mass commences its eccentric revolutions. Emery and water are then supplied, and the process of grinding goes on till the glass squares are all ground to the dead surface; the coarser emery is then washed out, and a finer grade supplied and the grinding goes on; again they are washed carefully, and an impalpable flower of emery applied. By this time, the surfaces become semi-polished, but the final exquisite gloss must still be given, which is done by substituting for the iron concave, one of felt, and supplying rouge and water instead of emery.

Some fifty of these grinding and polishing mills, arranged in suitable frames, and when all are busily in motion, look wonderfully industrious and business-like. This process finishes, as you will notice, only one side of the lens; the pitch is then softened, the half finished lenses turned over, the polished side imbedded in the pitch, and the second surface undergoes the same process; this is the construction of the convex lenses. Concave lenses are ground by fixing the pieces of glass to the concave bed, and the moving convex disk does the grinding and polishing. The same process is used in grinding the lenses for stereoscopic instruments, only larger squares of glass are used. Great care and experience are necessary in washing and grading the grinding emery, and also in preparing the rouge for the final polish. "Brazilian pebbles," "California diamonds," and all the various pebbles, of whatever name, undergo the same process, first being sawed in slips of the proper thickness; of the long focus, eight or ten dozen are ground at once, but of the short focus—cataract glasses—no more than four or six can be done at one time. All the various forms of lenses—meniscus, plano-convex, concavo-convex (periscopic) and concave—are made by varying the forms of the iron mills.

———o———

☞ We will pay fifty cents each for copies of Nos. 4 and 5, Vol. I., of the Horological Journal.

HINTS TO REPAIRERS.

NUMBER TWO.

Balance pivots, and other pivots running on cap jewels, can be made much thinner and yet much stronger than ordinary pivots, by making them conical. Not only are conical pivots stronger, but are also more elegant in appearance than straight pivots. To make conical pivots the repairer must provide himself with some pivot files and a pivot rest for his lathe; these extras he must construct himself (they not being sold in tool-shops), in the following manner. The pivot files being the first consideration, the repairer must provide himself with three pieces of long and flat steel, or three old pivot files; one for filing, one for grinding, and one for polishing the pivot. The first-named file is first heated to a cherry red and left to cool slowly; the edge to which the workman is accustomed to file with, is filed to exactly the shape for filling the cone of the pivot when in a finished state; the file marks are then ground off by grinding with a piece of copper plate and oil-stone dust with oil; then provide a punch (such as is used by chasers, and can be bought at any tool-shop), whose face presents the appearance of the cuts on a file—the finer the cuts on this punch the better; the ground edge of the file is then chased with this punch, held lightly above the file, imbedding the file-marks transversely the whole length of the file, and is then hardened and tempered to a light straw color.

The next file, or the one to be used for grinding, must also be softened and must have the edge filed exactly the same shape of the first file, and is also to be ground, but in a direction perpendicular to its length, and is then hardened and tempered to a dark blue color. The other file, or the one to be used for burnishing, is also softened and must also have the edge filed off to exactly the same shape as the first file, and is ground first with a piece of copper plate with oil-stone dust and oil, and lastly with a piece of type metal, with very fine oil-stone dust and oil—care being taken to grind in a perpendicular direction to the length of the file.

The next consideration is the pivot rest for the lathe. A piece of good English cast-steel is selected that will exactly fit the hole in the lathe for the reception of the pivot rest; this rest is provided with a notched wheel, whose object is to keep the rest in a rigid position while the repairer is at work thereon; the front part of the rest is then turned so that a head is left standing, whose breadth should be twice the length of a pivot; this head is filed into a number of flats, corresponding to the number of notches in the wheel at the the back of the rest, care being taken to file these flats exactly perpendicular to the point opposite in the lathe, when a notch at the back of the rest is in check by a piece of steel fastened into the base of the lathe; different sized notches are now filed into the flats, in a line with the point in the lathe exactly opposite. The fronts of the notches are now rounded, corresponding in shape to the cone on the pivot when in a finished state, which is done in the following manner: A perfectly round file is taken, pointed and provided with a collet, and placed in the ordinary turning lathe; or, if the workman is provided with an American lathe, the round file is screwed into a chuck; in either case the file is set in motion and the edge of the notch in the rest is brought to bear against it; the rest, meanwhile, being slightly moved up and down, until the notches have the proper shape, viz., corresponding to the shape of the pivot when finished; the notches are then ground and polished by substituting a round piece of iron wire, with oil-stone dust, for grinding, and a piece of zinc wire, with diamantine and alcohol for polishing. The rest is then hardened and tempered to a light straw color. Now the pivot, being turned to very nearly the shape it should have, is placed in the pivot lathe, so that the front of the pivot rests solidly in the notch on the rest, allowing the cone of the pivot to come as near as possible to the rest. The first file is then introduced, and the pivot filed until the pivot is very near the proper diameter; the grinding file is then taken, and the pivot ground with very fine oil-stone dust, and lastly the pivot is burnished with the burnishing file. A little practice will enable any one to make a very nice conical pivot. In the above description the style of pivot lathe supposed to be used is the ordinary Jacot lathe, they being the most handy. When the pivot lathe differs in style from the Jacot lathe, the above description of appliances will, of course, not apply, but the workmen will certainly have ingenuity enough, from the above description, to substitute the required changes.

To polish the face of a pinion requires a little tool, that can easily be made, thus: A piece of brass is filed into the shape of a T, with this difference, that the two short ends are bent up, and on these ends two screws are adjusted; between these, and running on these two screws, is a little brass piece, through which a hole is drilled, the hole being sufficiently large to hold little chucks, made of soft iron and brass, that also have a small hole drilled through them ; the brass piece must be able to revolve freely between the screws. Now, when the face of a pinion is to be polished, one of the little iron chucks is set into the brass piece, the tool held in the left hand, and the staff of the pinion is put into the hole (the hole being a little larger than the diameter of the staff of the pinion), so that the face of the pinion rests against the side of the chuck, and the other end of the pinion held against the vice; a little oil stone dust with oil is applied to the pinion, which is set in motion with the drill bow, and ground until a true flat is attained; the iron chuck is then replaced by one of composition, a little diamantine applied to the pinion, and set in motion in the same manner, until the pinion is nicely polished. The chuck accommodating itself to the face of the pinion (it hanging on two pivots or screws), must necessarily produce a true flat.

CHARLES SPIRO.

33 *John street, N. Y.*

——o——

☞ We have received from Mr. F. E. Allen one of his patent poising tools, also one of the screw stands, and a set of screw drivers, but for want of space cannot speak of them in detail. It always gives us pleasure to notice any thing that is calculated to assist the workman in doing his work better and with greater ease to himself. We think they will be well received by the trade.

GOOD TIME.

Below we give the results of observations of the running of Watch No. 1818, manufactured by the U. S. Watch Company, from Dec. 13th to Jan. 13th, taken at irregular intervals, at which date we carelessly let it run down.

December	13	4.5	seconds	slow.
"	15	8	"	"
"	19	6	"	"
"	27	4	"	"
"	30	6	"	"
"	31	5	"	"
January	4	1	"	"
"	5	1	"	"
"	9	1	"	"
"	13	3	"	"

The observations were not taken with a view of publication, and it is no more than justice to the watch to state that the test was not a fair one, as the winding was irregular—from nine to twelve o'clock. The running down seems to have proved a disturbing cause, for now it has a daily losing rate, but so uniform that the result is actually better. although the loss is nearly two seconds per day. The only true test of any time-keeper is in its daily rate—not in its showing the correct time once a week, once a month, or once a year. When we take into consideration how many disturbing causes there are to affect the pocket time-piece—the numberless jars it receives in the course of the day, as well as the frequent changes of position it is subject to—and then consider the fact that each twenty-four hours of time is subdivided into nearly four hundred and fifty thousand separate and distinct parts, each one of which is marked by a vibration of the balance, we can only look upon it in wonder and admiration, considering it, as it really is, the nearest approach to perfection in engineering skill the world ever saw.

The manufacture of watches in this country is of very recent date, and was commenced under the most embarrassing circumstances, the projectors of the enterprise having very little practical knowledge of the business, and there being absolutely no skilled labor available ; yet all the American factories have produced work of which they may well be proud.

Since the above was in type we have received from Messrs. Richard Oliver & Balen the following certificate. If the "H. G. Norton" was compared with Dudley Observatory time every day, and at no time showed a greater variation from mean time than one second, we should think W. H. Williams & Son would have no hesitation in recommending the H. G. Nortons to their customers:

Messrs. Richard Oliver & Balen,
Gen'l Agents N. Y. Watch Co.:

Gents,—One of your three-quarter plate watches named "H. G. Norton," which we bought of you in the early part of November last, we ran for four weeks by Dudley Observatory time, and it varied only *one second* during that time. We also ran one of your "Albert Clark" movements, and it ran nearly as close.

W. H. Williams & Son.

Albany, *Feb.* 14, 1871.

DONATION TO THE MUSEUM OF THE LAND OFFICE.

The Acting Commissioner of the General Land Office has received from J. Dickinson, Esq., of New York, for the Geological Museum a suite of classified specimens of diamond carbonate, bort, and diamond bort, in their proximate stages of formation, together with some carbon dust, produced by abrading one piece of carbon or diamond against another, in the process of shaping for ornamental and other purposes. The ordinary or white diamond has of late been used for drilling, turning, and dressing stone, as well as for planing and boring steel and other metals, but the cost has been a great objection to its extended application; the diamond carbonate, or black diamond, has been substituted, which also has the further advantage of being considerably harder than the white transparent diamond, and consequently has been applied to shaping and polishing the latter. The shaping of diamonds for ornamental purposes is comparatively a modern art. History informs us that Louis Van Bergen, of Burges, in 1456, first invented a process for cutting, then polishing, abrading one diamond against another, and by polishing them afterward with the powder produced therefrom. This is said to be one of the earliest patents granted. After careful research and inquiry both here and in Europe, it was found that neither the opaque, black, nor transparent diamond had ever been shaped into angular forms for the mechanical arts.

The merit of this invention belongs to Mr. Dickinson, and the Land Office is especially indebted to Dr. Ott, of New York, for his exertions in obtaining this valuable donation to the Museum connected with the General Land Office.

JEWELRY PEDDLERS.

Editor Horological Journal:

I know that I shall touch a sore spot in the feelings of nearly every country watchmaker when I allude to that bane of their existence—the jewelry peddler.

Flitting from place to place as trade grows dull or a better prospect appears, travelling from house to house in a manner compelling every one to at least look over their goods, they are—and why attempt to deny it?—most formidable rivals to the small dealer in the country. That they are, as a class, a nuisance in any community every watchmaker will readily admit; so, also, will all others as well who understand the subject.

The jewelry peddler is subject to very few incentives to fair dealing, or restraints against very sharp practice. The goods he deals in, next to horse-flesh, are perhaps the most suited to deceive; and his comings and goings hinder him from being called to a prompt account, sometimes forever preventing it. With them "all is gold that glitters," and their rates of profit are fixed only by the gullibility or means of their customers. The communities in which they trade derive nothing from them in the way of taxes, although the local dealer always has his taxes to pay, and nothing from the circulation of the money in their own neighborhoods. The only thing that can be said in favor of the jewelry peddler is, that they are too clever to be bores.

The principal remedy for this state of things is of course with the people themselves; whether it will ever be remedied is a matter of doubt. Still a great deal can be done by the watchmakers to drive them off. In this State (New York) a license fee of $20 is required for peddling goods of foreign manufacture, which covers most watches and spectacles, and some other goods. Any citizen can demand to see a peddler's State license, and if he refuses to show it, he can take him before a justice of the peace and have him fined $5. If it turns out that he has no license to show, he is fined $25. The licenses are granted by the Secretary of State, at Albany, and justices of the peace are furnished by the county clerk of their county with lists of all licensed peddlers. Some years there are not more than twenty licensed peddlers in the whole State. It should be a satisfaction to every tax-paying watchmaker to know that these men were compelled to pay their share of the State taxes, which would really amount to a considerable sum. But the best way to oppose them is for the local dealers to keep the best stock that their means will allow. No good watchmaker ought to try to compete with peddlers, fancy-goods dealers, stationers, and the hosts of others who trade in brass and cheap plated jewelry, and horn, and wood, and such stuff. If he has only a little money, let him deal only in watches, and, as his capital accumulates, add other staple goods, and let them only be good ones. It is far better to earn money by good work than to waste valuable time in trying to sell a poor article at a cheap price, which will never give satisfaction, no matter how cheaply it may be sold. Watchmakers are always held to a more strict account for their representations than other dealers in the same kind of goods, and very properly, too, for they know the quality and value of the articles that they sell. This fact alone should convince any one that a poor article should not be sold at all, it being far better to let some one else sell the poor goods.

As long as a watchmaker has not a good stock of watches, gold jewelry, clocks, silver and plated ware, and spectacles, he should avoid all other goods and confine himself strictly to his own class of trade. If with a good stock of such things on hand, and money to spare, why then he is a very fortunate man, and neither peddlers nor cheap jewelry will disturb his peace of mind. This, in my opinion, will go some way towards driving off peddlers. That they should be prohibited by law perhaps would be requiring too much; still the license fee might be raised to $250, which would not exceed the average rent which watchmakers are required to pay for their stores in the country, so that it would be no great hardship, and would tend to save the public from the least responsible of the peddlers. But alas! our fraternity have no "lobbyist" at Albany, and in case of a struggle, I don't know but the peddlers would overpower us there.

B. F. H.

———o———

QUERY.

Editor Horological Journal:

In your September issue, p. 62, there are directions for sizing pinions by measuring the teeth of the wheel. Rules of this kind may be resorted to in all cases where no better means are to be disposed of; certainly, they have no claim to giving the *exact* sizes of pinions. But what strikes me most of all in this table, is the statement that the pinions from 6 to 8 leaves and those of 12, 15, and 16, must be considerably larger for clocks than for watchwork. I always thought the mechanical laws for a correct transmission of movement by toothed wheels must be absolutely the same, no matter whether it forms a part of mill work or watch work. If, in a scientific organ like yours, such a statement passes unnoticed, it may lead to the belief that it is a dogma generally accepted by all its readers, and therefore I wish to ask:

1. By what reasons ought certain pinions to be larger when intended for clock-work?

2. On what grounds may certain other pinions be exempt from this necessity?

Saxon.

ANSWERS TO CORRESPONDENTS.

H. N. R., *Kansas.*—There is no greater error entertained by the majority of our trade, who have not had the advantage of thorough education to the business, than that which supposes there must be some great mystery, some profound secret in polishing steel work. There is no mystery—no secret process, nor material, it is only *patient labor*, and that is the "secret" of all excellence in any department of art, science, or mechanics.

Take any simple, beautiful, easy-flowing versification; it reads so smoothly that it seems possible for any body to have written it. But could you see the manuscript of the author—perhaps dozens of them—with all the erasures, alterations, interlineations, that consumed weeks of time, and intense mental exertion, you might then change your mind as to the spontaneous gushing of poetry. So with a picture, that appears so small for the price. $1,500 for a landscape 10 by 12 inches seems a fearful sum, but it is the labor bestowed on it that makes it so perfectly true to nature, and so highly prized; 'tis not inspiration, 'tis not slight of hand, but downright hard work. When a musician sits down at the piano, sweet sounds follow with such easy rapidity that the years of labor to acquire that skilful execution are lost sight of. An *unskilled* wood-worker will fancy that the exquisite polish on the case of the piano is put on by some peculiar varnish—to find which has been his inquiry for years. Did he but know that the finish he so much admires was *only* the result of labor—nothing but persistent hard rubbing—he would perhaps go to *work* instead of spending his time in the vain search for some short "royal road" to such perfection of polish. It's the same with the polish of steel work. Your work must be finished with file or graver, or whatever other tool is used; the marks of that tool must be *stoned* out, not a scratch or mark left; if there be you may polish till the "crack o'doom," and all in vain. Then the stone marks must be eradicated by fine emery, crocus, sharp, or whatever else you use; then you can hope to make a polish with rouge and rubbing, rubbing and rouge. You may as well expect a mill to grind without power as to expect any polish without labor. The error usually made is in not preparing for the polishing, a gloss being very quickly given when the necessary preliminary steps are taken. The labor mostly is in the first process, not the final one. Vienna lime is largely used with water to give the final gloss to soft steel work. Rouge is most commonly used; diamantine is also used, and gives rapid results when all the previous preparation of the work has been well done. All *labor* in polishing is lost; it requires no labor. The labor of *preparing* to polish is *not* lost; it is all spent necessarily, because no good results can be had without it.

O. D. B., *New York.* — A Chinese duplex watch, with centre seconds, would be better than an ordinary watch for taking transit observations of the sun only because the seconds are larger.

The best thing for that purpose, of course, is a chronograph; but the expense of such an instrument places it beyond the reach of the watchmaker. The next best thing is a good chronometer, beating half seconds. With practice no assistant is needed in taking an observation; by carrying the *beat* in the mind, and noticing between what beats the contact of the edge of the sun takes place with the line, the exact time of such contact may be noted to a very small fraction of a second. Messrs. John Bliss & Co., the chronometer and transit makers, inform us that very little experience is required to enable any person to note the contacts, using such a chronometer as we mention, within one quarter of a second, and that even greater accuracy is attainable. But for the practical purposes of the watchmaker it is not necessary to note them closer than the nearest second.

E. N., *Ct.* — Authorities on this subject differ in opinion as to the proper means of producing the curve in the Breguet hairspring. The end to accomplish is a perfect isochronism; some produce the curve by making two, and sometimes three, kinks in the spring; others produce the curve by a gradual sweep towards, and then concentric to, the centre, and without any kink whatever. In our opinion, the latter mode is much to be preferred, there being no interruptions in its action, as there certainly must be where kinks are resorted to to produce the curve.

E. L. M., *O.* — We have received several letters recently, speaking of the necessity of some means for the better education of watchmakers in matters pertaining to their profession, and, judging from specimens that a friend says he meets with almost daily on the road, should say there was. We append an extract from his last letter :

"A 'travelling jour.' applied to a friend of mine for a job. He was of the German persuasion. He told a pitiful story of being *unfortunate*, sick, and, worst of all, *out of money*. My friend consented to give him a few jobs to help him along. The first was an old-fashioned verge watch, which he put in order, and handed back for 'inspection.' It was apparently *well done*. But upon examination with a glass, a *little moisture appeared* on the contrite pinion. Upon inquiry what that was, he replied, 'De reel vas loose ; I put a little *acit* on him, and he rust and go tight.' His *first job* was also *the last*.

"I was selling one of my customers some 'material,' occasionally suggesting something he might need. Amongst other things, I asked him if he did not want some 'centre squares.' He said, 'I not puy tem any more.' I inquired if he did not find occasion to use them. He said, 'Oh, yes.' 'Well,' was my reply, 'What do you do then?' He said, 'I use dese little *shingle nails*; I files 'em town.'"

H. U., *Ill.*—If you will refer to the answer to W. W. S., page 69, Vol. II., you will find the information you desire in regard to plating.

AMERICAN HOROLOGICAL JOURNAL,

PUBLISHED MONTHLY BY

G. B. MILLER,

229 Broadway, N. Y.,

At $2.50 per Year, payable in advance.

A limited number of Advertisements connected with the Trade, and from reliable Houses, will be received.

☞ Mr. J. Herrmann, 21 *Northampton Square, E. C., London, is our authorized Agent for Great Britain.*

All communications should be addressed,

G. B. MILLER,

P. O. Box 6715, *New York.*

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For March, 1871.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian.	Equation of Time to be Added to Apparent Time.	Equation of Time to be Subtracted from Mean Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	M. S.	S.	H. M. S.
W.	1	65.43	12 35.62	12 35 73	0.494	22 35 23.76
Th.	2	65 36	12 23.51	12 23.61	0.515	22 39 20.32
Fri	3	65.29	12 10.88	12 10.99	0.536	22 43 16.87
Sat	4	65 22	11 57.77	11 57.88	0.555	22 47 13 42
Su.	5	65.16	11 44 20	11 44.31	0.574	22 51 9.97
M..	6	65.10	11 30 18	11 30.28	0.592	22 55 6.53
Tu.	7	65.04	11 15.74	11 15.85	0.610	22 59 3.08
W.	8	64.98	11 0.91	11 1.02	0.626	23 2 59.63
Th.	9	64.93	10 45 70	10 45.81	0.641	23 6 56.19
Fri.	10	64 88	10 30.16	10 30.27	0.655	23 10 52.74
Sat	11	64.83	10 14.29	10 14 40	0.668	23 14 49.29
Su.	12	64.78	9 58.11	9 58 22	0.681	23 18 45.85
M..	13	64.74	9 41.65	9 41.76	0.692	23 22 42.40
Tu.	14	64 70	9 24.93	9 25.04	0.702	23 26 38.95
W.	15	64 66	9 7 98	9 8 09	0.711	23 30 35.50
Th.	16	64 63	8 50 81	8 50.92	0.719	23 34 32.05
Fri	17	64.60	8 33.43	8 33 54	0.728	23 38 28.61
Sat	18	64 56	8 15.87	8 15.97	0.735	23 42 25.16
Su.	19	64.54	7 58.14	7 58.24	0.742	23 46 21.71
M..	20	64.52	7 40 26	7 40.36	0.748	23 50 18.27
Tu.	21	64 50	7 22.25	7 22.35	0.753	23 54 14.82
W.	22	64.48	7 4.13	7 4.23	0.757	23 58 11.37
Th.	23	64.47	6 45.91	6 46 00	0.761	0 2 7.92
Fri	24	64.46	6 27.60	6 27 68	0.765	0 6 4.48
Sat	25	64 46	6 9.22	6 9.30	0.767	0 10 1.03
Su.	26	64.46	5 50.81	5 50.88	0.768	0 13 57.58
M.	27	64 46	5 32.36	5 32.43	0.769	0 17 54.13
Tu.	28	64.46	5 13.89	5 13.96	0.769	0 21 50 69
W.	29	64.47	4 55.44	4 55.51	0.768	0 25 47.24
Th.	30	64.48	4 37.02	4 37.08	0.766	0 29 43.79
Fri	31	64 49	4 18.64	4 18 69	0.763	0 33 40.35

Mean time of the Semidiameter passing may be found by subtracting 0.19 s. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D H. M.
☉	Full Moon........................	6 15 39.2
☾	Last Quarter..	13 10 19.3
●	New Moon......................	20 16 0 5
☽	First Quarter......................	28 18 44.3
		D. H.
☾	Perigee	10 9 6
☾	Apogee	26 4.3

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1
	H. M. S.
Long. Harvard Observatory..............	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange................	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception......	8 1 42.64

		APPARENT R. ASCENSION.	APPARENT DECLINATION.	MERID. PASSAGE.
	D.	H. M. S.	° ′ ″	H. M.
Venus.....	1	0 2 58.23	– 0 56 2.9	1 27.6
Jupiter....	1	5 3 37.72	+22 63 41.5	6 27.2
Saturn....	1	18 34 42.3	–22 24 53.1	19 56.3

AMERICAN

Horological Journal.

Vol. II. NEW YORK, APRIL, 1871. No. 10.

CONTENTS.

*** *Address all communications for* Horological Journal *to* G. B. Miller, *P. O. Box* 6715, *New York City. Publication Office* 229 *Broadway, Room* 19.

ESSAY

ON THE

CONSTRUCTION OF A SIMPLE AND MECHANICALLY PERFECT WATCH.

BY MORRITZ GROSSMANN.

CHAPTER V.

THE TRAIN.

53. The first condition for the construction of the train of a watch is, to make it of as large dimensions as the diameter of the movement will admit of. The very limited space allowed by the reigning taste for the movement of a portable time-keeper is already an impediment to the attaining of a high degree of perfection in the gearings; and if it is possible to execute the wheels and pinions of a clock with a satisfactory degree of accuracy, it gets more and more difficult to do so according to the smaller dimensions in which the work is to be executed. If we had the means of verifying easily the accuracy of the division and rounding of our small pinions, even of the best make, we would soon come to the conclusion that it must necessarily diminish with their dimensions. The inequalities and alterations of shape by the stoning and polishing will be nearly the same with a large pinion as with a small one, only the small one suffers proportionally much more under them. This applies to the manufacturing of the pinions; but before the pinion runs in the train, it has to pass through the finishing process. The finisher, first of all, will have to verify whether the pinion runs perfectly true, and to set it true in case of need. In all operations of this nature the operative has to rely on his eye for distinguishing whether the state of the piece is satisfactory. But the eye, like all the senses of man, is reliable only within certain limits, and if a good workman pronounces a pinion to be true, this statement must not be taken mathematically ; it can only be understood so that an experienced eye can no more detect any deviations from the truth of running. There are, then, in any piece of workmanship some small defects escaping the most experienced eye, and their absolute quantity is about the same for the large pieces as for the small ones. Let us suppose, for instance, that a careful workman, when turning a pinion of 3 m. diameter, cannot perceive any defect of truth beyond one-hundredth of this size—say 0.03 m. The same defect, indistinguishable to his eye, with a pinion of 1 m. diameter will be, not one, but three-hundredths of it ; consequently it is of threefold more importance with the small pinion, taken proportionally.

The same considerations will, to their full extent, apply also to the correctness of the depths, or gearings ; and it will be clearly seen that it is of the greatest importance to construct the acting parts of the train as large as the diameter of the watch will admit of.

54. Another matter of great importance is the uniform transmission of motive power from the barrel, through the train, to the escapement. This uniformity can only be attained by good depths ; and as it is well

known that the depths are more perfect with the higher numbered pinions, it is advisable never to have the centre pinion with less than 12 leaves, the 3d and 4th wheel pinions with 10, and the escape pinion with 7 at least. The difference resulting therefrom in the cost of manufacturing is so very trifling that it could not be an obstacle to making even low class watches with these numbers.

The centre pinion, it must be admitted, will be more delicate, apparently, and more liable to injury by the sudden jerk resulting from a rupture of the main-spring, or by the pressure occasioned through careless winding. The teeth of the barrel, too, being necessarily thinner, will be more apt to bend from the same causes ; but this is partly remedied by the fact that with a pinion of 12 there are in almost every movement two teeth of the barrel acting at the same time on two leaves of the pinion; while in the lower numbered pinions one tooth alone has to lead through a more or less extended angle. Thus, any sudden shock will be divided between two teeth of the pinion of 12, and sustained in the same way by two teeth of the barrel belonging to it, whereby the apparent danger is greatly diminished. Besides, the finer toothing producing a better transmission of power, a weaker main-spring may be used, and in case of its rupture the shock will be less violent.

55. One of the chief conditions for a good and regular transmission of power is a good and suitable shape of the wheel teeth; and it is astonishing to see in what an indifferent way this important matter is treated. It is a well-known fact that the wheel teeth, in order to act properly, ought to have an epicycloidal rounding, and no engineer would suffer any other form for the teeth of star wheels. Berthoud treated this subject in a most elaborate way about a century ago ; Reid and others have also explained the principles of the construction of toothed wheels most explicitly, but in vain. It seems that the greater part of the Horological community have resolved to view the shape of their wheel teet as a matter of taste. All the wheels of English and other makers have, with very few exceptions, their teeth of a shape defying the rules of Berthoud, Reid, and other leaders ; a shape of which nothing can be said, except that they look very nice in the eyes of those that make them, or those who use them, and say, "They look much better, indeed, than those ugly pointed teeth." There is no possibility of being successful against arguments like these, and I have known many a respectable and good watchmaker who declared that he could not bear the sight of epicycloidally rounded teeth. This is a subject, however, which can not be more amply entered into for the moment, but if our Editor wishes it, and if the present little treatise is favorably received by his readers, I shall be ready to make it the subject of another treatise, closely following the present one, and extending to the different ways of cutting wheels and pinions, practical methods of finding the sizes of wheels and pinions, and the distance of pitch, as well as the eight sizes of cutters for a given diameter and number of teeth; all by easy and plain calculation and measurement, with tables for greater convenience.

56. The respective proportions of the wheels of a train ought also to present a certain harmony, attainable by a regular progression in the diameters of the wheels and the fineness of their teeth.

57. With respect to the escape pinion, at least for the larger watches, I would strongly recommend to have it of 8 leaves, with a fourth wheel of 75, and an escape wheel of 16 teeth. The last depth, the most sensitive of all to any irregularity of transmission, will be found greatly improved by so doing.

58. The following are the sizes of a train, which, according to my opinion, would answer perfectly to the above conditions, for a watch of 43 m.=19 lignes Swiss, or 14 English size :

Diameter of barrel	(25) 43.0.485=	20.85 m.
Centre wheel	....	15.4 "
Third "	....	13.0 "
Fourth "	....	11.8 "

The numbers would be :

Barrel,	90 teeth,	Pinion, 12.
Centre wheel,	80 "	" 10.
Third "	75 "	" 10.
Fourth "	75 "	" 8.

The sizes of teeth are accordingly :

Barrel	0.345 m.
Centre wheel	0.30 "
Third "	0.27 "
Fourth "	0.24 "

It is easy to see that this progression is a very regular one.

59. The train ought to be arranged in such a way as to have the seconds circle at a suitable place on the dial. This circle, of course, ought to be as large as possible, for the sake of distinctness of the divisions ; and, on the other hand, it ought not to be so large as to cover entirely the VI. of the hour circle. It may be recommended as a good disposition to have the centre of the circle of seconds exactly in the middle of the distance from the centre of the dial to its edge. The general observation of this rule would be a decided step towards a greater regularity of construction, and, besides, it would prove a great boon to all the dealers and manufacturers of dials, and to all the repairers who have to replace broken dials.

A greater circle of seconds might be attained by approaching its centre nearer to the centre of the dial, but this subordinate advantage would be too dearly purchased at the expense of the commodious arrangement of the wheel work.

60. The height of the moving arbors ought to be restricted only by the height of the frame. The longer the distance between the two bearings of an axis can be, the better it will prove for the stability of the moving part, as well as its performance. The same amount of side shake required for free action will influence the pitch of a long pinion less than that of a short one.

The diameters of the pivots in watch-work could not be made according to the generally established rules in the construction of machines, for if we should attempt to make the dimensions of our pivots in a theoretical proportion to the strain which they have to resist, we would obtain pivots of such extreme thinness that they would be very difficult to make and to handle, and it would be doubtful whether the cross section of such a pivot would not come into an unfavorable proportion with the molecular disposition of the steel. Besides, it ought always to be kept in mind that the pivots of the train must not be calculated to bear with safety the mere pressure of the main-spring, but also the sudden strains resulting from rupture of the spring, or from rough winding. Thus, there

Fig. 16.

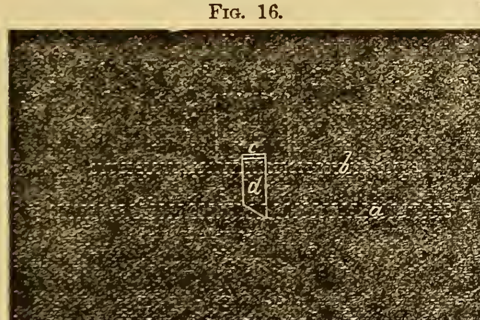
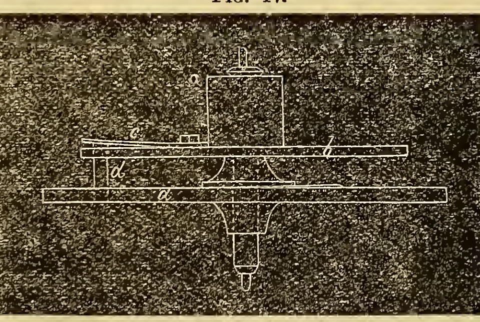


Fig. 17.



will be very little to say against the way in which the pivots of watch-work are generally made.

61. There remains a word to say on an improvement of recent date. It has already been mentioned (54) that the centre pinion and the barrel are in constant danger of having their teeth bent or broken by the sudden jerk of a breaking main-spring. These accidents are so troublesome, that a number of little contrivances have been made in order to avoid them. It will not be useless to give a look and a thought to these inventions, and to consider whether they are really what they ought to be.

62. There is one of these precautions consisting of a kind of elastic transmission on the third wheel. This wheel (Figs. 16 and 17) is fitted with a collet, loose on the pinion, which carries a disc, *b*, riveted to it. On this disc is fastened a spring, *c*, with a perpendicular arm, *d*, which extends towards the third wheel, and reaches the arms of this wheel with its end, thus carrying the wheel with it while the watch is going. The end of the arm has a slight slope, and when the spring breaks it is expected to slip over the arm of the wheel by the violence of the shock, and thus to stop it. I should not advise the use of this safety apparatus, because I think

it will fail by the inertia of the parts between the third wheel and the main-spring. The destruction, by a sudden jerk, will be completed before its power reaches the third wheel, in a like manner as the blast powder in a hole made in solid rock, and stopped up with a little clay, will split the rock by its sudden action before it has time to drive out the small stopping. Besides, this arrangement, if it should have any chance of success, must have the spring exactly regulated, so that it does not yield to the pressure of the main-spring when fully wound, but that any pressure beyond this will make it slip over. If this be not the case, the safety of the centre pinion will not be attained ; and, if it be, any excess of pressure, by inconsiderate winding at the end of the operation, will make the spring run over, and the result of this would be a deviation of rate. Now, I think the wearer of a watch will find an irregularity of its performance a fault of a much more grave character than an occasional accident which he knows to be out of connection with the time-keeping of the watch.

63. Other contrivances promise better success, because the regulating resistance is in the centre pinion. This latter has a rather large hole, and is adjusted on a staff or axis, to which the wheel is riveted, the pinion being held fast on the staff by a screw nut and a washer. This pinion, if it is set in motion, performs like a solid one, owing to the frictional resistance which keeps it to its staff, being a little in excess of the strain effected on it by the moving power ; but any addition to this strain causes the pinion to move independently of its staff, and thus to counteract the strain without injury to any of the acting parts. It will be readily understood that this disposition protects the centre pinion and barrel teeth, not only against the sudden shocks of a breaking spring, but also against any unequal strain in winding, and all this without any alteration of the time shown by the watch (62).

However, this contrivance has also its weak side. The centre pinion, with its large hole, especially when it is of a lower number than 12, has too little stock left between this hole and the bottom of the teeth, and thereby the solidity is endangered from another side. Therefore, it will answer in the case of a watch the hands of which are set at the front, but it will hardly do for the hollow centre pinions used for setting the hands on the back.

64. I recently had in hand a similar safety centre pinion of English make, also with a staff on which the pinion was screwed with a three headed screw. Tapped into the hole of the pinion, and cut on the staff, this screw, which must be a right handed one, if the centre wheel is above the pinion, and a left handed one if it is below the pinion, is kept tight in the ordinary course by the pressure of the motive power. But when a backward shock is applied to the pinion, it unscrews, thus obviating any injurious effect. This method, though it appears very effective, is still open to several serious objections. The additional strain at the end of the winding operation is not counteracted, but tends to screw the pinion still closer, so that it is doubtful whether, in case of emergency, it would break or unscrew, especially considering that the pinion itself, by the large dimension of its hole, is rendered rather frail. Besides this, there is no saying from which side the shock of the breaking spring will come. If the spring breaks near its outer end, the shock will apply in the way of the regular tension of the spring, and the safety apparatus will be of not the slightest use ; on the contrary, the pinion weakened by the large hole, will stand a poor chance. It will only be effective in case of the spring breaking near its inner end.

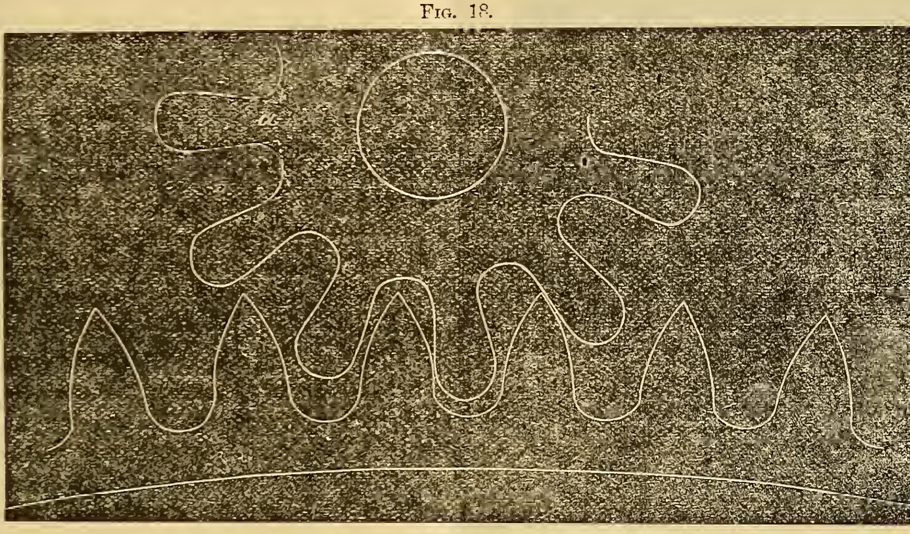
65. There is a general demand for anything effecting a guard against accident to the centre pinion, and every thinking manufacturer ought to make this an object of his reflections. Still, it seems the right thing is not found yet. The best contrivance is certainly that of adjusting the pinion on a round and slightly taper staff, and to hold it fast by a screw nut and washer; but it has the objection of diminished solidity of the pinion itself against it.

66. I never felt a temptation, however, to apply it to any watch of my own manufacture, as I believe that there is a plainer way of attaining the purpose. First of all, it will

lead in the direction of having, by observation of the preceding principles concerning barrel and train, a main-spring of comparatively great length and little thickness. In case of breakage, the shock resulting from it will be less injurious, and in winding it the interposing of the stopwork will be more readily felt than with a strong stubborn spring.

Secondly, I think it advisable, and practically possible, to strengthen the teeth of the centre pinion and barrel by giving them a shape more appropriate to their functions. Whenever one of these teeth is broken, the fracture invariably takes place at the bottom, where it is thinnest, and has two sharp corners, required by the taste of the great majority of watchmakers. An alteration of this

Fig. 18.



shape would give the teeth about double the strength, as it will be evident when looking at the dotted lines marked *a* in the cut, without interfering in any way with the service of the parts. I feel persuaded that the general employment of this form for the teeth of barrels and centre pinions would serve the purpose very well, though it is not pretended that a complete guarantee against fracture would ensue from it; but in this point all the other contrivances are equally doubtful.

CHAPTER VI.

THE MOTION-WORK.

67. There is not much to say about the construction of this part of the movement, because it is, to a certain degree, independent of the proportion of the train. In Swiss watches the motion works are generally much smaller than there is any necessity for making them. With the employment of the free springs, however, there might be some advantage in very small motion work, because the barrel heads of that kind have no shoulders allowing the necessary space for the hour wheel.

68. There are some trifling matters in the motion-work open to reform. In English watches, even of the better makers, the minute wheel moves mostly on a brass pin, driven rather carelessly into the pillar plate; an execution altogether unworthy of the character and general workmanship of these watches. The Swiss watches, on the contrary, down to their lowest qualities, have invariably a screwed staff on which the minute pinion is adjusted. These staffs are not easy to make, inconvenient to take out and screw in again, and by the tapping of the hole in the plate they offer less reliability of a true pitch than a round hole drilled on the pitch circle. I think there is a way between these two, which is easy of execution, and irreproachable as to solidity and diminished friction. A hole of the same size as that in the minute pinion is drilled through the pillar plate, on the pitch circle. A good round and well polished pin of hard steel, rounded at both ends, is driven into this

hole, even with the plate at its inner side, and projecting on the other side till it nearly touches the dial. The minute pinion has a small projecting cannon left beyond the riveting, to hold the minute wheel at a little distance over the plate.

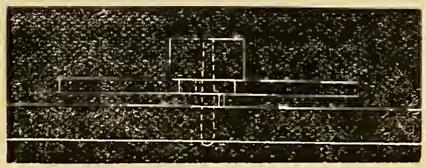


Fig. 19.

69. There is another matter which might easily be improved ; it is the way of adjusting the minute hand to the cannon pinion. In almost all Swiss watches the hand is adjusted on the end of the setting staff, and therefore it is necessary to support the setting square when putting the hand on, lest it should come out of its place by the pressure. This is not the case when the hand is adjusted on the extremity of the cannon pinion, which has a shoulder for this adjustment. Besides, this arrangement affords the advantage that the end shake of the hour-wheel can be regulated between the face of the cannon pinion and the lower end of the cannon of the minute-hand, thus dispensing with the small spring commonly in use for keeping the hour-wheel steady in its place.

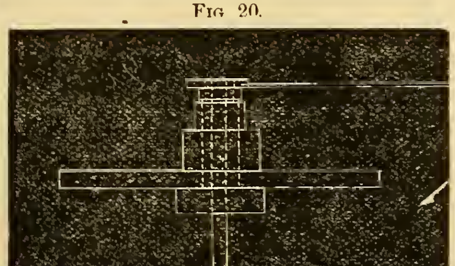


Fig. 20.

70. It remains only to say a few words concerning the setting the hands, which, in most cases, is done from behind, in Swiss watches. The setting the hands on the dial side is an inconvenience almost inseparable from the nature of a full plate movement, but in ¾ pl. and bridge frames there is not the slightest necessity for it. The gradual abandonment of the old plan of cases, with fixed domes, and the movement accessible only from the dial side, brought the reform of the way of setting the hands with it.

71. The dial of the watch, though of a material rather inconvenient to handle, is not much open to alterations. The liability to injury of the enamel dial has led to many endeavors to replace it by some more appropriate material. But the principal consideration of a good dial, distinctness, has never been attained in such perfection as with the enamelled ones. A perfectly white surface, with deep black figures on it, cannot be surpassed for this purpose. Silver dials, which were intended to supplant enamel, have nearly the same whiteness when new, but they are very liable to get dark from atmospheric influences or careless handling. Gold dials have also been tried, but being much less distinct, and especially a gold dial with gold figures and gold hands, they may be considered a nuisance, as in any place where it is not perfectly broad daylight, and to any person who is not endowed with a very sharp sight, it is impossible to derive any benefit from a watch fitted out in that way.

For these reasons, the enamel dial, in spite of its fragility and additional thickness, is, and will be, kept in use by all those who do not leave out of sight its principal purpose ; but it cannot be denied that the invention of a metallic, or other more appropriate material, possessed of the indispensable qualities, would indeed prove a great progress in practical horology. There is ample room for useful inventions. There was a period when, in England and elsewhere, dials were preferred of a yellowish or grayish tint. These are, of course, not so fit for the purpose as those of pure white enamel. In the same way, the slightly frosted surface of the English dials is thought a great improvement, as it is said to allow of looking at the watch in any direction without being disturbed by the reflection of the dial surface. This is a strange mistake, for if the dial of a watch does not reflect, when held in an awkward direction, the glass over it certainly will do so. Besides, it is so very easy to look at a watch without any danger of annoying reflex.

72. The fastening of the dial is effected in this direction by pins or screws. It is not advisable to fix the dial with two small screws and holes drilled through it, because the dial is very much exposed to injury by the slight-

est sideward pressure when shutting the case —the holes being so very near the edge of the dial. This method of fastening dials was formerly preferred by the best French and Swiss makers, and many a fine dial has been spoiled by it.

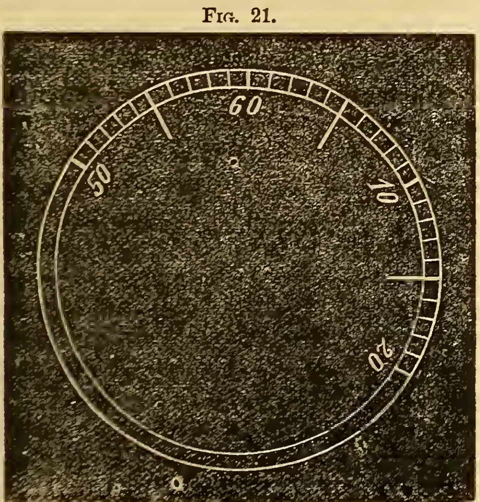
Another way of fastening the dial is with pins. It is quite efficient, and involves no danger ; therefore it has been much in favor in English watches, and if the movement can be got at there is nothing to be said against it. But in the movements of the present period, the greater part of which do not open with a joint, the fastening with pins would be rather troublesome, because, for taking off the dial, it would be necessary to take the movement out of the case.

In all movements cased in this way, the dial pillars ought to be held by key-screws, which allow taking off the dial without removing the movements.

A very good method of fastening the dial is to set it in a thin rim of silver or gold, and adjust this rim nicely on the outer edge of the pillar plate.

73. The hands, in order to be distinctly seen, ought to be of a dark color, and the generally adopted blue steel is far preferable to gold for this purpose, and the figures and hands ought to be a little more substantial than the present taste prescribes for them. The most convenient shape for the purpose is the spade pattern ; the Breguet and the

Fig. 21.



Fleur-de-Lis hands not being easily distinguished.

74. The circle of seconds ought to have every fifth degree visibly marked by a longer and stronger stroke, in order to facilitate the reading of the seconds.

Formerly all the dials had flat seconds, but for about thirty years it has been quite common to have sunk seconds, even for inferior watches. There is some advantage in that, especially in flat watches, where it affords acommodation for the seconds-hand, but at the same time it weakens the dial considerably. This may be the reason why some makers have the sunk part much smaller, and the seconds painted on the main dial, the lines extending inward to the edge of the sink. The seconds-hand is then shorter, and moves in the sink.

The dial ought never to be made larger than the pillar plate.

HEAT.

NUMBER EIGHT.

FURNACES—FUEL—LAMPS—COMBUSTIBLES—GAS—ALCOHOL, ETC. — BLOW - PIPES — METHOD OF USING—CONCLUSION.

Furnaces differ in construction according to the uses for which they are designed. The main parts of every furnace are the body in which the heat is produced, the grates or bars upon which the fuel rests, the ash pan for receiving the residue, and smoke-pipe for conducting off the gaseous products of combustion. The subject is one that would occupy far too much of our space to go fully into it, and we shall only consider one which may be termed a universal furnace, and which is suitable for almost every operation in the work-shop. This universal furnace is of cylindrical form—this form being the best adapted for producing a high heat with the least fuel. It is made of strong plate iron, and lined in the body and dome with refractory fire clay, the body being about fourteen inches high by seven inches in diameter. There are six doors, one at the base for the admission of air, another in the middle for the entrance of the fuel, and one for the reception of the muffle used in assaying or refining. The door in the dome is for the purpose of feeding the fire in crucible operations, and in the side and at the top for the reception of the neck of a retort. There are two lateral openings, opposite to each other, for the passage of tubes, or of an iron bar, as a support to the rear end of a muffle. The two circular openings are those by which it is coupled with the pipes connecting it with the flue of the room it is placed in, and are closed by movable plugs. In crucible operations the smoke-pipe should lead from the top opening, and in evaporations from the aperture in the back. The openings in the flue must be above the level of the furnace. An opening at the base is for the introduction of the mouth of a pair of bellows, by which it may be converted into a blast furnace if necessary. Blast furnaces are serviceable for expeditiously producing a great intensity of heat, and are used for fusions and other operations which require more power than can be obtained by a chimney draught. All furnace operations should be conducted under a stationary hood, so that the carbonic acid and other noxious exhalations may have an escape, and the sparks and heated air emitted be prevented from endangering the comfort and safety of the apartment.

Coal, coke, and charcoal are the fuel most used. Coal is the least available, for it contains sulphur, and yields a large amount of ash and clinker, which choke the grating; and it should, therefore, never be used in the blast furnace. Coke and charcoal, separately and combined, are used for all the furnace operations in the arts; the former being preferable for higher temperatures. Weight for weight, their amount of heat is nearly equal; but the greater density of the coke enables it to give more, bulk for bulk, by ten per cent. Charcoal ignites more readily, but coke is more durable. Moreover, when of good quality and free from sulphurous and earthy matter, it gives but little ash or clinker. By mixing the two together the good qualities of both are obtained; although charcoal alone is preferable for some purposes. Before using the coke or charcoal care must be taken that it has been freed from dust and dirt by sifting, and that the pieces are about the size of a walnut, so that they may pack away neither too loosely nor too compactly.

Lamps are convenient and economoical substitutes for furnaces in small operations. Being less cumbersome and more cleanly than furnaces. They are readily manageable and always ready for use; and they also afford the means of more rapidly multiplying results. The amount of heat to be obtained by these instruments depends upon their size and arrangement. A properly constructed lamp may be made subservient to all the requirements of an ordinary workshop. The heating power of the flame is most active immediately beneath its summit, and the vessel should be gradually brought into direct contact with that portion, and should be heated gradually in proportion to its thickness. When thick glass or porcelain, or brittle, bad conducting material is suddenly heated, the heated part expands while the rest does not, and this unequal tension of two adjacent parts causes the cracking or fracture of the vessel. There is therefore a great advantage in employing glass or porcelain vessels of *thin* structure, for the heat being rapidly conducted through them, the liability of fracture is diminished. As strength is, however, often required, and thicker vessels must be used, the above principles of expansion and of conduction must be remembered when they are employed.

In order to apply a small fire to a large surface, they may be diffused by setting the vessel in a sand or water bath, or, which is convenient and more cleanly, a plate of sheet metal or wire gauze may be placed between the vessel and the fire. It is safer not to allow the vessel to touch the plate or gauze. Iron or brass gauze may be used, although fine copper gauze is preferable, because it is more durable.

Gas is by far the most economical source of heat for small operations, it being always ready for use, easily manageable and cleanly. It may be conveniently led to any part of the room through a flexible caoutchouc tube, for which purpose one end is fitted with a brass nozzle for attaching it to the supply-pipe; the other end terminates in either an Argand or Bunsen burner, or any other burner suitable for the work intended. The Argand burner consists of a small circle perforated with a great number of small holes, and requires a chimney. The Bunsen burner consists of a metal tube of a suitable shape placed on the ordinary gas burner, and four or five small holes are cut in the tube a little below the gas flame. This burner gives a strong heat, and when properly made has little if any smoke that will discolor the article that is being heated. A good gas flame for blow-pipe operations is made by taking out the usual burner and filling up the space with a little bunch of small binding wire; or still better, if a brass nozzle is put in the place of the burner with room enough for a bunch of small binding wire larger in diameter than the space occupied by the old burner would admit of, it will produce a flame particularly fitted for blow-pipe operations, where a strong heat is required, while by regulating the stopcock a flame can be obtained suitable for the most delicate of operations.

Very neat gas furnaces are made by W. F. Shaw, of Boston. Those intended for work-room purposes have a broad base to steady their position on the table. Surmounting a wire gauze diaphragm, is a perforated cylinder, with large openings near its *top* circumference for the promotion of air currents. These, by perfecting the combustion of the burning mixture of air and gas, not only increase its heating power, but prevent all smoke and odor. It is necessary to add that the meshes of the wire gauze should be kept clean by the occasional application of a tooth brush.

Gas being in general use in the large cities and towns, an ample supply can always be obtained; but in the country and in thinly inhabited districts lamps must still be used. Lamps can be so constructed that they will produce a most intense heat by the use of alcohol, wood spirit, kerosene, camphene, and similar fluids, as fuel. Those hydro-carburets which have the lowest boiling point, and give the densest vapors, afford the greatest heat. Alcohol flame gives no smoke or unpleasant odor, the product of combustion being only carbonic acid and water, while lamp oil, especially where the supply of oil to the wick is insufficient, produces a black carbonaceous deposit upon the bottom of the vessel, which occasions a loss of heat by radiation. Pyroxylic spirit is much less objectionable than lamp oil, and is said to be much cheaper than alcohol in heating capacity. The many other advantages of the latter, however, give it the preference over all other combustibles as a fuel for lamps. It should be about the specific gravity of 0.85 for this purpose. When a lamp is not in use the wick should always be covered with the extinguisher to prevent loss by evaporation.

The blow-pipe is an instrument that has been long used in the arts, and in mechanical pursuits, when small currents of intense heat are desired. The forms of the various blow-pipes in ordinary use must be familiar to all ; still there are points in their construction to which we desire to direct special attention. They are generally made in the form of a tapering brass tube, and bent at the smallest end to a right angle, but without a sharp corner. Sometimes we find them made in the shape of a long cone, with the wide end stopped up, and a brass jet with a small hole through it inserted in the side of the cone, near the wide end. This form has the advantage of collecting the moisture with which the air is charged as it comes from the mouth, and prevents the moisture from interfering with the flame that is being operated upon. Its weight is, however, a considerable drawback to its general use, especially in operations where both hands are required to be free in order to handle the work.

There are many forms and methods of constructing blow-pipes. Some of them have ingeniously arranged stands to support them on the bench, thereby leaving the operator's hands at liberty ; and these stands are of much service in special operations. For all ordinary purposes, probably the first mentioned blow-pipe, with a round ball added to it, and placed about the centre, in order to collect the moisture from the mouth, is as good as any. The ball ought to be hollow, and made so as it can be taken apart to allow the condensed moisture to escape when the ball becomes full. Some of the blow-pipes sold in the tool shops have, to all appearance, this ball placed on them merely as an ornament, for sometimes we find the tube to pass through the ball without any opening for the moisture to collect in it, and consequently, in cases of this sort, the ball is useless. The metals blow-pipes are usually made of are very liable to become dirty through oxidation, and when placed between the lips are liable to impart a disagreeable taste. To avoid this, the top of the tube should be supplied with a mouth-piece of ivory or other suitable material, shaped like the mouth-piece of a trumpet.

This construction of the blow-pipe, for use at light work, has probably a combination of all the advantages that can be claimed for other forms. The moisture is collected and does not pass to the flame ; it is light, and, with the trumpet shaped mouth-piece, can be held easily in the mouth between the gums and the lips, without being in the least degree tiresome. Both hands are left at liberty to direct the work, while, by moving the head, the direction of the flame can be instantly changed, at a critical moment, which cannot always be done when a stand is used to support the blow-pipe.

In using the blow-pipe, the effect intended to be produced is an uninterupted, steady stream of air for some minutes together, if necessary, without an instant's cessation. Therefore the blowing can only be effected with the muscles of the cheeks, and not by the exertion of the lungs. It is only by this means that a steady, constant stream of air can be kept up, while the lungs will not be injured by the deprival of air. The details of the proper manner of using the blow-pipe are really more difficult to describe than to acquire by practice ; therefore the apprentice should apply himself at once to its practice, by which he will soon learn to produce a steady current of air. We would simply say that the tongue must be applied to the roof of the mouth, so as to interrupt the communication between the passage of the nostrils and the mouth. The workman now fills his mouth with air, which is passed through the blow-pipe by compressing the muscles of the cheeks while he breathes through the nostrils, and uses the palate as a valve. When the mouth becomes nearly empty, it is replenished by the lungs in an instant, while the tongue is momentarlly withdrawn from the roof of the mouth. The stream of air can be continued for a long time without the least fatigue or injury to the lungs. The easiest way for the apprentice to accustom himself to the use of the blow-pipe, is first to learn to fill the mouth with air, and while the lips are kept firmly closed, to breath freely through the nostrils. Having effected this much, he may introduce the mouth-piece of the blow-pipe between his lips, and by inflating the cheeks, and breathing through the nostrils, he will soon learn to use the instrument without the least fatigue; the air being forced through the tube, against the flame, by the action of the muscles of the cheeks, while he continues to breath without interruption through the nostrils. Having become acquainted with this process, it only requires some practice to produce a steady jet of flame. A defect in the nature of the combustible used, as bad oil, bad alcohol, etc., or a dirty cotton wick in the lamp, or an untrimmed one, will prevent a steady jet of flame. But frequently the fault lies in the small hole at the point of the blow-pipe being stopped by dirt or soot, and which prevents a steady stream of air, and leads to difficulty. Platinum pointed blow-pipes keep their shape better, and keep longer clean, than any other metal.

Any flame of sufficient size can be used for blow-pipe operations, but in special cases, where smoke or other impurities would be likely to damage the work in progress, an alcohol lamp should be used ; but there must be no loose threads or dirt of any kind on the wick, or these will produce a smoky flame. The wick, likewise, should not be pulled up too high, as the same smoky flame would be produced. In situations where it is necessary to use a candle, it is well to cut the wick off short, and to *bend it a little* towards the article to which the heat is desired to be applied. But candles are not the best for blow-pipe operations, as the radiant heat reflected from the substance upon the wax or tallow will cause it to melt and run down the side of the candle; while, again, candles do not give heat enough.

When a current of air is directed through a blow-pipe with a small straight aperture against a flame, it drives the latter before it in a long-pointed and conical projection. To produce a clean and uniform flame the tip end of the blow-pipe should barely penetrate the flame, and, when it is desired to give it volume, it must be slightly parted in the middle by drawing the tip of the blow-pipe across it. In this latter case, too, the blow-pipe should be directed at an angle of forty-five degrees across this channel. In blowing, the breath must be regulated, that the blast should neither be too strong nor too feeble; for in the first instance the excessive air cools the flame, and in the latter the combustion is slow and imperfect. The long, narrow, blue flame which appears directly before the jet is the same as the blue part of the flame before the blow-pipe was applied to it, although changed in form, being now concentrated into a small cylindrical space, whereas before it formed an envelope around the whole flame. Just before the point of this blue flame is the greatest heat, just as in a free flame, but with this difference — that in the latter case it formed a ring around the flame, while in the former it is concentrated into a focus. It is thus rendered sufficiently intense to fuse substances which were not sensibly acted on by the flame in its usual state. On this is founded the whole theory of the intense heat produced by the blow-pipe; the effect which would otherwise be distributed over the whole surface of the flame is concentrated into a small space, exactly as if the flame had been turned inside out. The surrounding illuminating portion of the flame prevents the heat from escaping.

When a flame is urged by the blow-pipe, the extreme heat is just at the tip of the outer white flame, where the combustion is most perfect, and where substances are rapidly burned or oxidized; whilst the interior blue flame, in consequence of its excess of combustible matter, abstracts oxygen from, or *reduces*, substances; so that several metals, when thus heated before the blow-pipe, are alternately oxidized and deoxidized by being placed in the outer and inner flame. For a practical illustration of oxidizing and deoxidizing, see page 219, Vol. I. of this JOURNAL.

In connection with the subject of the blow-pipe, a few remarks may be made as to the material that is the most suitable for holding or supporting the articles that are being operated upon. Pumice-stone is often used for this purpose, and it is very good, but probably charcoal is the best for all purposes. The value of charcoal as a material for placing small articles upon when under the influence of a flame from the blow-pipe, is as follows: It is infusible, and, being a poor conductor of heat, a substance can be exposed to a higher degree of heat upon it than upon any other substance. The best kind of charcoal is that of pine, linden, willow, alder, or any other soft wood. Coal from fir wood sparkles too freely, while that of the hard woods contains too much iron in its ashes. Smooth pieces, free from bark and knots, should be selected. It should be thoroughly burnt, and the annual rings or growths should be as close together as possible. If the charcoal is in masses, it should be sawed into pieces of convenient length, but so that the year growths run perpendicular to the broadest side, as the other sides, by their unequal structures, burn unevenly.

Such is a review of the subject of heat. We have from time to time during the past eight months discussed the nature of heat, the laws of its transmission, and its effects upon different substances, and some of the methods by which it can be used in the mechanical arts to the best advantage. The writer was first induced to study the subject while working out the difficult problem of improving the compensation of pendulums. The effects and consequences of heat are so visible all around us, and it is an agent that is required to be so universally used in our daily occupations — whether it be derived from combustion or chemical mixture, or any of the other sources — that a knowledge of the subject is of the utmost importance to all engaged in the mechanical arts. Let our young friends study the subject well. A clear comprehension of the laws of nature makes many operations beautifully plain which before appeared all mystery, and also tends to inspire within us greater reverence for the Great Architect of the Universe.

CLYDE.

——o——

☞ Any of our friends that have a desire to see to how many useful purposes electro-plating with nickel may be applied, will be gratified with a visit to the establishment of L. L. Smith & Co., No. 6 Howard street, N.Y.

THE PENDULUM
AS APPLIED TO THE
MEASUREMENT OF TIME.

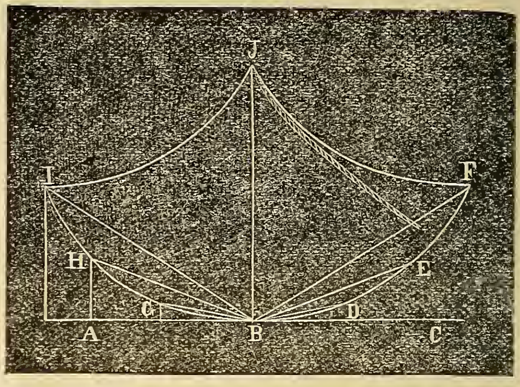
NUMBER TWO.

TERRESTRIAL GRAVITY CONTINUED—THEORY OF THE SIMPLE PENDULUM ILLUSTRATED—TENDENCY TO DESCRIBE AN ELLIPSE—FOUCAULT'S EXPERIMENT—MATERIAL PENDULUM—CENTRE OF GRAVITY—CENTRE OF GYRATION—CENTRE OF OSCILLATION—POINT OF SUSPENSION—ANGULAR PENDULUM—CONICAL PENDULUM, ETC.

In the last number we briefly investigated the laws that govern falling bodies, and observed that *all* bodies, irrespective of their size, when under the influence of gravity *alone*, fall with an equal velocity; and that this velocity is continually accelerated until the body reaches its resting point. At the end of a second of time, after being liberated, the body attains a certain amount of speed, and gravity continuing to act upon it, as much more velocity is imparted to it at the end of the next second, and as much again during the third, and so on. We also noticed that bodies acquire the same velocity in rolling down the path of an inclined plane as they do in falling from the same elevation in a vertical line; and also that the quickest way for a body to travel between two points is not always by following a straight line, but by following a cycloidal curve from the one point to the other. Gravity acts upon rising bodies in the same manner as it does on falling bodies, but in a reversed order, thereby producing continually a retarding motion while the bodies are rising. Thus, a body projected perpendicularly into the air, if not influenced by the resistance of the air, would rise to a height exactly equal to that from which it must have fallen to acquire a *final* velocity the same as it had at the first instant of its ascent.

On the foundation of these conclusions, which are to be found demonstrated mathematically in any text-book on natural philosophy, the whole theory of the oscillations of a simple pendulum will be explained by the following diagram.

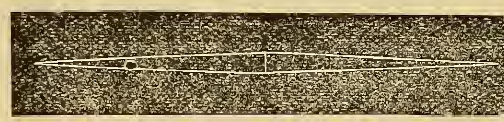
A B C is a horizontal line, and I B F is a cycloidal curve, the centre of which is the point J. The lines I J and F J are lines representing the evolute of the cycloid I B F. The point H represents the centre of



oscillation of an imaginary pendulum. If this point be allowed to follow the inclined plane in the direction of B, the same kind of motion will be produced, and it will have acquired the same velocity when it reaches B as it would if it fell in a vertical line from H to A; and the velocity thus acquired will be sufficient power, were it not for the resistance of the air and friction, to cause it to ascend, in the same time, from B up to E, as it took to fall from H to B. The same result will ensue, but in different portions of time, if the point H be made to follow the lines I B or G B; in both cases the point H will have acquired exactly the velocity on reaching B, to cause it to ascend on the opposite side to D or F in the same time as it took to descend from I or G to B. If this point, H, be attached to the thread K, and caused to follow the cycloidal curve I B F, it will reach B *in the same time, from whatever point in the curve it may have started from;* and will also have obtained that velocity, on its descent, that is required to cause it to ascend the same distance, in the same time, on the opposite side of B, and equal to that from which it fell.

This explains the reason why the long and short vibrations of a simple pendulum are isochronal, or of equal duration, or performed in the same length of time; or, in other words, the reason the pendulum always moves faster in proportion as its journey is longer, is, that in proportion as the arc described is more extended, the steeper are the declivities through which it falls, and the more its motion is accelerated. Thus, if a pendulum begins its downward motion at I, the accelerating force is twice as great as when it is set free at H. The reason why long pendulums vibrate more slowly than short ones, is, that in corresponding arcs, or paths, the ball of the long pendulum has a greater journey to perform, without having a steeper line of descent. If we suppose three balls, or points, to be attached to three strings of the same length, it matters not how unequal the balls may be in weight, if we liberate them at the same time, one at I, one at H, and the other at G, they will arrive at B together, and each will have acquired a momentum which would be sufficient, were there no impediments to the motion, to carry it to a distance on the other side of B, corresponding to the distance from which it fell. This is the reason why heavy and light pendulums vibrate in the same time if they be of the same length.

It has been observed already, that in practice a pendulum cannot be made to describe an exact cycloidal curve. In modern clockwork the maximum vibration of a pendulum need not be more than a degree and a half, or two degrees, on each side of the point of rest; and in that arc there is no difference between the cycloidal and circular curve that, in practice, makes itself visible by affecting the isochronal properties of a pendulum. Consequently, the pendulum may as well be allowed to swing in a circle as to endeavor to make it swing in a cycloid. If we take any fine clock, that is constructed on the common principle of maintaining the vibrations of the pendulum *directly* from the weight, and increase or diminish the weight, the length of the vibrations will be diminished or increased accordingly, and the rate of the clock will be affected according to the kind of escapement it may have. In the dead beat, or Graham escapement, any increase in the vibration of the pendulum has a tendency to make the clock go *slow*; but this change of rate does not occur because the pendulum in not describing a cycloid, but because it makes larger vibrations; the pallets have a corresponding increase of friction, by having to travel farther on the teeth of the scape-wheel, and hence the vibrations of the pendulum are slower. If the error in the rate of the clock had its origin in the pendulum describing a circular curve instead of a cycloid, it is remarkable that, under the same circumstances, a clock with a recoiling escapement goes very much *faster* as the vibrations increase. Almost any one, who is not already aware of the fact, has an opportunity of satisfying himself by direct experiment of the different effects of increasing the weight of a clock with a dead beat escapement, and one with a recoiling one.



Ellipse.—If the bob of the simple pendulum be slightly displaced, by any cause, it describes an ellipse, and its lowest position is the centre of the ellipse. This ellipse may, of course, become a straight line or a circle. The bob does not accurately describe the same line in successive revolutions; in fact, the elliptic orbit just mentioned rotates in its own plane about its centre in the same direction as the bob moves, and with an angular velocity nearly proportional to the area of the ellipse. There is an interesting experiment, which can be watched by any one who will attach a small bullet to a fine thread, or, still better, attach to the lower end of a long string, fixed to the ceiling, a funnel full of fine sand, or ink, which is allowed to escape from a small hole. By this process a more or less permanent trace of the motion is recorded by which the elliptic form of the path, and the phenomena of progression, are well shown. According to what is stated above, there ought to be no progression if the pendulum could be made to vibrate simply in a straight line, as then the area of the elliptic orbit would vanish. It is found, however, to be almost impossible, in practice, to render the path absolutely straight, so that there always is, from this cause, a slight rate of change in the position of the line of oscillation; but as the direction of this change depends on the direction of rotation in the ellipse, it is as likely to affect the motion in one way as in the opposite, and is thus easily separable from the very curious result obtained by the French *savant* Foucault.

In his experiment, when a round body, suspended by means of a flexible thread, is once set to oscillate in a plane, it continues to move in that plane if there be no disturbing cause. M. Foucault took advantage of this property in order to demonstrate the diurnal rotation of the earth. If the earth were at rest, the direction of the vibration would remain the same, and would appear to remain fixed ; but as the earth turns, the plane of oscillation preserves its parallelism, and that plane appears, in reference to surrounding objects, to turn in the direction of the apparent motion of the stars. This beautiful experiment is of French origin, but it was very successfully repeated in this country at Bunker Hill monument, about twenty years ago. We have, ourselves, tried the experiment, and any one anxious to repeat it must be careful to get as high and as firm a support as can be had ; and great care must be taken that the ball be symmetrical in shape, and that no bias be given it at the outset, lest some of the complex movements we have now been describing be induced.

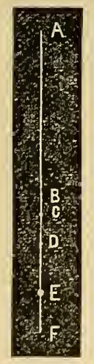
Material Pendulum.—Up to the present stage we have been considering the laws that govern the simple or imaginary pendulum of nature ; but as no such pendulum can exist, or can be made by the hand of man, or applied for his benefit, we are obliged to construct a material one, and as nearly as possible follow the laws of nature. Clock pendulums are usually constructed with bobs of a lenticular shape, or shaped like a lens, or a disk—thick in the centre, and tapering towards the edge—and is adopted principally with a view of taking up as little room in the thickness of the case as possible. It is a mistake to suppose that this form is the one best adapted to obviate the effects of the resistance of the air on the motion of the pendulum. The solid contents of a simple sphere, or round ball, is greater than any other shaped body of equal size ; consequently, a bob of this shape is less affected by the resistance of the atmosphere, because it contains a greater amount of weight in a smaller space, and presents less actual surface exposed to the air than any other form that can be devised. It, however, occupies a greater amount of space in the thickness of a clock case than can often be spared; still there are many instances in which it might be adopted oftner that what it is, especially when utility does not require to be sacrificed for the sake of appearance. In turret clocks there is no reason why a spherical-shaped pendulum bob should not always be used. They are as cheaply made as those of a lenticular or cylindrical pattern, and the pendulums are more steady in their vibrations, and less liable to be affected by currents of air, than those having bobs of any other pattern. Some may think that for the purpose of very fine clocks these bobs do not afford the same facilities for compensation as bobs of other forms do; but when we come to consider the subject of compensation we will describe a method by which they are compensated with the greatest nicety. Lead is the best metal for pendulum balls of all shapes, and should always be the principal one used in their construction when it is practicable. It occupies less space than any other metal available, and is not influenced by magnetism as iron is. It is a most important consideration in the making of bobs, that care be taken to have the holes that pass through them exactly in the centre of the mass. When this is attended to, and other parts are also right, there is not that tendency for the pendulum to "wobble" that we so often see, and which is so fatal to the regularity of the clock. In constructing the rod, no more metal should be used than is just necessary to make it stiff enough not to bend or yield by the vibration of the ball, and it ought also to be shaped with a view of attaining the same object—stiffness and lightness. Wood is probably the best material that can be employed for the rod of a cheap pendulum, as it varies but little in length, and therefore does not require compensation. Some attribute the general good performance of wood pendulums partly to the lightness of the rod. Any wood is suitable for this purpose that has a fine straight grain. The wood ought to be split up, like laths, to near the size desired, and when fitted ought to extend the whole length of the pendulum, from the suspension spring to the regulating screw, and should be carefully protected from damp by varnish, coated over several times, taking special care to have any end wood that may be exposed thoroughly saturated with the varnish to protect the wood from the influence of damp.

In constructing pendulums, generally, there is not that care taken with some of the important points that ought to be. It is usually the last thing that is made about a clock, and on that account the workmanship is often hurried. It is also becoming too common to consider the pendulum only as a showy appendage to the clock, whereas the fact is, that the clock is but an appendage to the pendulum. So far, indeed, are the wheels, or any other part of the movement, from contributing to the time of the pendulum, they are mostly found to disturb it. In constructing a material pendulum, whether it be a plain or a compensated one, it ought to be a point of prime consideration with the artist to have all the weight that constitutes the pendulum as much as possible concentrated in the ball. A pendulum is a body revolving about a fixed point or axis, and there are points in it subject to the same rules as other bodies in mechanics that revolve about a fixed axis. In the imaginary pendulum the centre of gravity, centre of gyration, and centre of oscillation are all at the one point; but in the real, or material pendulum, they occupy different points, according to the form of the pendulum, and the weight of its rod, in proportion to the weight of the ball. We shall now proceed to consider these several points briefly, and give rules by which they may be found.

Centre of Gravity is a point so situated, in the centre of a body, or system of bodies that are rigidly connected to each other, that any plane whatever, that passes through it, divides the body into two segments, the weights of which are exactly equal. In irregular shaped bodies, the place of this point may be found mechanically, in several ways. One method consists in suspending the body, successively, from the different points of its surface, and, by an attached plumb-line, find, in each case, the direction of the vertical line through the body when it has come to rest. These lines will intersect each other at a point, and this point will be the centre of gravity of the body. The centre of gravity of a material pendulum may be determined mechanically by first balancing it on a knife edge, and making a mark where the knife edge is when the pendulum is balanced. Afterwards, suspend the pendulum and let it hang freely, then hang a fine plumb-line from the same point of suspension, and the point at which the plumb-line crosses the first line is the centre of gravity of the pendulum.

Centre of Gyration of a body, or system of bodies, is a point in which, if the whole mass were collected, a force applied at any distance from the axis of suspension would communicate to the mass thus collected the same angular velocity that it would have communicated to the system in its first condition. It is evident, from this definition, that the point in question must have this property, that if the whole mass were united in it, the moment of inertia, or the power of resisting the effort of any force, will be the same as the moment of inertia of the body in its first state.

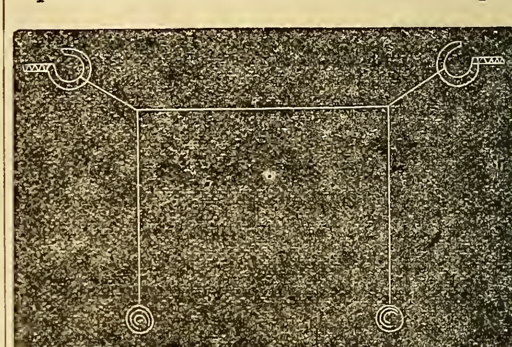
Centre of Oscillation is that point in a body, or system of bodies rigidly attached to each other, and oscillating about a fixed axis, into which if the whole mass were collected, the body would vibrate through a given angle, by the force of gravity, in the same time as in its first condition. The centre of percussion and the centre of oscillation in a pendulum are at the same point. The method of determining the centre of oscillation of the material pendulums was first given by Huyghens, in his celebrated work, *Horologium Oscillatorium*. His demonstration is this: "That if several weights, attached in any manner to an inflexible rod or pendulum, descend by the action of gravity, and if at any distance they are detached, or disengaged from each other, each of them, in virtue of the velocity it had acquired during its descent, would mount to such a height that the common centre of gravity of all of them would reach exactly the same height as that from which it descended." The centre of oscillation may be found by measurement, in the following manner: If several bodies be fixed to an inflexible rod, and suspended from a point, and each body be multiplied by the square of its distance from the point of suspension, and then each body be multiplied by its distance from the same point, and all the former products, when added together, be divided by the latter products added together, the quotient will be the distance of the centre of oscillation of these bodies from the said point.



Thus, if A F be a rod, on which are fixed the bodies B C D, at the several points B C D, and if the body B be multiplied by the square of the distance A B, and C be multiplied by the square of the distance A C, and so on the rest; and then if the body B be multiplied by the distance A B, and C be multiplied by the distance A C, and so on the rest; and if the sum of the products arising in the former case be divided by the sum of those which arise in the latter, the quotient will give A E to be the distance of the centre of oscillations of the bodies B, C, D, etc. from the point A.

In the material pendulum, the centre of oscillation is not always at a fixed point in the same pendulum, but varies in relation to the part where the spring bends. The centre of gravity differs from it in this respect, that it is a point that is always at the same place in the same pendulum, but generally both points are above the centre of the ball. In a wood rod pendulum, about 10 lbs. weight, the centre of gravity is about .8 of an inch, and the centre of oscillation about .1 of an inch above the centre of the ball. In a Gridiron pendulum of the heaviest class, weighing in all about $19\frac{1}{2}$ lbs., the centre of gravity is about 4.75 inches, and the centre of oscillation about 2.30 above the centre of the ball. In a Gridiron pendulum, with the ball much lighter in proportion to the weight of the rod, and weighing about $16\frac{1}{4}$ lbs. in all, the centre of gravity is about 7 inches above the centre of the ball, and the centre of oscillation 3 inches; which will give some idea how these points vary according to circumstances.

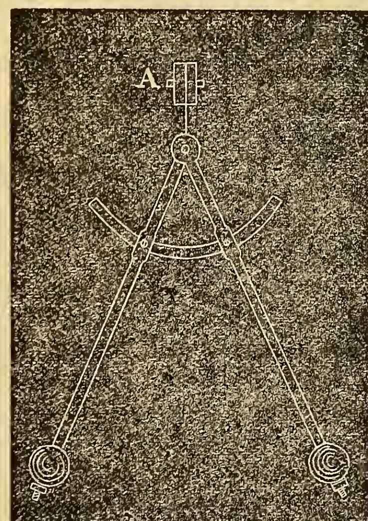
Point of Suspension.—In all our investigations, the point of suspension of the pendulum has been supposed to be absolutely immovable; but in a mathematical sense there is no substance which does not yield to the pressure applied to it, and therefore, as the pendulum swings from side to side, the point of suspension oscillates also, and the whole frame-work becomes truly a part of the vibrating mass. There are many well authenticated instances where a number of clocks, placed in close proximity to each other, would, under certain conditions, disturb each other's motion. The one would stop the pendulum of the other, and after a time the stopped pendulum would resume its vibration, and in its turn stop the others; and so they would continue to stop and start again in alternate succession. This statement, at first, may seem incomprehensible, but it is easily explained by the following experiment: Attach the ends of a string to



two supports (the walls of a room for instance), and, from somewhere near the centre of the cord, suspend two balls on two pieces of cord of equal length, in the same manner as shown in the diagram. If we set the one ball vibrating while the other is at rest, the moving ball will immediately communicate its motion to the other. The ball that was at rest will gradually increase its vibrations in proportion as the other falls off, and finally the first started one will come to a standstill, then gradually resume its motion, while the other will, in its turn, stop, and start again, and in like manner they will continue till they both come to rest. While we write we have a string stretched from the two windows of a corner room, and two empty ink bottles of the same size suspended from it. They continue to swing, to stop and start alternately, with the greatest regularity, till finally they both come to rest. The pendulums of clocks are stopped and started again exactly from the same cause as these temporary pendulums we speak of. If two clocks be firmly placed on the same table, and if the table be very loose in its joints, and be shakey, the same phenomena will occur as happened in the case of the two balls suspended from the loose string, and from the same cause, namely, the point of suspension of the one pendulum yielding to the motion of the other. If the same clocks be placed together on a firmer support, they may not be entirely stopped, but the effect will be visible on their rates, if they be fine clocks, and are closely watched.

Conical Pendulums.—If we suspend a slender rod, with a ball attached to the end of it, in such a manner that it will swing freely in every direction, and impart to it a circular motion, it will describe a cone, the base of which will vary in diameter in proportion to the force of the circular motion that has been given to it. Pendulums that are the proper length to vibrate seconds in the usual way, if made to revolve in a circle, and describe a cone, will only make one revolution in about two seconds; and one that vibrates twice will only make about one revolution in a second; and pendulums of other lengths will give the same results in a like proportion. This kind of pendulum is frequently applied to clocks that are intended for bedrooms of invalids, or in hospitals, or in other situations where silence is an object, and the usual ticking of a clock is objectionable. Of late years large quantities of such clocks have been manufactured in Connecticut, and on the continent of Europe. Pendulums of this construction are more liable to vary from irregularities in the motive power that drives them, than vibrating ones are; still, we have seen clocks of this sort go well enough for all ordinary household purposes, when great care is taken to have the wheel work accurate, and the main-spring properly adjusted by a fusee. Conical pendulums are sometimes applied, in Europe, to regulate the motion of chronographs, and the clock-work that drives equatorial mounted telescopes. In such cases it is desirable, in fact it is imperative, that a regular continuous motion should be given to the instrument, free from the usual jumping or intermittent motion that exists in clock-work regulated by a vibrating pendulum. A conical pendulum gives a continuous motion, but it cannot be made to give a regular one, although many supplementary contrivances have been devised for the purpose of helping it to do so. The necessity of using this kind of pendulum for this purpose, has of late years been entirely obviated by the invention made by the late Mr. R. F. Bond, of Boston, for converting the intermittent motion that exists in clock-work that is regulated by the vibrations of a pendulum, into that of a uniform continuous motion, and at the same time retain the accuracy that is derived from the vibrating pendulum. All American chronographs, and the clocks of American equatorial mounted telescopes, and also some European ones, are made on this principle. No other plan yet devised appears to give more satisfactory results in producing that accurate rotary motion so necessary in certain astronomical instruments. A description of this invention has already appeared in the first volume of the Journal, but we shall take further notice of it when we come to consider the subject of escapements.

Angular Pendulums are formed of two pieces or legs, like a sector, and suspended



by the angular point A. This pendulum is constructed with a view of diminishing the length of the common pendulum, but at the same time to maintain, or even increase, the times of vibration. In this pendulum the time of vibration depends on the length of the legs, and on the angle contained between them conjointly—the duration of the time of vibration increasing with the angle; consequently, a pendulum of this construction may be made to oscillate in any given time. At the lower extremity of each leg of the pendulum is a ball or bob, as usual; and if it vibrate half seconds when its legs are closed, it will vibrate whole seconds when the legs are opened, so as to contain an angle equal to 151° 2′ 30″. This pendulum is used on occasions when it is desirable to have a pendulum vibrate long portions of time, and when the situation will not admit of one of the usual construction; but it is not suited for any purpose where accuracy is required. The difficulty of compensating it, and the great and fatal tendency it has to "wooble," or to swing in an elliptical plane, renders it unsuitable for purposes where precision is an object.

We once applied it to an ornamental French clock, with a movement in it that required a pendulum much longer than the height of the case would allow to swing. The result was satisfactory as regards the slowness of the vibrations, but the regularity of the time was not as good as that of a pendulum of the usual construction. When instances of this kind occur, as they sometimes do, if filing a little off the ball has not the desired effect, it is always cheaper and better either to alter the train or get another movement.

When a clock has to be placed in a building where there is not sufficient room for the pendulum near the dials, it is always preferable to place the movement in some situation where there *is* room, and make a connection between the movement and the dials by means of shafting made of light tubing.

An opinion is prevalent among some people that watches and clocks are in principle the same, and it is true that to a limited extent they are. The wheel and pinion work of both class of instruments, up to the escapement, are in principle the same. The main-spring and fusee, and also the going barrel, are used in both clocks and watches as occasion may require; still, although these parts be the same in principle, how few think of the scheming and planning necessary in arranging them to answer all the requirements of the particular purpose intended. To construct a watch, and arrange the component parts so that the watch, or its case, will conform to every caprice of fashion, and at the same time be a safe and reliable time-keeper, or to construct a clock to fit a building where some unaccommodating architect, considering all that was necessary for the clock was to leave holes in the walls for the dials, involve questions altogether different from each other, and bear but little resemblance, further than in both instances they are often ill requited labors, if the artist has a conscientious desire to have his machine mechanically correct. The modes of reasoning, and the principles that are involved in perfecting the marine chronometer, are altogether different from those for improving the astronomical clock; and in reality there is but little similarity between watches and clocks, except that they are both used for the same purpose—that of measuring time. To such of our readers as may not be familiar with all the questions involved in adapting the *pendulum* for measuring time, we would advise them, in studying this subject, to banish from their minds all theories about watch or chronometer balances, and balance springs, and their various peculiarities, because they bear no parallel to the subject under consideration.

We have described the laws that govern the motion of a pendulum, and the peculiarities of the various forms of pendulums used for measuring time. Before entering upon the question of compensation, and the general effects of heat and cold upon pendulums, we shall first consider some of the causes that tend to disturb their natural vibrations, and in the next number begin with those that arise from the mechanism of the clock, and the influence the various forms of escapements exert upon the pendulum in maintaining its vibrations, and counting or registering their number, through the agency of the hands moving on the dial.

NICKEL.

A metal of grayish white color, nearly silver white, possessing magnetic properties inferior to iron, but greater than cobalt, but which are destroyed by a heat of about 660°. It is ductile and malleable, both hot and cold, and may be drawn into wire one-fiftieth of an inch in thickness, and rolled into plate one five-hundredth. A small quantity of arsenic destroys its ductility; a small quantity of cobalt improves both its ductility and color; when fused it has a specific gravity of 8.27, and when hammered, 8.66 to 8.82. It has a high melting point (1,900 to 2,100 C). It cannot be fused in a common metallurgical furnace; one per cent. copper and a small quantity of sulphur render it fusible in a good air furnace. Pure nickel, when taken from the reducing vessel, possesses metallic lustre; adhering drops of glass indicate the presence of an alkali; if the drops are blue, cobalt is present; if yellow, iron.

It is but little acted on by dilute acids, and, unlike silver, is not affected by sulphuretted hydrogen. Heated in contact with the air it assumes various tints like steel, and becomes coated with a green oxide. Native nickel has been found in small quantities, but is usually associated with arsenic, copper, cobalt, silver, and iron, and is an ingredient always found present in meteoric stones, in the form of an alloy of iron and nickel.

It is found in Saxony, Bavaria, Hungary, Bohemia, France, and England..

The cobalt ores are the most productive for commercial purposes. *Kupfer-nickel* is an arseniuret, and is usually associated with the copper ores; the old German miners regarded it as a kind of false copper, and termed it *nickel* by way of contempt. It is not necessary, and would be foreign to our purpose, to go into a detail of the various processes for obtaining the pure metal; it is used exclusively as an alloy, and comes into market in the form of granulations, of the size of a small bean, or in small cubes; when alloyed with copper, in small cakes like refined copper. Argentina, nickel silver, albata, new silver, white copper, German silver, are a few of the names used in trade for this alloy of copper and nickel. We know of no practical use the *pure* metal is put to except for plating.

All the nickel watch movements (that are not brass whitened with silver) are some alloy of nickel and copper, usually the twenty per cent. German silver; the proportions of such alloys varying with the uses to which they are to be applied.

M. Gersdorf, of Vienna, says, that when intended as a substitute for silver, it should be composed of

Nickel	50
Copper	25
Zinc	25
	100

An alloy better adapted for rolling is,

Copper	60
Zinc	20
Nickel	25
	100

For casting,

Copper	60
Zinc	20
Nickel	20
	100

An addition of 2.2½ per cent of iron, in the form of tin plate, adds to its whiteness, but at the same time renders it harder and more brittle.

Keferstein has given the analysis of genuine German silver, as made from the original ore found in Hildberghausen:

Copper	40 4
Nickel	31.6
Zinc	25.4
Iron	2.6
	100.00

Chinese packfong, according to the same authority, consists of 5 parts copper, 7 parts nickel, 7 parts zinc.

A very inferior quality of German silver (so called) is copper whitened with arsenic. To form this alloy, successive layers of copper clippings and white arsenic are put into an earthen crucible, covered with sea salt, closed with a lid, and gradually heated to redness. If two parts of arsenic have been used with five of copper, the resulting compound contains one-tenth of its weight of metallic arsenic. It is white, slightly ductile, denser and more fusible than copper, and is not acted upon by oxygen at ordinary temperatures; but at a higher heat is decomposed, with an exhalation of arsenious acid. This whitened copper has no doubt given rise to the popular notion that German silver is poisonous when used in the form of forks, spoons, etc., as table furniture. No doubt but the chemical product of the decomposition of albata, by remaining a long time in any domestic compounds containing an acid, might be deleterious; but illness produced from such a cause would be just retribution for the sin of untidy housewifery; the fear of poisoning the family has kept many a spoon and fork clean that might otherwise have been — otherwise.

The white copper of the Chinese is identical in its composition with the German silver of Hildberghausen. It is very sonorous, nearly silver white, takes a good polish, is malleable at a cherry-red heat, and at common temperature, but at white heat is very brittle.

German silver has become almost as indispensable as brass; the amount used for spoons and forks alone is enormous, and is produced by a very few concerns for all the multitude of plated ware manufacturers of German silver. Probably no company in the country furnishes a larger amount to the manufacturers than the Scoville Manufacturing Company, of Waterbury, Ct. The quality is known by the per cent. of nickel in its composition; that mostly used for spoons and forks by all the reliable makers is eighteen per cent. of nickel; some parties use as low as six per cent., and consequently can offer to the dealers *larger* discounts than can possibly be given on eighteen per cent. goods. Pure nickel is coming into notice extensively of late in electro-plating; it can be deposited on baser metals in exactly the same manner as silver, giving a coating of any desirable thickness, which is much harder than silver, nearly as white, and not readily oxidizable by atmospheric exposure; it has already become a very useful branch of the electro-metallurgic art.

——o——

WATCH BRASS.

To a really mechanical mind, the satisfaction of knowing how a thing is done is sufficient reward for the labor and time bestowed upon the acquisition of such knowledge. And the ability to answer any query that may be raised touching any mechanical art, is a most sure and certain method to gain the reputation of being thoroughly learned in your own occupation. Of particular interest to our trade is the manufacture of sheet brass; and probably no company in the country excels the Scoville Manufacturing Company in the production of watch and clock brass — a business which the exigency of demand has developed so successfully as to drive the foreign article from our market.

A large share of the brass and nickel for all the American watches is made in Waterbury, Conn. All compounds in part nickel are here called "German silver." Five per cent. nickel is the lowest quality; eighteen per cent. is considered excellent; twenty-two per cent. is very white and hard, and is made only for watch movements. The process for making German silver is nearly the same as for brass. The varieties of brass are almost endless — spring brass, engravers' brass, Reid brass, gilding metal, tough brass for lamp-burners, composition bearings for cotton machinery, watch brass, etc., all of which are different mixtures. A compound good for one purpose would not answer for another; consequently, the use to which the brass is applied must be known, to adapt it to that particular purpose. The watch manufacturers require brass that will turn and drill free, and at the same time it must be perfectly sound, hard, and of good quality. About the last thing done to the watch movement is gilding, and if there are any imperfections in the surface, the gilding process will show it up. Soundness is the thing particularly essential in watch brass, which quality depends entirely upon the casting, which must be done with great care. A good caster requires great practical experience, as everything must be done exactly at the right moment. The metal is melted in pots, or crucibles, that hold about 12 lbs. each, and is cast in bars, or slabs, $3\frac{3}{4}$ inches wide, 18 inches long, and one inch thick.

Brass casting is neither a cool, nor a pleasant job. The workmen commence as early as three or four o'clock in the morning in summer, and finish by twelve to two o'clock P. M. Dense white fumes arise from the melting spelter, filling the shop with a thick vapor of oxide of zinc, which in a few hours covers the workmen as completely as if rolled in ashes; the only pleasant thing about the business is the forty to sixty dollars per week, for the most skilled labor.

After casting, the bars are thrown into the muffle (like an oven), where they remain all night at a red heat, and are drawn out in the morning and allowed to cool off; next they are taken to the immense shears, and the gate or unsound end is cut off as easily as a boy would bite off a stick of candy. The next operation is "breaking down." The metal is rolled, annealed, pickled, and rolled again, till reduced to $\frac{3}{8}$ inch in thickness; the huge rolls and frame weigh 2,400 lbs.; each roll is 20 inches in diameter, 36 inches long, and weighs 4,000 lbs. The finishing rolls are 18 inches in diameter. It is no uncommon thing to break three or four of these large rolls in a year; even the massive frames sometimes give out.

The sheets are now about 5 feet long, and must next undergo the "scalping" operation. The sheet is clamped on a long, narrow table, movable at the will of the workman, up or down, right or left, under a sort of hoe that shaves or digs off all the surface of the metal, and when there is a flaw or an appearance of unsoundness, the hoe digs away till it is all clear and sound; next the sheet is rolled, annealed, and pickled, and then goes to the "scratchers," where it is all scraped over again with the same kind of hoe, and all the imperfections dug out by hand. Next the brass is rolled down to No. 14. Brown & Sharpe's gauge, annealed, pickled, and run through the rolls several times, till brought to the proper degree of hardness and thickness. If for top plates, No. 17, or $\frac{1}{20}$ inch in thickness.

With these 20-inch hardened rolls it is impossible to roll several sheets of hard brass and have them just the same thickness throughout. It will be a little thicker in the centre, and the watch manufacturers will not allow in the upper plate a variation of $\frac{1}{20}$ m. in thickness. After being rolled, the sheets are all gauged, and such as are not true to the gauge are re-cast, after entailing a loss of one-third.

When very hard brass is required, say No. 20, finished, the roller commences with the sheet soft—$\frac{1}{10}$ inch thick, or No. 10—runs it through the rolls five or six times, reducing the thickness a little each time, till brought down to $\frac{1}{32}$ inch in thickness. After a certain limit brass will crack and break up under the rolls.

At the commencement the bar is $3\frac{3}{4}$ inches wide, and after rolling down to $\frac{1}{20}$th, it is over four inches wide, and eight to ten feet long. Of course the flaws, blow-holes, and all other imperfections are proportionally enlarged. Probably the greatest density and hardness possible to attain is by taking, say, a round blank $\frac{1}{8}$ inch thick, one inch diameter, confine the edges in a hardened steel ring, rendering it impossible to spread laterally; place it over a die, and strike it two or three good blows with a drop weighing 300 or 400 lbs., and it will be as hard as can be made. This plan would not be practicable for watch plates, owing to the impossibility of obtaining uniformity of thickness.

The hard sheet brass is next taken to the power press, and the blanks cut out at the rate of eighty per minute; the blanks for the framework of the movement, and all the thick parts,—bottom and top plates, barrel, cover and bridge, cock and potence, ring for expansion, balance, etc. It requires over 20 lbs. of sheet brass for 10 lbs. of blanks; for balance rings, it takes 24 oz. brass for $3\frac{1}{2}$ oz. rings, or 50 balances.

The metal for the wheels, called Lancashire brass, must necessarily be very hard and strong, or the teeth would crumble off. It has always been imported from England till within the last two years. The present superintendent of the rolling mill, Mr. E. D. Tuttle (than whom there is no man takes more pride in his profession), determined not to be excelled on the other side of the water, and succeeded, after considerable experimenting, in producing wheel brass that is pronounced by the leading manufacturers of American watches to be superior to any imported. This brass, and the dial copper, is sent to the factories in sheets, and the blanks cut as described in former numbers of the Horological Journal.

The above description of watch brass will also be of interest and service to all engaged in the manufacture of fine clocks, as well as every other description of fine machinery. All workmen realize the difficulty of obtaining good brass, and how unsuitable the ordinary brass of commerce is for the manufacture of light wheels with delicate teeth, and at the same time having the necessary amount of strength and stiffness.

ANSWERS TO CORRESPONDENTS.

F. I. W., *Bishopthorpe.*—Amber is a hard, solid, semi-transparent substance, found in some mines of Prussia, in a bed of argillaceous mineral. It is also found in Poland, France, Italy, on the shores of the Baltic and Mediterranean, in the vicinity of London, and various other parts of England. It is generally supposed to be of vegetable origin, and to be composed of bituminous vegetable matter in a state of congelation. The extraordinary property which amber has of attracting, when excited by friction, light bodies, such as feathers,, bits of paper, pith, dust, etc., etc., was known to Thales, the great philosopher of Miletus, who flourished 600 years before the birth of Christ. The Greek term for amber is *electron*, and from this comes the title of electricity; the effect of excited amber in attracting light substances being attributed to its electric powers. It is found of various colors, but the most common is a deep yellow or orange. When broken the fracture is smooth and glossy, and is susceptible of a fine polish. If gently rubbed it emits a slight agreeable odor. At a temperature of 550° Fahr. it melts, which destroys its transparency. It is insoluble in water, but highly rectified alcohol extracts a slight portion of its coloring matter. Sulphuric acid dissolves it, and then it may be precipitated by water. Pure caustic alkalies also dissolve it, and some of the essential oils.

C. B. M., *Mo.*—The best method is to buy a quantity of diamond splints or bort, and if no splint can be found suitable for a drill, and you have no diamond mortar to break or crush it in, put a piece of the "bort" in some writing paper, carefully wrapping it up, and lay the paper on a piece of flat steel, and give it a sharp, but not very hard stroke, with a flat-face hammer; then carefully open the paper, and select a splinter suitable for the size drill that you want. Now drill a hole in the end of a piece of brass wire, of suitable length. The drill used must be about the size of the diamond splinter, or if the splinter is much wider in one direction than another the hole in the brass wire should be somewhat smaller than the widest direction of the splinter; now turn down the end of the wire having the hole in it to a taper, and with the plyers mash the end so as to shape the hole to fit the splinter as nearly as possible, and then insert the splinter and carefully press the brass around it so as to hold it fast, and if you are able to use the burnisher to advantage, such as is used for rubbing in jewels, you can burnish or rub it in and make a good job. Now turn off any surplus brass and you have your drill ready for use. Great care will have to be exercised in using, or you will break it. In drilling always keep the stone wet with water; jewellers usually wet the drill by applying it to the tongue.

L. K., *Ill.*—Your questions received. Will answer No. 1 without going into mathematical details, which it is probable (from your question No. 4) you might not fully understand. To find the numbers for a lost wheel and pinion, you must first find the number of revolutions the escape-wheel makes in an hour; this you can do by counting the vibrations of the balance and spring belonging to it. Two vibrations are made (by a lever) to every tooth of the escape-wheel; ordinarily, 14,400 are made to one revolution of the centre wheel (1 hour); two vibrations to a tooth, and fifteen teeth to the wheel, give thirty vibrations to one revolution of escape-wheel, gives 480 revolutions of the escape-wheel in one hour. Assume the train to be made up of

Centre wheel	......80 teeth	..... pinion 10 leaves.	
Third "	......75 "	......pinion 10 "	
Fourth "	......64 "	......pinion 8 "	
Escape "	......15 "		

Multiply the number of revolutions of escape-wheel, 480, by the number of leaves in its pinion, $\frac{8}{3840}$, the number of leaves that must pass in an hour. Imagine the fourth wheel and pinion gone, which leaves a gap in the computation sought to be filled. Now begin computation at the centre wheel, which turns the third wheel pinion (of 10) eight times in an hour, which causes a passage of 8×75 (teeth of the third wheel) $= 600$, which brings us up to the lost (fourth) wheel, which wheel, with its pinion, must bring the number of teeth passing up to the escape-wheel pinion (which we found to be 3,840). Now this number, 3,840, divided by 600 (the number produced by the train up to the lost wheel), gives $6\frac{2}{3}$, which will be the multiplier to any pinion you choose to put in the place of the lost one, viz., pinion of $10 \times 6\frac{2}{3} = 64$, the number of teeth required in the wheel, if you use that pinion. If you assume the pinion to be $8 \times 6\frac{2}{3}$, it will give you $51\frac{1}{3}$ for the number of teeth in the wheel, which is impossible, being fractional. Take for illustration another train which beats seconds 3,600 to the hour; gives 120 revolutions to the escape-wheel, the train being

60........Centre wheel.		
50........Third wheel........	pinion of	10
40...... Fourth "	"	10
15 ...... Escape "	"	10

One hundred and twenty revolutions of the escape-wheel, multiplied by 10 leaves in its pinion, produces 1,200 ; the fourth wheel being lost, we must go back to the centre wheel, and reckon the teeth up to the lost wheel, which will be 300, making the fourth wheel and pinion $\frac{1200}{300} = 4$, the multiplier for the lost wheel. You can use a

Pinion of $1\frac{1}{2} \times 4$	gives wheel of......	44 teeth.
" 12×4	" "	48 "
" 8×4	" "	32 "
" 6×4	" "	24 "

Either one of these wheels and pinions will fill the requirements, but a pinion of six or eight would be too small, and one of twelve too large. Consequently, ten and forty are the proper numbers.

By the same process you can determine the numbers for any lost wheel of the train ; the size you can get from the old holes, or you may calculate it; the radius ($\frac{1}{2}$ diameter) of the wheel and pinion should be to each other as the numbers of the teeth in the wheel and pinion.

Question No. 2. Know no difference between the American and Swiss; except in the *form* of the lever, the principles are exactly the same in both.

No. 3. Never heard of Hopkins' Jewelry Tool.

No. 4 requires too detailed an answer. Perhaps you can get an idea from the answer to your first question. There may be something on that subject in future numbers of the JOURNAL.

C. E., *Cal.*—To harden and temper a chronometer balance spring you must first wrap the flattened steel wire, from which it is made, around a block that has spiral grooves carefully cut in it to receive the wire, fastening the two ends of the wire to the block by screws. The whole is then covered up with carbon, and heat is applied in the manner described in the article on "Heat," in the March No. of the JOURNAL. It is not absolutely necessary that it be carbon that the spring is covered up with, as any other similar substance will do, for the whole object of covering it up is only to protect it from the action of the atmosphere when being heated, and thereby prevent oxidization, and preserve the clear lustre the steel has previous to hardening. After being hardened it should be brushed clean, *while on the block*, and carefully colored to a blue ; we prefer that it should be a deep blue. Jurgensen, of Copenhagen, and others, have experimented extensively on gold balance springs ; but when placed on trial in competition with steel ones, the steel springs in all cases prove the best. Gilding steel springs, or varnishing them, tends to interfere with their elasticity, and we know of no way of remedying the evil of rust. The most rigid care must be taken to keep the springs from damp, but where there is a damp atmosphere this is a matter of much difficulty. The subject of chronometers accelerating on their rates when a new spring has been applied, will be considered in a future No. of the JOURNAL.

A. B. M., *Texas.*—You can procure a new escapement for your French clock from Mr. G. A. Huguenin, 64 Nassau street, N. Y. We saw some there lately of the description that will suit you.

A. K., *Ohio.*—There is a great advantage gained by using conical shaped pivots, they not being so easily broken as straight ones that have a square shoulder.

C. K., *Buffalo.*—The tower clock on the old State House in Philadelphia has an escapement such as you describe. It is a dead beat one, but the pallets are attached directly on the pendulum, and the pendulum works in a plane with the scape-wheel. This manner of constructing the dead-beat escapement is rare, and the advantages gained are more imaginary than real.

G. E. M., *Ky.*—Bond's chronograph must

not be confounded with what is known as chronograph watches. It consists of a cylinder, about twelve inches long and six inches in diameter, and mechanism to produce a continuous and uniformly regular motion of the cylinder. The regularity of the motion is produced by a pendulum, and the uniformity by Bond's spring governor. A sheet of paper is attached to the cylinder, and the observer registers his observations by means of an electrical recording apparatus, the sheets being bound and preserved for reference. Greater accuracy in dividing small portions of time is obtained than by any other method of either American or European origin.

M. L. J., *Me.* — Cleaning Yankee clock movements, when together, by boiling them in water, or by the use of benzine, turpentine, or any other fluid, is not to be recommended. Any of these methods may be used in cleaning the brass and steel work, if judiciously used ; but in every case common sense will teach that the clocks should be taken to pieces, every tooth brushed, and every pivot hole pegged out. If people will not pay for this trouble, decline their custom. It will pay you in the end.

T. C., *Mass.*—There are about as many ways of polishing or glossing brass as there are workmen doing it. Probably the French excel all others in this matter. Their secret is said to be a mixture of Castile soap and rotten or blue stone, wrought with brandy.

E. M., *N. Y.*—Although closing pivot holes with punches is sometimes resorted to, it is a practice not always to be recommended. Wide holes should be bushed.

AMERICAN HOROLOGICAL JOURNAL,
PUBLISHED MONTHLY BY
G. B. MILLER,
229 Broadway, N. Y.,
At $2.50 per Year, payable in advance.

A limited number of Advertisements connected with the Trade, and from reliable Houses, will be received.

☞ MR. MORRITZ GROSSMANN, *Glashutte, Saxony, is authorized to receive subscriptions, or transact any business for this* JOURNAL.

☞ MR. J. HERRMANN, 21 *Northampton Square, E. C., London, is our authorized Agent for Great Britain.*

All communications should be addressed,
G. B. MILLER,
P. O. Box 6715, *New York.*

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For April, 1871.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian.	Equation of Time to be Added to / Subtracted from Apparent Time.	Equation of Time to be Subtracted from / Added to Mean Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	M. S.	S.	H. M. S.
Sat	1	64.50	4 0.34	4 0.39	0.760	0 37 36.90
Su.	2	64.52	3 42.14	3 42.20	0.757	0 41 33.45
M..	3	64 54	3 24.06	3 24.10	0.751	0 45 30 00
Tu.	4	64.56	3 6.09	3 6 13	0.745	0 49 26.56
W.	5	64.58	2 48 29	2 48.32	0.737	0 53 23.11
Th.	6	64.61	2 30.67	2 30.70	0.729	0 57 19 66
Fri	7	64.64	2 13.26	2 13.29	0.720	1 1 16.22
Sat	8	64.67	1 56.08	1 56.11	0.710	1 5 12.77
Su.	9	64.71	1 39.15	1 39.17	0.699	1 9 9.32
M..	10	64.75	1 22 48	1 22.49	0.688	1 13 5.88
Tu.	11	64.79	1 6.09	1 6.10	0.676	1 17 2.43
W.	12	64.84	0 50.00	0 50.01	0.664	1 20 58.98
Th.	13	64.88	0 34.23	0 34.24	0.650	1 24 55.54
Fri.	14	64.93	0 18.81	0 18.82	0.636	1 28 52.09
Sat	15	64.98	0 3.74	0 3.74	0.621	1 32 48.64
Su.	16	65.03	0 10.98	0 10.98	0.606	1 36 45.20
M..	17	65.08	0 25.32	0 25.32	0.590	1 40 41.75
Tu.	18	65 14	0 39.26	0 39.26	0.573	1 44 38 30
W.	19	65.20	0 52.81	0 52.82	0.556	1 48 34.86
Th.	20	65.26	1 5.96	1 5.97	0.539	1 52 31 41
Fri.	21	65 32	1 18.69	1 18.70	0.521	1 56 27.97
Sat	22	65.39	1 30.98	1 30.99	0.503	2 0 24.52
Su.	23	65 46	1 42.83	1 42.84	0.484	2 4 21.07
M..	24	65.53	1 54.24	1 54.25	0.465	2 8 17.62
Tu.	25	65 60	2 5.18	2 5.20	0.446	2 12 14.18
W.	26	65.67	2 15.64	2 15.68	0.426	2 16 10.74
Th.	27	65.74	2 25.64	2 25.68	0.406	2 20 7.29
Fri	28	65 80	2 35.17	2 35.20	0.386	2 24 3 85
Sat	29	65.88	2 44 21	2 44.23	0.366	2 28 0.41
Su.	30	65.92	2 52.74	2 52.76	0.345	2 31 56 96

Mean time of the Semidiameter passing may be found by subtracting 0.18 s. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
☺	Full Moon	5 2 23.0
☾	Last Quarter	11 17 51.7
●	New Moon	19 7 3 4
☽	First Quarter	27 11 47.5
		D. H.
☾	Perigee	7 2 0
☾	Apogee	22 19.7

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1

		H. M. S.
Long.	Harvard Observatory	4 44 29.05
	New York City Hall	4 56 0.15
	Savannah Exchange	5 24 20.572
	Hudson, Ohio	5 25 43.20
	Cincinnati Observatory	5 37 58.062
	Point Conception	8 1 42.64

		APPARENT R. ASCENSION.	APPARENT DECLINATION.	MERID. PASSAGE.
	D.	H. M. S.	° ′ ″	H. M.
Venus	1	2 24 13.71	+14 23 44.7	1 46.7
Jupiter	1	5 17 40.49	+22 55 5.7	4 39.4
Saturn	1	18 41 42.70	−22 18 22.1	18 1.2

AMERICAN

Horological Journal.

Vol. II. NEW YORK, MAY, 1871. No. 11.

CONTENTS.

ESSAY

ON THE

CONSTRUCTION OF A SIMPLE AND MECHANICALLY PERFECT WATCH.

BY MORRITZ GROSSMANN.

CHAPTER VII.

THE ESCAPEMENT.

75. It cannot be the object of this treatise to describe and illustrate the various escapements, or to discuss their relative merits. We have merely to occupy ourselves with the exterior parts of construction, which serve to bring the escapement in its place, and to keep it steady there.

76. To begin with the horizontal or cylinder escapement, I always thought the "chariot," a movable fastening of both the balance cocks, a rather superfluous complication. If the distance between the cylinder and wheel has been correctly pitched, it is only desirable to keep it intact, and the movability of the chariot is a danger for the good performance of the watch. On the other hand, no one will pretend that the correct pitching of a cylinder escapement will at first be a very difficult job, while the duplex escapement, requiring by its delicate nature the most perfect accuracy, is, in the majority of cases, planted without movable chariot; besides, the cylinder escapement admits, more than all the other escapements, of being manufactured and planted by the system of perfect identity, and it would seem advisable to take advantage of this circumstance. The suppression of the chariot would render the movement more simple, and easier of execution to a considerable extent, because the lower balance cock could then be omitted, by setting the balance hole in the same way as that of the wheel, in the bridge ; or, in absence of this, in the plate itself. The necessity of the chariot is only a prejudice originated by habit and blind routine. If a cylinder escapement, then, is correctly pitched, it will be so for ever, and no inexperienced hand would be able to alter it; and as to those escapements which are incorrectly pitched, they ought not to pass examination wlthout being corrected.

77. The disposition of the cylinder escapement being not so extended as that of the lever escapement, the space in the movement is not so much occupied; therefore the train, to begin with the centre wheel, can be made one size larger than in a lever movement of the same diameter, in order to secure the advantages to be obtained thereby. (53.)

78. The cylinder escapement is at this period nearly superseded in almost all countries, except France, by the lever escapement, and with respect to this latter, there are a few more observations to make.

The arrangement of this escapement admits of a greater variety ; and, in the first place, the question must be settled, whether it is to be set in a straight line or at right angles. This latter system recommends itself by an economy of space, or, what is the same, by a more convenient placement of the parts. Thus it would allow the wheel, lever and pallets to be made larger for the same size movement. For the reasons alleged for the sizes of wheels and pinions (53), this might appear advantageous ; but in the case of the escapement we have to consider it from another point of view. We must consider in the first place that in the intermittent action of a dead beat, or detached escapement, the inertia of the moving parts must be overcome at each vibration, and that this impediment must be reduced as much as possible. Besides, the sliding friction of the wheel on the pallet planes is of a very different nature from the rolling friction of the wheel teeth ; and this former kind of friction increases considerably with the extension of the planes to be traversed. For these reasons the wheel, pallet, and fork ought not to exceed certain limits in size, and they ought to be worked out as light as their necessary strength will allow. The length of the fork, too, must be restricted. I will not repeat here what I have treated in full detail in my "Treatise on the Lever Escapement," Chap. IX., p. 62. The action of the fork and roller is also not of such a very delicate nature as to make us wish to execute it on a large scale in order to verify easier its performance.

For the same reasons, it is not advisable to make the wheel, or other parts of the escapement, of gold, the specific gravity of which is here an objection.

79. The arrangement of the escapement in right angle offers thus, as we have seen, no advantage by its economy of space, except in complicated constructions, where the space is restricted by other parts of the mechanism. It may be considered but little more than a matter of taste to employ the one or the other arrangement, still there is a slight difference in favor of the escapement in right angle.

The pressure which is acting on the pallet pivots, may be considered a threefold one : 1st. The pressure of the wheel on the locking faces. This is exerted with the full power of the escape-wheel, and acts on both arms in the direction of a line drawn through the locking edge of the entrance-arm to that of the other arm, and will tend to wear the pivot holes in the direction of the second arm. 2d. The pressure resulting from the decomposition of the force of the wheel when acting on the inclined planes of the pallet. It is, of course, much weaker, but it acts during a more extended angle of movement. It increases with the lifting-angle, and has a tendency to widen the holes in the direction of a straight line from the centre of the wheel towards the centre of the pallet. 3d. The reaction of the resistance in unlocking. It acts alternately to both sides of a line at right angles with the line joining the centres of balance and pallet. Both the effects under 1 and 2 take place equally, and in the same direction, for any lever escapement; but the third one coincides in direction with that under 1, if the escapement is in straight line, while, with the escapement in angle, it falls into the direction of the one under 2, which is essentially weaker.

It will easily be seen that this difference is hardly of any practical importance ; at least not sufficiently so to render it unadvisable to construct escapements in straight line.

In all cases of this latter construction, the pallet holes, as a rule, ought to be jewelled ; because the bushing of a worn pallet hole in a straight line escapement is more troublesome than in another one, as any deviation of the exact pitch must necessarily here produce a defect in both the actions of wheel and pallet, and of fork and roller.

80. According to the foregoing demonstrations, the diameter of escape-wheel in a lever watch ought not to exceed one-fifth of the diameter of the pillar-plate, and then it will be a good proportion to have the acting length of the lever—that is, the distance from the pallet centre to the acting edges of the fork—equal to the wheel's radius, or one-tenth of the diameter of the pillar-plate.

With these proportions the pallet centre will be within the circle of balance, if this latter is not disproportionately small.

81. There might be found a trifling economy in having wheel and pallet under one and the same cock, but then we would have either to renounce the advantages of a short lever, or to make the escape-pinion as short as the pallet-staff which is to lie under the balance. This ought to be avoided, because the stability of the axis is greater when the pivots are far apart (60). Therefore, the little additional trouble or cost of making a

separate cock for the wheel ought not to be an objection.

82. The action of the fourth wheel into the escape-pinion ought not to be placed too high; for, if otherwise, the good service of this depth, by its nature the most imperfect and most delicate of the train, might be endangered by the slightest alteration in the steady pins of the escape-wheel cock.

For the same reason this cock ought to be placed so that a straight line through the pivot hole and the screw hole points towards the centre of the fourth wheel, or nearly so, because then any bending of a steady pin will influence the depth in a less degree.

83. The balance-cock, in the course of making or repairing a watch, must be very often removed and put on again; therefore it is of great importance to pay much attention to its steady pins, for, if badly made, they give much trouble. A well adjusted cock, especially that of the balance, ought to be firm in its place; it ought to go easy into the steady pin holes till at a distance of some tenths of a millimetre, and then be so firm that the escapement may be safely tried without using the screw. This result can only be attained by steady pins of a conical form. I would not recommend the English way of screwing the steady pins in, because it is not so easy, and does not offer the same surety of exact fitting as a pin driven into a round hole. The following is a way to do it which I always found to answer perfectly well. I take a piece of wire, a little thicker than the hole, and file it to the ordinary taper of a broach, till it will enter about half way into the steady pin hole in the pillar-plate. Then I take a burnishing file, and, holding the pin with the pin-vice in a suitable groove of the wood in the bench-vice, I apply the burnisher to its end, so as to burnish a length, a little more than the thickness of the plate, into a more conical shape than that of a broach. After this, if properly done, the pin will enter fully into the hole in the pillar-plate. Then I take a good broach and make the corresponding hole in the cock wider till the pin, thus prepared, goes in far enough to have its extremity level with the lower surface of the cock. This, however, is a matter of experience, because it depends on the relative hardness of the cock and of the pin-wire. Then I cut the wire off, leaving a sufficient length projecting at the upper surface of the cock, and then, after putting the lower side on a piece of flat steel, with a hole in it only a trifle larger than the pin, I drive the pin tightly in, trying it from time to time into the hole in the pillar-plate till it holds the cock fast. The other pin is made in the same way, and a cock, well fitted according to this principle, goes on quite easy till the pivot is in the hole, and then it gets more than sufficient hold by the last pressure, which may be exerted safely and without injuring the jewel hole. These conical steady pins offer the additional advantage, that a small bending of them will not affect the position of the cock; because, in consequence of their taper form, they catch their hold in the plate merely by the part next to the cock, while the parts of the pin exposed to bending are free in the hole.

84. Two steady pins, well adjusted, are quite sufficient, and much better than three pins made in the common careless way, with which a cock often goes on rather hard at the beginning, and allows some shake when close down to the plate.

The steady pins ought not to be too long, for if they are they bend too easily. The length must not exceed double their thickness, and the pin-wire must be drawn as hard as possible. To be effective, they must stand as far apart as the foot of the cocks will allow of.

85. The balance is a part, the dimensions of which show very great variety in watches, and without undertaking here any dissertation on this subject, I will restrict myself to stating that I believe it a good proportion to multiply the diameter of the pillar-plate with 0.4, or to take four-tenths of it as the diameter of the balance. With a movement of 18 size, or 44 m., this would be $44 \times 0.4 = 17.6$ m.

86. If the movement is to have a compensation balance, great care must be taken to have ample space for the inside and outside of the rim. I have noticed many cases of inexperienced workmen being nearly driven to despair by a watch apparently in the most satisfactory state, and performing quite well, but at the beginning of the cold season stop-

ping regularly every night. When being examined, of course in a warm room, the watch resumed its ordinary march without showing the slightest disorder, till it was found out that the expansion of the balance brought it into contact with a cock, or other part too near its circumference.

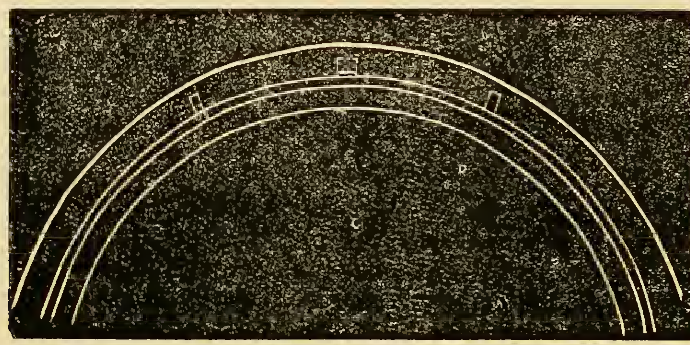
CHAPTER VIII.

THE CASING.

87. The method of casing presents a variety of features, and necessarily varies according to the style of case; therefore, in order to settle this point, we must first decide on the best plan of case.

There is, first, the old English style of case, with a fixed dome; the hands to be set, and movement to be opened, from the dial side. In this kind of case, the movement is fixed at the 12 with a joint and held in its place by a catch at the 6, which, for opening, can be pushed in with the nail of the thumb. This method makes, undoubtedly, a good strong case, but it has many inconveniences for the wearer of the watch. For winding, the case must be opened behind; and for setting the hands it requires to be opened on the dial side. A very bad feature of this arrangement is the opening of the movement by means of the catch; a slipping off from it of the nail of the thumb has caused the ruin of many a good seconds or minute hand. A case of this kind may be employed for a full-plate movement, in which, by its nature, the hands must be set on the dial side, but any $\frac{3}{4}$ plate or bridge frame ought to have the setting square behind. (70.)

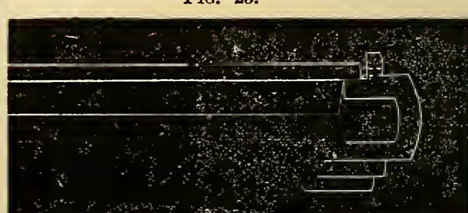
Fig. 22.



88. For this latter kind of watches the modern form of case will be the most convenient. The movement is fixed to the case by one steady pin and one, or two screws—the latter being best. The Swiss watches generally have three pins driven into the edge of the pillar plate at some distance from each other. The middle one of those is the strongest and of a square shape, and partly enters into a small recess in the rim of the case, thereby preventing any circular displacement of the movement, and the outer end of it, filed sufficiently down from its upper side, takes hold under the rim as well as the two side pins. This mode of fixing the movement generally with only one screw, is rather troublesome in putting in and taking out the movement, especially with the very thin cases of so many Swiss watches.

89. Therefore, I propose another plan, which, if the pillar plate and its shoulder be properly fitted into the rim of the case, will answer completely, though of very simple and easy execution. A hole must be drilled through the upright part of the rim surrounding the pillar plate, into this plate. A pin driven into the hole in the plate, and shortened so as to enter into the rim without exceeding its outer side, serves at one and the same time to hold the movement down in its place, and to prevent any side displacement. Two common key-screws, each 120°,

Fig. 23.



or $\frac{1}{3}$ of the circumference apart from the pin and from the other screw, and taking their hold on two studs, soldered to the inside of the rim, complete the fastening.

90. The pin ought to be always placed near the balance, so that this most precious and delicate part of the movement comes first into its position in the case, and is not exposed to

any violence when forcing the movement down on its seat. It is very essential to adjust a movement carefully into the case, so that it enters quite smoothly, and without any pressure; because, in this latter case, especially if the case is strong, and the plate thin and not hard, it might easily suffer a deflection in a sufficient degree to alter the end shake of the pinions.

91. I would not recommend to have the key screws for the casing in the upper plate and taking their hold outside on the rim of the case, because the plate is too thin to offer sufficient stock to the screw, and because this thin plate, if the screws are strongly turned in, is liable to bend. The pillars must then be considered as a fulcrum, and in the ratio as the screws bend to lift the outer edge of the plate, the inner parts will bend down, and thus diminish the end shake of the pinions.

92. The movement, in the modern case, is accessible from behind by opening the dome, and as the hands are set from this side, the wearer of the watch has no occasion whatever to open the dial side of the case. In this kind of case the dial ought to be fixed with key-screws, and not with pins, else it would not be possible to take it off without previously taking the movement out of the case.

93. I often see Swiss watches, of recent make, having the heads of the casing key-screws below the dial. This arrangement has no comprehensible advantage, but subjects the repairer to the vexation of being obliged to take hands and dial off before he can remove the movement from its case.

94. The setting square ought to be provided with a cap, as well as the winding square, in order to prevent any particles adhering to the key, from entering into the movement. Care must be taken to have these caps reach up to the inner side of the dome, and without any excess, because this would, especially in a strong case, produce a pressure on the plate when the case is shut, and which would often be sufficient to stop the watch by reduction of the necessary end shake of the pivots.

95. The cases in which the movement can be opened with a joint offer a greater convenience for the exact timing of the watch, because the timing screws of the balance are more accessible; but this convenience is of no great consequence.

96. It remains to say a word about the contrivances having for their object the protection of the movement, or of certain parts of it, from the dust penetrating through the case. The most perfect dust cap is that of the old English full-plate watch, because it covers the whole movement, without the slightest exception. In the majority of cases it is admirably made, and effects its purpose very well. It has been tried with similar success to protect the movement of $\frac{3}{4}$ plate watches, though the dust cap, by the additional height of case it requires, does not harmonize with the modern watch. It was an absolute necessity to employ it with the old cases opening and shutting with springs, and consequently far from being dust-proof. But with the gradual progress of case-making, the cases shut tighter now than they used to do, and therefore the dust caps can be entirely dispensed with. The fittings of the cases, if they are made with a little care, shut very closely, and nevertheless open and shut with ease. For this purpose the rims must not be too much undercut. The better class of English cases are generally fitted with much care and judgment. The rim ought to be slightly rounded for the smooth passage of the shutting edge of the rim over its highest point. (See Fig. 23.)

97. The dust covers in ring shape, surrounding the frame of full-plate movements, avoid the disadvantage of occupying more height in the case, but they are also so much less efficient. What is the use of protecting the train from dust, if at the same time the balance, the pendulum spring, and the counter sinks in the upper plate with the oil in them, are exposed ?

---o---

Erratta.—If, in deference to popular opinion, we concede it to be a fact, that "figures wont lie," we can show that they sometimes fail to tell the whole truth ; as for instance, in the article on watch brass, in the last number. They should have given the weight of the frame and rolls as 24,000 instead of 2,400; also the weight of the drop as 3,000 or 4,000, instead of as many hundreds.

THE PENDULUM

AS APPLIED TO THE

MEASUREMENT OF TIME.

NUMBER THREE.

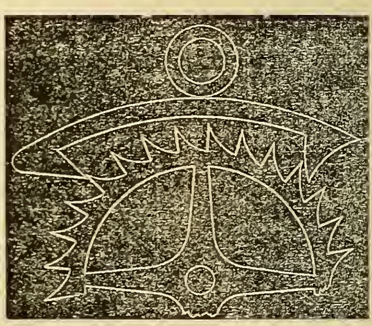
RECOILING ESCAPEMENTS—THE EXTENT OF THEIR USE—ERROR IN THE YANKEE CLOCK FORM—NATURE OF THE IMPULSE AND RESISTANCE GIVEN TO THE PENDULUM—LARGE VIBRATIONS.

We have now to consider the influence which the various forms of escapements exert on the motion and regularity of the vibrations of the pendulum, and for the benefit of those who may not be conversant with all the branches of the subject, we propose to give a detailed description of the anchor or recoiling escapement, the dead beat or Graham one, and other escapements of that class, and also the various forms of gravity and detached escapements of ancient and modern construction, and of European and American invention, and the influence they have upon the pendulum.

The Vertical, or verge and crown wheel escapement, used in the early days of clock-making, may now be considered to be obsolete; and although there are many important questions involved in its construction, it is unnecessary to occupy the space of the JOURNAL to give a description of it at present, as the necessity for its use has been avoided by other escapements that have entirely superseded it, and which are more easily made, and better adapted for every purpose approaching to accuracy in performance, which is the point we aim at.

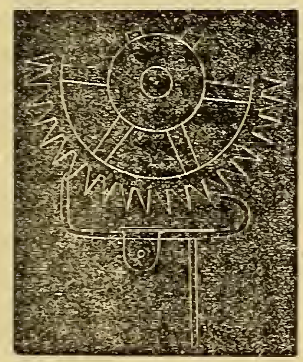
Recoiling or Anchor.—In the year 1680, or 1681, Mr. William Clement, a London clock-maker, produced a clock with the escapement known at the present day as the anchor or recoiling one. This escapement allows the scape-wheel teeth to escape with a much shorter arc of vibration of the pendulum than the old verge one allowed, and the arc of vibration being smaller, a longer and heavier pendulum can be used with a smaller driving weight. The arc of vibration being materially reduced, the necessity for any attempt to make the pendulum describe a cycloid is obviated, although we find that Berthoud, of France, and others of less eminence, devised plans to obtain this object, by making the faces of the pallets a particular shape, and this idea lingers among a portion of the trade at the present day.

As it is with all important discoveries or improvements, so it was with the recoiling escapement. Several claim the honor of the invention. Mr. Clement had no sooner given a description of his escapement to the world than Dr. Robert Hooke, a celebrated mathematician of that period, whose father was a watchmaker in the Isle of Wight, claimed that in the year 1666, fourteen or fifteen years previous, he showed to the Royal Society a clock having this kind of escapement, and it is generally admitted that Dr. Hooke's claim to priority of invention is just, although the fact in no way detracts from the credit due to Mr. Clement for his labors.



The recoiling escapement has, in its turn, been superseded by others where great accuracy is desired; still it is one by far the most extensively used in all countries in clocks intended for the ordinary purposes of life. It is the prevailing escapement in those clocks having seconds pendulums and tall cases that are to be found all over the British Isles, and in countries and states of British origin. The owners of almost every one of these clocks tenaciously adhere to the notion that *their* clock is the best in the whole town or parish, although in some instances the mechanical execution of these same clocks may be of the most wretched description; and this circumstance proves in a forcible manner the superiority of clocks having long pendulums over those having shorter ones, although they are made with a greater amount of care. The recoiling escapement is also used in different forms in Scandinavian countries, as well as in Holland, and all over

Germany and the South of Europe, and to a large extent in those charmingly executed French mantle-piece clocks of modern construction. It is the escapement universally adopted in our own irrepressible Yankee clocks, which have won their way to popular favor all over the American continent and almost every part of the civilized world.



There is one point in the construction of the escapements of Yankee clocks, which we would like to see rectified. The point of suspension and centre of motion of the pendulum is much lower than the centre of motion of the pallets. The effect of this arrangement is apparent to all by the bad action and increased friction given to the wire that connects the pallets with the pendulum. This part of the arrangement of Yankee clocks is all wrong in principle. There is no necessity for its existence, and we would be pleased to see some of our manufacturers, in carrying out the growing tendency to improve on these clocks, adopt some plan of construction whereby the pendulum spring would naturally bend at a point near to the centre of the stud which carries the pallets, and thereby bring the centre of motion of the pendulum and pallets to the same point, because in a mathematical sense the pendulum and pallets are considered as one.

All these recoiling escapements, although differing in form, are in principle the same. The faces of the pallets are shaped in such a manner, that when the pendulum is made to ascend beyond the perpendicular line, the pallets impart to the scape-wheel a retrograde motion, or, as it is termed, a recoil. So soon as the pendulum has reached the extremity of its arc, and begins its return course, this force that has been stored up by the recoil of the wheel work, acts with the force of a spring that has been compressed, and causes the scape-wheel teeth to press on the pallets, and thereby communicate a force to the pendulum. This force maintains the vibrations of the pendulum that would otherwise fall off gradually, owing to the friction of the pallets on the scape-wheel, and the resistance offered to the pendulum by the density of the atmosphere, and from the stiffness of the suspension spring. This recoil maintains the vibrations of a pendulum with the old vertical escapement exactly in the same manner as in an anchor one, and so far as the quality of the impulse given to the pendulum on its descent, or the nature of the resistance that the pendulum meets with on its ascent, there is but little difference; and the superiority of Hooke's escapement over the vertical one consists principally in the easiness of its execution, the better action of the wheel work, and the shorter oscillations that are required to be made by the pendulum.

Still there are, however, some eminent clock-makers, who in past times and at the present day entertain an idea that these short arcs of vibration are not to be recommended. Mr. Cumming, an English clock-maker of the last century, and the author of an Essay on the Elements of Clock and Watch-making, which he dedicated to King George the Third, takes extreme grounds on this point, and advocates vibrations of great extent, without giving any good reason whatever for his opinion. The scientific man finds no proof among nature's laws that will confirm the utility of large arcs of vibration in a pendulum designed for an accurate measure of time. The supposed necessity for large vibrations, and also the supposed necessity for a pendulum to describe a cycloid, in our estimation, consists in the fallacy of applying rules that were applicable and also necessary for the original vertical escapement, to *all other* escapements, as if these rules were dogmas to be followed on all occasions, and under every circumstance.

Here we would remark, for the benefit of those workmen who, in making and repairing clocks, imagine that large vibrations are beneficial. If an escapement has been originally designed and drawn off in such a manner that the pendulum will have to make a large vibration before the wheel will escape, and after the clock is made, or has been repaired, the pendulum does not take the desired vibration, it indicates that something is wrong; probably too much drop to the teeth of the scape-wheel; and in these instances, which often occur, the clock will not go well, and will be easily stopped. Still it will be apparent that this circumstance cannot be taken as an argument against small vibrations when the escapement is designed and executed with the object of small vibrations in view.

It was our first intention, at the commencement of these articles, simply to illustrate the tendency which the different forms of escapements had of interfering with the compensation of a pendulum, and of destroying its isochronal properties; however, it has been deemed advisable to digress a little from the original plan, and to give a short sketch of some of the methods used for drawing off, and directions for constructing these escapements.

Although the effects of the action of the recoiling and dead beat escapements on the going of the clock are of an opposite nature, when any disturbing cause affects them, the recoiling escapement differs but little from the dead beat one in the elementary principles of its construction.. The distance of the centre of motion of the pallets from the centre of the wheel are the same in both instances, in proportion to the number of teeth of the wheel that are embraced, but the nature and peculiarities of the recoil will be better understood after describing and illustrating the dead beat, which we will proceed to do in the following number.

———o———

VIBRATORY MOTION OF THE CRUST OF THE EARTH.

Mr. William J. Steiger, of Maryland, gives the results of some experiments made by him in regard to the change of direction of gravity, from which he concludes that there is a general vibratory movement or elongation of the whole crust of the earth. This movement is necessarily slow, and depends upon the aggregate action of the earth. That in addition to this movement there is another, due to the direct action of the sun and moon; the power of the former being derived from its immense size, and the latter from its proximity to our globe. Also that these regular elongations are accompanied by irregular disturbances, attributable to local causes, chiefly changes of atmospheric pressure, and gradual accretions and sudden diminutions of the matter of the crust.

Careful observations upon bullets suspended by silk fibre, to poles firmly fixed in the ground, shaded from the wind, and swi ging freely, as well as upon accurately adjusted dipping needles, first suggested to this observer's mind that the earth is a plastic body, yielding to external forces, and changing its contour constantly in obedience to their attractions. That independently of the tides of the ocean, there are also two or more tides of the whole crust in each twenty-four hours, which tides are in themselves insensible earthquakes and rise to a height, and occur at times, depending upon the relative position of the sun, moon, and planets. If these points can be demonstrated by further observations, the following important consequences of his hypothesis are thrown out by the author:

1. It confirms the nebular theory and the liquefied condition of our planet.

2. It will throw light upon the causes of earthquakes or violent undulations of the crust; these, in accordance with the true pathological theory, being only prolongations of the mild disturbances which normally take place.

3. It will account for the so called "neap" tides.

4. It will go far to explain the cause of storms and irregular winds, and why storms move in curved lines, as recently ascertained.

5. The extraordinary risings and fallings of the barometer are in part due to this cause; and

6. It may go far to account for the conflicts and disagreements in those delicate astronomical observations ascribed to defective mechanical construction of the instruments, or clumsy manipulation of them.

We have for a number of years suspected that there was a vibratory movement in the earth's crust. From practical observation we can testify to the possibility of bullets suspended by a silk fibre to poles fixed firmly in the ground, swinging irregularly. We have seen pendulums suspended from supports of various kinds, some of them on pyramids of solid masonry, that when left in a state of rest and detached from any clock-work, would begin to move in very small arcs, without any visible cause. If there be a vibratory movement of the earth's crust, it will go a long way to explain the cause of the small irregularities in the highest class of clock-work, and we will watch the discussion of the matter with much interest, and report the result to our numerous readers that are interested in the subject.

——o——

ALLOYS OF GOLD.

Gold, the basis of all artistic adornment used by our craft; the elegant drapery in which the public demand our minute horological machines shall be clothed; its beautiful rich color, so capable of fine artistic effects; its density and compact grain, susceptible of the most exquisite polish; its wonderful malleability and ductility, eminently qualifying it for the skilful manipulations of the engraver, enameller, and chaser; its almost total exemption from corrosion, defying the strongest simple acids,—give it a just claim to the title "regal;" and right majestically does it tower above its fellow-metals in gravity, ductility, malleability, and permanency.

Want of space, as well as a rigid adherence to alloys used in the trade, forbid our going into the intensely interesting details of its history; the operations of mining and refining; the sources and annual amount of production from every quarter of the globe—iron being the only metal exceeding it in general distribution.

Alloys of gold form the basis of nearly all metallic ornamentation, leaf gold and gold foil being the only forms in which the pure metal is used; all alloys debase it; on the contrary, it confers upon the baser metals intrinsic value, as well as useful properties. Coin, the basis of all mercantile transactions, and the unit of measure for all values, is an alloy, the composition of which is determined by governmental enactment, based upon their several necessities.

The quality of gold alloys is measured by the term karat, or carat; frequently the simple abbreviation K is used. It is said to be derived from the name of a bean, the produce of a species *erythina*, a native of the district of Shangallas, in Africa, a famous mart of gold dust. The tree is called *kuara*, a word in the language of the country signifying sun, because it bears flowers and fruit of a flame color. As the dry seeds of this pod are always of nearly uniform weight, the natives have used them from time immemorial to weigh gold. The beans were transported into India at an ancient period, and have long been employed there for weighing diamonds. The carat of the civilized world consists of 4 nominal grains a little lighter than 4 grains troy—it requiring $74\frac{1}{10}$ carat grains to equipoise 72 troy grains. In estimating or expressing the fineness of gold, the whole mass spoken of is supposed to be divided into 24 equal parts, and the number of those parts that are fine gold determines the quality. If 16 of the 24 parts are fine gold, and 8 are of baser metal, the quality is 16 k. If 22 parts of a mass are fine gold and 2 parts base, the mass is 22 k. fine. Fine gold, that is chemically pure gold, is divided into the same 24 parts, and as each part is pure gold, the mass is 24 k. fine. Half fine gold and half base metal is 12 k. fine. The money value of the base metal added to reduce the quality of the gold, does not at all enter into the determination of the quality of the alloyed mass. Whether we add silver, or brass, or copper, or a mixture of all of these, the number of parts of pure gold is the quality of the mass. Intrinsically the value of 12 k. gold, alloyed with silver only, is greater than 12 k. gold alloyed with copper, by the difference in price between silver and copper, but both alloys are 12 k. fine.

A new and more intelligible nomenclature has been recently adopted by the Governmental assayers. Gold or silver which is chemically pure, is called 1000ths fine; it being understood as consisting of 1,000 parts of pure metal. If 500 parts be gold, and 500 parts some other metal, the alloy thus formed is said to be $\frac{500}{1000}$ fine, which is equivalent to 12 k. of the old nomenclature. To reduce the quality of gold, as expressed in carats, to

1000ths, it is only necessary to know that there is $41\frac{2}{3}$ thousandths of fine gold in one carat; and the number of carats multiplied by $41\frac{2}{3}$ gives at once the thousandths fine; conversely, to convert carats into thousandths, it is only necessary to divide the 1000ths by $41\frac{2}{3}$.

The present standard in the United States for gold coin is $\frac{900}{1000}$ fine. The 100 parts alloy is copper and silver, and at least 50 of the 100 parts must be silver. Before July, 1834, the gold coin was $\frac{916\frac{2}{3}}{1000}$ fine, the "Eagle" weighing 270 grains. From that date to January, 1837, U. S. coin was $\frac{899\frac{1}{4}}{1000}$ fine, the "Eagle" weighing 258 grains. Since then it has remained at $\frac{900}{1000}$ fine, the "Eagle" weighing 258 grains. The following table shows the quality of such foreign coins as are usually met with:

Australia Sovereign, 1855-60	916	Fine.
Austria, Ducat	989	"
Austria, Souverain	900	"
Brazil, 20 Milreas	917.5	"
Central America, 2 Escudos	853.5	"
Chili, old Doubloon	870	"
England, Av. Sovereign	916	"
France, Av. 20 Francs	899	"
North Germany, 10 Thaler	895	"
South " Ducat	986	"
Italy, 20 Lire	898	"
Mexico, new Doubloon	870.5	"
Netherlands, 10 Guilders	899	"
Peru, Doubloon	868	"
Prussia, 10 Thaler	903	"
" New Union Crown	900	"
Russia, 5 Roubles	916	"
Spain, 100 Reals	896	"
Sweden, Ducat	975	"
Turkey, 10 Piasters	915	"

It is a matter of considerable importance to the jeweller to know the quality of the various gold alloys in which he deals. Assaying is the only process for obtaining such knowledge, and to arrive at truthful and economical results requires the best chemical knowledge, and the most careful manipulations. Two ways are practised by assayers, one called "parting," by dissolving the alloy by acids and recovering the separate metals by precipitation, the other by cupellation. This is founded upon the feeble affinity which gold and silver have for oxygen, in comparison with copper, tin, and the other cheap metals, and on the tendency which the latter metals have to oxidize rapidly when in contact with lead at a high temperature, and sink with it into any porous earthy vessel, in a thin vitriform state. The porous vessel is made of wood ashes, free from soluble matter, or from burned bones reduced to fine powder.

It has been found by experiment that 16 parts of lead are sufficient to pass one part of copper down into the cupel, and $\frac{3}{10}$ of lead will pass one of silver. The cupels allow the fused oxides to flow through them as through a fine sieve, but are impermeable to the particles of metals; and thus the former pass readily down into their substance, while the latter remain upon their surface; hence the liquid metal preserves a hemispherical shape in the cupel, as quicksilver does in a glass cup, while the fused oxide penetrates their substance like water. Long practice and delicate trials can alone guide to the proper quantity of lead to be employed for every various state of the alloy. The most expert and experienced assayer by the cupel, produces a series of approximate conjectural results which fall short of chemical demonstration and certainty in every instance. This mode of assaying depends so much on the variable temperature, the unknown proportion of copper, and the mere judgment of the senses, that it has been mostly superseded by the humid process, which has all the precision that can be desired.

Assaying is not refining of gold; it is simply taking a very small fragment of a homogeneous mass of alloy, and operating upon it to determine its intrinsic value—that is, the quantity and value of whatever metals may be contained in it. Refining, on the contrary, is operating upon the whole quantity, and separating and recovering the whole of the metals in a pure state. It might be interesting to some to detail these processes, but would be of no practical value, as no one, without proper facilities, and the greatest experience, could operate successfully. The custom now is to send to the United States Mint, or any branch office, or to some reliable assayer. For a small fee, an assay, truthful in results, can be had; or, if gold is to be refined, send at once to a professional refiner, and the pure metals are returned to you at an expense far less than it is possible to do it yourself, even were you capable.

As very many of the readers of the Journal are obliged, by the necessities of their location, to do a little of everything, combining the occupation of jeweller with that of watchmaker, a few rules, with illustrations, will be given, which will enable them to produce any quality of alloy desired, from such material as they have at hand, without being obliged to resort to either assayers or refiners. Gold coin—whose quality is known—and a set of "test needles," are the basis of all the operations of compounding. Test needles can be had of any assayer, and are usually for sale by material dealers. They consist simply of eight or ten little slips of metal, on the end of each of which is soldered a piece of gold of known quality, from 6 k., 8 k., 10 k., up to 22 k. Such a set of test needles are exceedingly useful in a shop where there is constant inquiry as to the quality of gold articles; and, in the present advanced state of alloying, it is not safe to pronounce an opinion as to the quality of gold, by simple inspection—color being, in such cases, the principal guide to judgment. With these, and a piece of black basalt, or a piece of black slate-stone, which is a very good substitute, and a bottle of good nitric acid, very correct judgment can be formed of the quality of a gold alloy.

Rub the article to be tested upon the stone till you have a bright metallic spot or stripe; by the side of it rub off some of the test needle which you *supposed* to be the same quality, then apply to both spots at the same moment a drop of the acid. The inferior quality will first change color under the action of the acid, or if the quality be very low, both metallic streaks will disappear almost as soon as the acid is applied. In that case, the spot first to disappear is the poorest quality. Try your needles higher and lower, till one is found whose action under the acid is the same as the alloy under inspection; 18 carat and upward will require "aqua regia" as the test acid, because nitric acid does not act upon gold of that quality, and would give no indications by change of color. With a very little practice, very correct results can be arrived at by these tests, and the error in all ordinary transactions will be trifling. This method has the additional advantage that the test can be made in the presence of the customer, who can see for himself that it is truthful, and that he is not the victim of deception, and there is no class of tradesmen who are so dependent for success upon their reputation for honest dealing, as jewellers. The opportunities for cheating are so great that the public are quite too willing to suspect, and even accuse the trade of "ways that are dark and tricks that are vain."

In connection with inquiries as to quality of gold, there is always the additional question, "What's it worth?" Pure gold, at the United States Mint, is valued per oz. troy, at 20,67.183468; and to find the value of gold per oz. of any degree of fineness expressed in 1000ths, multiply the above amount by the number of 1,000ths. Example, 1 oz. gold $\frac{900}{1000}$ fine, is worth $20{,}67.183468 \times 900 = 18{,}60.4651212$. Pure silver 1000ths fine, is valued at the United States Mint per oz. troy, at 1,34.444 + or 1,34$\frac{4}{9}$; and the value for any other fineness is found by the same rule as for gold.

The subject of alloying gold in the proper proportions, to obtain some desired result, either of quality or value, has probably puzzled practical jewellers more than any other one thing; and the dozens of different qualities of goods, all *warranted* the same fineness, places the compounders of those alloys among that class of tradesmen who wish to "deceive," or who "don't know." It is no uncommon thing to see a practical melter go nearly distracted over the query of how much of this, that, or the other thing, is required to produce this, that, or the other quality. His dilemma results from want of a little mathematical knowledge, and which he might acquire in the time he is scratching his puzzled head for solutions of his problems. This may be one reason why jewelry, guaranteed by houses that are called "first class," shows such a diversity of quality as to lead inevitably to the presumption that they are really ignorant (assuming their honesty) of the real fineness and value of their wares. Such discrepancies in the statement of qualities is probably the basis of the wide-spread and almost universal suspicion with which all such statements are received; and a customer's countenance often says, "*perhaps* that's so," when his politeness refuses to put the suspicion into words.

ENAMELS.

The basis of all descriptions of enamel is a perfectly transparent and fusible glass, which is rendered either semi-transparent or opaque, by admixture with metallic oxides. White enamels are made by melting the oxide of tin with glass, and adding a small quantity of magnesia, in order to increase the brilliancy of the color; the addition of oxide of lead or antimony produces a yellow. Reds are made by mixtures of the oxides of gold and iron; that composed of the former being the most beautiful and permanent. Greens, violets, and blues are formed from the oxides of copper, cobalt, and iron; and these, when used in different proportions, afford a great variety of intermediate colors. Sometimes the oxides are mixed before they are united to the vitreous base. Purple, which is the color most in use for enamelling, is the chloride oxide of gold, and may be prepared in different ways; by precipitation by means of a muriatic protochloride solution of tin, and nitro-muriatic solution of gold, diluted with water. A very small quantity of the solution of tin will be sufficient to form this precipitate, and must be added gradually until the purple color begins to appear, when no more is needed. After having suffered the color to deposit itself, it is put in an earthen vessel, and left to dry slowly. The different solutions of gold, in whatever manner precipitated, provided the gold is precipitated in the state of an oxide, always give a purple color, which will be more beautiful in proportion to the purity of the oxide; neither the copper nor silver with which gold is generally found alloyed injures this color in a sensible degree, but it is changed by iron. The gold precipitate, which gives the most beautiful purple, is fulminating gold, which loses that property when mixed with fluxes. Purple is a strong color, and is capable of bearing a great deal of flux, as a small quantity communicates its color to a great deal of matter, but will not bear a strong heat; and the color is always more beautiful if the precipitate is ground with the flux before it becomes perfectly dry.

The principal quality of good enamel, and that which renders it fit for being applied, is the facility with which it acquires lustre by a moderate or cherry-red heat—more or less according to the nature of the enamel—without entering into complete fusion. Enamels applied to metals must possess this quality. They do not enter into complete fusion, taking only the state of paste, but of a paste so exceedingly firm that, when baked, one might say that they had been completely fused. There are two ways of painting on enamel—on raw and on baked enamel. Both these methods are employed for the same object. Solid colors, capable of sustaining the fire necessary for baking enamel ground, may be applied in the form of fused enamel on that which is raw, and the artist may afterward finish with the tender colors. The colors applied on the raw material do not require any flux; there is one, even, to which silex may be added; that is, the calx of copper, which gives a very beautiful green, but when used on the raw material it must be mixed with nearly two parts of its weight of silex, and the mixture brought into combination by means of heat, and afterwards pulverized before using. For good white enamel, it is of great importance that the lead and tin should be very pure. If these metals contain, as is often the case, copper or antimony, the enamel will not be fine. Iron injures it least of any of the metals. All these colors may be produced by the metallic oxides, and are more or less fused in the fire, as they adhere more or less to their oxygen. All metals which readily lose their oxygen cannot endure a great degree of heat, and are unfit for being employed on the raw materials.

The enameller, though provided with a set of good colors, is far from being ready to work unless he be skilled in the methods of applying them, and in the nature of the grounds on which to use them. Many of the metals are too fusible to be enamelled, and most of them are corroded by the action of the fused glass. For this reason the metals, gold, silver, and copper, only are used. Although platinum has been used in some instances, little can be said in its favor. Twenty-four carat gold produces the best effect with enamel, as it preserves its metallic brilliancy without being oxidized in the fire, and being less fusible, admits of a harder, and, consequently, more beautiful enamel; but gold finer than 22 carats is seldom used. Gold less than 18 carats would render the work very defective, as more alkali would have to be added to make the enamel softer, and, therefore, less brilliant. We will describe fixing a transparent blue enamel on 22 carat gold. The enamel, after being broken into small bits in a steel mortar, is pulverized in one of agate, water being added to prevent the small splinters from flying about. Experience can only tell how fine the powder ought to be, as some may be used coarser than others. When fine enough, it is washed by agitation in water, pouring it off as it becomes turbid, which is continued till the water remains as clear as when poured on. It is then put in a china saucer, covered slightly with water, and taken up with an iron spatula, and spread as equally as possible on the surface of the gold, which may be ornamented in any way calculated to produce a good effect through the enamel. The thickness of this first layer depends entirely upon its color ; delicate colors, in general, require that it should have no great thickness. The moist enamel, after being placed on the gold, is very carefully dried with old linen, to avoid injury by wiping, and is then ready for the fire. If both sides are enamelled, place it on a plate of iron, hollowed out so that the uncovered edges of the work only are in contact with it. If only one side be enamelled, lay it on a tile or plate of iron; but if it be very small, or cannot be enamelled on the other side, the plate should be flat, or the work may bend when heated. If the piece is large, it should be counter-enamelled, if possible. The furnace should be square, and made of bricks, bedded in earth. The lower part receives a muffle, and rests on the floor of the furnace, and is open on both sides. The upper part of the furnace is a fire-place (larger and longer than the muffle) which holds the charcoal, surrounding the muffle, except the bottom. The coal is supplied at a door above the muffle, which is closed when the fire is lighted. A chimney from the top of the furnace, with a medium-sized aperture, may be closed, if desirable, by a cast-iron plate. This furnace is different from the assayers', because the air is supplied through the muffle, in order to prevent too great heat beneath. After the fire is lighted, and the muffle sufficiently heated, the coal is so placed around the lower part that it cannot fall on the work, which is then carefully put in the muffle on the iron plate or tile. As soon as the artist sees an appearance of fusion, he turns it carefully, so that the fusion shall be uniform. When this is complete, he instantly takes it away, or the gold will melt and spoil all. When cold a second coating is applied, if necessary, and the same care must be repeated for every coat the work requires.

When coated sufficiently, an even surface must be given to the enamel, which is yet irregular. This is done with a very fine file and water, and afterwards sand is used. Much care and skill are required in this, as the enamel easily splinters from the metal, and the color would not be uniform if thinner in places. The marks of filing are then removed with a piece of hard wood, fine sand and water, and is then polished. The material used by enamellers as a polish is rotten stone, prepared for use by pounding, various washings, and then allowing the fine particles to settle, after which it is levigated on a glass slab. The work is cemented to a piece of wood with resin and brick-dust, fixed in a vice, and rubbed with rotten-stone on a small straight bar of pewter. Supreme delicacy is here necessary to avoid scratching or producing flaws in the enamel, by pressing it too hard. Thus it is rendered perfectly even; but the last brilliant polish is given with a piece of hard wood and the rotten-stone. This is the usual way of applying enamels, but some colors require more caution in the management of the fire. Opaque colors require less care than the transparent. A variety of circumstances must be noticed in the management of transparent colors, every color requiring gold of a particular fineness. Different colors, placed one beside another, are kept separate by a small edge or prominency, which is left in the gold for that purpose, and is polished with the enamel. Silver is enamelled in nearly the same way as gold, but the changes of the colors on the silver, by the action of fire, are much greater than when gold is used. Copper is rarely used, on account of the difficulty of fixing fine colors on it. When this metal is used, it is usual to first apply a coating of opaque white enamel, and upon this, other colors more fusible than the white. For leaving part of the gold bare, its surface is cut into compartments, by the engraver. This is expensive, and may be imitated by putting thin and small pieces of gold on the surface of the enamel, where they are fixed by the fire, and afterwards covered by a transparent vitreous coating.

——o——

THERMOMETER IRREGULARITIES.

The principle upon which all thermometers are constructed is the change of volume which takes place in bodies when their temperature undergoes an alteration. Generally speaking, all bodies expand when heated, and contract when cooled; and in such a manner that, under the same circumstances of temperature, they return to the same dimensions, or nearly so, so that the change of volume becomes the exponent of the temperature which produces it. But as it is necessary, not merely that expansion and contraction take place, but that they be capable of being conveniently observed and measured, only a small number of bodies are adapted for thermometrical purposes. Solid bodies, for example, undergo so small a change of volume, with moderate variations of temperature, that they are in general only used for measuring very high temperatures, as the heat of furnaces, melting metals, etc., and instruments for such purposes are called pyrometers. The gaseous fluids, on the other hand, are extremely susceptible of the impressions of heat and cold; and as their changes of volume are greater, even with moderate accessions of heat, they are only adapted for indicating very minute variations, or for forming differential thermometers. Liquids hold an intermediate place, and by reason of their moderate but sensible expansion through the ranges of temperature within which observations have to be made for the greater number of purposes, they are commonly used for the construction of thermometers. Various liquids have been proposed, as oils, ether, spirits of wine, and mercury, but rarely any other than the two last are used at the present day, and mercury the most generally.

The properties which render mercury preferable to all other liquids may be summed up as follows: It takes the temperature of the medium in which it is placed, more quickly than any other fluid. It has been determined by direct experiment that, while common atmospheric air takes 617 seconds, and water 133 seconds, to be heated from the freezing to the boiling point, mercury only takes 58 seconds. The variation of mercury in volume, within limits which include the temperature most frequently required to be observed, are found to be perfectly regular, and proportional to the variations of temperature. In order to render small changes of volume sensible, a glass bulb, having a slender hollow tube attached to it, is filled with mercury, so that expansion or contraction can only take place by a rise or fall of the liquid. The diameter of the tube may be of any convenient size, but the smaller it is the larger will be the scale of the variations. It is *essential* that the bore of the tube be of a *uniform* width throughout; a quality that may be tested by drawing up into the tube a short column of mercury, and measuring its width at different parts with a pair of compasses. So important is this point in constructing a good thermometer, that scarcely one in ten, as they come from the glass-house, are fit for the purpose.

After a good tube has been selected and filled with mercury, a scale must be adopted in order to have a complete thermometer. The graduation of the scale is in some degree arbitrary; nevertheless, in order that different thermometers may be comparable with each other, it is necessary that two points, at least, be taken on the scale corresponding to fixed and determined temperatures, the distance between which will determine the graduation. The two points which are now universally chosen for this purpose, are those which correspond to the temperatures of freezing and boiling water. With respect to the first, there is not much difficulty, it being only necessary to surround the bulb with ice, and to mark on the stem the point at which the mercury stands when the ice begins to melt;

but the boiling point is not so easily determined. Several minute circumstances must be attended to in determining this point with *accuracy*. Water boils at different temperatures, according to the pressure of the atmosphere; and the temperature of boiling water is different at the top and near the bottom of the vessel in which it boils. The vessel should be of metal, because water boils at different temperatures in vessels of different substances, such as metal and glass. Distilled water, or clear, soft water, should be used, for if mixed with any kind of saline ingredients the temperature would be affected, and the instrument rendered inaccurate. The thermometer tube should not be plunged into the water itself, for accurate purposes, but be placed in the vapor that rises above it, in a close vessel with an aperture to allow of its escape.

The two points of freezing and boiling being fixed, the distance between the two may be be divided into any number of degrees at pleasure, and the graduation continued above and below these points as far as may be thought necessary. The numeration may also be begun at any point whatever on the scale, but there are only three methods of division so generally known or adopted as to require particular notice. The first is Fahrenheit's, which is commonly used in the United States, Holland, and Great Britain and her colonies; the second, Reaumer's, which was formerly used in France, and is still used in Spain and some parts of Germany; and the third, that of Celsius, or the Centigrade scale, now used in France, Germany, and Sweden. It will be evident that whatever scale be adopted, the divisions are founded on the assumed principle that equal increase of heat produces equal expansions; and the difference between these three scales is so well known, or can be so easily ascertained, that it is unnecessary for us to mention them other than to give two examples of converting Reaumer into Fahrenheit, and the reverse: Multiply the degrees of Reaumer by 9, divide the product by 4, and to the quotient add 32. The sum expresses the degree on the scale of Fahrenheit.

From the degree of Fahrenheit subtract 32, multiply the remainder by 4, and divide the product by 9. The quotient is the degree according to the scale of Reaumer.

There is a circumstance connected with thermometers requiring particular attention when very exact determinations of temperature are to be made. It has been observed that when thermometers which have been made for several years are placed in melting ice, or otherwise exposed to cold, that the liquid inside the tube stands higher than the zero point of the scale; and this circumstance, which renders the scale inaccurate, has been usually ascribed to the slowness with which the atoms of the glass tube acquire their permanent arrangement, after being heated to a high degree, either in boiling the air out of the mercury after the tube has been filled, or by the heat used in making it. When thermometers have been kept during a certain time in a low temperature, the zero point rises, but it falls when they have been kept in a high temperature; and this remark applies equally to old thermometers as it does to new ones, or those recently constructed, and to thermometers made of brass or other metals, as well as to those made of glass tubes with a liquid enclosed. (See article on Heat, page 99, current volume of the Journal.) When great accuracy is required, as in scientific experiments, it is always necessary to verify the zero point.

From the above remarks it will be seen that it is as difficult to find a correct thermometer as it is to find a time-keeper absolutely correct. The ordinary thermometer will sometimes change its zero point as much as three degrees. Apart from scientific experiment, where accuracy is absolutely necessary, we seldom in every-day life see two thermometers that read the same. Besides the causes above described, which are applicable to all constructions of thermometers, the variation in the thermometers in common use are aggravated in a great measure by the capacity which the surface of the thermometers, or large bodies in the neighborhood, have for absorbing, radiating, and reflecting heat, in addition to the cool winds or hot breezes that may be passing the vicinity.

The large and imposing thermometers in common use in our leading thoroughfares, for the purpose of attracting attention to some particular place of business, for the above reasons, seldom indicate the true temperature. The thermometer that makes the weather appear coldest when an extreme fall of temperature takes place, and the one that stands highest when the temperature suddenly rises to an extreme point, is always the most popular, and it is the one the accuracy of which is most readily believed by the shivering, or sweating and sweltering crowds of humanity that may be passing. But as we have already remarked, a correct thermometer is as difficult to find as a correct timekeeper, although in both instances they may approach near enough to perfection to answer the ordinary purposes of life, while their eccentricities are unobserved by the general public.

——o——

REMINISCENCES OF AN APPRENTICE.

OUR TOWN CLOCK.

A familiar friend and monitor was our town clock. It stood high up in the gray sandstone steeple, in the centre of the town, and, with its large, bright hands, told the time to all; willing to please and accomodate everybody, north, south, east, and west. Few troubled themselves as to how the hands went, or what caused them to move. It was supposed that they went twice round the dial every twenty-four hours, and that was all that was necessary. Our town clock was the standard by which all the transactions of life in our town and neighborhood were regulated. On Saturday nights, when the ordinary house clocks were wound up, if they were not with the "town," they were set with it, in the full assurance that everything was all right. When a dispute arose about the going of watches, an appeal was made to our town clock, and whatever watch happened to be nearest to it, was right, as a matter of course. The mail coach was pronounced to have arrived late or early, according as our town clock made it; and, I have heard people remark, when there was scarcely a cloud on the sky, that it was soon dark to-night, or that it was early light this morning, such was the confidence people had in our town clock.

As far as I know, it had done its best to please everybody, and, although universally respected, it received but little attention. True, once during a storm the wind wrenched the hands off the dial facing the sea, and after a time they were put on again, and a great time there was about it. The man who was lowered over the dial on a rope, and did the work, was, in the eyes of the boys below, a hero of the first magnitude, excelled only by those who could climb up to the top of the mast of a ship. I remember a very stout man used to come from a neighboring town every Saturday, and go in at the door at the foot of the steeple, stay half an hour, and come out again; but we took little notice of what he was doing, till on one occasion, during a snow storm, our town clock stopped, and remained stopped for several days. The mysterious man went in at the door on Saturday, as usual, and a little while after, to the amazement of all the boys that witnessed the sight, the hands of our town clock commenced to move round at a rapid rate, all at the same time, and they all stopped at exactly the same place. This was a mystery quite beyond our comprehension. It was nothing strange for the hands to move slowly twice round the dial every day; the moon and sun appeared to move slowly, and why not the hands of our town clock? but had the moon or the sun, by some agency, been moved round the whole circle of the heavens in two minutes, it could not have created more consternation—perhaps not so much; for there is only one moon, and one sun, but our town clock had four pair of hands. When the stout man emerged from the door at the foot of the steeple, puffing and blowing, and covered with dust and perspiration, he was at once set down as the cause of the mystery; and, every Saturday afterwards, he was eagerly watched for, while all the time he was inside we gazed at the dials to see if the hands would not move again. Once I had the courage to follow him cautiously up two flights of stairs, and along a passage that led into a dark room, and in looking up, there was a series of long ladders, reaching far up, and the stout man at the top of one of them, struggling desperately to get himself through a hatchway in one of the floors. I would not venture farther, but felt sure that there was something at the top of these ladders that ought to be explored. So things went on in our town, and the townsfolk were satisfied. The town bell was rung every morning at six o'clock, and every evening at six and at ten o'clock ; and, if workmen were late or early at their work, or came home too soon, or too late, everything was right if they came and went by the town clock.

After a time a steam railroad was built through our town, and strange as it may seem, the trains on that railroad, going in either direction, would never come in or go out of the station at the time our town clock said they should ; but, of course the trains ran too fast or too slow, and when anybody missed the train, the railway people got all the blame, as they deserved to get. At length, the railway folk got a clock of their own, and said their time should be regulated by it. Now, was it not presumptuous on their part to make us believe that their small and insignificant clock, with only one pair of hands, was better than our large and respectable town clock ? How could a new-fangled set of people that were running steam-engines on wheels, know if they were running them too slow or too fast, and how could they get any better authority than our town clock? But these railway people would listen to no reasoning on the matter, and they positively refused to run their trains to suit our town clock.

About this time, or later, fate placed me as an apprentice in a watchmaker's shop, and the very first day I was there my boyish feelings were shocked at the irreverent manner in which " our maister " spoke about the town clock. Customers complained that their watches would not keep time with the town clock, and it appeared to me that " our maister " was as bad, or worse, than the railway folks in his estimation of our town clock. Among one of the first days I was at the business, on hearing the town clock strike, I put on my cap and jacket and was going out of the shop ; on being asked where I was going, I replied that I was going for my dinner, but was promptly called back to wait half an hour. I waited, but it was a tyranny that I would not submit to. I had always before got my dinner by the town clock, and why not now? My spirit rebelled against this injustice to myself and our town clock, and I did not go back to work that afternoon.

One day, shortly afterwards, our town clock stopped ; it had stopped sometimes before, but on these occasions the wind blew hard, or there had been a snow storm, and these were considered satisfactory reasons for it stopping ; but in this instance it was fine summer weather, and the people were at a loss to account for its acting so, but a sufficient excuse was soon found in its favor. It appeared that, sometime before, the stout gentleman that used to come from a neighboring town to look at our clock once a week, stopped coming, and his place was supplied by a *shoemaker*, a veritable knight of St. Crispin, who undertook the duty of visiting our town clock once a week, and it was little wonder that it felt indignant at the change, and, quite fearless of the terrors of stirrup oil, or a waxing, it stopped altogether, to mark its indignation at being looked after by a shoemaker.

We had a genius in our town, as there is one in every other town, who supplemented his income as a hand-loom weaver, by cleaning clocks. Johnny was a quiet, inoffensive body, and I do not doubt but there were latent talents for mechanics within him, which, if they had been properly developed, might have been of service to himself and the world. At all events, Johnny had a hankering after clocks, and I remember, if he was carrying a clock, when he had occasion to pass our shop, he always hung down his head and tried to hide the clock underneath his coat. His *skill* in the business was, in the eyes of some people, perfectly prodigious. Certainly Johnny would stick at nothing, and nothing daunted him. Without his having the slightest knowledge of the elementary principles of making or sizing a pinion, I saw a pinion that he put in a clock, and which he made out of the solid steel without the aid of any tools whatever except a rough three-cornered file, and the owner of the clock was satisfied that it was very much improved with the new pinion, and that it was better than if it had been done by the regular watchmaker. Johnny's services were called into requisition to try and persuade our town clock to move on as usual. He went up into the steeple, and, either by accident or design, made the clock strike two or three times. Now there is nothing strange in a clock striking itself at the proper hours, but the fact of making it strike at any other time showed great learning; and any of the people who had been dubious about Johnny's qualifications for the work, had their doubts removed by this display of his *skill*.

For a few weeks afterwards our town clock appeared to have relented, and the shoemaker and it appeared to be getting along tolerably well together, when suddenly the old indignation came over it. It would stop, and then for a few days go on again; then it would go fast one day, and slow the next. Some Sabbaths the farmers and the people from neighboring towns would be half an hour late for church, and the next Sabbath they would have to sit half an hour waiting for the minister; and after revenging itself in various ways, our town clock stopped altogether, and it positively refused to proceed one minute farther, or to strike another hour.

Now the crisis had come, and what was to be done to induce our town clock to behave itself in a becoming manner? This question was in no danger of remaining unanswered for a lack of wisdom, because a superfluity of that gift was the very thing that stood in the way of the question being settled. Various plans were proposed, but for a long time nothing could be decided upon. At last, after mature deliberation, it was decided that the clock needed cleaning—a fact there was not much reason to doubt, seeing that it had not been cleaned for twenty years or more.

"Our maister's" opinion was called for in the matter, and in the face of the fact that our town clock had regulated all the movements of the town for twenty years, he advanced the heresy that it had never been right since it was put up; or if it ever went well for twenty-four hours in succession, it was by accident. "Our maister" was usually a humorous, good-natured man, but evidently he had no sympathy for the town clock, and nothing less than a radical change in its construction would please him.

I have mentioned that "our maister" was a humorous individual, and I would also add that he had and deserved the confidence of the inhabitants of our town, but the hard things he said against our town clock brought him enemies. It was as bad as setting up a new religion, to question the soundness of our town clock; but "our maister," although he did not receive the support of the other watchmaker in the town, maintained he had every opportunity of testing its soundness by its performance, while theirs was but a blind belief. The matter was the subject of much conversation among all classes, while it was ably and logically discussed by the scientific weavers of the town. Public examinations of our town clock were now frequently made, and the worthies went about it with as much gravity, and looked upon themselves as great public benefactors, as if they were going off on an expedition to the North Pole to examine and grease the pivot of the earth that is supposed to be up there. These parties invariably made the clock strike a number of times so that all the town would know the exact instant that their deliberations were going on, and some of them, to give double proof of their skill, would make the hands go round rapidly a number of times; but when "our maister" went up he never made it strike—at least if he had occasion to put the striking machinery in motion, the hammer was always prevented from falling on the bell, and so his skill was not so loudly proclaimed as that of the others.

About this time a natural watchmaker came from the Highlands on a visit to our town, and he was considered a fit and proper person to put our town clock to rights. His *skill* in repairing watches was tremendous, and he was never known to take a gold pin out of a watch and put a bit of common wire in its place. He had worked for some years at a perpetual motion machine, and he had it nearly completed; he only wanted one thing, and it was done. He examined our town clock, made it strike many times, and he made the hands spin round at a great rate, and then took sides with the party against the regular clockmakers, just as natural as a quack doctor takes sides against the regular medical practitioner. Finally it was agreed that something must be done, and a committee was appointed to collect money to pay for the repairing of our town clock ; and this part of the business they thoroughly understood, for they soon collected £20. A meeting was called to decide what was to be done. Our Highland friend offered to clean the clock and make everything right, and grease it with some kind of patent oil that would make it run almost without any weights, for the modest sum of £4. The other watchmaker in the town would do it in a workmanlike manner for £6, while "our maister" actually wanted the whole £20, and thought it little enough.

Now, could there be any greater proof of the roguery that exists in our trade than this, or the wide manner in which doctors sometimes differ ? As for the Highland professor, he was skilful and honest, beyond doubt. The other watchmaker was only a trifle less honest, but he was to be excused because he was a watchmaker; but "our maister"—only think of it—he wanted five times more money for making our town clock right than the honest professor did, and that, too, after saying so many hard things about it. "Our maister" wanted to give it a new pendulum, twice as long as the old one, a new escapement, and the wheels altered to answer the long pendulum, and the other parts to be thoroughly repaired and painted and lacquered. The Highland professor argued that the pendulum was "*weel eneuch*," that it made no difference about the length if it was heavy enough ; and it *was* heavy enough ; and he also drew notice to the fact that "our maister" said nothing about cleaning anything, which was the most important thing to be done, but he was only going to paint and lacquer it. The other watchmaker said but little ; he stood on his dignity, for had not "our maister" learned his trade with him ?—and it was therefore easy for him to see who knew best what the clock really did want. The money, however, was collected to repair the clock, and had to be spent for that purpose ; and although, in the eyes of the public, a new pendulum or a new escapement was of little importance, the proposal to alter the wheels seemed to please the scientific ones. They seemed to think that while new wheels were to be put in, the old ones were also to be retained, and consequently the clock would have more power, and would go better ; and this unsophisticated idea carried the day, with but few dissenting voices, and "our maister" was empowered to make the clock to his satisfaction.

The work was commenced, and after a number of months everything, from the bell away up in the steeple to the saw-dust box for the clock weights, was put in perfect order, and all was as neat as a new pin. In fact, so very particular was "our maister" with everything, that once I was afraid he was going to make us polish the great big weights the clock had.

When the work was completed, our town clock behaved itself to the satisfaction of all, and even the railway folks began to respect it. It was the special pride of "our maister," and he wound it every week himself while I helped him. In a few years I got larger and stronger, and had learned enough to take care of it myself. Fnally, a strong desire to develop and fully comprehend all the mysteries of our town clock, and which has grown on me with years, induced me to seek wider fields of observation, and "our maister" resumed charge of it himself ; but his eyes suddenly failed him at an early age, and he retired from business, and I fear that our town clock is again sadly neglected. When I retrace my wandering steps and climb up those long ladders again on a visit to the place where, in my boyhood days, I thought there was so much mystery, I shall be glad to find our town clock in as good condition as "our maister" left it.

THE BOREL AND COURVOISIER WATCH.

Messrs. Quinche & Krugler desire us to say, in answer to numerous queries in regard to the advance in price of the Borel and Courvoisier movements, that it is in consequence of the increased duties on foreign watches, and that they have divided the amount, adding only one-half the actual increased cost.

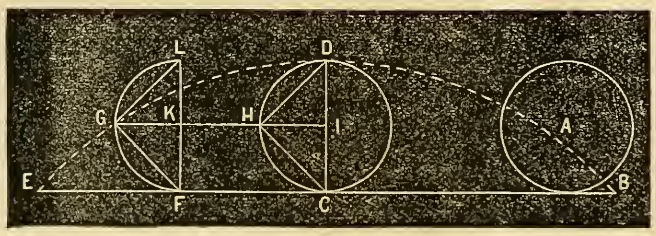
A FEW WORDS ON PENDULUMS.

EDITOR HOROLOGICAL JOURNAL:

Having read with much satisfaction many valuable articles in your JOURNAL, and among others some very interesting ones upon pendulums, the thought occurred to me that perhaps a few more words might be written on that subject which would make it more clear to those who had not given it that careful thought and attention which the authors of the articles referred to had supposed.

The celebrated Christian Huyghens demonstrated that all the vibrations of a cycloidal pendulum, whether long or short, are performed in equal times; but whilst to an adept the isochronism of the cycloidal pendulum is perfectly clear, there are those of the guild that furnishes the world with time, to whom this subject is not so clear. Now, as I suppose the mission of the HOROLOGICAL JOURNAL is to enlighten that class of workmen, it may not be amiss to say that when a circle A containing a point B is rolled over a straight line C, the curve described by that point in its passage is called a cycloid curve, D.

FIG. 1.



A pendulum whose *point of percussion* or *centre of oscillation* describes this curve, is called a cycloidal pendulum. The reader will please remark that I have stated, *point of percussion* or *centre of oscillation*, not the centre of gravity, nor the centre of the pendulum ball, for those only coincide in a mathematically perfect pendulum, which can only be a creature of the imagination. The reasons why a cycloidal pendulum possesses this quality will appear from the following demonstration:

We lay down as a fundamental proposition that the velocity of a cycloidal pendulum in its lowest point is proportional to the space passed through, viz.: the arc of the cycloid which the pendulum has described in its descent.

Now, it is obvious that the base B C E, in Fig. 1, is equal to the circumference of the generating circle, for it is rolled over it, to make the curve just one revolution.

Then the axis of the cycloid D C, is equal to the diameter of the generating circle.

The part F E, of the base, viz.: the part between one extremity of it, and the place which touches the generating circle in any situation of it, is equal to the corresponding arc F G, or H C, of the generating circle; the ordinate G I, being parallel to the base C F, or its equal I K, is equal to the remaining arc H D, or G L.

The chord G F is perpendicular to the cycloid. The chord G L, being perpendicular to G F, is a tangent to the cycloid at G.

The tangent at G is parallel and equal to the chord H D, also the chord G F is equal and parallel to H C.

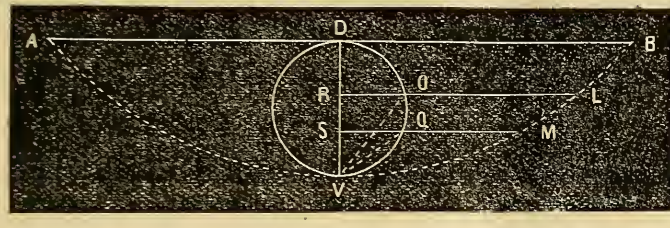
The length of the semicycloid D G E is equal to twice the diameter D C of the generating circle; and any cycloidal arc G D cut off by a line G I parallel to the base, is equal to twice the chord D H, of the corresponding circular arc D H, which is cut off by the same line G. I.

A mere statement of these properties of cycloid we deem sufficient for our purpose; and now, to change the figure for convenience of illustration, if the pendulum begin to descend from B, Fig. 2, at V its velocity will be as the arc B V; and if it begin to descend from L, then when it arrives at the lowest point V, its velocity will be as the arc L V.

A body will acquire the same velocity, whether it descends obliquely from L to V, or perpendicularly from R to V.

Also the square of the velocity of a falling body is as the space passed through, or the velocity is as the square-root of the space; therefore the velocity acquired by the pendulum L in its descent from L to V is as $\sqrt{RV}$. But R V : V O : : V O : D V, consequently R V $=$ V O $\div$ D V, and D V being a constant quantity, R V is as VO^2, or $\sqrt{RV}$ (viz., the velocity in question) is as V O, which is equal to half the cycloidal arc V L; hence the velocity is as the cycloidal arc, or space passed over.

Fig. 2.



But in all sorts of motion the space is as the product of the time multiplied by the velocity, viz., S is as T V, which gives the following analogy, S : V : : T : 1 (space is to velocity as time is to unity). But it has just been shown that in case of a cycloidal vibration the space passed over is as the velocity; therefore the time must be as unity, or always the same. There are certain reasons why the cycloidal pendulum is not available, which I do not propose to discuss at this time; but I mentioned the fact that the centre of oscillation and the centre of gravity were not identical, and perhaps it would be well to more particularly notice this property of the pendulum. If a pendulum consists of a spherical body fastened to a string, most persons would imagine that the length of the pendulum must be estimated from the point of suspension to the centre of the ball, but the real length of the pendulum is greater than that distance. The reason of which is, that the spherical body does not move in a straight line, but in a circular arc; in consequence of which that half of it which is furthest from the point of suspension, runs through a longer space than the half which is nearer the point of suspension, and the two halves of the ball though containing equal quantities of matter, do actually move with different velocities; therefore their momentums are not equal. If the ball of the pendulum could be concentrated into one point, that point would be the centre of oscillation. The centre of the ball is the centre of gravity, but the centre of oscillation is in the lower half of the ball on account of its increased momentum. The centre of percussion is that part or point of a pendulous body which will make the greatest impression on an obstacle that may be opposed to it whilst vibrating; for if the obstacle be opposed to it at different distances from the point of suspension, the stroke or percussion will not be equally powerful, and it will soon appear that this centre of percussion does not coincide with the centre of gravity.

Let the body A B, consisting of two equal balls fastened to a stiff rod, move in a direction parallel to itself, it is evident that the two balls must have equal momentums, since their quantities of matter are equal, and they move with equal velocities. If on its way an obstacle C be opposed exactly against its middle, E, the body will be effectually stopped, nor can either end of it move forwards. But let an obstacle be opposed to it nearer to one end not in the direction of the centre of gravity, and only part of the momentum will be expended upon the obstacle, and the other end will move forward with the unexpended momentum, as shown by the dotted representation; nor will the percussion be so powerful as in the foregoing case. But in a pendulum the case is different; for let the same body be suspended by the addition of a line A S, which line we will suppose to be devoid of weight and flexibility, and let it vibrate from the point of suspension S; it is evident that the two balls will not move with the same velocities, for one

Fig. 3.

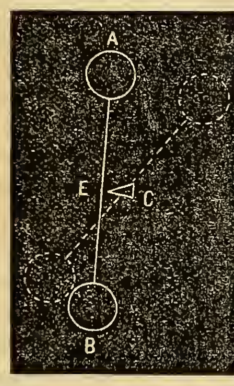
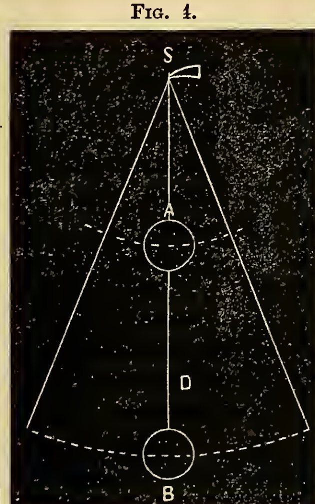


Fig. 4.



describes a larger arc in the same time than the other, and of course the point where the forces of the two balls balance each other lies nearer the lower ball, consequently the point of percussion does not coincide with the centre of gravity; but it is that point wherein all the forces of all the parts of the body may be conceived to be concentrated. Hence, the centre of percussion and the centre of oscillation coincide. It is this difference of these centres, that is of oscillation and gravity, that renders it so difficult, and I might say impossible to perfectly compensate a pendulum.

Whilst the centre of gravity may be maintained, the centre of oscillation is changed by the very forces that maintain the other, and for this reason Graham's mercurial pendulum is not absolutely perfect, and for *this reason* Mr. Grossmann's pendulum, though reflecting great credit on his ingenuity, is worse than Graham's. The true principle of pendulums is as near as possible to concentrate the weight of the pendulum in one point, and compensate with as little expansion as possible. It strikes me, with all due deference to others, that a wooden pendulum, made of straight-grained, well-seasoned white pine, and properly protected from the moisture of the atmosphere by varnish (which will need, according to Dr. Rittenhouse, something less of compensation than glass), properly compensated in the pendulum ball itself, either in the material or form, would give less trouble than the elaborate ones made of other materials. The smallest vibration possible to the running of clock-work should be aimed at, for if the pendulous body could move along the chords of arcs, instead of the arcs themselves, the semi-vibrations, whether long or short, would be all performed in equal times, viz.: each in the time that a body would employ in descending perpendicularly along the diameter of the circle, or twice the length of the pendulum. But in very small arcs the chords are nearly equal to the arcs which they subtend ; therefore, the vibrations along very small arcs, though of unequal lengths, are performed in times nearly equal.

J. C. Hagey.

Jarrettsville, Md.

HARDENING STEEL.

Editor Horological Journal :

In making small articles of steel, one often has to devote more time and labor to finishing and polishing a piece of work, after hardening, than was previously expended in its manufacture. Steel may be hardened without *scaling*, or injury to finish.

First, dissolve common salt in soft water, until there is an excess of salt at the bottom of the vessel; take a quantity of buckwheat or coarse flour, and some of the salt solution, sufficient to make a thick paste, which should be thick enough to retain its form and shape when in use ; cover the article to be hardened with this paste, pressing it together firmly, so that it shall adhere to every part of the surface. A small article will require a coating at least as thick as its diameter ; a large piece requires a thicker coating, and should be of sufficient quantity to prevent the surface of the steel being exposed during the process. Heat it carefully at first, until the water is all evaporated; then bring the mass to a bright red heat, and plunge it into the salt bath until nearly cold. After washing, the surface will appear of a dirty white, or, if not very hard, of a light gray, as if stoned off for polishing, then polish and temper, as usual. This process may not be new to others, but it is original with me.

G. M. Howe.

Madrid, N. Y., *March* 25, 1871.

---o---

SIZES OF PINIONS.

Editor Horological Journal:

The query of "Saxon," in the March No. of the Journal, should appeal to the good sense of every watchmaker who reads it. Watchmakers, like men of other trades, are apt to rely too much upon printed statements, and give them a greater value than their reason, if brought to bear upon the subject, would allow. Even if a clock should require a relatively larger pinion, which no one upon consideration can allow, the interesting query might be put as to at what size a watch ceased to be a watch and became a clock. Ried and other writers make no distinction between the names watch and clock; certainly none in the sizes of pinions, etc. The only differences in large and small wheels' pinions, that I ever heard of, are in the manner of drawing the Epicycloid arc on the teeth. On small wheels it can be drawn in a single arc, but large wheels require separate arcs for flanks and faces; but small wheels, in this case, refer to wheels even larger than six inches. In laying out a pinion there are certain laws more infallible than those of the "Medes and Persians, which altereth not." They ought to be understood by every watchmaker, although they are required in practice very seldom, if ever.

A set of arbitrary sizes are to be avoided, because they cannot, in all cases, be correct; and a man who knew no other way would be just as likely to take out a correct pinion, which did not agree with this standard, and put in a bad pinion that did. The best way, and one within reach at all times, is to try the wheel and pinion in the depthing tool. If the pinion is lost, set the tool to the proper distance between the centres and try pinions till the proper one is found. The workman must come to that finally, no matter by what rule he selects the pinion at first. Clock pinions may be lost, and no doubt have been; but rarely as they are lost, it will be just as rare to find a watchmaker who has the means of replacing them at all, let the size be what it will, so that part of it is hardly practical; but with the size of the wheel, number of teeth of the wheel, and number of revolutions of the required pinion, being given, it is very easy to give the size of the pinion and the distance from the centre of the wheel to the centre of the pinion, to the thousandth part of an inch.

SAG HARBOR, L. I. B. F. H.

We perfectly agree with "B. F. H.," that a set of arbitrary rules are to be avoided in laying out a pinion, and that there are certain geometrical laws more infallible than those of the "Medes and Persians," and which ought to be understood by all watchmakers. These same laws teach us that there *is* a difference in a pinion according to the number of teeth contained in the wheel that it works into. Ried does not draw the line to determine the point when a watch ceases to be a watch and becomes a clock, because it is as unnecessary to do so as it is to settle the exact point when a pair of plyers become blacksmiths' tongs. On page 101 of the first edition of his work, Ried gives a table for sizing pinions, where he makes a distinction between the sizes of pinions for watches and those for clocks. Mr. Spiro's table resembles it in some points, and he advances his views further on the subject in this number of the Journal. We do not hold ourselves responsible for anything written over the signature of a correspondent, and would only mention that we never supposed that Ried made the distinction in his book *solely* on the grounds that the pinions were intended for a watch or a clock, but for the reason that the trains of wheels in watches and clocks, not being of the same numbers, the sizes of the pinions varied a little in proportion to the number of teeth contained in the wheels, and consequently he gave the table for the convenience of those making clocks and watches under the system common in those days.

We coincide with the views of our correspondent, "Saxon," that the system of sizing pinions by measuring the teeth of the wheels with callipers, is at the best but a rude method. In reply to his querries, we say that there is no difference in the size of a pinion of a given number of leaves, working into a wheel of a given number of teeth, whether employed in a watch or in any description of clockwork, *when they work under the same conditions, and under the same circumstances.*

ANSWER.

EDITOR HOROLOGICAL JOURNAL:

In answer to "Saxon's" "Query," it must be admitted that in the theory of sizing pinions by the number of their leaves, there is no reason why pinions intended for clockwork should be disproportionately larger than those intended for watch-work; but in practice it has been deemed prudent, by experienced clock-makers, to enlarge pinions having a certain number of leaves, in order to counteract the influence of wear and tear occasioned by the disproportionately larger amount of motive force generally employed in clock-work than that employed in watch-work, as well as possible without sacrifice to good gearing. How often do we see clocks coming for repairs, the teeth of their wheels *perfect round stumps* from wear, and thereby rendering the gearing so shallow as to make going absolutely impossible. But we are limited to a certain number of pinion leaves with which to apply the above principle, for the reason that other pinions are debarred therefrom by their calculation, which in their case would render good gearing impossible. It is for the above reasons the table of pinion sizes has been set up in the manner referred to by "Saxon." CHARLES SPIRO.

MONOGRAMS.

The most innocent "mania" is the sudden fancy for monograms. To be good, a design must be ingenious, perplexing, and graceful. Combinations are infinite in possibilities of arrangement, and the finest faculties of artist and geometrician are inwoven in the web of the design. We have had many successful designers in this art, but all we have done, gathered into one work, would be hopelessly eclipsed by the recent publication of J. Sabin & Sons, 84 Nassau street, New York, an octavo volume of 78 plates, and over 1,000 designs. Among these are alphabetically arranged monogrammatic pictures of rarest grace and beauty, and many are extremely surprising puzzles. The general arrangement is first in single groups of two, from A to Z, in the most usual combinations. These are again involved in more intricate studies, and finally wrought into a full web of a whole name or a poetical motto. Many alphabets of curious and beautiful capitals, close the volume, combined with a group of coronal heraldry.

As a contribution to the jeweller's stock of designs, it is priceless; as a mere work of art, a delightful study, and even a pastime. As to its origin, some of its designs are the love-works of the master artists of Europe, and the engraving is the finest of lithograph. We predict a great popularity for this beautiful volume. Price $6.50, $7.50, and $8.00.

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For May, 1871.

Day of the Week.	Day of Mon.	Sidereal Time of the Semidiameter Passing the Meridian.	Equation of Time to be Subtracted from Apparent Time.	Equation of Time to be Added to Mean Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	M. S.	S.	H. M. S.
M..	1	66.04	3 0.76	3 0.78	0.323	2 35 53.51
Tu.	2	66 12	3 8.25	3 8.27	0.301	2 39 50 07
W.	3	66.20	3 15.20	3 15.21	0.278	2 43 46.63
Th.	4	66.28	3 21.59	3 21.60	0.255	2 47 43.18
Fri	5	66 36	3 27.43	3 27.44	0.231	2 51 39 73
Sat	6	66.44	3 32.71	3 32.72	0.207	2 55 36 29
Su.	7	66.52	3 37.41	3 37.42	0.183	2 59 32.84
M..	8	66.61	3 41.54	3 41.55	0.159	3 3 29.40
Tu.	9	66.69	3 45.09	3 45.10	0.135	3 7 25.95
W.	10	66.78	3 48.05	3 48.06	0.110	3 11 22.51
Th.	11	66.86	3 50.41	3 50.42	0.086	3 15 19.07
Fri.	12	66.94	3 52.18	3 52.18	0.061	3 19 15.62
Sat	13	67.02	3 53.36	3 53.36	0.037	3 23 12.18
Su.	14	67.10	3 53.94	3 53.94	0.012	3 27 8.73
M..	15	67.18	3 53.94	3 53.94	0.012	3 31 5.29
Tu.	16	67.26	3 53.35	3 53.35	0.037	3 35 1 85
W.	17	67.34	3 52.17	3 52.17	0.061	3 38 58.41
Th.	18	67.42	3 50.42	3 50 42	0.085	3 42 54.96
Fri.	19	67.50	3 48.12	3 48.11	0.108	3 46 51.51
Sat	20	67.58	3 45.27	3 45.26	0.131	3 50 48.07
Su.	21	67.66	3 41.87	3 41.86	0.154	3 54 44.63
M..	22	67.73	3 37 94	3 37.93	0.176	3 58 41.19
Tu.	23	67.82	3 33.48	3 33.47	0.197	4 2 37.74
W.	24	67.89	3 28.51	3 28 51	0.218	4 6 34.30
Th.	25	67.96	3 23.05	3 23.04	0.238	4 10 30.85
Fri	26	68.03	3 17.12	3 17.11	0.258	4 14 27.41
Sat	27	68.10	3 10.73	3 10 71	0.277	4 18 23.97
Su.	28	68.16	3 3 88	3 3.86	0.296	4 22 20.53
M..	29	68.23	2 56.57	2 56.55	0.314	4 26 17.08
Tu.	30	68.29	2 48 82	2 48.80	0.332	4 30 13.64
W.	31	68.35	2 40.64	2 40.62	0.350	4 34 10 20

Mean time of the Semidiameter passing may be found by subtracting 0.18s. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
☺	Full Moon	4 11 0.3
☾	Last Quarter	11 2 23.6
●	New Moon	18 22 45 1
☽	First Quarter	27 1 2.1

		D. H.
☾	Perigee	5 8 2
☾	Apogee	20 3.9

	° ′ ″
Latitude of Harvard Observatory	42 22 48 1

	H. M. S.
Long. Harvard Observatory	4 44 29.05
New York City Hall	4 56 0.15
Savannah Exchange	5 24 20.572
Hudson, Ohio	5 25 43.20
Cincinnati Observatory	5 37 58.062
Point Conception	8 1 42.64

		APPARENT R. ASCENSION.	APPARENT DECLINATION.	MERID. PASSAGE.
	D.	H. M. S.	° ′ ″	H. M.
Venus	1	4 52 29.63	+24 2 2.8	2 16.7
Jupiter	1	5 39 47.02	+23 15 26.6	3 3.5
Saturn	1	18 42 18.05	−22 17 43.6	16 3.7

AMERICAN

Horological Journal.

Vol. II. NEW YORK, JUNE, 1871. No. 12.

CONTENTS.

ESSAY

ON THE

CONSTRUCTION OF A SIMPLE AND MECHANICALLY PERFECT WATCH.

BY MORRITZ GROSSMANN.

CHAPTER IX.

THE JEWELLING.

98. The jewelling is an improvement in horology belonging to its newest period. It is evidently a great progress to introduce a material indestructible by friction, not susceptible to chemical influences, and capable of the highest polish, for the bearings of the pivots, thereby insuring the stability of their actions, the preservation of the oil, and the reduction of frictional resistance to a minimum.

99. Jewel holes ought to be well examined before using them, because, if the hole is not carefully polished, or if its edges are ragged, they are worse than metal holes, for they wear the pivot very quickly.

100. According to my opinion, a movement ought to be jewelled throughout. The price of a pair of jewel holes is not so high as to form an obstruction to their use, and especially the pallet holes ought not to be left without jewelling. The angular motion of the pallet is very trifling, it is true, but experience tells us that when grinding any substance, the reciprocating motion answers best of all, and the wear of a pivot in its hole is nothing else but a very slight degree of grinding. Besides, the jewelling of the pallet holes might be thought useful by the diminution of friction, and this is very essential in the lever, the inertia and resistance of which has to be overcome at every beat of the escapement.

101. For similar reasons, the third and fourth wheel holes ought also to be jewelled, if the quality and intended value of the watch will any way warrant the expense.

102. To have the escapement, that is, the wheel and pallet cap jewelled, or with end-stones, is more a matter of taste than of practical utility. In the case of the balance, with its quick vibration to the extent of about 400°, it is of the utmost importance to avoid the amount of additional friction which would result from the bearing of shoulders against the faces of the holes, and thus the end-stones of the balance cannot be dispensed with. It will be obvious at the first glance, that the pallet and wheel work under vastly different circumstances. In a movement of the usual arrangement, the pallet makes an angular movement of 10° to 15° for every vibration of the balance, and the wheel accomplishes, if it has fifteen teeth, 12° of its rotation in the same period. Besides, their weight cannot be supposed to press so much in the vertical direction, because they are working under a continual and considerable side pressure. But the greatest difference between the position of balance pivots and that of wheel and pallet is, that these latter parts may be made as light as possible, while the balance is, and must be, considerably heavier.

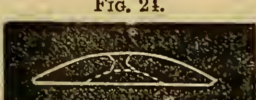
103. The difference between the friction of

a plain jewelled pivot and a cap jewelled one, is extremely small. According to a generally established law in mechanics, that, the pressure being the same, the amount of friction is not altered by the extent of the bearing surface, it would be *nil*. But in our case, and especially because lubrication is required, the adhesion must be considered. Anyhow, the resistance to the motion of the cap jewelled pivot can only be easier as the ratio of the difference of the bearing surface, and this difference between the surface of the pivot end and that of a properly reduced shoulder, is a trifling one. With an angular motion of more than thirty times the extent of that of the wheel and pallet, it acquires, of course, a greater importance, and therefore the end-stones are indispensable to the balance. I freely admit that there is a little economy of power in the cap jewelled escapement, but I wish only to point out that this very trifling advantage is generally overrated. The fact that a number of the best English watches are without end-stones to the escapement, seems to indicate that the English horologists look at this matter about in the way above mentioned.

104. The employment of a diamond as an end-stone to the upper balance pivot, is a very good practice, because the watch, in its horizontal position, performs with almost all the friction on this pivot end, and the extreme hardness and fine polish of the diamond face will reduce the wear and friction to their smallest amount. It only requires some care to select the diamonds, because among those which can be bought in the material shops, there are sometimes pieces defective in the point of polish; and, in this case, instead of conserving the pivot, they might prove the means of its destruction.

105. The good and careful execution of the balance holes forms the most important point in the jewelling of a watch. Not only must they show, like all the other jewel holes, an irreproachable polish, but they must be rounded in a proper manner in order to make the friction in the vertical and horizontal positions equal, or as nearly so as it can be done.

Fig. 24.



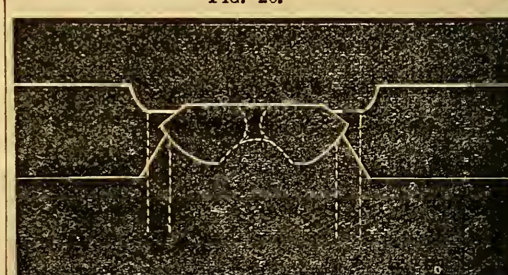
106. It may be considered a good plan to make the balance holes on the conical method, in order to give them a greater strength, and to facilitate the entrance of the pivot when putting the balance-cock on; but they require great care in their shape, lest the adhesion might be increased. Besides, a cock with its steady pins, made in the way previously described (83), renders it very easy to put the cock on without injuring the jewel hole.

Fig. 25.

107. The setting of the jewels is a matter of very different execution. In some, especially the better class of English watches, the jewels are set in brass or gold settings, which latter are fitted into holes with countersinks, and fastened with screws, the heads of which partly intersect the circumference of the setting, while the thread is tapped in the plate, and the head of the screw sunk into it, so as to be level with its surface.

108. The advantage claimed for setting jewels in this way, is a greater facility of replacing a broken or damaged jewel without regilding the plate or cock. This, however, does not weigh very heavy, because if a good stock of jewel holes is within convenient reach, it will be easy to find one fitting into the old setting; and even if this should not be the case, the purpose can be attained by setting the new jewel in a piece of brass wire of suitable thickness. This wire, after being turned exactly concentric to the hole, and of a slight taper, is adjusted into the hole in the plate, previously turned out, and then it is cut off at a length a little in excess of what it is required to be. This setting now must be gently driven into the hole in the plate till the proper end-shake is attained. The plate

Fig. 26.



or cock is then cemented to a flat chuck, and well centred to the hole in the jewel, after which the taper is turned. If the brass setting has been turned to a proportionate size, it will be easily attainable that the taper extends a little beyond it into the plate ; and in a plain jewelled watch, if well done, the replacing of a jewel in the way just described, can hardly be detected.

109. A movement with plain set jewels is in no way inferior to one with screwed jewels, even, as has been explained, in the very exceptional case of the replacement of a jewel hole. The movement with screwed jewels has a more elegant appearance, but it implies, if not done with the greatest care and discernment, a vast deal of trouble in the manufacturing, and still more so in the repairing. Not only must all the screws and jewels be taken out for thoroughly cleaning a watch, and put in again, but the very little thickness in which the screws have to take their hold, is a great source of annoyance to the repairer, especially in the English watches, with their thin upper plates of brass, rendered quite soft by gilding, and with screws of rather coarse threads. (22.) Any screw failing in its hold, has to be replaced by one of the next number of thread, having by its greater thickness still less chance of a sound hold, and very often it is necessary to make other holes at fresh places. If, now, the screwed jewel presents the advantage of easy replacement of a broken jewel without leaving any lasting mark of the operation, this small advantage may be considered to be neutralized by the above-mentioned drawbacks.

110. However, the screwed jewelling may be improved in such a way as to make it much less liable to failure. There is not the slightest necessity for countersinking the screws in the upper plate ; they might, without the least detriment to their functions, have flat heads, rounded at the top, which merely serve to hold the jewel down in its place, thereby reserving the whole thickness of the plate for the hold of the screws. The jewel setting might be dotted as usual, for always having it in the same place in its sink, which is not without importance ; and if it should be thought necessary to insure this position of the jewel, even against careless repairers, who might not pay any attention to the dotting, this might easily be attained by drilling a very small hole in the bottom of the countersink, into which a pin might be driven, and for the reception of which the jewel setting ought to have a small groove.

CHAPTER X.

THE FUSEE.

111. In the period of the recoil escapement, the invention of the fusee was undoubtedly one of the most important steps towards perfection in time-keeping. The old vertical watch is to such a high degree under the influence of the variations in the intensity of the moving power, that it hardly deserves the name of a time-keeper, if not provided with a mechanism for equalizing these irregularities. The vertical escapement was superseded by the dead beat escapements, especially the cylinder escapement. One of the principal features of this latter is, that the locking and lifting take place at equal distances from the centre of the balance. The friction on the locking, therefore, is considerable, and acts during the greater part of the vibration. These circumstances have the effect that, with any increase of the impulse power, there is a corresponding increase of friction at the locking. This friction, it will be obvious, acts in a corrective way, and if the proportions of the escapement are well chosen, it is in a surprisingly small degree influenced in its time-keeping by any irregularity of the moving power. The duplex escapement works under similar circumstances, while the detached escapements, which have no correctional friction, may enjoy the independence of their time-keeping only by a judicious arrangement of the pendulum spring.

112. To begin from the time of the clear establishment of these facts, a rather different course was taken by the leading horologists in the different centres of horological manufacturing. The French and Swiss, with their practical endowment, immediately took advantage of this changed situation, and simplified the movement by dispensing with the fusee and its appendices. This step, together with some other circumstances, was the base

on which the Swiss manufacture largely developed itself, because, by these means, they were enabled to produce a cheap watch of convenient and even delicate dimensions, and still satisfying the wants of common life.

113. The English, on the contrary, kept to the traditional fusee movement, even under so vastly changed conditions ; and even now, notwithstanding a number of advocates of the going barrel have sprung up amongst them in the latest period, the majority still adhere to the belief that the fusee is an indispensable characteristic of a truly English watch. The consequence of this conservative inclination is, a well-maintained superiority of time-keeping in their better class of watches, but a gradual decrease of demand for the inferior qualities, and which, in fact, have ceased by degrees to be a marketable article.

114. These are the practical and commercial consequences of the retention and the omission of the fusee in the modern watch, as experience has shown them in those two old manufacturing countries. It is strange to see that the highly creditable invention of Graham, that of the cylinder escapement, has not been a source of much benefit to his countrymen, merely because they rejected the idea of coupling its adoption with a remodelling of the movement rendered admissible by the nature of the new escapement. The Swiss, by adopting this latter course, and by a thorough division of labor, have succeeded in producing a watch of satisfactory time-keeping quality, marketable by its price and elegant form and dimensions, and thus powerfully raised their horological industry.

115. There can be no doubt that the fusee, with its equalizing power, insures a greater uniformity in the rate of a first-class time-keeping instrument, but the degree of superiority obtained by this means has been vastly overrated ; and for the wants of common life there is no difference of any practical importance between the performance of a fusee watch and that of a going barrel one. Even if the difference between the rate in the first and in the last six hours of spring development in a going barrel watch should amount to ten or twenty seconds, which is far more than ever will result from this cause in a good watch, this would be no impediment to the watch running a general steady rate, because the error would repeat itself regularly in the course of every twenty-four hours, and it would only require to wind the watch in as regular a manner as could be afforded.

116. The employment of the going barrel allows of a stronger train of wheels and pinions, of a more capacious barrel, and of a less restrained arrangement of the moving parts. It economizes power by the omission of the frictional resistance of two large pivots, like those of the fusee, and it has the great advantage of not being exposed to as many accidents as the fusee movement, in which there is the additional danger of a rupture of the chain, besides the breaking of the spring. The going barrel movement, if properly constructed, so as to have a thin and long main-spring, can be set going with the middle part of a total development of at least six turns ; and this main-spring is not so much exposed to breaking as the thick and short spring of a barrel in a fusee movement.

117. But the greatest advantage of all is, that the going barrel movement, with its greater abundance of moving power, is much more than the fusee movement appropriate for a quick train, viz.:—one with 18,000 vibrations in an hour. This quick vibration makes a watch much more fit for good performance, especially when worn by persons riding in carriages or on horseback, or in any other way exposed to continual external shocks. It is quite obvious that the much greater momentum of a balance in such quick vibrations, will be much less under the influence of such disturbances, than another balance, vibrating $\frac{1}{5}$ slower. This increased activity of the movement, producing 3,600 more vibrations in an hour, must, of course, be maintained by a greater moving power ; and in this point the fusee movement will be found deficient, if it has not an excessive height and diameter, or a very light balance.

118. The consequences of the above considerations may be condensed in the following conclusions :—

The employment of the fusee is recommendable for all watches of which the most accurate time-keeping is expected. The going barrel ought to be resorted to for all watches not belonging to this class, and especially for the use of such wearers as have to rely on a performance as much as possible free of disturbance; for instance, travellers, soldiers, etc.

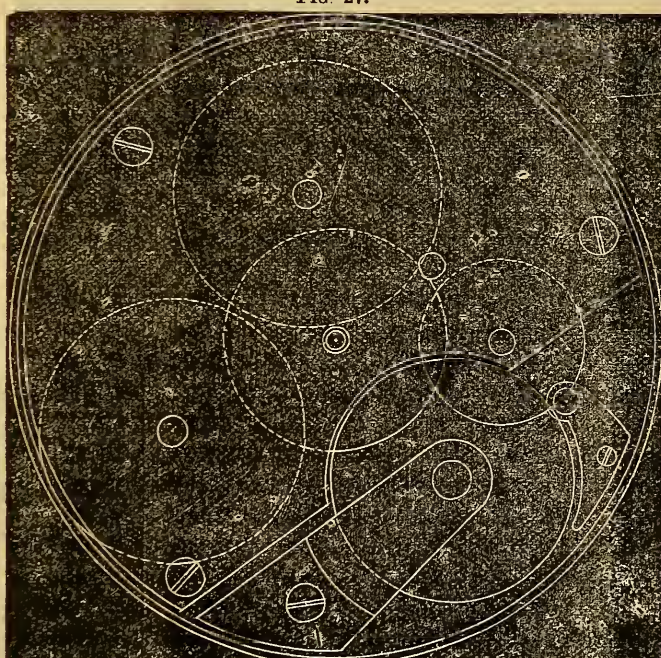
119. This point of view was most likely taken by the first watch manufacturers of the United States, when they very judiciously dispensed with the fusee movement, and which, in my opinion, is a most essential element of their success.

120. Having thus exposed the nature of those cases where the employment of the fusee may be thought useful, it will perhaps not be amiss to say a word on the best mode of constructing a sound and well-proportioned fusee movement. In doing so, I cannot help stating that the historical English fusee movement, according to my way of viewing the matter, is not a perfect arrangement, because it is not capable of containing a main-spring of a breadth proportionate to the height of the frame. This, as I intend to show by figures and diagrams, is mainly the result of the placement of the centre wheel in those movements. When I was working in London, I had some conversations about this point with very good horologists, but they were quite positive in dissuading me from attempting any alteration whatever in the construction of the fusee movement. I got up a drawing in which I could not see any mechanical defect, and was quite sure of my plan; but I had not then the facilities for carrying it out in practice. This, however, I did later, and the experiment fully confirmed my former supposition. In the hope that it may be useful to some of your readers, I give a diagram and description of the fusee movement, with comparative figures of its advantages over the English movement.

The greatest alteration in this movement is, as will be easily seen, the transposition of the centre wheel from its usual place below the barrel, to the opposite part of the frame, above barrel and fusee. The centre wheel can very conveniently be sunk into an upper plate of proper thickness, so as to lie flat with its surface. Then the fusee may come as near the upper plate as in the English movement. The barrel cannot pass through the upper plate, as it does in the usual movements, but it can reach almost down to the dial, save only the thickness of its lower bridge. In the English movement the centre wheel is an absolute bar to giving any more height to the fusee and barrel, and all the height of frame between centre wheel and dial is lost for these important organs.

For illustrating the advantages to be derived from this arrangement, I give the following comparative sizes :—

Fig. 27.



I have a good English ¾ plate movement, diameter 44 m.; the total height of frame is 7.2 m., the height of fusee 3.2 m., and the height of barrel 2.65 m.

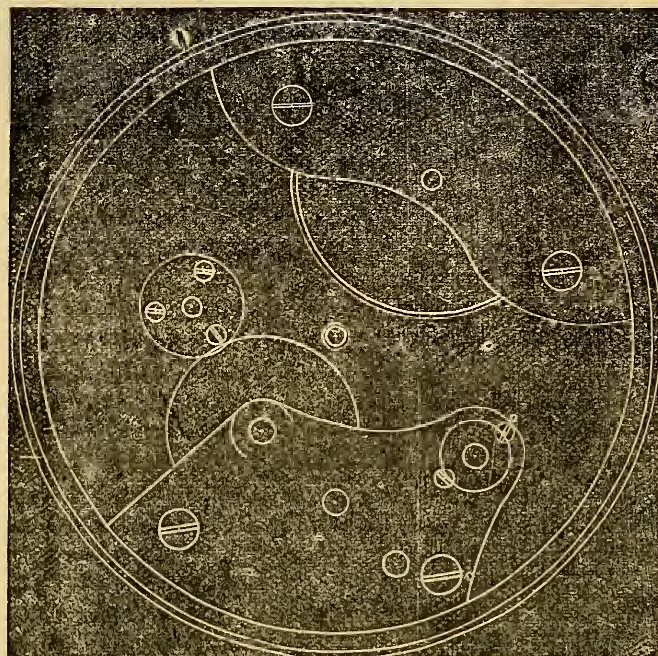
My movement, of the modified disposition, has a diameter of 46 m.; its height is also 7.2 m., the height of fusee 3.8 m., and that of barrel 3.9 m.

The height of frame being equal in both cases, it will be evident that there is a considerable advantage in the arrangement I propose:—

	Height of Fusee.	Breadth of Spring.
In my movement....................	3.8 m.	3.9 m.
In the English movement.............	3.2 m.	2.65 m.
Difference in favor of the former.......	0.6 m.	1.25 m.

Compared to the English movement, the construction with the centre wheel above

Fig. 28.



the fusee results in a percental gain in the height of fusee, of 18.74 per cent., and in the breadth of spring, of 47.17 per cent.

This latter is an increase of nearly one-half, and I think it may be considered a most essential improvemement of the fusee movement. From the following description and drawing, the reader may conclude that this gain is not bought at the price of any loss in the solidity of some other part of the movement.

The third wheel, in a movement of this kind, must get its place at the dial side of the pillar plate, under the fusee wheel. In all other particulars there is no difference from the usual position of the acting parts.

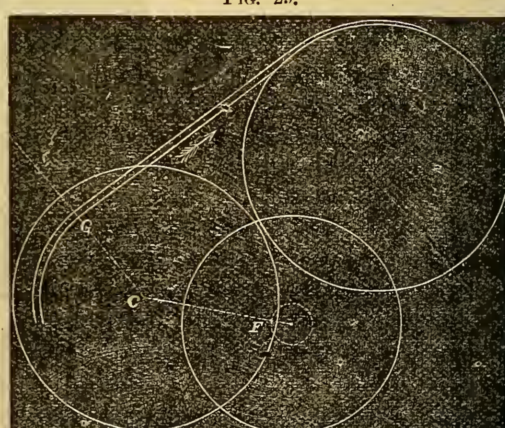
121. The respective position of barrel and fusee in all the English fusee movements is also irrational, and ought to be inverted. This latter position of the fusee would save a considerable amount of friction on the pivots, without a loss or disadvantage on any other side.

The pressure acting on the pivots of the fusee in the English movement is, by this defect of construction, the highest attainable maximum. The diagram, 29, represents the fusee wheel and centre pinion. In order to ascertain the pressure on the pivot, it must be supposed that the point of contact between the wheel and pinion at F is the fulcrum of a lever, on the other end of which G, the power transmitted by the chain, is acting. It requires no proof that the pressure on the fusee pivot C is equal to double the power exerted at G.

With the other plan of construction, illustrated by diagram 30, the fulcrum is the same, at F; the power acts very near it, and the pressure at the pivot C will consequently amount to about $\frac{1}{4}$ of the power exerted at G.

The difference of pressure in the two cases spoken of is as 8 to 1; and as the friction is in the ratio of the pressure, the advantage to be attained by this modification is considerable, though it must be remembered that the dif-

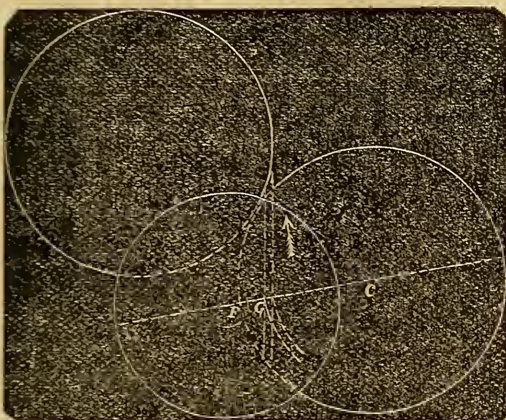
Fig. 29.



ference of pressure in the two cases is in the ratio of the pressure, the advantage to be attained by this modification, is considerable, though it must be remembered that the difference of pressure in the two cases is greatest when the chain acts at the bottom of the fusee, and diminishes towards the top.

of it; but even there it will be about as 4 to 1.

Fig. 30.



It is surprising that this arrangement, the advantage of which is beyond any doubt, and which is due to Julian Leroy, has not found any followers in England, the country of the fusee movement. It has been employed so much the more by French and German makers.

——o——

ALLOYS OF GOLD.

In the preceding article it was suggested that the discrepancies existing in the absolute qualities of gold goods—all asserted to be the same quality—might occur from the loose method of compounding them; very few melters being absolutely *sure* of the relative quantities and fineness of the metals from which they are compounded. When pure metals only are used there is no possible excuse for error; and if there be one, it should be christened with a more harsh name; cheat, swindle, or deception being a better word to use.

If ten pounds, ounces, pennyweights or grains, of chemically pure gold be melted with fourteen pounds, ounces, dwt., or grains, of some other metal, it will produce 10 k. alloy for a certainty. But if 10 dwt. of gold coin be melted with 14 dwt. of some other metal it will *not* make 10 k. alloy, because the gold coin is not 24 k. fine. Many manufacturers have taken the unwarranted liberty of calling an alloy 18 k. which is made up of 18 parts coin and 6 parts base metal.

When alloys of various qualities are compounded with each other, the resulting mixture is a little more complex. For instance, melt together—

11 oz. gold.................. 23 k. fine.
8 " .... 21¼ "
6 " .... 24 "
2 " base metal.

The resulting quality is easily found by multiplying

11 oz. × 23 = ... 253
8 " × 21¼ = ... 170
6 " × 24 = ... 144
2 " × 0 = ... 00

27 oz. 567 k.

$\frac{567}{27} = 21$ k. for the quality of the mass.

The complication increases somewhat when it is desired to produce an alloy of 18 k. from alloys of several different qualities, say 12 k., 22 k., 15 k., 20 k.; then it becomes necessary to know exactly the quantity of each to be taken to produce the required quality. The rules simply will be given without going into explanation of the "reasons for the rules." Write down the statement of the problem in this form.

18 k.	12	4
	15	2
	20	3
	22	6

Link, by a line, any quality of alloy *greater* than the desired quality to one that is *less*, and set the difference between the given quality and the quality sought opposite the number to which it is linked, and it will show you at once the quantity to be taken of each kind to produce the 18 k. desired. In proof that the result is correct we have

4 dwt. × 12 k. = ... 48
2 " × 15 k. = ... 30
3 " × 20 k. = ... 60
6 " × 22 k. = ... 132

15 dwt. 270 k.

270 ÷ 15 = 18 k. the quality sought.

The formula may be varied without affecting the truth of the result, as

18 k.	12	2 × 12 = ...	24	$= \frac{270}{15}$
	15	4 × 15 = ...	60	
	20	6 × 20 = ...	120	
	22	3 × 22 = ...	66	

Suppose you have gold 17 k., 18 k., 22 k., and wish to produce an alloy of 21 k. fine.

21 k.	17	.... × 1 = ...	17	$= \frac{189}{9} = 21$ k.
	18	.... × 1 = ...	18	
	22	(4+3)×7 = ...	154	
		9	189	

Again with some pure gold and some of 12k., 16 k., 17 k. and 22 k., you wish to produce 18 k.

18	12	.... $4 \times 12 =$	48	
	16	.... $6 \times 16 =$	96	$\frac{450}{25} = 18$ k.
	17	.... $6 \times 17 =$	102	
	22	.... $6 \times 22 =$	132	
	24	$2 + 1 = 3 \times 24 =$	72	
		25	450	

With a little practice there is no difficulty in reaching correct results. The problem becomes more complicated when any one of the ingredients is limited. For example, you have 10 dwt. 18 k. gold, some 16 k., 20 k., and 22 k.; you wish to know how much fine gold you must add to bring the alloy up to 22 k. fine.

22	16	.... $2 \times 16 =$	32	
	18	(10 dwt.).... $2 \times 18 =$	36	$\frac{440}{20} = 22$ k.
	20	.... $2 \times 20 =$	40	
	22	.... $2 \times 22 =$	44	
	24	$6+4+2+0 = 12 \times 24 =$	288	
		20	440	

This gives you the quantity of each of the various kinds to produce 22 k. Now there is 10 dwt. of the 18 k., and the same proportion must be taken of each of the other qualities. *Then as the difference against that quality whose quantity is limited, is to each of the other differences, so is the quantity of that to the quantity required of each of the others*, thus:

2 : 2 : : 10 : 10
2 : 2 : : 10 : 10
2 : 12 : : 10 : 60

Consequently the ingredients will be,

10 dwt.	16 k. (proof)	$10 \times 16 =$	160
10 "	18 k.	$10 \times 18 =$	180
10 "	20 k.	$10 \times 20 =$	200
60 "	24 k.	$60 \times 24 =$	1440
		90 dwt.	1980 k.

Often two or more of the ingredients will be limited in quantity,—as how much gold of 14 and 16 k. must be melted with 6 dwt. of 19 k., and 12 dwt. of 22 k., to produce an alloy of 20 k. fine?

First find what will be the quality of a mixture made of the given quantities of the given ingredients. In the case given these are,

6 dwt. 19 k. = 114 k.
12 dwt. 22 k. = 264 k. $= \frac{378}{18} =$ 21 K. fine.

From which the quantity of 14 and 16 k. can be found as previously shown.

20	14	....	1
	16	....	1
	21	$6 \times 4 =$	10

The proportions are there found as in

10 : 1 : : 18 (sum of the given quantities) : 1.8,

the quantity required of the 14 and 16 k.

Proof 1.8 dwt.	14 k. = ...	25 2		
1.8 "	16 k. = ...	28.8	$\frac{432}{21.6} = 20$ k	
6 "	19 k. = ...	114.0		
12 "	22 k. = ...	264.0		

Another case will often occur, when it is desired to produce a certain quantity of a given quality from various ingredients. Having gold 15 k., 17 k., 20 k., 22 k., you wish to melt up 40 dwt. of 18 k.

First find how much of each of these qualities are required to produce 18 k.

18	15	4	
	17	2	= 10.
	20	1	
	22	3	

Then as the sum of *all* the ingredients is to the required quantity, so is the quantity of *each* of the ingredients found to the quantity required. Thus

10 : 40 : : 4 : 16 of 15 k.
10 : 40 : : 2 : 8 " 17 k.
10 : 40 : : 1 : 4 " 20 k.
10 : 40 : : 3 : 12 " 22 k.

Or the proportions can be varied, and the result will be the same; thus,

18	15	2 which will give	8 dwt 15 k.
	17	4 " "	16 " 17 k.
	20	3 " "	12 " 20 k.
	22	1 " "	4 " 22 k.

From these illustrative examples, no one need be at a loss to readily figure out any combination of qualities and quantities with mathematical certainty.

Gold will unite with nearly, if not quite, all the metals, making alloys of more or less usefulness. Gold has a strong affinity for iron, and unites readily with it and with steel; 8 per cent. iron is a pale yellow-gray color, very ductile and tenacious, and harder than gold, 15 to 20 per cent. iron has a gray color, and takes a beautiful polish. 75 to 80 per cent. iron is so hard as to be very well adapted for cutting instruments, and is nearly the color of silver.

Copper, also, sustains most friendly relations with gold, freely uniting in any proportion. A very little sensibly alters the color of gold, and almost any desired color may be obtained by skilfully admixing copper and silver. The maximum hardness of copper and gold alloy is attained by the use of $\frac{1}{4}$

copper. All gold alloys are more fusible than pure gold.

Silver and gold also unite in all proportions, the maximum hardness being attained with $\frac{1}{3}$ silver.

The *green gold* of jewellers is 70.8 gold and 29.2 silver. To deepen the color of gold and silver alloy, the following composition is sometimes used :

1 oz. yellow wax.
2 " calcined alum.
12 " red chalk.
2 " verdigris.
2 " peroxide of copper.

All the ingredients except the wax must be ground to an impalpable powder, and mixed with the melted wax, moulded while plastic into sticks like sealing-wax. The surface of the gold to be darkened is rubbed over with the mixture, and heated till the wax be all burned off—then wash the article in a liquor;

1 pint water.
2 oz. ashes of calcined crude tartar.
2 " common salt.
4 " sulphur.

If designed to be bright, it must be burnished—not polished.

Manganese 1 part, and gold 88 parts, form a pale, yellow-gray alloy of considerable lustre and hardness, but little ductility.

Nickel and gold produce an alloy of brass-yellow color, quite brittle.

Cobalt and gold unite, forming a dull yellow brittle alloy.

Antimony unites with gold, but the most minute quantity entirely destroys its ductility.

Tin and gold form a compound more fusible than gold, and is somewhat ductile when *cold*, but easily crumbles at a red heat.

Zinc in very small quantities renders gold brittle. Melted gold will absorb sufficient of the *vapor* of zinc to render it brittle.

Lead in any quantity as minute as $\frac{1}{2000}$ will impair the ductility of gold.

The vapor of arsenic, in contact with heated gold, renders it brittle; and the minute quantity so absorbed cannot be separated, even at a very high temperature.

Such facts go to show most conclusively that the slovenly, careless manner of handling and melting gold, in many shops, is the cause of the great difficulty experienced in getting gold to *work*. The smallest particle of zinc, lead, tin, antimony or bismuth, creeping in accidentally with a lot of old gold, and going into the crucible, will make long hours of painful labor, and perhaps never be eliminated, except by refining. Inquiries come in public and private from all quarters, for instruction how to make brittle gold "work." In nine-tenths of the cases, more or less of these base metals are in the bar and refuse to vacate; they wont be entirely burned out, nor will they leave by rolling and remelting and fluxing; sometimes, by persistent means of this sort (depending on what the obnoxious metal is) they are diminished to such an infinitesimal quantity that the artisan is able to get it to work. All such stuff had better be sent at once to the refiner; get pure metals, alloy them properly and carefully, and such troubles will seldom vex you.

——o——

REMINISCENCES OF AN APPRENTICE.

MAKING PINS.

I was not a precocious boy, and was slow to learn anything good ; still the solicitude of earnest parents and the labors of faithful schoolmasters, which were sometimes of a decidedly physical nature, instilled or developed something within me, and the day I left school I chanced to be at the head of every class that I was learning in. However, this circumstance may be partly explained by the fact, that although the school was a large one, I was the only pupil in some of the classes.

The minds of the boys in our town wandered mostly on a seafaring life, but my father and the leading watchmaker of the town arranged that I should go and be a watchmaker. The watchmaker wanted an apprentice and my parents desired to see me learn a respectable trade and be at home. At first, when it was proposed to me that I should learn to be a watchmaker, I did not care much about it ; I wanted to go to sea ; but after a time I was persuaded to give the watchmaker's place a trial, and I was taken down to "our maister" and duly installed as his apprentice. I certainly thought "our maister" to be the most wonderful of men.

He could turn brass and steel into beautiful shapes in the lathe, and make the chips fly off as easy as I could cut wood with my knife. He could bore a hole in a piece of iron as quick as the blacksmith could do by heating it and driving a punch through it, and he could even saw a piece of brass or iron in two with the same ease as a carpenter could saw a piece of wood.

"Our maister" commenced operations on me by trying to initiate me into the mysteries of making iron pins for clocks ; but, although it was pins that I was making ostensibly, the real object was to learn me to turn the hand-vice regularly, and file articles round. The ordeal that I went through in mastering the operation, I can never forget ; and probably "our maister" never will either. First of all, I was too little and could not reach up to the bench; but "our maister" got a stool made for me which raised me high enough, and it suited very well, except when I stood too near the end of it, it would fly up and I would tumble down.

In making pins, I had first to cut the wire into lengths all the same, then they had to be straightened with a hammer ; and although the wire had to be filed all over, "our maister" would not allow a deep hammer mark to be seen in the wire, and it had to be made so straight that you might twirl it round in your fingers without seeing it move. The wire was held in a hand-vice in the one hand, and the file worked with the other. I had to lay the hand-vice in the palm of my left hand and catch it with my fingers a little above the middle, lay the wire on the wooden block, and turn my hand backward and forward, and in twisting the hand-vice forward I had to let it slip round in my hand a little each time. Then, with my right hand, I had to hold the file and press on it with my forefinger. I had to push the file slowly from me at the same time that I turned the hand-vice towards me, and while I had to press hard on the file in pushing it from me, I had to pull it back without any pressure, and I had to push it out and in perfectly straight ; and all these things "our maister" insisted on my doing without any deviation whatever from his established modes of procedure. I tried my best, but made but little progress at anything, except tumbling off the stool, and bruising my fingers. Making pins seemed little less than persecution to me, and sometimes, when "our maister" would be displeased with the manner I was handling the tools, and when he would come to show me the right way, if the wire would slip from the block, as sometimes it would, I felt a savage delight at seeing "our maister" knock his fingers up against the vice or the block, which was an inward pleasure to me at the time that compensated for a whole week of making pins, although now I am sorry that ever he hurt his fingers on my account. After many weeks' labor, with but little intermission, I could turn the hand-vice and handle the file to please him, and the pins I made were round and of a gradual taper ; but my troubles were not yet at an end as I thought they were, for I had to learn to smooth-file, draw-file, and burnish them. This was not so difficult to learn, although they had to be burnished with an oval burnisher till they looked like silver ; yet, in small pins, this was not a matter of much difficulty to me, except that I very frequently pricked my fingers with the pins.

At length, after all the coils of iron wire in our town, as I thought, were exhausted, I was put to making brass pins for watches. After the severe drilling I had got in learning to make the larger iron ones, I found making watch pins a comparatively easy matter. I soon learned to turn the pin-vice with my finger and thumb in a regular manner, and although I could never do it as well as "our maister" could, I did it to please him, and that was about as much as, at that time, I cared about.

I now think the same as "our maister" did, that it is a great acquisition to a workman to be able to make pins as they ought to be made. The pin itself is of greater importance than is often attached to it; besides, the ability to turn the hand-vice regularly is a great advantage in doing other work necessary to be done about a jobbing watchmaker's bench. Apprentices, learn to make pins! I do not wish to persecute you, but you will never regret it if you learn to make pins thoroughly, although you do begin with large ones first.

THE PENDULUM

AS APPLIED TO THE

MEASUREMENT OF TIME.

NUMBER FOUR.

DEAD-BEAT ESCAPEMENTS—GRAHAM'S—ANCIENT AND MODERN METHODS OF DRAWING IT OFF—DRAWING OFF SO AS TO HAVE A RECOIL—LE PAUTE'S, OR THE PIN-WHEEL ESCAPEMENT—COMPARISON BETWEEN IT AND GRAHAM'S — DIFFERENT METHODS OF JEWELLING AND ADJUSTING—GENERAL OBSERVATIONS ON DEAD-BEAT ESCAPEMENTS, ETC.

There are two classes of dead-beat escapements used in clock-work where the pendulum receives its impulse direct from the weight or spring. The one form is known as Graham's invention, and the other as Le Paute's, or the pin-wheel escapement. In the journals and magazines published about the middle of the last century, we find considerable discussion on the subject of the priority of invention, and the various merits of the two systems. From these discussions it appears that Graham had one of his escapements applied to a clock before the year 1720; and on French authority it is asserted that the escapement made by Clement, which we noticed in the last number of the JOURNAL, was a dead-beat one. We can find no trace or mention made of Le Paute's escapement till about thirty years after Graham's was put in operation, and other two French gentlemen, named Biesta and Caron, claim to have invented the pin-wheel escapement, while, on modern authority, it is also claimed for Whitehurst, of Derby, England.

FIG. 1.

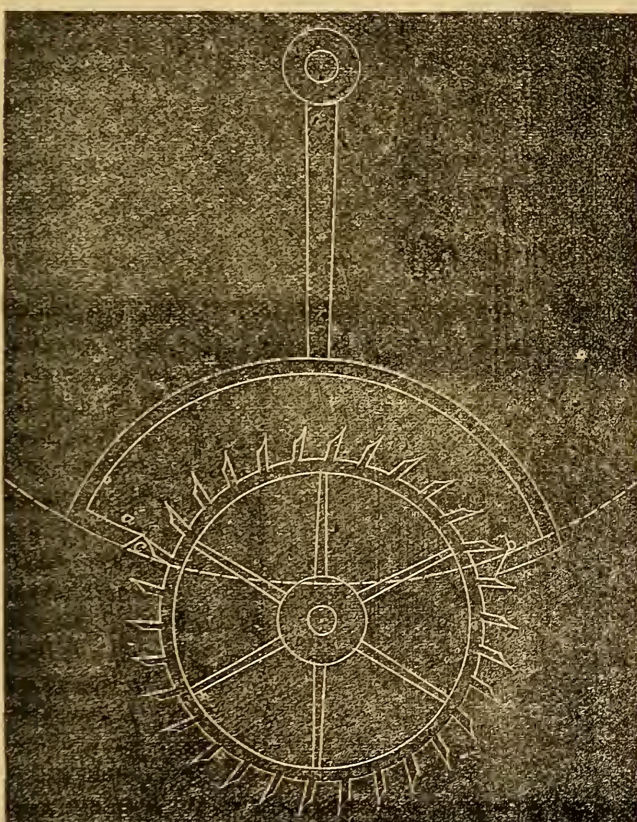
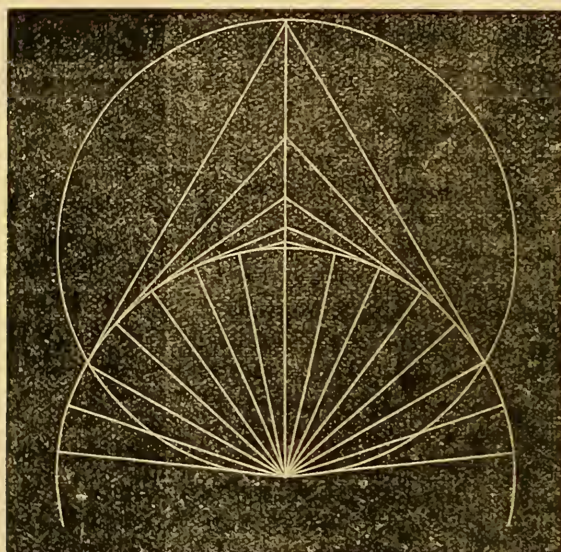


Figure 1 is an exact and full-sized representation of Graham's escapement, as it was originally made by Mr. John Shelton, who was employed by Graham for that purpose, and the following is his description of its action, and his method of drawing it off: "The tooth *c* having just escaped from the pallet, *a*, the opposite pallet instantly receives the full shock of the tooth *b* on its circular arc; and the vibration proceeding, this pallet enters deep between the teeth, but not so far as to touch the bottom, the swing (scape) wheel and second-hand remaining motionless till, by the succeeding vibration, the tooth *b* is brought to the edge of the inclined plane of its pallet, at which instant it begins to act, pushing away the pallet till it escapes at the lower point, when immediately another tooth, striking on the circular part of the other pallet, rides at rest upon it till the inclined plane begins to present itself, and then following the slope of the pallet, pushes it away, and at last escapes, as did the first tooth *c*; and so on."

This is the rule that was employed for drawing this escapement off: "Describe a circle, whose diameter is that of the intended swing (scape) wheel, and through its centre draw a perpendicular or vertical line, prolonged afterwards; then if the number of teeth in the swing (scape) wheel be thirty, as in clocks vibrating seconds, set off on the circle on either side the vertical point (from an exact line of chords) an arc of 69°, the double whereof, 138°, is the exact space taken up by eleven teeth and one-half, on the same circumference. From the centre of the circle to the points of 69° draw radii, and on their extremities erect perpendiculars, whose intersection in the vertical line will be the centre of motion of the anchor represented in the figure; the circle passing through the extreme points of the teeth of the wheel, shown also in the figure. From the centre of motion, through the points of 69°, draw a circular

FIG. 2.



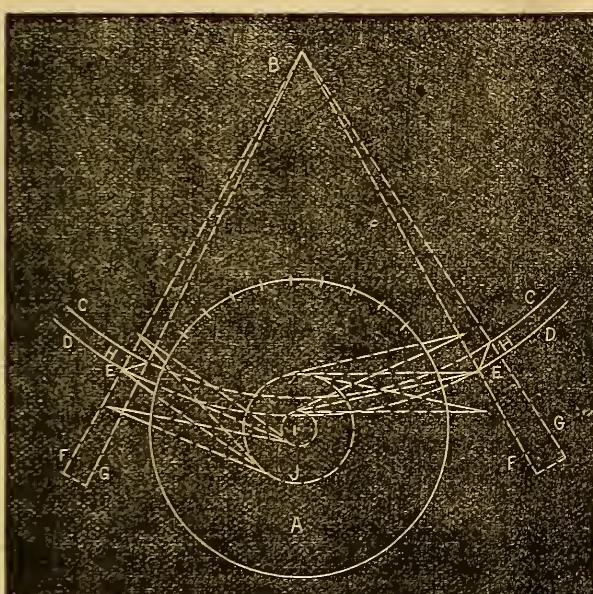
arc, with which that part of each pallet of the anchor, which receives the last scaped tooth, and keeps the second-hand from recoiling, must coincide, as the figure shows; lastly, the inclined planes of the pallets must make an angle of about 60° with lines drawn from the centre of the wheel to their obtuse terminations." Such was the first method that was used for constructing the Graham escapement, and the rule has been followed to a certain degree ever since, but modified somewhat according to the notions of the workmen who used it.

It is quite a common thing for some workmen to imagine that in making an escapement, the pallets ought to embrace or take in a given number of teeth, and that number which they suppose to be right must not be departed from; but there seems to be no rule that necessarily prescribes any number of teeth to be used arbitrarily. The nearer that the centre of motion of the pallets is to the centre of the scape-wheel, the less will be the number of teeth that will be embraced by the pallets. Figure 2 is an illustration of the distance between the centre of motion of the pallets and the centre of the wheel required for 3, 5, 7, 9 and 11 teeth in a wheel of the same size as the circle; but although we have adopted these numbers so as to make a symmetrical diagram, any other numbers that may be desirable can be used with equal propriety. All that is necessary to be done to find the proper centre of motion of the pallets is first to determine the number of teeth that are to be embraced, and draw lines from the points of the outside ones of the number to the centre of the wheel, and at right angles to these lines draw other two lines, and the point where they intersect each other will be the centre of motion of the pallets.

It will be seen by the diagram (No. 2) that by this method the distance between the centres of motion of the pallets and that of the scape-wheel is equal to the diameter of the scape-wheel, when eleven and one-half teeth are to be embraced, and that the distance is much shorter than that obtained by the Graham method of making his own escapement. This shortness may be imagined by some to be objectionable, on the supposition that it will take a heavier weight to drive the clock; but it can easily be shown that this objection is altogether imaginary, with no reality in it. If the distance between the centres is very long, as in Graham's plan, the value of the impulse received from the scape-wheel, and communicated through the pallets to the pendulum, is no doubt greater; for, the arms being long, the leverage is greater; yet we must not suppose that from this fact the clock will go with less weight, for it is easy to see that the longer the pallet-arms, are the greater will be the distance the teeth of the scape-wheel will have to move on the circular part of the pallets. The extra amount of friction, and the consequent extra amount of resistance offered to the pendulum, caused by the extra distance the points of the teeth run on the circular part of the pallets and back again, destroys all the value of the extra amount of impulse given to the pendulum, in the first instance, by means of the long arms of the pallets. It is for this reason that moderately short arms are used in clocks having dead-beat escapements of modern construction. Some of the first-class London makers of astronomical clocks only embrace eight and one-half teeth, with the centres of motion of the pallets and scape-wheel proportionably nearer.

Figure 3 shows a modern method of drawing off a Graham escapement. A is the wheel, and B is the centre of motion of the pallets, which point is found in the way shown in Figure 2 ; D D is a circle that has its centre at B, and C C is also a circle having its centre at the same point. The circle D D determines the angle that has to be given to the scape-wheel teeth, which must be undercut a little, so that the points of the teeth will only rub on the circle D on the one side, and C on the other. The faces and backs of the teeth are tangents to the circles I and J. The diameters of these circles are not arbitrary, but may be of any size to suit the particular angle required for the teeth. F F are dotted lines, drawn from B, so as just to touch the points of the teeth E E, and the dotted lines G G are drawn at an angle a short distance from F F, the one nearer to the centre of the wheel, and the other farther from the centre. The distance between the circular lines D and C determine the thickness of the acting faces of the pallets, which ought to be just a trifle less than half the space between the points of the teeth. The distance between the lines F and G determines the length of the angle of the impulse planes of the pallets H H. These planes begin at the one line and end at the other ; consequently the length of the vibrations intended to be given to the pendulum are regulated accordingly. For example, if it be desired that the angle of escape should be one degree, or that the bottom of the pendulum should move one degree from the point of rest before the teeth of the escape-wheel escapes, then the distance between the lines G and F must also be one degree of a circle, whose radius is B F, and the impulse angles drawn as the distance between these indicates.

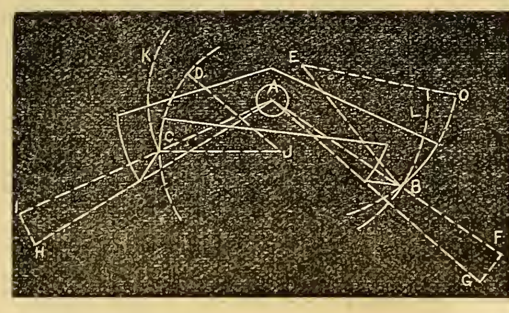
Fig. 3.



It will be observable that the modern Graham escapement differs from the original one in this particular, that the arms of the pallets are of unequal length. Figure 1 shows that the acting faces of the pallets are on the same circle ; while in Figure 3, the acting faces of the pallets are circles of two different diameters, and, consequently, one pallet-arm is the thickness of the pallet longer or shorter than the other. This discrepancy is, however, considered to be of no practical disadvantage, as at first sight it would appear to be; for, although the value of the leverage may be different in the one arm from that of the other, the difference is always *constantly the same,* and on that account it exercises no pernicious effects on the regularity of the pendulum, more than is exercised when the arms are exactly the same length.

Figure 4 represents a style of pallets much used in French clocks that have short pendulums, and the same principle is likewise

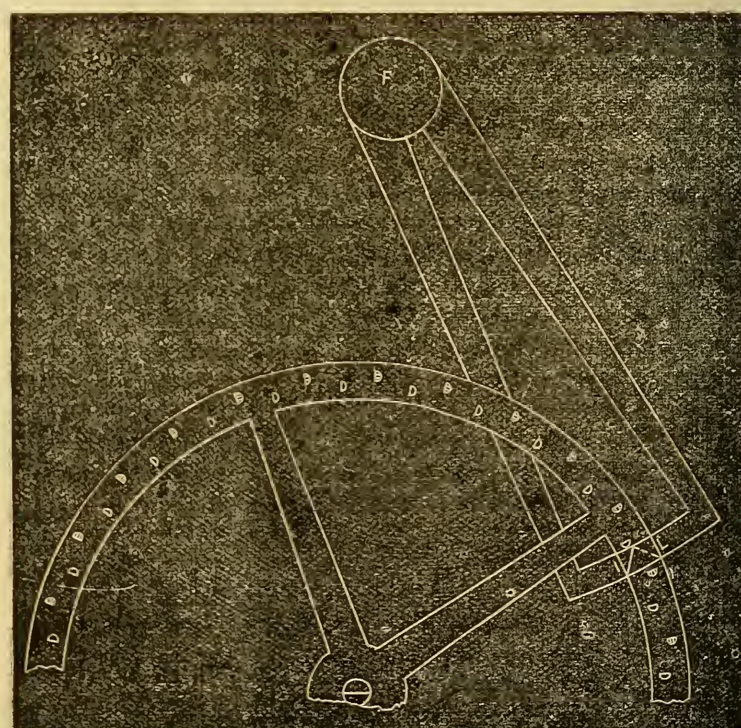
Fig. 4.



employed with great advantage in various descriptions of British clock-work with long as well as with short pendulums. It may be termed a half dead-beat, for while it has the impulse planes of the dead-beat, it has also a little recoil. This escapement is well adapted for all kinds of clock-work that is to be placed in situations where they are likely to be neglected, or where the motive power is limited, and when that power is liable from any cause to vary. It differs in nothing from the dead-beat except that the acting parts of the pallets, instead of being a true circle, are shaped so as to produce a slight recoil of the scape-wheel. The distance between the centres of motion of the pallets and scape-wheel is determined by the same method as shown in Figure 2, and the acting faces of the pallets by the same method as shown in Figure 3. Figure 4 shows the method practised in drawing off both the dead-beat and recoiling escapements. A is the centre of motion of the pallets, and the lines K and L are a circle that has its centre at A. The dotted lines I H and F G are to determine the angle of the impulse planes, the same as shown in Figure 3. The line C is a circle that has its centre at J, and the line B is one that has its centre at E. Therefore, it will be noticed that instead of the tooth of the wheel working on the circle K L, it works against the circles C and B, and a recoil is thereby produced. The amount of recoil is determined by the different positions the points E and J may occupy. These points can only be determined by some obtuse trigonometrical calculations, which we deem to be inexpedient to introduce here. In the meantime it may be an incentive to some of our young readers to study the subject, and when the present series of articles are completed we may give a more elaborate notice of this particular subject.

Figure 5 represents a view of the Le Paute,

Fig. 5.

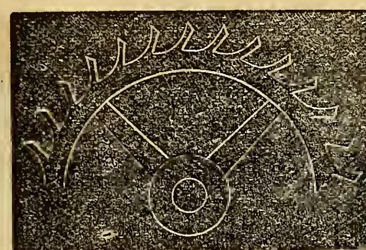


or the pin-wheel escapement, as it was originally made. The wheel had 60 pins set on its sides, 30 on each side, and the pallet-arms were placed a short distance apart, and the wheel worked between them. I and L are the acting faces of the pallets, which are a true circle, the centre of which is F. The wheel, as shown in the drawing, is supposed to be turning towards the right, while the pins strike both the pallets downwards; whereas in Graham's escapement, the one pallet is struck upward and the other downward. The impulse is given to the pendulum by inclined planes, in the same manner as in Graham's. The main object Le Paute and his contemporaries had in view in constructing this escapement was to have the acting faces of the pallets a circle of exactly the same radius, and the impulse-planes levers of the same length that would give an equal impulse to the pendulum at each alternate beat, and thereby contribute to the regularity of the vibrations of the pendulum. We have already noticed that while the system of making the arms of the pallets levers of the same length is entirely harmless, and quite a plausible theory, the advantages gained are not of that high benefit one at the first would suppose.

The modern method of constructing the pin-wheel escapement is to place the pallets perpendicular with the outer edge of the wheel, to have only one set of pins, and to have them made of hard brass, while both pallets work on the same side of the wheel, and the one pallet-arm is about the thickness of a pin shorter than the other. When the pins are cut away, so as to form half cylinders, with the flat sides in a line with the centre of the wheel, an escapement can be made in this way with very little lost drop. It seems curious that, while the originators of the pin-wheel escapement were so very particular about having the pallet-arms levers of the same length, so as to give an equal impulse to the pendulum, they should lose sight of the effects of placing the pallets at the angle represented in the diagram. It seems that, although the pallets were constructed to give an equal impulse to the pendulum, the weight and pressure of the pallets, working in that position, would destroy all the advantages supposed to be gained; because, when the pendulum moves in one direction, it has the pallets to lift up, and when it moves in the other, the weight of the pallets press on the pendulum, which amounts practically to the same thing as the unequal impulse they studied so much to avoid.

Sometimes what are known from their appearance as club-shaped teeth are used in the wheels of Graham's escapements. Figure 6 represents their outline. Pendulums receive their impulse from escapements made in this manner partly from the pallets, and partly from the scape-wheel. The advantage gained by this system is, that wheels made in this way will work with the least possible drop, and, consequently, power is saved; but the power saved is thrown away again in the

Fig. 6.

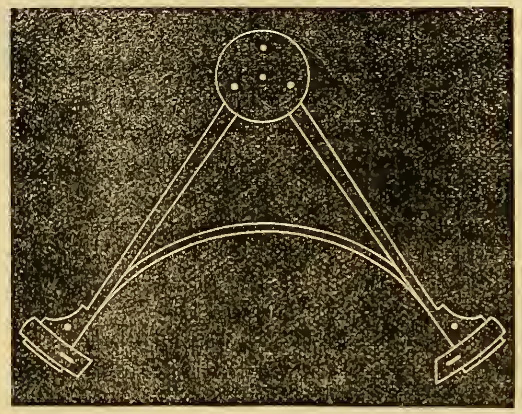


increased friction of the wheel against the pallets, which is considerably more than when plain-pointed teeth are used.

Clock pallets are usually made of steel, and jewels set into them, after the same fashion as jewels in steel pallets in a lever watch; but it is obvious that pallets made in this way have to be finished with polishers held in the hand, and that they cannot be made so perfectly regular, especially that pallet that is struck downwards, as the particular action of a Graham escapement requires. When great accuracy is required, the pallets are usually made of separate pieces, and the acting circles ground and polished on laps, running in the lathe, that have been made for the purpose. This method of constructing pallets also allows a means of adjustment, which in some particular instances is very convenient.

Figure 7 shows a plan of making jewelled pallets adjustable, which is practised in London, and also in the United States. The pallet frames consist of two pieces of thin hard sheet brass, cut out as shown in the diagram. Circular grooves are cut in the sides of both plates, at the proper distance, and of the proper size, to receive the jewels marked I I, which are the acting part of the pallets. When jewels cannot be made that size, pieces of steel are made, and jewels set into the steel large enough for the wheel to act upon. The two frames are fastened at a given distance apart, and the two jewels, or pieces of steel, go in between them, and, after they have been adjusted to the proper position, are fastened tight by screws that pull the frames close together and press against the edges of the jewels. Pallets made in this manner have a very elegant appearance. Another method is to have only one frame,

Fig. 7.



and to have it thick enough, where the jewels have to be set in, to allow a groove to be cut in its side as deep as the jewels, or the pieces of steel that hold the jewels, are broad, and which are held in their proper position by screws. This is the system of jewelling pallets adopted by the Altona clockmakers, and many others on the continent of Europe and elsewhere.

Fig. 8.

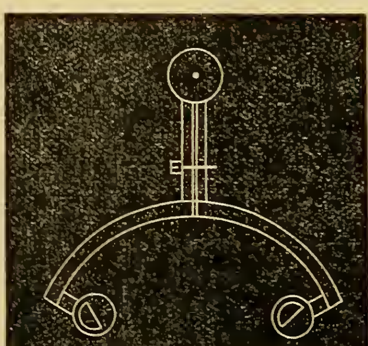
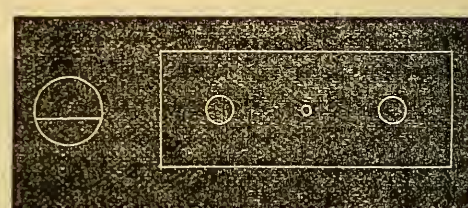


Figure 8 represents a system of making and jewelling pallets much used by the French in their small work. The acting part of the pallets are simply cylinders, the one half of each being cut away. These cylinders extend some distance from the front of the pallet frames, and work into the wheel the same as the action of a Graham escapement—the round part of the pallets serving as impulse planes. The neck of the brass frame is cut up in the centre, and the width between the pallets is adjusted by a screw, as is shown in the diagram.

In adjusting an escapement, perhaps it may be advisable to mention that moving the pallets closer together, or opening them wider, will only adjust the drop on the one side, while the other drop can only be affected by altering the distance between the centres of the pallets and scape-wheel. This is accomplished in various ways. Figure 9 shows the French method, which consists of

Fig. 9. Fig. 10.



an encentric bush, riveted in the frame just tight enough to be turned by a screw-driver. Figure 10 shows another plan, which is simply pieces of brass fastened on the inside of the frames. The pivots of the pallet axis work in holes in these pieces, and an adjustment of great accuracy is obtained by means of screws. However, we do not approve of adjustments of any kind, except in the very highest class of clocks, where they are always likely to be under the care of skilful people, who understand how to use the adjustments to obtain nicety of action in the various parts.

In making escapements, lightness of all the parts ought to be an object always in view in the mind of the workman, and such materials should be used as will best serve that purpose. The scape-wheel, and the pallets and back-fork, should have no more metal in them than what is necessary for strength or stiffness. The axis of the pallets, and also the axis of the scape-wheel, should be left pretty thick when the wheel and pallets are placed in the centre of the frame. We have often been puzzled to find out the necessity or the utility of placing them in the centre between the frames, as they are so generally done in English clock-work. The escapement acts much firmer placed near to one of the frames, and it is just as easy to execute it in this way as in the other.

It is often assumed that the friction of the teeth on the circular part of the pallets of a dead-beat escapement is small in amount, and unimportant in its value. With respect to its amount, we believe it is often not far short of being equal to the combined retarding forces presented to the pendulum independent of that of the escapement; and with respect to its being unimportant, this assumption is founded on the supposition that it is always a uniform force, when it is easy to show that it is not a uniform force. It is very well known that the force transmitted in clock trains, from each wheel to the next, is very far from constant. Small defects in the forms of the teeth of the wheels and of the leaves of the pinions, and also in the depths to which they are set into each other, cause irregularity in the force transmitted from each wheel to the next; and the accidental combination of these irregularities, in a train of four or five wheels, makes the force transmitted from the first to the last exceedingly variable. The wearing of the parts, and the change in the state of the oil, are causes of further irregularities; and, from these causes, it must be admitted that the moving force of the scape-wheel is of a variable quality, and a more important question for consideration than it is usually supposed to be. To avoid the consequences of this irregular pressure of the scape-wheel on the pallets being communicated to the pendulum, is a problem that has puzzled skilful mechanicians for many years; for, although we find the Graham escapement to be pronounced both theoretically and mechanically correct, and by some authorities little short of perfection, we find some of these same authorities—both theoretically and practically—testify their dissatisfaction with it by endeavoring to improve on it. In Europe the experience of generations, and the expenditure of small fortunes, in pursuit of this improvement, through the agency of gravity, and other forms of escapements, proves this fact; while of late years, in the United States, much time and money has been spent on the same subject, and results have been reached which have raised questions that ten years ago were little dreamed of by those clockmakers who are generally engaged on the highest class of work.

While considering this class of escapements, we would say a few words in regard to the size of escape-wheels generally used. We can see no reason or necessity for continuing the use of a wheel the size Graham and Le Paute used, and which has been the size generally adopted by most makers who use these escapements with but few exceptions. The Altona clockmakers, and those who follow that school, make wheels much smaller for Graham escapements than the London makers do; while the Boston clockmakers make them smaller still. On the continent of Europe the wheels of Le Paute's escapement are made much larger than they are made in England and in the United States. No wheel, and more especially a scape-wheel, should be larger than will just give sufficient strength for the number of teeth it has to contain, in proportion to the amount of work that it has to perform. The amount of work a scape-wheel has to perform in giving motion to the pendulum is of the lightest description, and not more than one-tenth of what it is popularly supposed to be; therefore we do not consider that we take extreme ground in recommending wheels for these escapements to be made one-half the size their originators made them, and the pallets drawn off in proportion to the reduced size of the wheel. It is plain that by reducing the size of the wheel its inertia will be reduced, and the same effect will be produced by making the teeth the shape shown in Figure 3, in preference to those shown in Figure 1, because they are lighter, while they both are of equal strength. When the teeth begin to act on the inclined planes of the pallets, the wheel will be set in motion with greater ease, and the amount of the dead friction of the scape-wheel teeth on the inclined planes and circular part of the pallets will also be proportionably reduced by making the wheel smaller.

MONOGRAMMATIC ART.

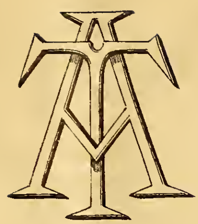
The art of pleasing, caught from the thousand fancies of loving hearts to adorn the object of its devotion, and to dwell on the cherished name, finds its most beautiful exponent in the monogrammatic art. The fancy is as ancient as letters. Some of the oldest monuments of history exhibit these pleasant conceits of designing, and the rubrics and missals of the mediæval age, with their monkish illuminations, still present some of the marvels of tasteful and elaborate designing by hands that seemed only to strive how long they could employ themselves on a word or letter. The idea is involved in the composition of the word *monos*, single, and *gramma*, being a design, cipher, or character, inwoven as *one letter*, or *monogram*. They were used on coins, standards, seals, coats-of-arms, and tapestries in ancient times, and later, as signatures by princes, ecclesiastics, notaries, etc. Plutarch mentions them, and many Greek medals show them in the time of Philip of Macedon, and Alexander the Great. As a key to the monuments and documents of the middle ages, the knowledge of the subject is important, and forms a part of a diplomatic education. The art was kept alive by the artists and engravers, and even now continues in their hands. The ancient art was beautifully illustrated in Montfaucon's "*Paleographie Grecque*," and an elaborate German work was published in 1747, by John Fr. Christ. *Brouillott's "Dictionnaire des Monogrammes*," a celebrated work, was published in Munich in 1820, and this is the latest special work on the subject until the present.

The general considerations to be observed in monogrammatic designing is to mingle clearness and obscurity, involving and implicating the general design, while the elements are clear and obvious, when unlocked by the key. The surname initial demands a special prominence, and there is no other limitation but the ingenuity and patience of the artist. Different grounding or tinting of each letter gives distinctness to the combination; but this is not always essential except to prevent confusion. The scrip letter and the Gothic are still the most available for the best ideas, from their curves and points, and flowing lines, and yet a fancy rendering of the Roman and block letter produces some most attractive fancies. The art of seal engraving has always required the monogram since the decline of heraldic devices. Even now some of the best artists in this branch are the French, English, and American seal engravers and lapidaries. Recent fashions in jewelry give to the monogram the prominent feature in designing, and lockets especially present the finest tablets for the most elaborate work. The brooch, the sleeve-button, and the earring, are also thus designed, and some exceedingly beautiful work is made by engraving the monogram only, clear, out of sheet gold, finishing the edges. Any round, square, oval, or tablet form, and particularly the escutcheon figure, are the best grounds for engraved, enameled, embossed, or applied profiled designs. A beautiful fancy vest button is also a popular idea.

For jewellers, engravers, and lapidaries, a work has just appeared, which, without a word of text or introduction, exhibits a collection of exquisitely beautiful designs. The work is published by J. Sabin & Sons, 84 Nassau street, New York. Over 1,000 designs cover the whole field of alphabet, and two and three letter designs, and many of whole names and mottoes, on the same plan. As the work of some of the best native artists, as well as of some of the most select foreign designs, it deserves the notice of the curious and the artistic. It will prove an unfailing resource to the manufacturing jeweller and the engraver, as well as the students of the beautiful. To unravel some of these intricate subjects is really a pastime to a refined taste. There is always a kind of pleasure in unfolding a perplexity, and some of the elaborate ingenuities of the better class of monograms really demand an accomplished eye and experienced taste.

Doubling, and reversing, and inverting letters, increases the perplexity, and improves the general outline, for the best designs are those which make an even and harmonious outline figure. As diversions, these fancies have always been popular with artists, for their breadth of scope for quaint fancies. The most difficulty lies in making a selection

A S



A T

A T

A T

A T

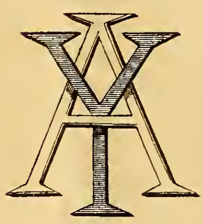
A U

A V

A V

A W

A X



A Y

A Z

from a number of conceits, each of which seems more beautiful and unique than all the rest.

——o——

ANSWERS TO CORRESPONDENTS.

S. E. F., *Pa.*—You are wrong in this respect. You cannot take more power out of any machine than you put into it. A watch, to go a week, must have a spring seven times stronger than one that goes twenty-four hours with the same number of turns; besides, you must allow something more for friction. In constructing any machine you can *waste* power, but never *make* it.

C. O., *Ct.*—When your arbors get bent in hardening, they can be easily and effectively straightened by placing them on a piece of soft iron, and striking them on the *hollow side* with the pin of the hammer. Arbors should be tempered in oil, and not by bluing, as you practise. A more regular and uniform temper is obtained by smearing them with oil and burning it off.

G. B., *N. Y.*—You will find the following formula for a solution for cleaning tarnished silver or plated ware, as good as any that are sold by travelling "humbugs" for a good price. It is used and recommended by the principal plated ware manufacturers:

Dissolve one-half pound of cyanide of potassium and one-half pound salts of tartar in one gallon soft water. Dip the tarnished article in the solution for a *few seconds only*, and wash with clean hot water, wipe dry with a soft towel or chamois skin. Be careful not to take the solution into the stomach, as it is a deadly poison.

W. S., *Philadelphia.*—We are not aware of any small motors for sale that would answer your purpose. There are many inventors at work trying to perfect such machines, but it would appear that there are difficulties to overcome greater than any has yet been able to surmount. If a spring is to be used as a source of power, why not try and construct one yourself at your leisure hours? The intelligent watchmaker is far better fitted for arranging springs and transmitting power through wheels and pinions, than any other class of mechanics. Such a contrivance is greatly wanted by others as well as by yourself, and there is a sure fortune in it to the man that can produce the machine desired.

Y. B., *Mass.*—We have but little faith in trade secrets and have no sympathy with the system of peddling them around. In most cases these kinds of secrets have their foundation in ignorance. Everybody ought to know that blue can be taken from a steel surface without repolishing it.

S. W., *Virginia.*—You can prevent your steel from rusting by the action of vapors by dissolving a given quantity of white wax in twice its weight of benzine and applying it with a brush.

E. R., *Mich.*—Such expedients are like the various devices for lathes and tools of *gentlemen* turners, who waste their time and cut their fingers in ineffectual attempts to make a box worth 25 cents, with tools that cost $1,000. The skilful workman requires no such aids, and you cannot accomplish your object in any other manner than by skill and dexterity, acquired by study, practice, and great perseverance.

J. C., *St. Johns, N. B.*—No, we have no time ball in New York. The ball you saw at the entrance to our Central Park is only a signal that the ice on the ponds in the park is safe for skating. There are three different methods by which the time indicated by a standard clock is made visible to a large number of people. In Boston the City Government use the city fire alarm telegraph as a means of indicating noon, by striking one blow on all the fire bells in the city. In some parts of Europe a cannon is fired off daily at 12 or 1 o'clock by automatic machinery in connection with a standard clock. In some instances several guns many miles apart are fired instantaneously from the same clock by the use of the electric telegraph. Time balls are probably the oldest methods used for indicating the time to shipmasters for ascertaining the rates of their chronometers, if they have them on shipboard when in port. Of all the methods, firing off a cannon is probably the most effective, for besides making itself visible to the senses by sound, one who requires great accuracy can also notice the flash of light from the gun, and thereby the advantages of a time ball and a time bell are all concentrated in a time gun.

R. S., *Jersey City.*—Use benzine. It is a better and much cheaper liquid for dissolving greasy matter than alcohol, and it does not dissolve shellac if it be used in fastening any parts of the instrument. See page 114 of the second volume of the Journal.

F. M., *Boston.*—Mr. James Queen, 64 Nassau street, N. Y., can execute your order. We had frequent occasions, as you are aware, to use jewels of peculiar forms, and those made by Mr. Queen were always exactly the same as the models, and their general appearance bore the marks of an artist in his profession.

——o——

THE HOROLOGICAL JOURNAL.

As nearly every subscriber to the Horological Journal has been a reader of the two volumes now completed, it is hardly necessary to speak at length of either the past or future. No branch of the mechanic arts can boast of more intelligent artisans than are to be found among the practical horologists; and as it is from this class that the Horological Journal receives its support, it is presumed that they are fully aware of whatever of merit it may possess.

As soon as the present essay from the pen of Mr. Grossman is completed we expect to have the pleasure of presenting another from the same source, as also contributions from other noted Horologists in Europe, in addition to the best talent to be procured in our own country. As it is universally acknowledged that Mr. Grossman is the most eminent Scientific and Practical Horologist now living, his contributions possess a value that can hardly be overestimated.

For the many complimentary messages and kind wishes received in our daily correspondence, we can find no adequate expression of gratitude in words, and can only hope to show our appreciation thereof by a constant effort to render the Horological Journal still more worthy of the generous support of the practical Horologist.

EQUATION OF TIME TABLE.

GREENWICH MEAN TIME.

For June, 1871.

Day of the Week.	Day of Mon.	Sidereal Time of the Semi-diameter Passing the Meridian.	Equation of Time to be Subtracted from / Added to Apparent Time.	Equation of Time to be Added to / Subtracted from Mean Time.	Diff. for One Hour.	Sidereal Time or Right Ascension of Mean Sun.
		S.	M. S.	M. S.	S.	H. M. S.
Th.	1	68.41	2 32.05	2 32.04	0.367	4 38 6.76
Fri	2	68.47	2 23 07	2 23.05	0.383	4 42 3.31
Sat	3	68.52	2 13 71	2 13.69	0.399	4 45 59.87
Su.	4	68.57	2 3.98	2 3.96	0.414	4 49 56.43
M..	5	68.61	1 53.88	1 53.86	0.429	4 53 52.98
Tu.	6	68.66	1 43.43	1 43.42	0.443	4 57 49.54
W.	7	68.70	1 32.65	1 32.65	0.456	5 1 46.10
Th.	8	68.74	1 21.56	1 21.55	0.468	5 5 42.65
Fri	9	68.77	1 10.17	1 10.16	0.480	5 9 39.21
Sat	10	68.81	0 58.51	0 58.50	0.491	5 13 35.77
Su	11	68.84	0 46.61	0 46.60	0.502	5 17 32 33
M..	12	68.88	0 34 47	0 34.46	0.511	5 21 28 89
Tu.	13	68.90	0 22 11	0 22.11	0.520	5 25 25.45
W.	14	68.92	0 9.56	0 9.56	0.527	5 29 22.00
Th.	15	68.94	0 3.14	0 3.14	0.533	5 33 18 56
Fri.	16	68 95	0 15.97	0 15.97	0.538	5 37 15.13
Sat	17	68.96	0 28.95	0 28.93	0.542	5 41 11 68
Su.	18	68 97	0 41.96	0 41.95	0.544	5 45 8.24
M..	19	68.98	0 55.04	0 55.03	0.545	5 49 4.79
Tu.	20	68 98	1 8.14	1 8.13	0.545	5 53 1.35
W.	21	68.98	1 21.24	1 21.23	0.544	5 56 57.91
Th.	22	68.98	1 34 32	1 34.30	0.543	6 0 54.47
Fri	23	68 97	1 47.34	1 47.31	0.540	6 4 51.03
Sat	24	68 96	2 0.27	2 0.25	0.536	6 8 47.58
Su.	25	68.94	2 13.10	2 13 08	0.531	6 12 44.14
M..	26	68.92	2 25.79	2 25.77	0.525	6 16 40.70
Tu.	27	68 90	2 38.32	2 38.29	0.519	6 20 37.26
W.	28	68 89	2 50.68	2 50.64	0.510	6 24 33.82
Th.	29	68.86	3 2.85	3 2.82	0.503	6 28 30.37
Fri	30	68.83	3 14.80	3 14.77	0.493	6 32 26.93

Mean time of the Semidiameter passing may be found by subtracting 0.19s. from the sidereal time.

The Semidiameter for mean noon may be assumed the same as that for apparent noon.

PHASES OF THE MOON.

		D. H. M.
☉	Full Moon........................	2 18 27.3
☾	Last Quarter......................	9 12 37.3
●	New Moon........................	17 14 29 5
☽	First Quarter.....................	25 10 44.4

		D. H.
☾	Perigee..............................	2 18 1
☾	Apogee...............................	16 6.2

	° ′ ″
Latitude of Harvard Observatory	42 22 48.1

		H. M. S.
Long.	Harvard Observatory..............	4 44 29.05
	New York City Hall..............	4 56 0.15
	Savannah Exchange..............	5 24 20.572
	Hudson, Ohio	5 25 43.20
	Cincinnati Observatory	5 37 58.062
	Point Conception...................	8 1 42.64

	D.	APPARENT R. ASCENSION. H. M. S.	APPARENT DECLINATION. ° ′ ″	MERID. PASSAGE. H. M.
Venus.....	1	7 31 28.75....	+24 3 43.1.....	2 53.4
Jupiter....	1	6 7 52.02....	+23 22 55.9.....	1 29.6
Saturn....	1	18 36 44.16....	−22 23 42.2.....	13 56.2

AMERICAN

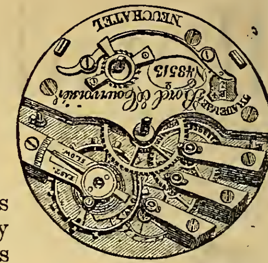
Horological Journal.

VOL. II. NEW YORK, JUNE, 1871. No. 12.

BOREL & COURVOISIER

CELEBRATED

NICKEL WATCHES.



These justly celebrated Watches were first introduced in this country in 1860, and have become as famous for their excellence of performance as they are justly celebrated for time-keepers in all the principal cities of Europe.

We can guarantee these Watches to perform with the same uniform regularity as those made by the best manufacturers in this or the European market. We have applied all the latest improvements to our Watches, such as full Ruby Jewelled Chronometer Balance, tempered and hardened Breguet hair springs; also, adjusting them with Equilibrium Escapements, all of which, to a practical man, is a warrantee that they are just what we claim, viz.: good as the best.

The Messrs. BOREL & COURVOISIER have taken the only prize medal granted a foreign manufacturer at the London Exhibition in 1862, and the grand prize at the recent Paris Exposition of 1867. We manufacture four grades of movements: extra, 1st, 2d, and 3d quality. The movements are made of a uniform size, so that they will fit any cases made in gold, silver, or patent filled gold, corresponding with the models which will be furnished by the undersigned, obviating the necessity of taking each movement apart to have cases made—on the same principle as the American Waltham Watches. We manufacture all the Swiss sizes, viz.: 15, 16, 17, 18, 19, 20, and 21 lignes.

The 15, 16, and 17 are for Ladies' Watches, 18 and 19 medium for Gentlemen, 20 and 21, large gents', and designated as follows :

No. 1, 2, 3	15 ligne., 16 ", 17 "	First quality Nickel Movement, Equilibrium Escapement, full ruby jewelled Chronometer Balance, Breguet hair spring, ¼ pl. Chaton jewel setting for Ladies' Watches	$23 00	Gold
4, 5	18 ", 19 "	Same as above, medium, for Gents	23 00	"
6, 7	20 ", 21 "	Same as above. large fo Gents	23 00	"
8, 9, 10	15 ", 16 ", 17 "	Same as above, with Chronometer Balance, plain ruby jewelled, plain hair spring, 2d quanty, for Ladies' Watches	16 00	"
11, 12	18 ", 19 "	Same as above, medium. for Gents	16 00	"
13, 14	20 ", 21 "	Same as above, large, for Gents	16 00	"

All the gents' sizes and qualities in Brass, at $2.00 less.

Gold cases in 14, 16, and 18 carat, always on hand, from 20 to 60 dwt.

Patent Gold Filled Cases, warranted to wear twenty years, from $25 to $30 each, according to size.

PRICES OF STERLING SILVER CASES,

With Gold Joints, First Quality Workmanship, in 2, 2½, 3, 3½, and 4 oz.

No. 15, 2 oz.	Sterling Silver case, gold joint, 1st quality workmanship	$11 00	Gold
6, 2½	" " "	12 50	"
17, 3	" " "	13 50	"
18, 3½	" " "	15 00	"
19, 4	" " "	17 25	"

When ordering any of the above Watches, be particular to mention the number on this list.

A discount of ten per cent. on all Movements and Silver Cases. An extra discount to dealers who will act as agents, and make it a specialty to sell them as a standard watch.

N. B.—All the first quality can be adjusted to Heat, Cold, and Position, for $25.00 currency, extra.

QUINCHE & KRUGLER, 15 Maiden Lane (Late 8 & 10 John St.), **N. Y., up stairs,**

Only Wholesale Agents in the United States.