A MANUAL

OF THE

STUDY OF DOCUMENTS

TO ESTABLISH THE INDIVIDUAL CHARACTER OF HANDWRITING

AND

TO DETECT FRAUD AND FORGERY

INCLUDING

SEVERAL NEW METHODS OF RESEARCH

BY

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TO

DR. EDWARD PEPPER

THIS WORK IS AFFECTIONATELY DEDICATED

BY

THE AUTHOR

PREFACE.

The first attempt to separate a branch of study from other cognate branches; to define it and establish for it an individual existence, is not always successful. Any one man is likely to be too much influenced by his own point of view, and thereby to include too much or too little.

But any earnest effort will be attended with the result of directing other minds to the subject, so that if the object be worthy its evolution will be aided, and if not it will be dropped. I have this conviction to fortify me for producing another book, and hope this subject will be given its final shape by abler hands if, as I believe, it has a reason for existing.

I have suggested *Bibliotics* as its name, because *Βιβλίον* (book, sheet, scroll, libel at law, etc., according to the best authorities) is broad enough to apply to any object which it may be desired to investigate, such as parchment, wax tablets, papyrus, printing-paper, stone, or, in fine, any substance capable of receiving and retaining characters. It will include hieroglyphics, writing, printing, or designs of any kind intended to impart specific information by symbols, in contradistinction to general impressions conveyed by art designs. It will include also all the materials used to

make tracings, such as paint, inks, and other coloring matters. In a word, *Bibliotics* would include the study of all the materials used in making designs for the transmission of intelligence, as well as the individual character exhibited in the designs themselves; and though it is distinct from art conceptions, from literary or historical criticism of the intelligence conveyed, and from accurate chemical investigation into the nature of bodies, yet it accepts and needs the aid of all three of these studies in obtaining its results.

It will follow that Bibliotics as such is not exclusively concerned either with the establishing of character, or the discovery of fraud, but includes both subjects.

The first of these I venture to call *Grammapheny*, from *Γράμμα*, a writing, and *φαίνω*, I demonstrate. It is the elucidation of the individual character of handwriting: that by which it distinguishes itself from every other handwriting.

For the art of detecting forgery or fraud in documents, seals, writing-materials, or in the characters themselves, I have suggested the word *Plassopheny*, from *Πλάσσω*, I forge, and *φαίνω*. This study is directed to any part of a written or printed or sculptured record, and makes use of all resources to test its genuineness. By its very nature it cannot be expected to demonstrate genuineness except by exclusion in its failure to demonstrate fraud.

Rather more space than would have been otherwise necessary has been devoted to Twisleton's book on

the letters of Junius because of the unjust attack which was made upon it, and the somewhat too complacent attitude of annihilator which Mr. Jeaffreson assumes in his memoirs. I do not think the method employed by Messrs. Chabot and Netherclift the best, but the book is the best example of what may be accomplished by that method, and in the case of the Junian letters it is convincing.

My personal thanks are due to Professor S. P. Sadtler, Ph.D., and to Mr. John Douglass Brown, Jr., LL.B., for valuable advice relating to the chemical and law portions of the book respectively; and to the Hon. F. Carroll Brewster, Mr. Samuel Dickson, Mr. George B. Johnson, Dr. Horace Howard Furness, Dr. D. G. Brinton, and Professor E. D. Cope, for the loan of documents and other courtesies.

I have freely used the books mentioned at the end of the manual wherever I thought their contents assisted me in making the subject clear.

PERSIFOR FRAZER.

JUNE, 1894.

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INTRODUCTION.

Owing to the author's inability to find a less pretentious title for this little work, he has ventured to call it a manual or hand-book; but he means what the word implies, and not what Gmelin meant when he published a hand-book of chemistry in eighteen volumes and an index. It is intended to be taken in the hand, and is so shaped that it may be placed in the pocket.

The following pages cannot pretend to meet all the wants of the student of handwriting, but they may be found useful for reference, and to suggest means of attacking a problem which might be overlooked.

Although the subject of which the little book treats has claimed the attention of civilized man ever since there have been records traced in characters and committed to the custody of guardians, there has been no comprehensive treatise on it discovered by the author of this book. Here and there in the technical journals articles have appeared on one or more subdivisions of this unnamed study (which for the want of a better word may be termed *Bibliotics*, or the study of the essential characters of documents), but no at-

tempt has been made to classify the subject and to put its branches in their proper places.

Under the general head *Bibliotics* come in order *Grammapheny*, or the determination of the specific character of a handwriting, and *Plassopheny*, or the exposure of forgery and falsification in either writing or documents. *Grammapheny* is that investigation which aims to extract from a sufficient number of characters written by the same hand the type which is the result of the physical structure and habits of an individual, and by which that writing is distinguished from every other.

It is not uncommon for questions of the greatest interest to attach themselves to such a determination totally apart from any question of fraud or forgery.

As instances may be mentioned the classic investigations of the handwriting of the letters of Junius, which will shortly be referred to again. A novel and equally interesting problem in connection with a case of double consciousness, involving a difference between the acts performed in one state from the same acts performed in the other, was submitted to the author by Dr. S. Weir Mitchell, of Philadelphia. It consisted in the comparison of two different handwritings corresponding respectively to the two different mental states of Mary Reynolds.[1]

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[1] Mary Reynolds: A case of double consciousness, by S. Weir Mitchell, M.D., Transactions of the College of Physicians of Philadelphia, April 4, 1888.

These studies are directed to the establishment of certain elements of script, which are the external expressions of inherent peculiarities of structure, will, and imaginative power of the person who has written, but they are not to be confounded with the amusing but somewhat fanciful methods of graphology. The patient analysis of the elements of character in handwriting differs from graphology as craniology differs from phrenology so called, astronomy from astrology, or the study of finger-prints from palmistry.

As a general rule, the method of pursuing this investigation has been similar to that in judging of works of art. The question has been addressed to the unaided eye and to the judgment unfortified by data, as to whether certain marks or symbols or groups of them were like or unlike.

That splendid specimen of honest painstaking work by the Hon. Edward Twisleton, assisted by Messrs. Charles Chabot and Frederick George Netherclift, exhausts the subject of the comparison of the writing in the letters of Junius, the writing of the anonymous note, and the writing of the anonymous verses to Miss Giles, and seems to connect Sir Philip Francis indubitably with the first two, and Richard Tilghman, of Philadelphia, with the last. But to do this it requires 289 pages of large quarto form, thickly strewn with cuts and engravings, and whole pages of facsimiles, not counting 266 plates containing all the letters in controversy, and many others which bear

upon it. One is struck with astonishment at this wealth of illustration, this unstinted generosity of plates and text figures, and with admiration at the dignity of tone of the whole text; but one is tempted to ask whether the conclusions finally reached might not have been attained in a much less tedious and expensive manner. The appearance of the book might have suffered, but probably the results would have been just as firmly established by the system of measurement and composite photography, of which descriptions will be found in later chapters.

The author (Hon. Edward Twisleton) has enhanced the value of this contribution, important not only to the Junian discussion but also to general literature, by his admirable style, his impartiality, and his earnestness. The example of his thoroughness, his disregard of the difficulties of exhaustive research, and the consequent delay and cost, may be imitated with advantage by those who take up a problem of this kind.

While modestly keeping his share of the joint work in the background, he says,[1] "Still, although Mr. Chabot has written his reports under professional responsibility, and they thus deserve to be read with more than ordinary attention, he is desirous—and I publish his reports with the same desire—that his conclusions should in no respect be accepted on grounds of mere authority, but that they should be judged of

[1] Preface, p. xiii, third paragraph.

entirely by the reasons which he advances in their behalf. It is important to bear this in mind, for it is the practice of inferior advocates in courts of justice where evidence on handwriting is given contrary to the interest of their clients, to indulge in rhetorical declamations against experts; and the same practice is sometimes adopted by others who have not the same excuse for desiring to avoid rational discussions."

No one could take a higher stand in relation to a subject on which he had spent so much time and thought.

As an illustration of the truth of the reference to "inferior advocates in courts of justice," the following excerpt is taken from a daily newspaper, which appeared some time in April, 1894, and had reference to a trial then attracting great public attention in the United States.

"The expert testimony was taken up and torn into tatters. He said it was time that legislation put a stop to this travesty on justice, where experts got $25, $50, $100 a day, according to how hard they were willing to swear. The time would come, he said, when the court, and not litigants in a case, would select the experts, and until that was done there would not be justice or decency in expert testimony."

It possibly did not occur to this advocate (an ex-Judge by the way) that his words, with little alteration, would convey the very stricture on his profession which he sought to throw upon experts. There are venal

and purchasable experts, and there are venal and purchasable attorneys; but fortunately neither one nor the other represent the class to which they belong. The allusion to this same subject in the body of the text was written before the above words were made public. It is there stated that while such a plan as the speaker proposed might indeed be better than the one now in vogue, it is probably inferior to the plan of compelling expert witnesses to give their methods and the results of their work, and to explain what conclusion, in their judgment, these results support. When this is done it will be competent for the opposing side to criticise their methods, results, or conclusions, and to state the grounds on which the criticism is based. If these are too technical to be readily comprehended by the jury, the court's expert might with advantage be called on to explain them, and thus the question would be narrowed to one of fact.

The advantage of this method is that it allows full liberty to every litigant to employ what agents he may please, but it confines the expert testimony to such conclusions as he may justify by intelligible reasons, of the sufficiency of which the jury must form its own opinion. A great deal of rubbish would disappear from expert testimony if this rule were followed. If a witness endeavored to befog the jury, the court expert could be called to explain the real significance of the results reached by the former. Let expert testimony be defined by law to be such testimony as rests

upon the application of principles (which are susceptible of explanation, and, as explained, approve themselves to persons of average intelligence) by means of reasoning; such application being made by one skilled in the subject either by observation, experience, or investigation; the testimony being important to the attainment of conclusions material to the case on trial. Testimony which does not come under this definition should not be admitted as expert testimony.

When there is presented before a court of law a document, of which it is important to know whether a part or the whole of the body, or the signature, or all, is actually in the handwriting of some person whose writing or signature in other exhibits is admitted to be genuine, the counsel on each side usually seeks the aid of one or more handwriting experts.

Commonly a teacher of writing or a paying-teller of a bank is preferred. It must be confessed that there seems good reason for the latter choice, for the man upon whose immediate judgment as to genuineness of signatures (reinforced by a large knowledge of human nature and quick observation of any suspicious circumstance) depends the safety of a bank is likely to have gained much experience, and not to be easily deceived in the kind of cases coming daily before him. How much the average paying-teller depends upon the trifling circumstances attending the presentation of the cheque, the appearance of the person presenting it, the probability of the drawer inserting such a sum,

etc., becomes apparent when one has heard a number of these useful officers testify in cases where they are deprived of all these surroundings, and required to decide whether a certain writing is by the same hand which produced another writing, both being unfamiliar to them.

In this case they are obliged to create a familiarity with the signatures of a man whose character and peculiarities they have never known.

They miss the aid of some feature, such as a dash, a blot, or the distortion of a letter which would recall to them the character of the writer. Most of the best experts of this class confess that they cannot tell on what their judgment is based. They simply think that the writing is not by the same hand as that admitted to be genuine. "No," they will tell you, "it is not merely superficial resemblance. I don't know what it is, but I feel sure," etc. These witnesses are more frequently right than the more pretentious professors of pot-hooks and hangers. The former trust to the instantaneous impressions which they receive when papers are handed to them; the latter too often give their attention to the merely superficial features of chirography without getting beyond the more obvious resemblances and differences which are frequently the least important.

The case is analogous to that of the determination of a mineral species. There are many persons who, in spite of a lack of knowledge of chemistry and crys-

tallography, can readily determine a mineral species by looking at and handling a fragment of it. There are others more versed in book knowledge, who can write the formulas of most mineral species on the black-board, and repeat from memory the characters which each of these minerals should show, but who are very inferior to the first-class in actually detecting and naming a fragment at sight. But if the case is an important one involving the disposition of money, or the establishment of a principle, recourse is had to the analyst who determines, by repeated observations and complex processes in his laboratory, the real constituents of the substance. From his results there can be no appeal except as to the accuracy of his work and the soundness of the conclusions he has drawn from it. Yet this analyst may be very inferior to the first observer in power of instantaneous determination, and to the second in book knowledge.

Nevertheless, so deeply seated is the conviction, in bench and bar, that the only means of discovering a forgery is by comparing an undefined ideal in the mind with the writing in question, that in the review of the law in Pennsylvania by Chief-Justice Woodward, elsewhere quoted, it is expressly so stated.

It has occurred more than once in the writer's experience that papers have been handed to him, while on the witness stand, with the demand that he should state whether or not they were forgeries, and although he has always protested that this kind of guessing is

unworthy of occupying the time of the court, the presiding judge has on some occasions insisted that it should be done. It would be as reasonable to hand to a witness a piece of a cast-iron bar and require him to state, by inspecting it, how much phosphorus it contains, and whether it was run from the same furnace as another specimen.

The fundamental idea of an analytical investigation implies a careful and laborious study of all the facts by the use of instruments, and by the aid of methods which cannot be carried on in a court-room. Within reasonable limitations the more rapidly an opinion is formed the less value it has on this as on other subjects.

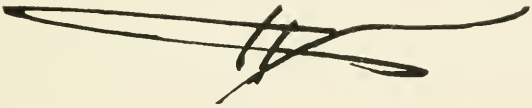
The procedure suggested in the following pages presupposes a place where observations can be carried on without surrounding distractions; instruments suited to the investigation; and plenty of time to make it. The court which requires an expert who bases his conclusions on this class of work to resort to the practice of guessing clearly oversteps its duty and does a wrong to the witness.

While considering the subject of expert witnesses the necessity of extreme caution in forming conclusions cannot be too strongly emphasized. The first legitimate conclusion which is likely to be reached in the course of discovering a fraud is merely that the document is suspicious, or cannot be proved to be genuine. Every contingency which the experimenter can

think of should be considered to explain away a circumstance seeming to corroborate the theory of fraud. Where a number of unlikely hypotheses must be invoked in order to explain the appearance, they will ultimately force the conviction of falsification, and this conviction is less liable to be changed if it has grown steadily in spite of all attempts to avoid it by explanations.

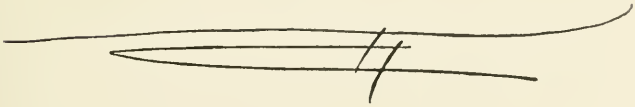
The following flourish line is an illustration of the necessity of caution in forming conclusions.

FIG. 1.



Upper sheet.

FIG. 2.



Lower sheet.

It occurred under a signature in the ordinary way. The writing was done on two sheets of paper separated by a sheet of carbon paper for the purpose of making a duplicate. The stroke was made rapidly and with some force, as was the custom of the writer. When the sheets were separated and examined, his surprise was great to find the lower flourish (which is the lower in the accompanying illustration) entirely different

from the upper one as to the direction of the line. Whereas the first stroke from right to left on the upper flourish turned downward abruptly, in the carbon copy it continued parallel to the edges of the paper. The only explanation is that in making it the pen-hand must have turned the upper sheet on the back of the carbon paper nearly at right angles to its former position, and the upper sheet must have come back to its place before the second stroke and the final vertical dashes were made. The final horizontal loop of the second stroke in the upper sheet was not repeated by the carbon paper on the lower sheet.

If an important issue had depended upon proving that the carbon copy was an identical reproduction of the upper writing, this non-agreement of the two flourish lines would very likely have been fatal to the establishment of what was actually the fact.

PART I.

PHYSICAL EXAMINATION.

CHAPTER I.

INDIVIDUAL CHARACTER.

The Manner of Writing.—For the purpose of this little work it is sufficient to consider the art of writing as practised by most civilized western nations. The writer has never yet had experience with documents in Japanese, Chinese, Arabic, or Persian, and only once in Hebrew characters. In all these cases the character of the writing instrument and the direction followed by that instrument (whether from left to right, right to left, or vertically upward or downward) would lead to new applications of the general principles herein noted, but would not change those principles in any respect.

In ordinary writing the page is laid on a support, usually near the edge of a table, and the hand holding the pen is laid either on or immediately below the paper. The elbow, some part of the fore-

arm,[1] or the side of the hand, is generally used as a pivot, and the hand somewhat bent, while the pen, supported by the fingers, moves across the paper from left to right, the fingers in the main producing the movement of the pen up and down, and the wrist, forearm, or shoulder giving the lateral motion necessary to execute any desired mark requiring a longer excursion than the fingers can perform.

Fig. 3 represents the ordinary position of the arm in the act of writing; a skeleton arm being selected in order to show the positions which the bones assume, and to draw attention to the fact that an essential part of the character of handwriting depends upon the habit of placing a particular part of this rigid structure on the table as a pivot around which, as a centre, the writing is traced. Habit enables the writer to prevent the appearance of a curve in the line of writing by compensating movements of the fingers. Every time the pivot is changed the pen is naturally raised from the paper, and therefore the number of

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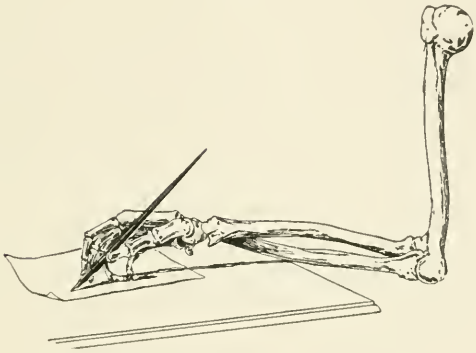
[1] "The forearms and not the elbows should rest upon the desk. The pen should be passed across the paper by a movement of the wrist and not of the arm."—A Manual of Handwriting, etc., by F. Betteridge, London, 1887.

It should be borne in mind that the author of these pages has no intention of entering the field of instruction as to the proper manner of writing, but merely wishes to represent the principal methods which are actually employed, whether they be faulty or not.

times the pen is removed from the paper will in great measure depend upon the length of the radius be-

Fig. 3.



tween the point of support and the point of the pen. In Fig. 3 the arm could write entirely across the note-paper page represented without curving the writing, by shifting its position once or twice, but it would not be easy to write fluently without such changes.

Fig. 4.

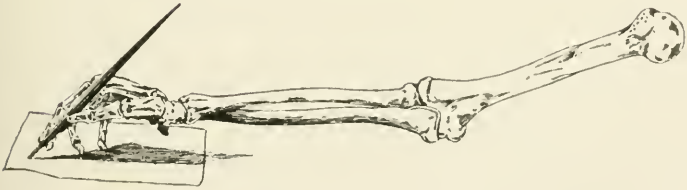
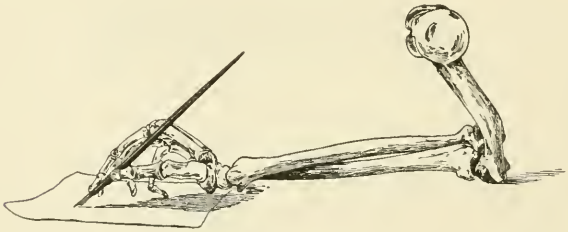


Fig. 4 represents the arm pivoted on the elbow, thus increasing by half the length of the forearm the radius of lateral motion, and rendering fewer changes

of position of the pivot necessary. Handwriting of experts in calligraphy is often made in this way. It permits a greater range of motion and allows more paper to be covered without removing the pen.

In Fig. 5 the elbow, forearm, and wrist are all in contact with the table, and the range of free motion without change of position is as small as it can be for any given arm. In this attitude it would be necessary

Fig. 5.



to shift the arm continually at the conclusion of every one or two words traced on the paper. It is the position naturally assumed by those writing with a board on the lap, in bed, or on a very high table.

Of course these are but three of innumerable positions which may be assumed by a writer, but they are the most common.

Some writers who are obliged to sign their names very often, or who act as paying clerks in large mercantile establishments, write the few words continually demanded without touching any support at all with the hand or arm. Some pivot the wrist on the top of the table, others hold the pen in an unusual position

and bring different parts of the hand in contact with the paper. But however a man may write, if his style become a habit, it may be reduced to the elements of a fairly constant pivot and radius, and certain methods of using the fingers, which together give a character to the writing which may be detected wherever it is seen.

Position.—The hand soon moves so far along the paper that a new position must be taken by that part of the forearm or hand used as a pivot. This fact, together with the individual peculiarities of every bony structure, and the very different methods which different persons employ to avail themselves of it, is of prime importance in studying the results of these efforts in a page of writing or a signature. These will be more fully referred to hereafter, but it may be generally mentioned that some writers move the forearm at the end of every two or three letters, while others attain the power of compensating, by larger excursions of the fingers, for the naturally descending curve of writing traced by the pen.

The same peculiarities are noticeable in the manner in which the pen is lifted from the paper, some writers, and usually those who have a great deal of writing to do, lifting the pen only when the pivot must be changed, and others fashioning each letter separately and often leaving space between the individual letters of a word as large as between separate words. This latter habit is commonest among those

who have little writing to do, and among the aged or infirm.

Contraction of Habits in Writing.—These peculiarities, as well as the shading of the letters, and the hesitating or the determined manner of making dashes, dots, and flourishes, are all connected with the character of the writer, and have been made the subject of study with a view of reading the character of the writer by his handwriting.[1]

Of all the above, the manner of changing the pivot in writing is the most important object of preliminary study, because, when the points of change have been ascertained, the general slant or slope of the letters and the angles of the different parts of a single letter with the general direction of the line of writing are easily understood, and form an important guide for establishing the genuineness or non-genuineness of the writing.

The parts of a writing which demand the closest attention are those which have been made unconsciously and which are not easily noted by a superficial view. The height, the spread of the letters, the peculiarities of the endings, the flourishes, and the general shape are things which the forger observes and imitates, often with success; but the curvature of a letter in its different parts is not easily appreciated by the naked eye,

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[1] See The Philosophy of Handwriting, by Don Felix de Salamanca.

and cannot even be easily traced without showing under a magnifying glass distinct signs of hesitation and labored effort very unlike the unconscious ease of the genuine writing.

The peculiarities of the angle with the horizontal, and of the unconscious rise and fall of the lower extremities of the letter with reference to a real or imaginary line drawn from the beginning to the end of the signature, and sometimes called a "base line," and habits of shading or amplifying parts of letters too small to be seen with the naked eye are tests of value which can be applied by the aid of a simple horn protractor and magnifying glass, but which generally elude the scrutiny or evade the successful imitation of expert forgers. But there are variations in the separate parts of all long lines which come to view in examining a carefully-made composite under the microscope, which must ever defy imitation on account of their extreme minuteness, though they are fairly constant. Many of these have frequently been noted on a single long stroke of a capital letter, an "f," or the like. They will be more particularly mentioned under the head of the method by composite photography. It is to these peculiarities, inappreciable to the naked eye, and yet very constant in the habit of any writer, that the expert should give his most careful attention.

It is often asserted in trials that tracings of a genuine signature invariably show hesitation and painting. This is not always the fact. Tracings, proven, and

subsequently admitted to have been such, have shown an apparent absence of all constraint, and a careful examination of the result revealed no pause of the pen. But, on the other hand, these freely written tracings have invariably shown either a deviation from some habitual practice of the writer, or, if the model was followed with skill, two or three such tracings, when photographed on a transparent film and superposed, have shown such exact resemblances as to proclaim their character at once.

Evolution of an Ideal Pattern.—The natural tendency of man is to introduce some elements of symbolism in what he is obliged to copy, and to seek some sort of geometrical symmetry in what he designs. Wherever he is not restricted by certain forms which he must introduce, and which may render a balance of parts about a median line unattainable, he tends to evolve symmetrical designs, as in the highest and simplest forms of ancient architecture. When the parts of the design are prescribed, as in the representation of objects in nature, he soon tires of mere mechanical repetition of the same things in a given sequence, and strives to convey some ulterior idea by the manner of joining these parts. This gives life and language to sculpture and painting, and gives character to handwriting.

In the process of evolving a signature, which must be again and again repeated from an early age till death, new ideas occur from time to time, are tried,

modified, improved, and finally embodied in the design. The idea finally worked out may be merely a short method of writing the necessary sequence of characters, or it may present some novelty to the eye. Signatures consisting almost exclusively of straight up-and-down strokes, looking at a short distance like a row of needles with very light hair-lines to indicate the separate letters: signatures begun at the beginning or the end and written without removing the pen from the paper: signatures which are entirely illegible and whose component parts convey only the mutilated rudiments of letters, are not uncommon. All such signatures strike the eye and arrest the attention, and thus accomplish the object of their authors. The French signature frequently runs upward from left to right, ending with a strong down flourish in the opposite direction. All these, even the most illegible examples, give evidence of experience in handling or mishandling the pen. The writing most difficult to read is frequently the production of the hand which writes most frequently, and it is very much harder to decipher than the worst specimens of an untrained hand. The characteristics of the latter are usually an evident painstaking desire to imitate faulty ideals of the letters one after the other, without any attempt to attain a particular effect by the signature as a whole. In very extreme cases the separate letters of the words constituting the signature are not even joined together.

A simulation of such a signature by an expert penman will usually leave enough traces of his ability in handling the pen to pierce his disguise. Even a short straight stroke into which he is likely to relapse against his will gives evidence against the pretended difficulties of the act which he intends to convey. It is nearly as difficult for a master of the pen to imitate an untrained hand as for the untrained hand to write like an expert penman. The difference between an untrained signature and the trembling tracing of his signature by an experienced writer who is ill or feeble, is that in the former may be seen abundant instances of ill-directed strength, and in the latter equally abundant instances of well-conceived design with a failure of the power to execute it.

Observations such as the preceding are frequently of great value in aiding the expert to understand the phenomena which he meets, and they belong to a class which does not require the application of standards of measure, but only experience and memory of other similar instances of which the history was known, and a sound judgment to discern the significance of what is seen.

No general rules other than those referred to above can be given to guide the student of handwriting in such cases, but the differences will become sufficiently apparent with sufficient practice.

CHAPTER II.

THE WRITING INSTRUMENT.

Pens, Past and Present.—The age has been for two generations a steel-pen age. The greater number of forgeries have been accomplished by means of this instrument in deference to its all but universal adoption as the instrument of writing. It would be more exact to say that metal pens have superseded the old goose-quill, which latter is only found among the conservators of by-gone customs, along with shirt-frills and snuff-boxes.

Except that the old-fashioned article makes a "softer" pen,—*i.e.*, one with which less pressure is needed to induce a flow of ink,—the principle involved is the same. A semi-cylinder to retain the supply of ink by its capillary attraction, fashioned to a point split in two, so that by pressure a measurably broad column of ink may be made to rest upon the paper, and by moving the pen the liquid is left behind as a line which marks its course. More pressure is required to separate the nibs of metal pens, but the force required is seldom great, and the choice of a stiff or a yielding pen is the result of the habit of the writer to employ little or much pressure. One difference, however, is to be noted,—namely, that whereas

furrows made by quill-pen nibs are rare, they are, as a rule, easily observable under the microscope in writing which has been done by metal pens.

These furrows are often of importance in forming an idea of how the characters were traced, whether rapidly or slowly, with or without unusual tremor, etc., and in this respect metal pens (steel, gold, iridium pointed, etc.) add a characteristic worthy of notice to those left by quill-pens. Again, in old times, when the trimming of a pen was constantly undertaken in the course of any long writing, the same document was liable to show differences of thickness and smoothness of lines, free or ink-filled loops in different parts, even when written by the same hand and at the same sitting.

With a metal pen such changes are less likely to occur, and consequently one element of confusion is avoided.

It is sometimes of interest to note the fact that different parts of a writing have been made with different kinds of pens, fine- and coarse-pointed, broad-nibbed, stiff or pliant; and such observations have more significance in a steel-pen than in a quill-pen age. But latterly there has arisen a Mackinnon and stylographic pen rage which threatens to pervade all classes of writing, and to modify the methods of studying the tracings of the writing instrument in some degree. The principle of these pens, known by various names, is that of a hollow holder to contain

the ink, tapering to an acute hollow cone, the perforation being closed by a wire of platinum, tipped with iridosmine, or some other extremely hard substance, to resist the abrasion of the paper, and held down so as to prevent the continuous flow of ink, either by a small leaden weight (the Mackinnon) or by a fine spiral spring (the stylograph).

The pressure of the point upon the paper pushes back the tapering wire and allows the ink to escape around it to the paper. The writing appears under the microscope as a central shallow furrow on the soft paper, usually narrower than the ink line which stains the edges of the furrow for a greater or less distance from the margin, depending upon the breadth of the truncation of the hollow cone. The absence of the widening or narrowing of the ink-line by variations of pressure removes one mark by which forgery, tremor, or illiteracy may be indicated, while the nature of the instrument and its method of feeding the ink upon the paper destroys the possibility of shading, so dear to the heart of the calligrapher, but it has compensating advantages in the facility it furnishes to write uniformly, rapidly, with a constant supply of the same ink, without blots, and without the necessity of pausing to replenish the supply of writing fluid. Still the main characteristics which can be made the subjects of exact measurement remain, and the stylograph has not rendered the practice of forgery notably easier.

CHAPTER III.

THE WRITING FLUID.

Inks Usually met with.—The inks in common use over the United States at the present time, and for some years past, are not as numerous as one might be led to conclude. They are probably fifteen or at most twenty in all, including the most popular blue, red, magenta, and green inks. But among these there is a notable difference in character. Some are thick, heavy, and glossy in character, and flow sluggishly from the pen. Few of these become much darker by standing. In this class will be found the copying inks and those in which a large quantity of gums or similar thickening agents are used.

Other inks are pale, limpid, and flow easily from the pen, and this class usually shows a notable darkening by exposure to sunlight and air.

It will be unnecessary here to refer more particularly to the intermediate varieties or to discuss their various composition. The exhaustive treatise of Schluttig and Neumann on this subject may be referred to for further information than is contained in this little book.[1]

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[1] Die Eisengallustinten. Grundlagen zu ihrer Beurtheilung. Im Auftrage der Firma August Leonhardi zu Dresden, chemische

It should be remembered here that in the last twenty years, or since the introduction into general commerce of aniline colors, which Hofmann discovered in 1856, these latter have been employed more and more in writing fluids; not only in mixtures of which they are the principal ingredients, but to a greater or less degree in all inks. Their presence, even in small quantity, in the gallo-tannate of iron and logwood inks can be generally detected by an iridescent and semi-metallic lustre.

The presence of numerous blots and unduly thickened lines in writing will indicate a more than desirable flow of ink which may result from its fluidity, or the clumsiness or unnecessarily strong pressure of the writer, or both. In certain cases this may furnish a clue to assist in determining whether two writings or parts of the same document have been written by the same hand or with the same ink.

Judgment of Color and Shade.—The color or the blackness of one ink as compared with another are very difficult to judge by the naked eye, or when a broad is compared with a fine line. In very numerous cases an examination of the two lines under the microscope will lead to the reversal of a judgment formed by the assistance of the naked eye alone.

Fabriken für Tinten, bearbeitet von deren Chemikern Oswald Schluttig und Dr. G. L. Neumann. Mit 2 Holzschnitten, einer schwarzen und 2 farbigen Tafeln. Dresden: Zahn und Jaensch, 1890.

This kind of preliminary examination, which at first thought seems easy, had better be postponed and recourse had later to the microscope, which presents a smaller area with greater distinctness.

Other observations indicated above having been made, the free or cramped character of a signature or a word is often of importance in the preliminary examination about to be described. It happens not infrequently that the desire to get a given number of words into a definite space leads to an entirely unusual and foreign style of writing, in which the accustomed characteristics are so obscured or changed that only the systematic analysis to be detailed farther on can detect them. If there be no apparent reason for this appearance in lack of space, the cause may be the physical state of the writer or an attempt at simulation. If a sufficient number of genuine signatures are available, it can generally be determined which of these two explanations is the right one.

CHAPTER IV.

PRELIMINARY EXAMINATION.

Care of the Document.—At the very outset of an examination the greatest care should be taken to guard the document which is to be its subject from handling and soiling, and especially to protect it from

finger and other marks on the written characters. A suspected document is generally not in first-class condition when it comes to the expert, because expectant litigants who have scanned it, and, it must be said, some highly eminent attorneys, who ought to know better, are singularly careless about their treatment of an object upon which the fate of the litigation may turn. It is not unusual to find foreign pen-marks (!) on the pages of contested papers which could be traced to the careless handling of pens moistened with ink by attorneys or their clerks.

Usually it is the litigant who suspects that there is something fraudulent in the document, and by way of satisfying himself on the subject thumbs it or pricks it with pins, with as little regard for the consequences as if the delicate points to be investigated could not be obscured. If it be the counsel who first decides to subject the document to expert examination, it may fare little better. It would seem that a specific amount of rough handling and of extraneous matter deposited must pave the way to the conviction that the paper should be an object of scrutiny. As if the thumbing and pulling were not enough, it is usual for the keeper of the document to fold and refold the paper each time it is taken from its repository.

It is very strange that gentlemen who, more than all others, should know the value of keeping documents in their original state, and whose daily experience teaches them that continually refolding a paper must

wear, tear, and destroy it, should persist in doubling up a valuable paper every time it is used. A document which bears upon it the evidence which may convict a malefactor of forgery, or which may decide the ownership of a fortune, should be carefully and tenderly handled. It should be laid between sheets of clean white paper without folding, unless its size be so great as to render this very difficult, in which case it should be folded but once, and, if possible, in other than the original lines, and invariably so that the folds do not cross any important part of the paper. It is usually practicable to fold the document without crossing any lines; but when this is not the case, those parts of the instrument should be chosen which are immaterial to the investigation, no matter what sort of a form this leaves it in. In most cases the document can easily be laid out flat, covered with two pieces of clean writing- or wrapping-paper, and carried in a large envelope or portfolio. It is much better even to roll it lightly in its covering papers than to fold it after it has once been taken up for study.

Least of all should any object capable of imparting a color to the paper be brought near the part or parts of the document about which suspicion exists. In the interest of justice this should be as sacredly guarded as a ballot-box, for upon the testimony which it gives important questions may depend.

When the microscope is to be used to examine parts of the writing, it is usually necessary to fold the

document to bring the part to be scrutinized under the lens without interference from the stand of the microscope, which will only afford a space of but seven or eight centimeters between the brass upright and the axis of the lens.

In this case it is better to make new folds, and to steady the document on a plate of clean glass or metal of about five centimeters on a side, for it is usually convenient to remove the ordinary table for microscope-slides.

A photograph, if possible of natural scale, should always be taken before the investigation begins, either of the whole or of the important part of the document, and none but chemists, experienced in testing important papers, should apply reagents to them.

First Scrutiny.—It is a very useful preliminary to any physical investigation to look at the document carefully, reading its lines, and thus familiarizing one's self with the style of expression, as well as the character of the writing as expressed in the letters, the groups of letters, the spaces between words, and the placing of sentences. By doing this, and without any conscious effort, a certain general effect due to the writer's habit in dealing with these elements of individuality will dawn upon the observer. It is in this way that connoisseurs judge of the authorship of paintings or statues, and are enabled to distinguish copies and even replicas from originals.

In every case the investigator should endeavor to

think himself into the position of the writer whose work he is studying; to imagine himself opposed by the resistance of the little grain in the paper which has caused the pen to deviate or to sputter; to reproduce the sensation of not having space enough to finish a word which has caused the original writer to crowd his letters together unnaturally, and, finally, to be confronted with the problem (whatever it be) which the face of the document pretends the writer has solved by the means which have aroused suspicion, such as the alteration of a figure, the interpolation of a word, or a complete interlineation, etc.

When sufficient time has been taken to get all the light to be derived after attaining this frame of mind, the next step can be taken.

Scanning by Transmitted Light.—It is never amiss to look at the document placed between the observer and a strong daylight,—not often direct sunlight. A northern exposure is a very favorable light in this hemisphere for these studies as well as those of art. Transmitted light often tells tales on a forger, sometimes revealing erasures by the area over which a stronger light reaches the eye; sometimes by a water-mark which is inconsistent with the supposed date of the paper.

Mr. Sittl, of Munich, the eminent expert on handwriting, relates an instance of a document bearing the date of 1868, which was written on paper with a water-mark representing the eagle of the German

empire, which, as all the world knows, was not employed until after the French war, in 1870.

Remains of Tracings.—It sometimes occurs that the forger, fearful that his attempt to imitate another's writing would be too easily detected if made with a free hand, sketches in pencil the characters he intends to make in ink on the document, or traces them by means of blackened paper at the appropriate place. The evidences of this are very likely to appear when the document is examined in transmitted light.

General Style of the Document as a Whole.—When an entire document or page is forged, the ornamentation, flourishes, or capitals at its head will often be seen to be out of keeping, either with its nature or with the supposed author's habits in similar cases. As observed by Mr. Sittl, in a writing all must agree, place, day, year, handwriting, superscription or heading, signature, and material carrying the writing, especially paper, both as to constitution and color, and ink.[1]

Selection of a Method of Procedure.—A basis can usually be laid for the choice of a line of investigation by a careful study of the writing or writings by the unaided eye. It is to the unaided eye that these writings have been addressed, and to the unaided eye

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[1] Illustrirtes Lexikon der Verfälschungen, etc. . . . Herausgegeben von Dr. Otto Dammer, Leipzig. J. J. Weber, 1887. Article "Handschriften."

they tell their story, either simple and straightforward, or hesitating and suspicious, or labored and doubtful. The latter class of cases presents the greatest difficulties, for it is not always proof of spuriousness that the writing has been painfully and slowly produced. There are minds so easily impressed with a sense of responsibility, that the writing or signing of any paper important in its bearing on the writer or his property will cause him to disguise his hand to some extent involuntarily, as many persons disguise their features involuntarily when being photographed. It is not at all easy to distinguish by the naked eye alone between this form of disguise and a forgery, but it will generally be found possible to do so by the application of the methods described farther on.

Nevertheless, the contemplation of the writing or writings under investigation will generally result in putting one in possession of the general character of the hand, and will aid the after-study when it transpires through more minute analysis what causes the characteristic features.

An hour may usually be profitably spent in merely scanning each letter of a document, and the writing by lines, paragraphs, and pages before a closer scrutiny. Gradually, if the writing be genuine, its character will begin to reveal itself, and unconsciously an hypothesis as to the physical causes of the irregularities or characteristics will be formed. When this preliminary glance is concluded, some course will suggest itself for the

next step. If it be a question of the genuineness of a single signature, and thirty or forty undisputed signatures (the more the better) are at hand, the most universally applicable method to employ is that of a careful measurement of the sizes, distances apart, etc., of the letters and of their angles with some selected standard line.

CHAPTER V.

EVIDENCES OF TAMPERING.

Kinds of Forgery.—A forgery consists either in erasing from a document certain marks which existed upon it, or in adding others not there originally, or in both operations, of which the first mentioned is necessarily antecedent to the last; as where one character or series of characters is substituted for another.

The removal of characters from a paper is effected either by erasure (seldom by pasting some opaque object over the characters, painting over them, or affixing a seal, wafer, etc., to the spot where they existed) or by the use of chemical agents with the object of dissolving the writing fluid and affecting the underlying paper or parchment as little as possible.

Erasures.—If the erasure be affected by scratching or rubbing, this removes also the surface of the paper, which consists of some sort of "size" or paste with resin soap, which is pressed into the upper pores to

give the paper a smooth appearance, and to prevent the writing fluid from "running," or entering the pores and blurring the edges of the lines.

If the paper were left as it exists when the scratching or rubbing is completed, it would be very easy to see that it had been tampered with, for not only would the parts thus abraded show the running of any fluid which was subsequently laid upon them, but the surface would appear rough to the eye in comparison with adjacent parts of the paper, and the place would appear thinner by transmitted light. Even to the touch the surface would reveal differences from the ordinary condition of other parts of the paper.

But the forger usually endeavors to overcome these difficulties by applying to the scratched area sandarach, resin, alum, paste, or two or three of these together, the effect being to prevent an unusually large flow of ink from the pen and its abnormal absorption by the paper.

The paper should be placed between the observer and a strong light, by which means, either with or without a magnifying-glass, a distinct increase in the brightness of the suspected area may be noticed, indicating a thinning, and even traces of letters, or marks which have escaped the erasing-tool, may be seen.

A close scrutiny may show places where the surface has been partially torn, and the fibres of the paper united together into little knobs, and almost inva-

riably a magnifying-glass will clearly show the disturbance of the superficial fibres, as compared with other and normal parts of the paper. If the latter be tinted, the change of appearance may extend to color. The color of the paper should always be attentively observed.

Washing with Chemical Reagents.—A change of color over the part which is the subject of investigation may indicate the mechanical removal of the paper itself, or a washing either with water or with acids, alkalis, or saline solutions. A certain spotted character which follows this latter treatment differs from the changes of color due to age or soiling.

When the heavier strokes—usually the down strokes—of a writing are thicker and more blurred than usual a removal of sizing is indicated, or an original imperfect sizing of the paper.

On the contrary, where the strokes are thinner and closer together than usual, the cause is generally the application of resin, which has been added, in all probability, to conceal a previous scratching of the surface.

The spots produced by washing are more like penumbra, or blurred marks bordering the tracings of the character, and are generally colored.

Restoration of Original Marks.—In order to bring out any traces of ink-marks which have been so far removed as not to be observable by the naked eye, Coulier recommended the placing of the document

between sheets of white filter-paper and passing a hot flat-iron over it, allowing the latter to remain on the spotted parts for a short time.

Warmé preferred to wet the suspected document with alcohol, wrapped in another piece of paper also saturated with alcohol, for the purpose of bringing out as yellow rusty marks all the pen-strokes which had not been entirely removed by the forgers.

This treatment fixes the appearance of the spread lines and colored spots in the space that has been washed and renders more noticeable the stain caused by a partial sizing. In this manner apparently white papers on which at first no traces of characters could be found showed a yellow tinge, denoting the presence of previous writing, and on the application of gallic acid and an infusion of nut-galls became sufficiently distinct to permit the forgery to be detected.

Chevallier and Lassaigne discovered a very satisfactory method of making previous writings appear by the aid of heat.

The paper to be examined was placed near the fire in a stove, care being taken not to permit it to ignite, but to give it a pale yellow chamois color. In papers which had been deprived by washing of their writing the latter almost immediately reappeared.[1]

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[1] Dictonnaire des altérations et falsifications, etc., par Er. Baudrimont. Sixième édition, Asselin et Cie, Paris, 1882.

CHAPTER VI.

THE USE OF MAGNIFYING INSTRUMENTS.

Choice of a Magnifier.—Although a great deal can be determined in a general way by close observation with the naked eye, it is always best to employ some magnifying power,—usually an ordinary hand lens or pocket magnifier will suffice,—but the writer has found it better to use a microscope objective of low power (four or five diameters), which is provided with an easily-slipping sleeve, terminating in a diaphragm which cuts out the light entering the outside rim of the lens. This sleeve may be pushed out for one or two centimeters, and the particular spot under examination isolated from the adjacent parts without undue magnification. It is one of the popular fallacies that a high magnifying power is desirable in all cases of difficulty, but usually the reverse is the case in questions of handwriting.

Experts have sometimes impressed the jury with the fact that they had employed on some thick and opaque document, powers of several hundred diameters without the lately applied illumination from the side, reflected by a glass plate, introduced obliquely into the tube of the microscope. Without such aid no microscopist need be told that the light would be wanting

to illuminate the field under these circumstances. The best authorities prescribe a magnifying power of not more than ten diameters (*Hager and Holdermann: Untersuchungen*) for ordinary observations.

Restricted Use of Higher Powers.—For special purposes higher powers are sometimes useful, but seldom higher than ninety or one hundred diameters.

An ocular examination of the ink in the various parts of a written instrument will generally decide whether it is the same.

Aid to determine Slight Differences of Shade.—The judgment by the naked eye as to the colors or shades of two inks is very likely to be erroneous, as has been previously said, probably because, when a lighter ink is more heavily massed than a darker one, the effect on the retina is as if it were the darker. Under the magnifying glass the field is more restricted, the finer lines are broadened, and one has larger areas of ink to compare with less surface of strongly contrasted white paper. Similarly, an ink without noticeable bluish tinge to the naked eye may appear quite blue under the glass where the films of ink are broadened and thinned and their characters better observed.

The methods for detecting these slight differences by prisms of colored glass will be mentioned later.

In order to judge whether two marks have been made by the same ink, they should be viewed by reflected light to note the color, lustre, and thickness of the ink film. Many inks blot or "run" on badly-sized

paper,—*i.e.*, the lines are accompanied by a paler border which renders their edges less well defined.

Even on well-sized papers this class of inks usually exhibits only a stained line of no appreciable thickness where the fluid has touched the paper.

The copying and glossy inks, which often contain a considerable quantity of gum, do not "run" or blot even on partially-sized paper, and show under the glass a convexity on the surface of the line and an appreciable thickness of the film.

It does not always follow when an ink has made a blur on one part of the paper and not on another that the paper has been tampered with. A drop of water accidentally let fall on the blank page will frequently affect the sizing in that place, and, besides, all papers are not evenly sized in every part.

The inks rich in gum, or those concentrated by evaporation from standing in an open inkstand, give a more lustrous and thicker stroke. Some inks penetrate deeper into the paper than others, and some produce chemical effects upon the sizing and even upon the paper itself, so that the characters can easily be recognized on the underside of the sheet. In some old documents the ink has been known to so far destroy the fibre of the paper that a slight agitation of the sheet would shake out as dust much of the part which it covered, thus leaving an imperfect stencil plate of the original writing.

CHAPTER VII.

THE SEQUENCE IN CROSSED LINES.

Importance of Determination.—It often becomes important to determine which of two crossed ink lines was written first. Many cases of forgery depend upon the answer to this question, which therefore is one of more than general importance.

As a rule, when the underlying line has been drawn with a heavy black ink, and the overlying line with a lighter one, no direct observation in the usual way will suffice to determine their sequence with certainty.

Ink Lines Transparent.—Ink films which appear to the eye as black opaque lines in contrast with the lighter substance on which they are written are not so in fact, but, on the contrary, extremely translucent and even transparent, as an observation of an ink line made with a pen upon a piece of plain glass will show. Where the line is fine, as it is in ordinary writing, the obstruction which such a film would offer to seeing objects through it is much smaller than is generally supposed.

If a drop of the heaviest black ink be placed upon a plain glass microscope-slide, and a cover glass or another slide be placed over it, with slight pressure

the film will become as thin as it is after drying on ordinary paper. It will impart some color to the objects viewed through it, but it will not entirely obscure even very light lines or points on paper below it.

This being the case, we should regard two crossed lines as transparent films like two strips of lightly-colored glass crossing each other. The light which falls at the point of intersection penetrates to the paper below, and is reflected to the eye with a loss by absorption equal to the absorptive power of both of them together. That light which strikes but one of the lines loses in its passage through the film only so much of its rays as that one ink with the thickness in which it appears is capable of absorbing. Consequently the absorption at the point of intersection of the limbs of the cross will be greater, and the color darker than on either of the two branches which make the cross. Each of the films is usually so thin that it is impossible to observe any stereoscopic effect when the direction of light is perpendicular to the plane of the paper. Two phenomena, however, may sometimes be observed in this way, which bear upon the question of superposition.

Widening of the Upper Line.—The overlying line is likely to show a widening which is masked at the small area of their intersection for the reason just given, namely, because their respective effects upon light over this little square are so blended that they cannot be separately distinguished by the eye, but if

the colors or shades are sufficiently different to enable the eye to distinguish one ink from the other (as is likely to be the case if any considerable period of time have elapsed between the tracing of the two lines), the line of the later ink will often be seen to broaden just before it traverses the first, and to narrow on leaving it. See Plate I., Fig. 1, which is a photograph of a cross made with red ink and magnified twenty-four diameters. The line *c d* was drawn over *a b* while the latter was wet. Observe the broadening of the descending line *c d* at the first and its narrowing at the last contact with *a b*. If the two fluids are indistinguishable in color, lustre, or shade, etc., this method will fail. The broadening effect due to capillarity will be greater when the lower line is still wet than when it is dry.

Plate I., Fig. 2, represents a twelve-fold linear enlargement of part of a letter in a signature. The straight line passes over the curved line. The broadening of the straight upper line as it crosses the curved line from left to right, and its narrowing on leaving it, are probably due to the passage of the ink line into and out of the sphere of capillary attraction of the still moist underlying line. Plate I., Fig. 3 represents the same object magnified thirty-five diameters.

Staining of Straggling Fibres.—The other observation also applies to those cases where there is a visible difference in the appearance of the two inks whereby the overlying ink imparts its color, or lus-

PLATE I.

FIG. 1.

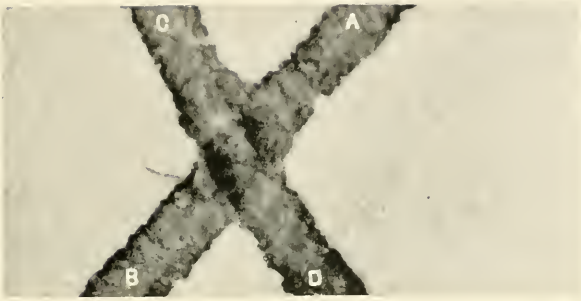
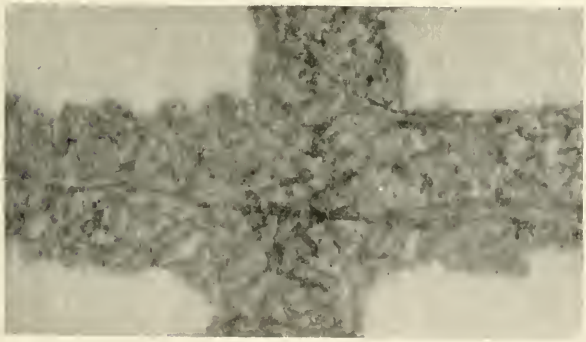


FIG. 2.

FIG. 3.



tre, or other visible peculiarity to the lower ink at their place of crossing. Often when a more glossy ink underlies, this appearance will be nothing more than a slight dulling of the lustre, or if the overlying ink have a peculiar color a few straggling fibres may be noticed on the upper surface of the place of junction which show traces of this color. If there be no such differences between the inks this method also is inapplicable.

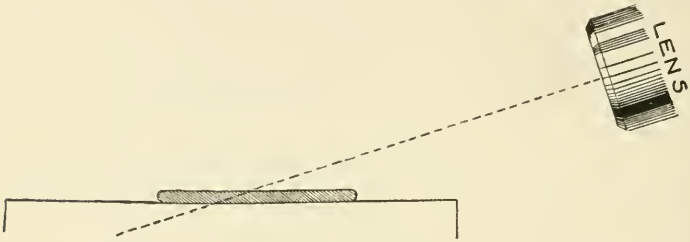
Method by Oblique Vision.—A third method employed by the writer has been more successful. It is by viewing the crossed lines obliquely.

If two strips of differently-shaded glass be crossed, the edges of the square formed by their junction bound with black tape (to conceal as far as possible which strip is uppermost), and the whole backed by white paper and held several feet from the observer in a strong light, the central square of their junction will appear darker than either of the strips, and it will not be easy to determine which of the two is uppermost. If now this cross, with its paper, be gradually inclined to the horizon, less and less of the rays which strike its surface will twice traverse both plates at their junction before reaching the eye, and the number of rays which penetrate only the upper strip and reach the eye will be continually greater at each successive degree of inclination.

When the angle is such that no rays which penetrate both glass strips at their junction reach the eye,

the overlying strip will be seen to correspond in color and other characteristics with two of the arms of the cross, and to differ from the other two. The uppermost strip will appear to be (as it is in reality) a con-

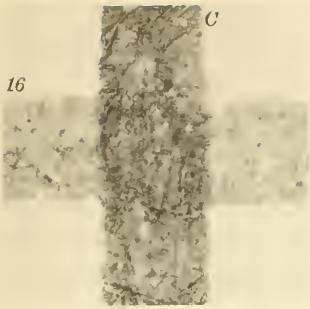
Fig. 6.



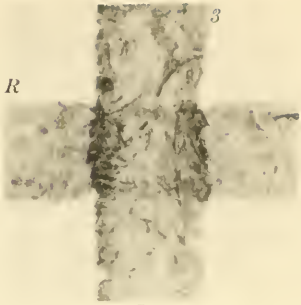
tinuous body, either lighter or darker than the other, from the extremity of one arm across the middle square to the opposite extremity. The underlying strip will seem to be cut in two, and its peculiarities of color, lustre, structure, etc., will only appear in the two opposite arms, divided by a square centre which does not share them.

Applying this principle to the crossing of lines of ink on a paper, if a lens of small magnifying power be so placed that the axis of vision be inclined at an acute angle to the plane of the paper, and directed to the place of junction, the illumination as before being oblique, one of the two lines, whether it be lighter or darker than the other, will be seen to make one continuous limb of the cross alike in color or shade from end to end. Such a line is the upper one.

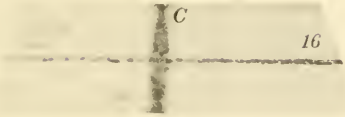
PLATE II.



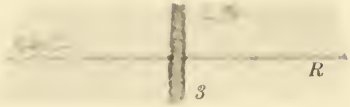
A



B



A 1



B 1

A 2

B 2

Plate II., Figs. A, A1, A2, B, B1, B2, represent photo-micrographs of intersections of the lightest and the darkest of commercial inks. The darker (designated by *C* when it is underneath and by *3* when it is above) and the lighter (designated by *R* when it is underneath and by *16* when it is the upper line) are given each once in an inferior and once in superior position by perpendicular, and twice in each situation by oblique vision. The more strongly marked character of the darker ink makes it appear to be the superior line in both cases where the axis of the photographic instrument was perpendicular to the plane of the paper. When these same slides are photographed with the axis of the instrument oblique to the plane of the paper, however, the true order of superposition becomes apparent to the eye. (See A1, A2, B1, B2.) The No. *16* ink, although much lighter in color than the other, is distinctly seen to pass continuously across the darker ink in an uninterrupted line in A1 and A2.

It will be understood by those familiar with microscope photography that if the plane of an object be ever so slightly oblique to the axis of the instrument only a very minute area adjoining the axis of rotation will be approximately in focus, and in all positions except where the plane of the slide is perpendicular to the axis of the microscope, the front and rear portions of this plane will be out of focus.

This gives to the ink line perpendicular to the axis

of rotation less intensity than it really has, and might lead some persons to suppose that, owing to this fact alone, the lighter ink maintains its character across the darker. It should be remembered, however, that the portion of the darker line which is crossed by the lighter is equally with the latter in focus. This crossing is not a mathematical point, but an area of sensible magnitude rendered easily visible by the magnification employed. If the darker line were really superposed, therefore, it would appear to be the darker in all positions and under any illumination, as can be seen in Figs. B1 and B2.

Figs. A2 and B1 are represented in order to show that the appearance is the same when the underlying line is made to coincide with the axis of rotation of the slide. In Fig. A2 the same slide was photographed as in A1, but the overlying ink, *16*, instead of crossing the field from left to right runs from top to bottom, yet although by this position the extremities of this line are out of focus, it is clearly seen to overlie the line *C*.

In the figure B2 the overlying ink, No. *3*, is as distinctly above the line R while in a horizontal position as it is in B1 while in a vertical position.

A2 and B2 were prepared to meet a possible objection that either ink may be made to appear the upper or the lower in a phototype reproduction according to the manner of its presentation. This is true of the lighter of two inks, but not of the darker. No

change in the conditions of making the picture could make ink No. *3* appear to be the lower in the three figures B, B1, and B2, as Mr. Wingate states in his note which follows. It is hardly necessary to say that these phototypes have not been retouched or the negatives altered in any way.

The phenomenon is much easier to observe in the microscope than to represent in a photograph or a phototype print made from one, for the reason that the "glare" or lustre from the surface of the paper interferes with the definition of the ink lines.

Nevertheless, Mr. Harold Wingate, of Philadelphia, an amateur who has devoted much time and achieved great success in microscope-photography, has succeeded in fixing the image seen by the eye as a positive on glass, and has then enlarged this to a glass negative. The difficulties he encountered were greater than we had supposed, although we had not been sure of attaining the desired end.

His account of the method he found it necessary to pursue here follows:

PHILADELPHIA, April 19, 1894.

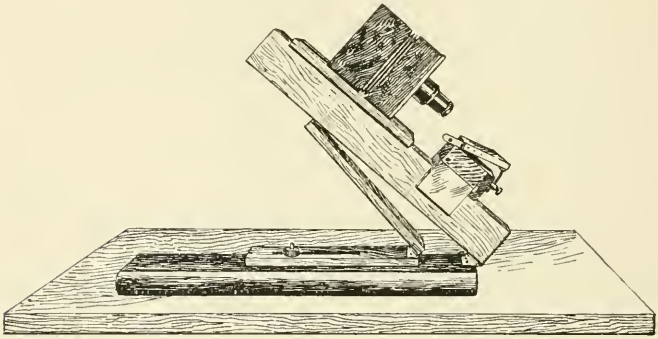
DR. PERSIFOR FRAZER:

MY DEAR DOCTOR,—I am sending you to-day the last negative of the series illustrating your method of determining the superposition of pen-strokes. I first photographed the crosses C—16 and R—3, magnified to a little more than twenty diameters, with the light ink horizontal and the dark ink vertical in both instances; but in the former (C—16) the light ink, 16, superposed, and in the latter (R—3) the same light ink, R, underneath. I used a one-and-one-half-inch objective and a Lieberkühn, getting thereby a nearly vertical illumi-

nation, or almost the same effect as is seen in the microscope when diffused daylight is used as the illuminant. You notice that both photographs show the dark ink on top. (See A and B.)

In order to get pictures of the slides in an inclined position, after much experimentation I was forced to construct a photo-micrographic camera for the purpose, with the stage of the microscope part inclinable throughout ninety degrees distally. (See Fig. 7.)

Fig. 7.



As a good microscope lens has almost no depth of focus, it was impossible to get immediately an enlarged picture of the cross, as only one plane would be in focus at one time. Mr. Zentmayer kindly lent me a lens made on the principle of the portrait-lens of two inch equivalent focus, and I stopped it down to f. 20. With this I was able to get a fair field and a magnification of a little more than one-half diameter. From negatives made in this way lantern-slides were made by contact, and from these the larger negatives,—thus bringing the enlargement up to more than four diameters.

The direct negatives were made by daylight, facing a small window, with the stage at an angle of 8° to 11° upward inclination from the optical axis of the lens, and the whole apparatus inclined in such a way that the stage holding the slide was nearly horizontal, or inclined a little downward.

In slide R—3, where the very black ink was on top, no great

trouble was encountered in photographing the cross as it appears to the eye; but in C — 16, where the light ink, 16, formed a very thin layer over the underlying black stroke, it became difficult to make the plate reproduce what the eye saw, as the underlying mass of black at the cross dominated the fainter ink, owing to the greater absorption of light at this point; but by slightly rotating the whole apparatus to the right or left I found that an illumination could be secured which gave the differentiating tone to the lighter ink and permitted the taking of a photograph showing the continuity of the superposed line. But in this case of C — 16, if the light 16 ink were not on top, I could not by any possible means make it appear so, nor do I believe any one else can.

Very truly yours,

HAROLD WINGATE.

For ordinary purposes the compound microscope, consisting of an eye-piece as well as an objective lens, is not necessary, and the test is more easily made with such a long focus and low power objective as was alluded to on a previous page.

If, for instance, a one-and-a-half-inch objective with a tubular diaphragm be laid almost parallel with the paper, and the latter held towards a good but not too strong sky-light, the order of placing two crossed lines will be observable with greater facility than in a compound microscope.

CHAPTER VIII.

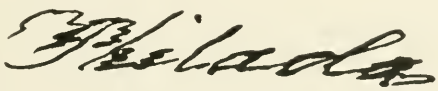
HESITATION AND TREMOR OF FEEBLENESS, ILLITERACY, OR FRAUD.

Labored Writing.—It is not always an evidence of fraudulent intent that the writing shows evidences of slow and labored motion of the pen, but in connection with other facts this becomes an important point to observe. It has been stated under the head of general observations of a writing that the hesitation and tremor, as shown by an illiterate person, by a feeble person or one under some condition of mental aberration, and by a well-skilled penman anxious to deceive, are all different. The pen-strokes of the illiterate person are strong enough, but uneven and erratic. No strokes nor parts of strokes are symmetrical. The handwriting is unformed and child-like, but not lacking in vigor. The pauses are made because of the inability of the writer to continue a line to its required length by a proper accommodation of the muscles, or to avoid an accidental obstacle, such as a grain of hard pulp or a crease in the paper, without making the pen sputter or taking a new position with the hand. The attempt to imitate a copy or ideal in tracing a word or signature is similar to an attempt by the same hand to copy a landscape

or to improvise one. Undue force is usually apparent everywhere, except on the hair-lines, where the attempt to be gentle necessitates drawing them slowly, and therefore in uncertain wavy lines. Parts of letters are drawn out of shape, and other parts written over them, as if the writer had memorized a certain number of strokes which it was necessary to make, and made them consecutively without regard to where his pen might be at the time he began each. In this respect it resembles the writing in the dark of a man whose faculties are dulled by fatigue or drugs.

Feebleness.—The signature or other writing of a not inexperienced penman, who is ill or feeble, is characterized by a general lightness of stroke and much tremulousness. If any parts of the lines are heavy, these parts are short, and not infrequently terminate with a perforation of the paper.

Fig. 8.



Tremor of Feebleness.

The pressure of the fingers is light, and the attempt to make parts of the writing heavier is by throwing too much weight upon the pen without the ability to accurately gauge the amount of the added pressure, with the result frequently of a puncture of the paper. No line of any considerable length is free from the

wavy evidences of tremor, yet there is a distinct resemblance between the word and the same word written in a state of health.

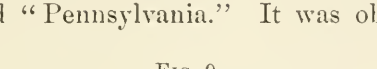
In the example given of the tremor due to feebleness (the word "Philada"), it is clearly manifest not only that the idea of form which the writer had in his mind was excellent, but that in the main it was well carried out. The mean of all the divergences and waved lines makes a well-formed and symmetrical word. It must be confessed that the persistence in flourishes which bring out into prominence the writer's weakness, and the correct general direction in forming the letters are unusual, but the same features may be observed in lesser degree on any writing of a good penman which is tremulous on account of his feebleness.

All the points noted as characteristic of this kind of imperfect writing are strongly accentuated in this example. The writer was a gentleman of over ninety years of age.

Illiteracy.—In the case just mentioned there is a manifest attempt to reproduce a reasonable ideal which is partially successful, whereas in the illiterate signature the attempt seems to be to repeat a certain number of up-and-down strokes and their connecting strokes without considering as a whole what they were intended to produce. An identification of the signature of a very illiterate person becomes almost purely an identification of separate lines or letters.

The example of the tremor due to illiteracy is given in the word "Pennsylvania." It was obtained from

FIG. 9.



Tremor of Illiteracy

an ignorant carter, who, however, was not illiterate enough to produce so good a type as the preceding. The tremors and angular features introduced are by no means indicative of lack of power, but the power is misdirected. After traversing the road which traced the name of the great Colonial Governor, the real difficulties begin, and in the struggle to master them the combat is transferred far from the guide-line of the paper. The last three syllables are little else than a repetition of the prescribed number of strokes up and down, but the second part of the "n" has been carried over to the "i" and has made an "n" of that letter, so that the appearance of the word resembles "Pennsylzoina."

It is instructive to compare the two words with each other.

Fraud.—The simulated tremor of a skilful penman is rarely successful in deceiving a trained eye aided by a moderate magnification of the writing.

The tendency to produce symmetrical tracings and natural curves is a second nature which cannot be readily overcome. Under the microscope the rhyth-

mic lapses from easy to perturbed writing and back again, remind one of the imitation of a drunken man in amateur theatricals. The things which are really difficult for an illiterate or feeble person to do, such as the proper union of the small letters, are performed usually with address, as if the writer were in a hurry to commence acting his part in the next following letter. The dash (if there be one) will assume a graceful curve. The dot will appear in the place where the forger is accustomed to write it, or if both of these be carefully imitated there is sure to be some betrayal in the crossing of the "t's," the shading of some of the letters, the preservation of a straight line for the base line, or in some other part of the writing.

Fig. 10.

Tremor of Fraud.

The signature of Isaac Taylor, above represented, will serve as an illustration of the tremor almost inseparable from forgery.

A comparison of this signature and those of George W. Hawley and Enos V. Garrett (Fig. 12), with the composites of the names they were intended to simulate (Plate VI.), will illustrate the fundamental differences of their characters and also the difficulty experienced by a good penman in feigning to be a bad one. The real signature of Isaac Taylor is not only

tremulous from age, but is angular, unsymmetrical, and lacking in proper curves or proper straight lines. The forged signature, on the contrary, is full of evidences that the hand which traced it was accustomed to make both with unusual skill. Observe, for instance, the general accuracy of the slope of the down stroke in the initial I, and T, and the l, and first part of the y.

In these and similar instances used in the book for illustrations, for special reasons the tables of measurement have not been printed. It will be apparent that such a table would show the same discrepancies which have been fully set forth in the preceding pages, where the names have not been given. The purpose of these illustrations was to show that the method of study by composite photography is valuable in getting at essential character and in detecting fraud.

The tremors of a simulating hand are never so numerous nor so fine as real tremors.

Observations will be referred to farther on which demonstrate that in a single long stroke, like that of an "f" or an "l," there are often many deviations right and left from the straight line which the will desires to trace, by the ordinary penman in a normal state of health; and, while it is not possible that these should exactly overlap in any two signatures, nor probable that they are invariably identical in number, yet in both respects two such lines by the same hand are apt to resemble each other more closely

than any such line by another hand will resemble either of them. This tremor is natural to all hands, and is what prevents the most practised hand from drawing a perfect straight or curved line, though its effects are not easily visible except by the use of magnifiers. The faltering due to age or feebleness is greater in the excursions of the pen; but, besides this, these deviations have superposed upon them even more numerous and finer tremors than are observed in the writing of a person in health.

So fine are these, indeed, that it is doubtful if they can be simulated, and still more doubtful if the tremors, even if artificially produced, would resemble those they were intended to imitate.

If this be so, one of the best means of detecting the fraudulent character of a writing purporting to be by a feeble person is the comparison of the tremors evidenced in his genuine writing with those in the suspected imitation.

Retouching.—The repainting or retouching of a letter or part of a letter is not always evidence of fraud. Many persons contract the bad habit of going over what they have written with a pen to correct blemishes, and this habit sometimes becomes so pronounced that the writer invariably repaints his signature, whether it show blemishes or not. To a person in the habit of retouching his own writing an unconscious skill is ultimately developed which enables him to put his pen at the exact point required, and to join

two disconnected lines with an accuracy far in excess of anything else of the same kind which he is capable of accomplishing. It is not rare to discover the habit only after a minute examination of numerous specimens of the writing under considerable magnification.

No hand is capable of tracing a line of any great length on paper without leaving traces of deviation from its projected direction. The more nervous the hand, the greater and more numerous will be these deviations. In the hand of one suffering from illness or weak from age the deviations will be most pronounced. To a less degree the same will be observed in a hand which is striving to accomplish something difficult, and to avoid betraying itself by falling into numerous pitfalls. However expert the writer, if the copy is beset with little peculiarities the tracing will be slower than is his usual habit, and the natural and unavoidable divergence from his ideal will have superadded to it that which comes from decreased rapidity of execution. It is like the deviation caused by the wind in projectiles. The greater the velocity of the latter the less will be the effect of the perturbing force.

One peculiarity of these tremors is that in a practised hand they are not easily visible except under considerable magnification. With a power of fifty or sixty diameters they become plain, and little knots appear in the writing which were almost unnoticeable before, and which seem to be due to the continued flow of

ink from a nibbed pen which has been brought for an instant to a full stop in the course of forming a letter owing to some feature in the copy which required a new adjustment of muscles to execute.

The natural tremors which can be discovered in free-hand writing are surprisingly numerous, including under that name all changes in pressure on the pen as well as alterations in the direction of its movement. Making due allowance for the irregularities in the paper, which would show differences in the result when none existed in the motor, there are probably not less than three or four in every centimeter of average handwriting.

There have been shown more than twenty impulses superposed upon the force exerted by a writer of moderate skill in tracing the single stem of a long "f." If this be so, it is not unreasonable to anticipate that twice that many may be found in the writing of the sick or infirm. In fact, the number of these deviations is concealed by the coarseness of the tracing in which they are sought. If writing were produced by a very fine-pointed stylus, this number would probably be very much increased.

With a previous knowledge of the signature, and the peculiarities which a forger would have to imitate, it is of great importance to note where the hesitation is shown by the examination under the microscope.

If it occur just before these difficult parts are attempted, it will probably distinguish false writing from

genuine, because habit will have caused the originator of these peculiarities to write them with as much freedom as any other part.

CHAPTER IX.

THE SUBSTANCE WRITTEN UPON.

Materials of which It is made.—The material which bears the writing under investigation may be of cotton, linen, esparto, wood pulp, or parchment. All but the last have readily recognizable fibres, each differing in appearance and in fact from the other. Photo-micrographs of these may be seen in the "Text-Book of Paper Making,"[1] by C. T. Cross and E. J. Bevan, and in other similar treatises and articles.

Paper Making.—The fibres are interlocked with each other during the process of "beating" the pulp, and are further "loaded" with clay, kaolin, or an asbestos-like material called "agalite," which is nearly pure magnesium silicate. These materials, which are added to all but special grades of paper, are not harmful constituents unless in excessive amount, and the last named being by nature fibrous, like the organic materials with which it is mixed, assists in binding them together and imparts a hard finish to the paper. The

[1] E. & F. N. Spon, 125 Strand, London, and 35 Murray Street, New York, 1888.

"pearl hardening" is effected by means of precipitated calcium sulphate (gypsum, plaster of Paris).

In addition to these "loading" ingredients, papers intended to be written upon are "sized" or immersed in an aluminum resinate soap mixed with about one-third its weight of starch paste, which serves to hold together the fibres and also to prevent the ink from running. After about four parts by weight of this mixture to one hundred parts of the pulp have been thoroughly mixed, a solution of alum is run in, after having been dissolved in lead or copper tanks, as this substance acts rapidly on iron, and would saturate the pulp with the iron salt and thus impair its value. It may be said that, in spite of the careful preparation of the paper pulp, the finished product is often adulterated by iron in some slight degree and will give a reaction for that metal by a sufficiently delicate test. Nearly three times the amount of alum is required to precipitate the resin from its combination with sodium. Ultramarine blues and aniline pinks are added to counteract the yellowish color of the cellulose. Handmade papers are sized by dipping them into a solution of gelatin and hanging them up on lines or poles to dry. The sheets are then calendered, either by passing them between heated or cold metallic rolls, or one of metal and one of compressed paper; or by pressing them in larger bundles of alternating paper and metal plates (*Cross and Bevan*). The effect of this is to give the surface of the paper a hard and often polished sur-

face, on which the tracing of ink remains without running or blotting, and is absorbed into the loading and size and also stains the fibres of paper of which these materials fill the interstices.

Erasures.—When an erasure is made on the surface of such a paper, the mineral and organic materials of the sizing and loading are removed, and the fibres of the paper which they unite are deranged in form and position. Such a surface exhibits invariably the teased-up ends of the fibres, and generally shows by the agreement in their direction in what way the scratching was done.

Even in cases where a substitute for the sizing has been so successfully added that no change in color or surface is observable, the fibres will show by their unusual positions that they have been disturbed. When an attempt has been made to write over the place without sufficiently restoring the sizing, the effects can be seen in the running of the ink between the fibres and the staining of the body of the paper to a considerable depth from the surface and to a considerable distance from the spot.

Insertion of Pages.—In cases where a document of more than one page is under investigation, and tampering is suspected with only one or more of the sheets, a general investigation of the character of the paper, as well as of the ink in each sheet, becomes necessary. If the paper be ruled, careful measurements of the distance apart of the lines in each sheet

and the distances of the first and last lines from the upper and lower edges of the paper should be made and compared.

Water-marks.—Any water-mark or other device wrought into the paper should be looked for. The water-mark is made by receiving the soft pulp on a wire screen on which a design of some kind is placed. When this pulp is raised out of the tub, there is less pulp over the raised design (or more if the design be in relief) than in the rest of the sheet, and although the subsequent pressure to which the paper is subjected prevents the eye from detecting the difference in thickness, the design remains.

Other marks are introduced by the "dandy roll," a light roll covered with raised wires in the form desired, pressing lightly on the paper while still moist, while the other side has the mark of the wire cloth. If the "dandy roll" be also covered with wire cloth, the two sides appear alike, and the paper is called "wove" (*Cross and Bevan*).

Any such marks in the paper furnish excellent means of establishing whether or not one or more of the sheets of the document has been substituted. When the water-mark is faint, or not immediately noticeable while using the paper, it is so much the better as a means of identification.

Concealment of Tell-tale Spots.—Awkward marks which might prove tell-tales are sometimes scribbled over with a pen, or covered by a seal, or in by-gone

days, when wafers were commonly used to close letters, one of them was affixed to the paper. Chevallier and Lessaigne have met with a case where pieces of paper were pasted over the suspicious place.

A patient and systematic study of the paper will usually lead to a suspicion of such treatment, and will suggest means for its discovery.

Parchments.—It sometimes happens that the document is a veritable parchment. Parchments are usually made of the skin of sheep or lambs, if intended for writing purposes. Goat and wolf skins used to be employed for drum-heads (*Peignot*).

The finer and smoother sorts of parchment called vellum are made from the skins of very young calves.

The preparation of the skin for writing purposes has scarcely been improved since the time when Hildebert, Archbishop of Tours (born 1054), described it incidentally in a sermon. He says, "A writer first cleanses his parchment from the grease, and takes off most of the dirt. He then entirely rubs off the hair and fibres with pumice stone. If he did not do so the letters upon it would not be good, nor would they last long. He then rules lines that the writing may be straight," etc. (*Penny Cyclopædia*).

Practically when the skin has been deprived of its hair or wool it is placed for a time in a lime pit, whence it is taken and stretched on a frame and drawn tight.

The workman then scrapes the flesh side with a blunt

iron instrument, and wets it with a moistened rag covered with powdered chalk, and rubs it with pumice stone. This operation is repeated once or twice, when the hair side is turned and scraped. After drying, it is again scraped with a finer tool.

The parchments of the time of the Romans must have been very superior to those of the early middle ages, and these again to the parchments of the eleventh and twelfth centuries. From that time to the sixteenth century when paper began to be employed, parchment gradually became an article of luxury and imperfect manufacture. It is still occasionally used on account of its great durability.

In examining a parchment on which a supposed forgery is inscribed, Mr. Sittl remarks that a similarity between the two sides of the sheet (which can be determined by the equal visibility of the ink) gives very strong reason to doubt the great age of the skin, because there is always a marked difference between the hair side and the flesh side in really old parchments. The great differences of inks of different periods enables the fraudulent character of corrections, emendations, and notes to be discovered. These observations, however, apply to cases where it is desired to judge parchment documents belonging to centuries long past.

Erasures in parchments produce prominences on the opposite side of the sheet. The ink placed upon such erasures has a peculiar bluish tinge. It happens at

times that a whole page is taken out, either by scratching or rubbing with pumice (which was the practice in the eleventh century, when parchment became so valuable that it was common to keep up the supply by erasing the writing on old parchments) or by washing.

When the latter method was used, the writing as in palimpsests can be made to reappear by warming.

The parchment can be either laid on a hot plate or pressed with a hot flat-iron between two sheets of paper (*Sittl*).

Furrows traced by the Pen-nibs.—Under the microscope the furrows traced by the pen-nibs are usually easily visible, and they differ with every variety of pen employed. A stiff, fine-pointed pen makes two comparatively deep lines a short distance apart, which appear blacker in the writing than the space between them, because they fill with ink, which afterwards dries, and produces a thicker layer of black sediment than those elsewhere. The variations of pressure upon the pen can be easily noticed by the alternate widening and narrowing of the band between these two furrows. The tracing appears knotty and uneven, when made by an untrained hand, while it appears uniformly thin, and generally tremulous or in zigzags when made by a weak but trained hand. A soft and broad-nibbed pen exhibits the same peculiarities with the difference that there are no fine lines, but broad and broader lines, not infrequently inter-

rupted by blots, and obliterations of letters by the untrained hand.

The depression of both borders of a pen-stroke gives rise to the appearance of convexity in the line which is observed under the microscope and in photo-micrographs of lines. This furnishes another means of comparison between the genuine and the suspected writing; but, owing to the fact that the differences in depth of the furrows is very slight, even with notable differences of pressure, it is not a guide upon which the investigator can always rely.

Within certain limitations it is an important object to study, and may give indications of value to corroborate or refute the hypotheses based upon other lines of study.

Mackinnon and Stylographic Pens.—As was remarked before, the introduction of the stylographic pen has changed the character of the letters when viewed under the microscope, and in the future, when instruments executed by this writing tool shall come under examination, some of the clues which were useful in the metal-pen era will disappear.

The stylus, or light metal wire, which acts as a plug to restrain the flow of ink when the pen is not in actual use, is kept down either by a very small weight, as in the Mackinnon pen, or by a fine spring, as in the ordinary stylograph. The amount of pressure necessary to press this needle back is so slight that the weakest hand is capable of accomplishing it, and as

there is practically no furrow observable, and the ink flows over all sides of the stylus to the paper, the effect is of writing with a very fine camel's-hair pencil. Furrow, convexity, and shading in the line disappear. Even the effects of tremor are with difficulty discernible, if they be visible at all, whether heavy or light pressure be employed, because the line is nearly of uniform width. The stopping of the pen on the paper does not produce a notably heavier deposit of ink, because the friction of the ink on all sides of the annular space in the nozzle is sufficient to stop the flow of ink until the pen is again put in motion (provided that the latter be in good order). The introduction of the stylograph type of pen deprives the expert in handwriting of several lines of investigation.

CHAPTER X.

ALTERATIONS OF THE CHARACTER OF THE DOCUMENT.

Difficulties.—It is difficult to lay down any general rules for guidance in establishing the fact of such alterations. There is usually something forced or unnatural which strikes the eye in looking at examples of this kind. They differ from the *bona fide* alterations made by the author, with no attempt at concealment, but they differ in so many different ways that it is not easy to bring them under one general category.

As a rule, they err on the side of too great care and legibility. A hand which has never made a clear and distinct figure "2" or letter "t" or word "five" here appears for the first time, under suspicious circumstances, to have thrown off ambiguity and to have plainly formed the letter or figure out of one of different character.

It may be that some trick of writing has ordinarily deprived the character of clearness, and in this case the peculiarity appears, but so subordinated that there can be no doubt as to what was intended to be conveyed to the reader.

Such reformations from bad habits in writing are always very suspicious when they occur at critical points and times, and when they show not only a desire to improve a bad handwriting, but to confer a substantial benefit upon some one which has nowhere else been alluded to. The aim of the forger has been to make the altered character distinct, in order that no ambiguity shall rob him of the benefit of the change, and this labored effort to be distinct may lead to his detection. In cases where it is the sense of the sentence which is altered by the addition or the elimination of words, the case falls under the general head of complete forgeries, and all the aids to investigation of the characters of handwriting, the constitution of inks, and the other branches of the subject discussed in this book, may be employed; but where a part of a letter or integer is grafted on another, in order to

change its value, the character of the ink in the two parts deserves especial attention.

Motive.—It is a just ground of suspicion if the document under investigation attempt to accomplish by a few added words more than such a document is ordinarily employed to accomplish: as, for instance, when a cheque, of which the mission is usually to enable the drawer to transfer a sum of money to a given person, by the added words "in full," etc., is transformed when cancelled into a receipt, which prevents the recipient from claiming any additional sum, even although the cheque was given only in part payment.

This was not the case in the illustration introduced elsewhere, but the plaintiff's plea was rendered plausible *prima facie* on this account.

Other alterations that may be expected are those of "raising" a cheque, or making it transfer a larger sum to the payee by the addition of ciphers, or integers, or the alteration of one digit to another.

Not all the digits are equally easy to change into each other, but a 1 is frequently changed to a 4; or a 3 or 6 to an 8; or a 7 to a 9, etc.

When there are traces of different inks on the same figure, and the mark of one kind makes a number inferior to that produced by both together, the probability of a forgery is much heightened.

Writing over a Stroke or Dash, or where One has been removed.—The methods given above for ar-

riving at a conclusion as to which of two crossed lines is above and which below, apply to the first of these cases, but others may be employed. The writer has examined a case where the forger, knowing that it was almost impossible to escape detection by erasing a line and afterwards writing over the erasure, determined to write boldly over a filling-out line, or flourish line (*i.e.*, the line drawn from the end of the last letter in a paragraph diagonally across a blank space, to prevent any words from being added). But when the words in the first line approached the diagonally descending flourish line, he showed his hesitation in performing this act by the alteration of the direction of his line of writing upward. The line of writing changed its direction sensibly upward to avoid the stroke, and as it was the only line of writing which did this, and its direction was parallel to the flourish line before the latter's erasure, it left convincing proof of the existence of the flourish line before this line of writing was penned. Where the writing finally did cross the flourish line, an examination in oblique light of the crossing, by a lens magnifying three or four diameters, showed conclusively which of the two was superposed. The intention of this forger was to write the line first, and subsequently to erase both line and letters, in order to give the impression that they were made contemporaneously. In this he failed, because the ink of the writing was shown to be above the ink of the line by oblique examination, and

a chemical test showed that the two inks were different in constitution. In this case, also, the erasing was purposely done for a considerable space above and below the line, as if to force attention to the fact that the letters of the writing had suffered in the same way as the line itself, and that both were there before the erasing process began.

Writing over an Erasure.—If any one will try the experiment of erasing an ink-mark on ordinary writing-paper, and then writing over the erasure, he will notice a striking difference between the letters on the unaltered and on the altered surface. The latter are broader, and in most cases, to the unaided eye, darker in color, while the erased spot, if not further treated to some substitute for sizing, may be noticed either when the paper is held between a light and the eye, or when viewed obliquely at a certain angle, or in both cases.

Very frequently it happens that so much of the size and the superficial layer of fibres must be removed that the mark of the ink can be distinctly seen on the reverse side of the paper, and the lines have a distinct border which makes them broader than in the same writing under normal conditions. If a sharp pen be used there is great likelihood that a hole will be made in the paper, or a sputter thrown over the parts adjacent to the erasure.

The latter effect is produced by the entanglement of the point of the pen among the disturbed fibres of the

paper and its sudden release when sufficient force is used to carry it along in the direction of the writing.

It is often of importance to know, in case of a blot, whether the erasure it may partially mark were there before the blot, or whether it were made with the object of removing the latter.

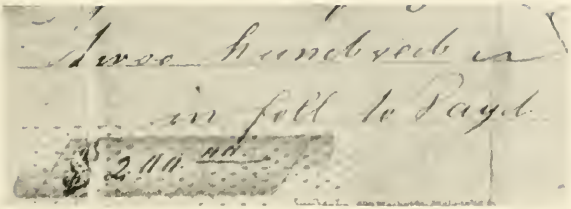
Inasmuch as an attempt to correct such a disfigurement would in all probability not be made until the ink had dried, an inspection of the reverse side of the paper will usually furnish satisfactory evidence on the point. If the color of the ink be not more distinct on the under side of the paper than the color of other writing where there was no erasure, it is probable that the erasure was subsequent to the blot.

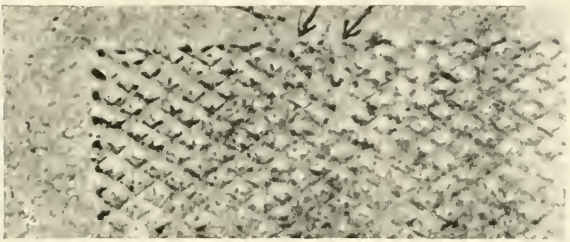
If the reverse be the case, the opposite conclusion may be drawn. Blots are sometimes used by ignorant persons to conceal the improper manipulation of the paper, but they are not adapted to aid this kind of fraud, and least of all to conceal erasures.

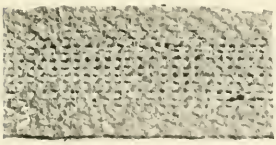
Additions and Interlineations.—The decision as to whether they have been made legitimately and before a paper was executed, or subsequently to its execution, and with fraudulent intent, must be arrived at by a comparison of the handwriting in which the words appear, the ink with which they were written, and the local features of each special case which usually are not wanting.

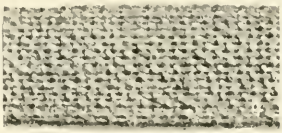
As an instance of these local accidents which always assist so largely in getting at the truth, the follow-

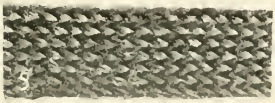
PLATE III.











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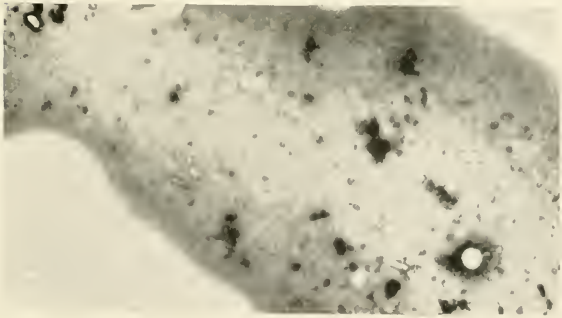

ing case in the writer's experience may be cited. The paper, of which the important part is represented below, was claimed by the plaintiff to have been altered by the insertion of the words "in foll to Dayt," after the cheque had been paid, cancelled by the bank, and returned to the payer. The plaintiff in the case did not deny that the sum was paid but claimed an additional sum on the transaction still due, and charged forgery against the drawer of the cheque.

It happened that part of a letter of one of these words crossed two punctures made over the figures giving the amount of the cheque to prevent subsequent alterations. Nevertheless, no ink had come through to the under side, there was no soiling of the edge of the paper by ink, and no way to account for the absence of these appearances, if the cheque had been actually punctured when the words were written. Consequently, the jury very justly gave a verdict for the defendant, and saved an innocent man from incarceration as a criminal.

In Plate III., Fig. 1, part of the face of the cheque, including the figures for the dollars, and the punctures over them to prevent alteration, is represented.

In Fig. 2 the reverse of the top of the "f" has been lightly traced in pencil to show the direction of its descent over the punctured part on the opposite side, and two arrows have been drawn in pencil to within minute distances of the holes, which the tail of the "f" (written in ink) on the face or opposite side traversed.

Had these holes been there when the "f" was written, the little thread of ink which flowed from the pen upon the paper would have inevitably penetrated them, and appeared on the opposite side. As not a trace of ink appears on the reverse side, it is conclusive evidence that the holes were not there when "in foll to Dayt" was written; or in short these words were written before the cheque was entirely filled up.

While the expert in handwriting should confine himself to the concrete examinations of the paper, ink, seals, etc., and leave to the counsel the task of reasoning on the purport of the words added, and all other matters not allied to the materials left as the result of the forgery, yet it would be unreasonable to neglect altogether these means of corroborating a previously formed suspicion, or directing a course of inquiry.

That expert would be more or less than human who could shut his eyes to the importance of the fact that certain words containing evidence in the manner of their formation or their position that raised doubts as to their genuineness by their import gave to the person who might have written them benefits which he would not have derived in their absence. It is of course improper to include such corroboration in his testimony or to allow himself to be influenced by it in his purely scientific investigation, but he need not deny himself the encouragement which is derived

from the discovery of an apparent motive for the act, nor neglect the clue which such a motive might suggest as an additional line of research.

Where the supposed writer of the document was a bad or careless penman the interlineations or additions are generally distinguished from his handwriting, which they simulate, by greater clearness and precision, as has been said above; for when a man will risk being sent to jail for forgery it is not likely that he is willing to lose any prospective advantage which his felony will bring him by lack of distinctness in the characters by means of which it is perpetrated.

Obvious Mistakes.—Considering the number of such fraudulent additions or interlineations with which the writer has become professionally acquainted, the number of mistakes in spelling or in following the method employed by the supposed writer in forming the same words is surprisingly great. Several instances are recalled where the name of the supposed writer was not only misspelled but spelled in two different ways in the same instrument. It occasionally seems as if the forger's attention is so earnestly directed to overcoming the difficult parts of his task that he neglects the simpler and more obvious parts.

CHAPTER XI.

STRUCTURE OF TAPES.

Use of Tapes.—Where a document of record consists of several sheets it is usual to attach them together by a tape and seal with the purpose of preventing the separate sheets from being detached without showing the fact by the disarrangement of these. It has happened that the forgers have not been able to replace both ends of the original tape, but have procured a new piece for one of them. This is a hazardous proceeding, because it is very difficult, if not impossible, to give the same appearance to a piece of tape by artificial means which another piece has attained in a natural way by age and ordinary handling.

Even if the colors can be made to agree very well to the eye, the structure of an old tape is sensibly different from a new one. With continuous handling or rubbing against other papers, with the minute changes which are brought about by the absorption of moisture and subsequent drying, an old tape shows a looseness in its woven texture very different from the compact web of a piece of tape fresh from its roll. (See photograph of tape on the Whitaker will, Plate V.) The interstices between transverse and longitudinal strands of a tape in use become enlarged and

irregular, and it is not infrequent to find these latter arranged in threes or fours together, with larger open spaces on each side of the group. No ordinary handling can produce this effect with a new tape. It seems to depend upon the character of the fibre which forms it, the number of changes in the hygroscopic condition of the air of the locality where it is kept, and probably on other causes imperfectly investigated.

Kinds of Tape.—The tapes in common use are made of linen or silk (the latter being called "taste"). They are usually red.

The differences between these are apparent under the microscope, where the fibres of these substances can be easily distinguished from one another.[1]

Uniformity of the Fibre.—It is important in cases where the tape may have been tampered with to ascertain what the fibre is. It is not likely that a forger will piece out a missing length of linen tape with one of silk, but all parts of this material used on a document should be scrutinized to ascertain whether the material be uniform or nearly so.

If the material is practically the same there may be differences in its condition due to usage.

A part may show the numerous and irregular interspaces, while another part shows the compact structure of a newer tape.

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[1] For the differences between these two fibres, see the plates in Cross and Bevan's work on the manufacture of paper, or any work on the textile manufactures.

Small particles of sealing-wax or stains of ink may suggest tampering, or the holes through which it passes in the paper may have been enlarged or torn by its passage and repassage.

Plate III., Fig. 3, represents linen tape unstretched, Fig. 4 the same stretched; Fig. 5 represents silk "taste" unstretched, and Fig. 6 stretched.

Sealing-wax.—The three kinds of sealing-wax in use in this country are the American express wax, usually brown, and inferior in quality to the other two, and two grades of red sealing-wax.

If the sealing have been done skilfully, it is very difficult to remove and replace the sealing-wax without allowing that fact to become apparent on close inspection. Remelting is liable to darken the color of the wax, and will certainly round the edges left by the impress of the hard seal. If the wax take fire, it is partially carbonized on top, and the black particles mix with those of the part which has been softened, and testify to the tampering.

The stamp of a seal on a sufficient body of wax presents the appearance of a depressed cup, at the bottom of which the design of the die is reproduced in relief. The sides of the depression are precipitate towards the centre, and slope gradually from all points of the exterior towards the level of the paper.[1]

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[1] For information in regard to the manufacture and characteristics of sealing-waxes, see Die Fabrikation der Siegel- und Flaschenlacke; von Louis Edgar Andés, Wien, Pest, Leipzig, 1885.

Rounding of Edges by remelting.—When the sealing-wax is softened or remelted, the sharp edges of the imprint are always rounded, and if the softening have been over a large part of the wax, the design is distorted or partially effaced, and this is true even if a a hot blade have passed between the paper and the lower layer of the wax; the heat from below serving to round off and destroy the sharpness of the design.

If, as often happens, the seal have been broken, the very existence of the fracture suggests improper treatment. When the wax has been detached from the tape and remelted to re-attach it, a partial burning of the tape may occur, and will furnish additional evidence of tampering; and the same is true of the underlying paper.

Skin-marks on the Wax.—It might occur (though the chance is remote) that a thumb or finger had been used to press down the soft wax more firmly on the paper. If an imprint of the skin should result, it might lead not only to proof of tampering, but the conviction of the forger through the means suggested by Mr. Francis Galton in his book on finger-prints.[1] The evidence adduced by Galton and Sir William Herschel, F.R.S., etc., seems to be that no two prints of the cuticle which covers the thumbs or fingers of different individuals are ever the same, and

[1] Finger-Prints, by Francis Galton. London: Macmillan & Co., and New York, 1892. Also, Decipherment of Blurred Finger-Prints, *idem*, 1893.

also that the "whorls" and curves and figures made by the little ridges of epidermis remain curiously constant in the same individual from early youth to advanced age. The method has been used with success to identify American Indians, Chinese, East Indians, and others not easily distinguishable from their countrymen, and in the lucky contingency (said to have once occurred in a criminal prosecution in this country) that a forger identifies himself by leaving a finger-print on the wax, the expert should be prepared to profit by it in the interest[1] of justice.

CHAPTER XII.

MICROSCOPE STUDY OF THE INK.

Characteristics of Inks.—In the exhaustive essay upon nutgall iron inks by Schluttig and Neumann, in the interest of the ink-manufacturing firm of

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[1] A committee appointed by the British Home Secretary, Mr. Asquith, to inquire into the best means for identifying criminals, has reported in favor of supplementing the method heretofore employed in England for the identification of criminals by others, taken partly from M. Bertillon's system and partly from that of Mr. Galton, of recording the impressions of finger-tips. The committee accepted as trustworthy Mr. Galton's conclusion that the chance of two finger-prints being identical is less than one in sixty-four thousand millions. —*Daily Press Report*, April 10, 1894.

August Leonhardi, in Dresden, the following characteristics are laid down as necessary for a perfect ink:

1. A clear, filterable solution, which shows no particles in suspension.

2. It must be limpid (easily flowing) and remain so for some time,—that is to say, it must flow easily from the pen, and neither stick fast to, nor fall from it, nor broaden on touching the paper.

3. It must possess durability in gloss (*i.e.*, in the ink-stand), and (*a*) must produce only a slight precipitate after a considerable time, and (*b*) must exhibit no crust on the surface or sides and no flakes.

4. It must produce on the pen only a slight lacquer-like smooth deposit, but not a loose crust.

5. It must possess no pronounced odor.

6. It must not be too acid, nor penetrate good paper.

7. It must have an intense color which neither in the fluid nor on the paper becomes lighter or is entirely bleached.

(In the latter case the bleaching is estimated from the time of the attainment of perfect dryness of the writing, because wet lines always appear darker than dry.)

8. It must produce characters which, after drying, are not sticky.

All good inks should possess these characters, whether they are copying-inks or writing-inks. In

the foregoing cases only the writing-inks and the combined writing- and copying-inks are considered, which latter, without regard to their copying properties, must have all the qualities of a good ink. The pure copying-inks which make more than two copies are not considered in the following.

Further, it is to be required of the writing-inks that—

9. They must produce characters which, after drying for eight days, cannot be so far removed by several days' treatment with water or alcohol that they will become illegible. With regard to the permanence of their written characters on exposure to light and air they are divided into (*a*) unalterable, or Class I., and (*b*) alterable, or Class II.

The unalterable are the so-called nutgall iron inks of documentary value: they must possess

10. A definite minimum content of iron, and

11. A sufficient content of nutgalls,—*i.e.*, they must produce written characters which in eight days turn into deep black, and then even after several days' treatment with water and alcohol still maintain a certain degree of blackness.

After stating that the value for use in legal documents of nutgall iron ink is established beyond peradventure, Schluttig and Neumann proceed to say that, although nutgall iron inks are the only inks whose permanency has been guaranteed by centuries of exposure, still not all documents written with so-called

nutgall iron inks have remained legible for several centuries.

On the other hand, the characters in other documents have been perfectly preserved up to the present day. Although the character of the paper has a certain influence upon the result, yet the conclusion is forced that only such nutgall iron inks furnish the guarantee of lasting for centuries of which the written characters are really black after drying, and that the same amount of confidence cannot be given to other nutgall iron inks of which the characters are gray or brown.

These chemists regard the introduction of gum or other substance to render the ink viscous as harmful and antiquated.

The above requirements of a good ink are seldom fulfilled, and the student of the writing-fluids employed in documents both old and recent would be very far misled if he were to suppose the objects of his examination were the dried remains of writing-fluids of such high character.

In another place the chemical constitution of inks will be considered. Here it is necessary to discuss the physical appearance of inks under magnification from a few diameters up to 100.

Appearance under the Microscope.—In spite of the theoretical speculations as to what a perfect ink should be, it usually consists of two parts, first, a staining fluid, and, secondly, small particles which are

distributed with more or less regularity over the stained surface.

This can be seen by examining a stroke made with a very black ink on a glass slide and magnified about thirty-five diameters. Here it will be observed there is a film which absorbs light through which are scattered dark opaque objects which add to the intensity of its black. (Plate III., Fig. 7.)

Part of these black spots may be due to the dust which has become mingled with the ink by reason of its exposure to the air, but most of the particles are derived from precipitation within the ink itself. The existence of these two sources of light absorption, the colored fluid and the dark particles, explains why in a badly sized or unsized paper the ink-marks are surrounded by a paler border.

The fibres of the paper act as a filter and prevent the solid particles from penetrating, while they allow the carrying-fluid of the ink to pass, and the fluid spreads by capillary action beyond the line traced by the pen; consequently the line over which the pen has passed, having both the stain and the free solid particles deposited upon it, is darker than the border which has only the staining fluid.

It is not so easy to distinguish the number of the solid suspended particles on paper as on glass, because the prominences of parts of the paper fibre take more ink than the interstices, and are liable to be mistaken for the solid constituents of the ink.

Under the microscope a pen-mark on paper exhibits most prominently the fibre of the paper, which becomes plainly visible as an irregular net-work, in striking contrast with the adjacent parts of the paper not written on, where the structure is not apparent.

In all the figures of ink lines thus far shown it will be seen that the fibre of the paper becomes prominent where the ink has stained it, and is not noticeable elsewhere.

Color.—The first notes to be taken in an examination of an ink under the microscope are the color; the presence in quantity or otherwise of the opaque particles of the ink; the lustre of the latter, and its change (if any) in various conditions of illumination.

It has been previously stated that it is extremely difficult to judge of colors, or the intensity of black by the naked eye. A very low magnifying power will suffice to resolve such questions. High powers are needed in but few lines of investigation to be pursued in the subject we are considering, but just here a power of sixty or seventy diameters is useful in examining the physical constitution of inks.

The accidental crumpling of a document does not prevent it from being studied under a power of sixty diameters, while the minute characters of the dried writing-fluid appear prominently, and will furnish a means of distinguishing different inks, and even sometimes between marks of ink from the same bottle at different epochs. The aniline inks or those

in which aniline is a constituent are seldom free from a characteristic metallic lustre, unmistakable when one is acquainted with it.

Dichroism.—Many inks possess distinct dichroism, or two distinct colors, when illuminated and viewed from different positions. Wherever this occurs the fact should be carefully noted, because it offers a means of discriminating between the ink possessing this property and other inks with more or less the same character and appearance.

Superposition.—Where two lines cross, and the upper and lower cannot be distinguished by perpendicular vision in the microscope, their order of superposition may occasionally be judged by the traces of flow from the sides of the later stroke in both directions along the edges of the line previously written but not across the track of the later line; and sometimes by two black lines corresponding to the paths of the two nibs tracing the upper line. These appearances are often only observable through the microscope. The cause of the first may be the greater capillary attraction of the particles of the ink-film first deposited than of the clean paper for the particles of the fluid ink; and of the second the larger quantities of ink deposited in the furrows.

Whether or not these be the principal causes, the fact remains, and a careful scrutiny of the edges of crossed lines at their point of contact will often reveal which was the last to be traced.

As has been already mentioned, another phenomenon sometimes observable under the microscope, which may lead to the same result, is the staining or coloring of the loose fibres overlying the first line, or of those adjacent to it, which may have escaped being colored by the first ink; or the dulling of the lustre of the inferior ink if the superior be less lustrous; or the contrary effect in the opposite case.

It may happen that in retouching a written document for purposes of fraud the writing-fluid last used is indistinguishable from the first in color and lustre, but may differ in the number or the size of its solid suspended particles or in some other characteristic.

In such a case the microscope can be made effective in determining the degree of uniformity which appears in the ink lines. However skilfully additions to the text may have been made they are not likely to elude this test, because the chances are very great against even the ink from a given bottle remaining constant for any considerable time in all the characteristics observable in the microscope.

Old Ink.—The ink in really very old writings shows a yellowish tinge around the letters which it is hard to imitate. An examination usually shows either no yellow border, or, if there be one, it lacks that gradual shading into the color of the letters, which is one of the characteristics of really old writing (*Sittl*).

Changes which occur in the Inkstand.—The chance of getting, whether out of the same inkstand or an-

other, at two widely-separated intervals of time, a writing-fluid of the same chemical constitution and physical appearance is not very great. Evaporation and constant contact with foreign substances may alter the character of an ink in a single day, so that it will not give the same reactions in the same degree or in the same time. It is, therefore, most important to test the character of the ink on the original stem and on the additional graft where changes in the letters have been made. The manner of making such tests will be taken up subsequently.

But if there be chemical tests which will accomplish this end, a close inspection by means of the microscope will usually divulge physical differences in constitution, color, lustre, etc., which are almost equally important, and besides this, under moderate magnifying power, the junction of the two parts—the original stem and the graft—is not difficult to find, and will appear unlike the ordinary formation of the character by the writer.

Tests by Light Effects.—It has been incidentally mentioned that the aniline inks have the characteristic of a metallic lustre in the dried tracing which they leave. There are other inks, however, which consist of metallic particles, suspended in the fluid by the addition of gums, which also have this lustre, but it is sufficient here to recall that in almost all cases presented by modern and ordinary writing a metallic lustre is indicative of the presence of aniline inks.

Their sediment or tracing possesses also the property of iridescence or play of colors which the purely metallic inks do not share. As a general rule a metallic lustre and iridescence may be assumed to indicate the presence in some proportion of aniline colors which are often found mixed with other inks. A very small percentage of aniline mixed with an ink will serve to distinguish it from that ink when used by itself.

The colors exhibited by inks when seen under the microscope differ from each other much more than a superficial examination would lead one to suppose. It has been before stated that one is apt to fail in valuing the colors or shades of inks by the naked eye when one is in considerable mass, and the other is represented only by one or more fine strokes. The act of magnifying these objects spreads them out over a broader surface and makes comparison fairer. One easily distinguishes in writings at different dates well-defined differences of color, even when the same brand of ink has been used but has been standing in the ink-stand in one case longer than the other.

In order to properly appreciate this difference, a color scale should be used, and the colors of the two specimens matched. In most cases no exact counterpart of either will be found, but the nearest matches will be seen to differ in proportion to the internal chemical and physical changes which have taken place, mainly through oxidation and evaporation.

But the changes of state which occur in the ink-stand are not the only changes which are of value in appreciating a difference of inks or a difference of dates in employing the same ink. In all inks which contain gums in solution the effect of evaporation in the ink-stand is to concentrate this ingredient in what is left. The concentration of the coloring matter may be too trifling to notice when the ink is first laid upon the paper, but that which contains the most gum will be subjected to less subsequent change in a given period, because the subsequent change is due to the oxidation of the air, as well as to the actinic action of the light, and the former is hindered by the covering of gum. After three or four months from the date of the writing the ink with least gum will begin to show a slight difference from that which has more, and in three or four years the distinction may be great enough to lead to the conclusion that entirely different inks have been employed.

By Camera Lucida.—Where two writings are to be examined which profess to have been made at the same time and with the same inks, it is well to examine them in succession under the microscope with a power of twenty to fifty diameters, introducing the camera lucida and passing a color scale under the divided image until a near approximation to the color of the ink be found and noted for each.

In this first experiment care should be taken to lay the writings on some opaque object, such as a sheet of

metal, or a piece of thick cardboard, in order to exclude all transmitted light.

The writer has found it better not to employ the parabolic reflector or the bull's-eye for illumination, but to turn the stage of the microscope away from the window, or other source of light, in order to get rays as perpendicular as possible to the surface of the object.

By Reflected and Transmitted Light.—When this has been done a similar experiment should be tried with the paper (if not too thick) by transmitted light.

The colors by reflected and transmitted light will not agree, and in general the amount of divergence between two inks will be different in the two cases; but care should be taken not to judge too hastily of the results by transmitted light, inasmuch as there is an unknown quantity represented by dirt, sizing, and natural variation in the thickness of the paper fibres, which in the case of transmitted light must be taken into account.

Even with these drawbacks, the plan is one which will throw light upon the physical properties of the inks though without ascertaining on what those properties depend.

Oblique Illumination.—After the two examinations with light, as nearly as possible perpendicular to the plane of the paper, in the one case reflected and in the other transmitted, it will be well to repeat the experiment with oblique illumination, using the bull's-

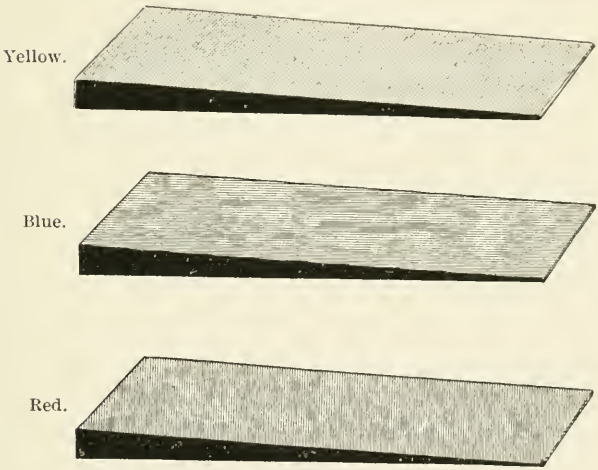
eye illuminator for reflected light, the document being laid on an opaque stage; and the concave mirror under the stage as the source of the light for transmission.

In many inks the side-illumination produces a striking difference from the color by perpendicular illumination, and inks which exhibit this peculiarity have been called dichroic. The degree to which this difference appears depends to a certain extent upon the character of the surface of the paper. Where the latter is rough and uneven, it allows more transmission of light from the lateral illuminant through the films spread upon the little prominences, and the change in lustre and color becomes more apparent than where the surface is perfectly smooth. Still no surface of writing-paper is entirely smooth under a magnification of thirty or forty diameters, and appearances entirely unsuspected by the naked eye become manifest under these circumstances.

Colored Prisms.—Another plan which has yielded the writer valuable results is that of examining inks both with and without the microscope through glasses of various colors. If, for example, both inks exhibit a blue tinge, it is because the red and yellow rays have been more absorbed than the blue. If red, blue, or yellow glasses of different thicknesses be placed over such inks,—or, better still, acute glass prisms of these colors (graduated to millimeters on the lower edges) be slid over the characters successively to the point of extinction of their color,—*i.e.*,

till the written line becomes quite black,—and the units of graduation be read off, the relative difference in the intensity of the colors of the two inks may be quantitatively ascertained. For further con-

Fig. 11.



firmation of this experiment with a blue ink a prism of yellow glass may be used with advantage after the red prism. In case the ink have a yellowish or yellowish-brown color, blue and red glasses or prisms may be employed; and for red inks, yellow and blue glasses or prisms. The object of all such experiments is manifestly to establish differences between different inks in their power of absorption for different colors.

The prisms devised and used by the writer for these experiments are seven to eight centimeters in length, five millimeters thick at the base, and 0.5 millimeter thick at the forward edge. The part of a line on which the color-experiment is to be tried is brought to the middle of the slide-holder, if the microscope be used, or to any thin vertical line traced on the paper, and extending slightly below the lower long edge of the prism. In the class of experiments last mentioned it will be found convenient to lay some particular mark of a ruler graduated to millimeters beneath the part to be examined, and at such a distance below, that the middle of the sharp edge of the prism is just in contact with the object. By pushing the prism carefully to the right or left, and keeping its lower edge always in contact with the edge of the ruler, the number of millimeters of movement necessary to extinguish the color may be read off, either on the ruler from the assumed zero to the point where the thin edge comes to rest at the moment of extinction, or on the glass edge of the prism itself, if the latter be graduated.

In cases where the color of the ink is too intense to be neutralized even by five millimeters of one of the colored glasses, another prism, of a color corresponding as little as possible with the general color of the ink, may be superposed on the first (but with its thinner edge turned towards the thicker edge of the nether prism) and slid in a contrary direction until

entire extinction of the color is attained. The thickness of the second glass at this juncture, added to the five millimeters of the first, will indicate what thicknesses of these two glasses are requisite to overcome the natural color of the ink.

If the test were to be used as a colorimetric description, it would be better to calculate the thickness of the prisms at each degree of graduation, and by establishing the absorptive power of each prism at each of these divisions to obtain the actual color value of the ink; but generally the number of millimeters over which the respective prisms must be moved in order to attain the extinction of the color will serve to express differences or similarity between two ink-marks, and this will be sufficient for the object in view.

Especially is this the case in an examination undertaken simply to establish the identity or non-identity of two ink lines, for here it is unnecessary to give the absolute color value by reference to the lines on the solar spectrum, but only the relative action of the same absorbing medium on two inks. In such cases it matters little what the character of the color in the glass prism may be, so that it produces a different appearance upon the two ink-marks. The main difficulty is to judge the point at which the colored line becomes actually black. When this point is reached, a further movement of the prism bringing a greater thickness of glass over the line will not increase the

blackness of the latter, but will merely darken the whole field.[1]

Monochromatic Light.—Finally, it is well to illuminate the writing by monochromatic light, and to examine it when thus illuminated both with the naked eye and with an ordinary hand magnifying-glass. Not infrequently a better general idea of the difference of the inks employed can be attained by this method than by examining minute portions of the writing with higher powers.

If the parts of the writing, of doubtful authenticity from other causes, show differences from those parts, of which they are the ostensible continuations, there is good reason for suspecting them to be fraudulent.

The experiment just referred to may be carried out either in a dark room by means of colored lights, such as the sodium flame made by alcohol and salt, and the red and blue lights of commerce, or in a camera ob-

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[1] It hardly needs to be said to those whose admiration for the beautiful and successful researches of my friend Mr. Frederic E. Ives has compelled them to eschew the Brewsterian theory of three primary colors, and to accept that of Young, Helmholtz, and Maxwell, that all color sensation is derived from nerve fibrils in the eye, which may be divided into three groups, sensitive to red, blue, and green light respectively; that there is no objection to selecting a red, a blue, and a green prism for neutralizing the residual color of a ray of light which has passed through the ink film under examination.

The only point necessary to observe is that the three prisms together should be capable of absorbing all the escaping colored rays and that no two of them should absorb nearly the same rays.

scura to which light is admitted on top through an aperture, which can be covered by red, blue, or yellow glass plates; or even by laying these latter over the writing placed on a table and illuminated by strong skylight or artificial light.

The corresponding experiment in transmitted light should also be tried, but here, owing to the large absorption of rays by the paper, the document should be placed on the colored glass and the latter held against a window; care being taken to prevent illumination of the surface. For this purpose an old camera or other box may be used, of which the two ends have been removed. The paper having been laid with the writing uppermost upon the colored glass, the latter held against a window-pane, and a black cloth thrown over the head of the observer and the end of the box, the observations just detailed may be carried out.

It is well to try this experiment both with the colored glass above and below the writing.

When the paper is thick or opaque, it may be necessary to allow direct sunlight to pass through it.

CHAPTER XIII.

QUANTITATIVE METHODS.

Insufficiency of other Methods.—Up to the present, the means suggested for the examination of documents have been qualitative, and the results have been attained by impressions on the senses, which at most have been comparative. This signature has been observed to be more freely written and the other more labored; one line has been observed to be over another; one ink bluer or blacker than another and therefore different from it.

Such methods serve a most useful purpose, and if many of them point to the same conclusion they may succeed in carrying conviction to the mind. But they have the disadvantage that if they point in different ways the judgment is bewildered, and they necessarily exclude from consideration all cases which in themselves are inconclusive. If, for example, it be desired to compare a genuine signature with the signature in dispute for the purpose of examining the differences in their characteristic features,[1] by what method is a

[1] An act, be it understood, which must be performed in the privacy of the expert's laboratory, since, according to the interpretation by certain judges of Chief-Justice Woodward's opinion elsewhere quoted, this direct comparison in court constitutes a crime against the jury, hardly less than forgery itself.

typical signature to be selected? Nothing is more common than to find the most salient feature of a man's ordinary signature very much modified, if not actually suppressed, in individual cases.

If a search be made through a series of undisputedly genuine signatures, it will be found that one characteristic fails in one and another in another.

In few if any signatures of a man throughout his life are all the elements which combine to constitute its character present at one time. Under these circumstances the selection is an arbitrary proceeding.

Is there any way which can be adopted to overcome these difficulties, and to avoid incompatible indications while making use of all the material which can be procured?

It was the writer's conclusion that such a way could be found which induced him some years ago to take up the subject of handwriting as distinguished from questions of the materials used in producing it.

The introduction of the experimental method into all modern investigation (biology, anthropometry, psychology, etc.) to replace disputatious metaphysics, and the vague indications of subjective impressions, led to the hope that in this difficult subject also means would be found to introduce the application of measurement and the simpler forms of the mathematical expression of probabilities. That such treatment of the subject is in the interest of justice hardly needs to be said. As long as the steps by which experts

reach their conclusions are so intricate or recondite that only the results may be stated to the jury, just so long will the character of expert testimony suffer in the opinion of the public, and the insulting charge against it be repeated that any side can hire an expert to support its case.

Expert Witnesses.—If a single competent expert could be selected by the court to take up questions of this kind and lay his results before it, the present system would be less objectionable than it is. Nevertheless, this solution is probably not the best, because no man is capable of always observing and judging correctly, and the most careful man may be led astray by elements in the problem before him of which he does not suspect the existence. It would seem, therefore, to be fairer and less open to objection if a plan of investigation were followed which can be clearly explained to those who are to decide a case and the resulting data left in their hands to assist them in their decision.

In such a manner of presentation, if any important data have been omitted, or if the premises do not warrant the conclusion, the errors can be detected without accusing the expert of lack of good faith or ignorance of his subject. The fact that he has testified in hundreds of cases and in every court in the world should not be allowed to influence the jury against a logical conclusion drawn from uncontroverted facts.

Three Postulates.—Three postulates to the procedure about to be described may be laid down.

1. Everything capable of being observed is capable of being measured, provided one can find the appropriate instruments and methods.

2. Where similar objects produced under variable conditions are to be observed, the method employed must be capable of separating that which is essential from that which is accidental, and such a method is the determination of the average and the maximum variation on either side of it.

3. The determination of average with limits of variation is applicable to the study of handwriting, and especially signatures, because handwriting is a result of the action of a motor (the will) on a machine (the bony structure of the arm with the particular muscles and nerves attached to it) attempting to reproduce a pattern which habit has gradually rendered permanent in the mind. The variations in the will-power and accidental external hinderances, such as a bad pen, rough paper, lack of space, etc., may modify this ideal in one or more parts, but usually more characteristics will remain than are removed by these causes, so that in being added to those in a given number of true signatures the determination of the elements of any one signature will raise the average of the sum of all nearer to conformity with the ideal of the writer, if only by a little.

Numerical Average.—Instead of selecting a single

signature to serve as a pattern, and comparing the doubtful signature with this, it remains to ascertain what characteristics of the signature are susceptible of measurement. By measuring these in all signatures, and taking the average of all the observations of each characteristic, one gets a numerical expression of each characteristic near to the ideal which the writer always strove without success to attain, and the approximation will be in inverse ratio to the variability of these characteristics.

This method is adaptable to all cases where the number of authentic examples is great enough to give weight to the average deduced from them, and may be called the method of numerical average.

The selection of the characteristics for measurement will be taken up very shortly.

Graphic Average.—Another method, which is based upon the same general principles, differs from the last only in the manner of obtaining the averages.

It will be seen, when the subject of selecting the characteristics of a handwriting is taken up, that the number of such characteristics is almost infinite, and the best that can be done by the system of measurement and tabulation is to select a few of the most striking to deal with.

But by the application of the beautiful method first introduced to the notice of the reading public by Francis Galton, the averages are not those of a few selected characteristics, but of all made automatically and at

once by composite photography. By this method all agreements and differences are noted together, and it may be called the method of graphic average.

Composite Photography.—If it be conceded that the result of an effort made by a living being to repeat an action it has become habituated to make is within certain limits uniform, then the way is clear to study these results, and to obtain from their average the ideal which each of these actions or series of actions has tended, probably without complete success, to produce.

If we could divide such an ideal into three component parts, *A*, *B*, and *C*, and if we found that out of thirty efforts *A* has remained constant in twenty-five, *B* in twenty-five, and *C* in twenty-five; while *A*, *B*, and *C* have only appeared together in fifteen cases out of the thirty, we are justified in concluding that these fifteen cases, though they represent but half of the whole number of results, constitute in reality the ideal which the agent has always intended to produce.

Measurements.—It is not a matter of indifference what points be taken in measuring, but there are rarely any entirely devoid of significance, and the more measurements which are made, the greater will be the accuracy of the description, and the larger the number of average agreements or disagreements with the signature in dispute, depending upon whether the same hand did or did not write the undisputed and the suspected series.

A little experience in this work will suggest the lengths, breadths, distances, spaces, heights, and angles which are most important or likely to be so. Previous experience in the office-work of topographical surveying or mechanical or architectural drawing, will be a valuable aid to the student of handwriting, for only such experience will enable him to overcome the difficulties of dealing with coarse and more or less irregular ink lines, and determining their beginnings and endings, the point of their greatest extension to the right or left, and their general direction; for they are usually much thicker than the angles on the protractor which they are made to join.

It is not uncommon for a writer to adopt some peculiarity in the initial of the first name, such as beginning it much above or below the line, carrying a flourish from its last-written part to surround part or all of the other letters, etc.

Attention to the relative sizes and angles of its different parts is usually rewarded in such cases by discovering a number of particulars in which it differs from spurious imitations. These latter, however carefully their writers try to carry out the general design, lack the ease and dash of the genuine letters even if they are more symmetrical and better joined. Leaving such peculiarities aside to be examined in all their parts under a high power of the magnifying-glass or the compound microscope, it is always well to

measure the height and breadth from easily recognized parts, and the slope or angle with the base-line of the straight parts of the letter if it have these. (In such letters as *E*, *O*, etc., this latter measurement is generally useless.)

After the examination of the whole series of undisputed signatures, some point on the first initial letter, or the next following, should be selected, which can be easily found on all of them, and from this the distance from the first to some similar point in the second letter, and to some similar point as near as possible to the end of the final letter of the first name, and to the end of any intermediate name as well as to the final letter of the signature can be measured. The distance apart of the consecutive letters, and the breadth of the spaces between the letters or names of the signature should be then measured. The more of these measurements, which are carefully taken, the greater will be the accuracy of the conclusion drawn from their averages, but the principal elements will be apparent after some practice.

It has been the practice of the writer to go carefully over the writings and decide upon the number of measurements of length, height, and angle to be taken, and then to rule off on a sheet of paper a number of columns equal to that of the elements selected, leaving a horizontal line for every signature studied.

In this way the numbers corresponding to the same elements of twenty or thirty signatures fall into ver-

tical columns and can be readily added and a mean taken. It will also be found advantageous to keep the measurements of height, of horizontal distance, and of angle together in order to avoid confusion.

After this has been done and the averages placed under the columns, the signature or signatures in dispute are carefully measured and the results set under these averages. This method has the merit of avoiding even the appearance of infringing the law as laid down by Judge Woodward against the direct comparison of signatures by experts, while leaving the facts in a convenient form for the jury to make this comparison.

Selection of Points.—It will often be found difficult to select the point from which to begin and that at which to end a measurement. Many names beginning with rounded letters, like *C, E, O,* etc., usually differ in breadth in different signatures by two or three units of the scale used, and the peculiar habit of writing it may make any letter difficult to start a measurement from. Wherever a flourish or other habit produces a crossing of one line by another, such crossing is generally a good point from which to start, more especially if it occur near the completion of the letter, because however erratic the general appearance of a letter may be, its writer will insensibly seek to begin it and end it in the same way. But no general description will suffice to indicate in all cases where to select the points for measurement. A careful study of the largest number of undisputed signatures will most

probably suggest to one of some experience what to choose, and if these fail, the investigator must have recourse to certain general principles. For instance, it is safe to assume that the general line of writing is governed by the writer's habit after the initial letter is formed. In the case of a blank sheet without guide-lines even an experienced writer may make the first letter in a very different relation to the top and sides of the sheet from that he naturally adopts when his guide-line is furnished, but after this first letter is made the following letters will preserve to it closely the normal relation. For this reason it will often be found advisable to commence the measurement with the second letter, and to carry the measurements only to the first part of the final letter to avoid the frequent distortion of the latter part, due to preparation for the ending, which usually has some peculiarity not found in the same final letter when written by the same writer in the body of a text.

Angles.—After all the characteristic distances between the selected letters have been measured, great care should be taken in measuring the angle or slope of the longer letters,—*i.e.*, the *bs, ds, fs, gs, hs,* etc.

The advantage of this is that the slope of letters, besides being determined by the natural structure of the arm of the writer, and his or her long habit of employing a particular point of it for a pivot, is a constant not easily appreciable by the eye, and likely to be deviated from even by expert forgers whose atten-

tion is chiefly fixed on imitating the forms of the letters and their distances from one another. Of course no general rule can be laid down as to the usual slope in these long letters, but in such documents as the writer has measured the great majority have shown the slopes of the letters with the actual or imaginary guide-line to be from the left to the right upward from forty-five degrees to seventy degrees. Very few have a less angle with the guide-line than forty-five degrees, and though there are not infrequent cases of back-hand writing where the slope is from the upper left hand downward to the right, these and other slopes exceeding seventy degrees bear a very small proportion to the whole.

Use of Averages obtained.—A large number of linear and angular measurements of undisputed signatures having been taken, averages of all are obtained, and these averages should be compared with either the single signature in dispute, or, if there be several of them, with each separately, and also with their average.

In the experience of the writer a difference of fifteen per cent. between the two constitutes a ground for suspecting the genuineness of the disputed writing, if this amount is reached or exceeded in several of the elements measured.

A difference of ten per cent. in several of the linear measurements of two genuine signatures is not unknown, and five per cent. difference in the angles of

TABLE I.

Angular Measurements of a Signature.

	1	2	3	4		5	6	7	8	9
DOCUMENTS.	*J* upper	*J* lower	*b*	*D* (down stroke). *a* upper part.	*b* lower part.	*M*	*M*	*M*	*M*	*ll*
	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
A	50	70	. . .	30	60	50	45	55	45	45
B	40	65	. . .	30	60	50	45	55	45	45
C	45	70	50	30	60	50	45	55	45	45
D	43	70	48	30	60	50	45	55	45	45
E	50	70	50	30	60	58	45	55	45	48
F	45	70	50	30	70	50	45	55	45	45
G	40	60	48	40	60	50	45	55	45	45
H	50	70	. . .	30	60	50	45	55	45	48 45
I	55	70	48	35	60	52	48	55	45	48 45
J	50	65	50	30	60	50	45	55	50	45
K	50	70	50	30	60	55	45	55	45	45
L	45	70	48	28	60	52	45	55	45	45
M	45	60	45	30	60	50	43	50	45	45
N	45	60	45	30	60	55	48	55	50	50
O	45	70	50	30	65	55	48	58	50	45
P	40	60	42	20	60	50	42	60	43	45
Q	50	70	50	30	60	58	45	60	45	50 48
R	50	65	50	35	60	55	45	60	50	48
S	40	65	45	missing	missing	50	40	50	43	45
T	50	60	. . .	30	60	55	50	60	50	48
Average of 20 signatures	46.4	65.9	48.06	30.42	60.79	52.25	45.20	55.65	46.05	45.55
Disputed signature (A)	50	70	. . .	30	60	50	45	55	45	45
Composite	50	68	50	32	60	50	45	55	45	45

the slopes is not inadmissible, but it is rare that an average of a number of genuine signatures will differ from any normal genuine signature by as much as fifteen per cent., either in linear measurement or in angle, though individual signatures may do so from each other.

The results once obtained are tabulated and placed in columns in order that the jury may compare them and draw their conclusions from such comparison.

In the tables cited here as examples of the method of tabulating the results of an investigation of handwriting it is unnecessary to use the names in full. They have all appeared in judicial proceedings, and in all cases the verdict of the jury was in accordance with their indications.

Example.—In Table I. of angular measurements of a signature the capital letters on the left refer to the different records or instruments on which the signature was found, whether note, cheque, letter, decree of the court, or what not. The angle with the horizontal, which was measured in column one, was the upper part of the descending stroke of a capital "J." In column two it was the lower part of this same stroke. In column three it was that of the down stroke of a small "b." In four it was the down stroke of the capital "D." In five it was the first stroke of a capital "M." In six it was the second down stroke of the same letter. In seven it was the third or up stroke. In eight it was the final down stroke of the same letter.

In nine it was the angle made by the two small "l's." The word "composite" indicates the measurements of the photographic composite of all the signatures. The method of preparing these composites will be explained later.

The question at issue in Table I. was whether or not a certain signature was genuine, and twenty undisputed signatures were obtained from which to make a basis of comparison. In this case, for particular reasons, only angular measurements were taken. These gave the average noted at the foot of the page. The same elements of the signature in dispute were obtained and written under these averages. The agreement was so close as to justify the belief that the disputed signature was genuine.

A composite photograph was then made of the twenty signatures, and the elements of the composite were also measured. The agreement of these with those of the disputed signature was extraordinary, and tends to show that wherever applicable the method of study by composite photography is more accurate than by numerical average or measurement. Fortified by this double corroboration it was only necessary for the witness to read and vouch for the accuracy of the observations successively recorded in the horizontal lines and for the jury to read these results in the vertical lines to enable the latter to appreciate the strength of the proof.

CHAPTER XIV.

COMPOSITE PHOTOGRAPHY.

THE following statement of the case, with very few modifications, is condensed from two papers presented by the writer to the Franklin Institute and the American Philosophical Society respectively in 1886.

Francis Galton was the first to point out in fugitive memoirs, and notably in his important work, "The Human Faculty," that one could sift the common from the accidental features of a number of objects by exposing them in succession to a sensitized plate in such a manner that the images of the similar parts of the different objects should occupy as nearly as possible the same parts of the plate; and that each object should be exposed for only a fraction of the length of time necessary to complete a picture on the film used. This fraction depended generally, if not always, on the number of objects and on the sensitiveness of the film. For example, if there were eighteen objects and the plate took thirty-six seconds to develop, each object would ordinarily be exposed for two seconds. It is easy to see that the result in the finished picture would be that those features which all the objects had in common would be reinforced by each separate exposure, whereas

those features which were accidental or variable, and which would be different for every individual, would be exposed for but two seconds and would be so indistinct as practically to disappear. Where the object was to catch a family likeness by exposing all the members male and female to the same portion of the plate, the result was a curious medley of faint whiskers and moustache; of hair parted in the middle and at the side; of female gowns with buttons to the throat, and of male shooting-jackets thrown open. But out of all this faint halo of confusion and blur, there starts a characteristic face which is the family type. Very often, too, this type-face resembles noticeably two different members of a family between whom no one can find a resemblance. It is this latter fact (which might have been expected) that induced the writer to look to the process for aid in solving the problem of identity of origin in handwriting. When a number of animals of the same race are thus treated, the method fixes the race or family characteristics, etc., as the case may be. When a number of pictures or coins bearing different representations of the same individual or scene are the objects, the result is to obtain either the average appearance of the same thing under different conditions (as for instance a man at different times of life), or the average of the impression made by identically the same thing on different artists. In this latter case the merit of the process is that it constructs its image out of all that

many pairs of trained eyes have seen, without giving undue weight to any one pair. So far, then, these efforts have been directed to recovering a lost or concealed existence through multiple testimony, very much as the law tries to get at the truth by examining a number of witnesses.

A line made by a human arm and hand is liable to the variations which such an arm or hand must produce when influenced, as they always are, by indefinitely numerous physical and mental forces. A line on paper so produced is as much a resultant of organic processes as the outline of the human figure or the expressions of the human face. It is a kind of fossil like the print of a footstep or of a leaf which, while it consists of nothing having life, or that ever need have had life, and possesses none of the material of the body which made it, is capable, like the impressions above referred to, of telling a great deal of the characteristics of its creator; it is, in fact, as organic as the forms of living things by which we judge them, for their forms or images do not possess life either.

With a given mental image of what one desires to write before one, and with a given relation of will-power, nerve sensitiveness, and muscular force, the same signature could be repeated a thousand times, provided that all these conditions were invariable, and no others were superadded. So far from this being the case, however, every one of the factors just

named which join to produce a signature depends on physical and mental—in other words, on extraneous—influences to a very large degree. The movement commenced to effect an up stroke is met by an unexpected obstacle in the paper, a slight twinge in the shoulder, or a sudden noise, and the resulting line would show (were we sufficiently cognizant of the detailed working of all the complicated parts of our mental machinery to interpret it) just the order in which our different sentient and executive functions have been affected, and to what extent. But while these ever-recurring accidents result in preventing any signature from being made exactly as intended,[1] the fact that no two of them represent the same kind or amount of deviation leaves it in the power of the experimenter to extract from this process the "ideal" signature,—a signature which probably never was seen as it appears, and yet which so combines all the visible results of a particular will acting on a particular arm to trace on paper a known design with a pen or pencil that it may justly be called the *type* signature of that writer. What was said of the resemblance of every object of a group of objects which have any claim to be associated together to the composite made of that group, even though it differ widely from other mem-

[1] The word "intended" is used to imply the effect which would be produced by the action of the will through the hand on the paper if not modified by these accidents, and not solely conscious intention.

bers of the same group, is true of handwriting. It has been remarked that the composite signature is an ideal, and never was realized. This is because the lines along which the strongest reinforcements are made are those parts of the signature where the pen most frequently passes. To put it in another form, suppose the signatures *a*, *b*, *c*, and *d* to be in agreement as follows: At the point *a′*, *b* does not coincide, but *c* and *d* do. At *b′*, *c* does not coincide, but *d* and *a* do. At *c′*, *d* does not coincide, but *a* and *b* do. The tracing which would represent to the eye part of the ideal signature would be that traversing the points *a′*, *b′*, *c′*, *d′*, because those points having superposed lines of three out of the four signatures would be darker, while the variations at each of these points would be indistinct.

In examining with care such a composite signature as has been just described, it at once arrests the attention that the variations are not equally distributed over the entire body of the letter, but that there are regions of each letter where variations of a particular kind are noticeable, and other regions where there are few or none. The greater the number of manuscripts of an individual which are compared, the more forcibly does this fact appear, until finally one is tempted to conclude that after a handwriting is once formed it cannot *naturally* exhibit deviations except within defined limits, and in certain small areas adjacent to the separate letters. It is thus as great an assistance to the ob-

server to study the variations as to study the ideal signature. Indeed, the variations are all important in the matter of identification, and if there were no variations the method would be inapplicable, because an exact copy might be made by tracing. A comparatively small number of signatures will give the maximum and minimum of variation in any given region of one of the letters forming it. Moreover, the kind of variation is easily observed where there are a number together, so that the most perfect adept at forgery could hardly hope to simulate the microscopically minute characteristics of variations which are simply the visible expression of a series of indefinitely complex relations of certain particular muscles and nerves.

Composite photography is a method of obtaining the essence of a number of objects and (in so far as those objects are typical of similar phenomena) of recording the relations of things to each other, and the effects produced by a certain force or certain forces on matter.[1]

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[1] In a pleasant letter received from Mr. Francis Galton, F.R.S., in answer to a copy of the paper on this subject which I sent him, he mentions that an attempt was made at the Kew Observatory to apply the principle of composite photography even to the meteorological charts, without great success, though with more than Mr. Galton would have anticipated.

A more recent and fortunate application of the principle appears in the *American Geologist* for April, 1894, where Mr. J. M. Clarke mentions the successful use of this method to procure a "fundamentum" for the variations of Leptodesma, a genus of lamelli

The merely formal and always repeated parts of a letter or other document have an entirely different character value from those parts which are composed of words and letters thrown together to represent a certain state of things, and which may never be repeated in exactly the same order. Obviously no composite of phrases can be expected unless the phrase have a technical significance, but separate words can be selected to form bases of composites, or even the two or three words which enter into an idiom, one of those well-trodden short cuts of language to a given idea. Such partial phrases (rendered frequently in other languages by a single word), as "in order that," "as well as," "not only," "but also," etc., will be found in the handwriting of any one accustomed to write much, and may be taken as elements out of which to construct composites of the words of which they consist; but the value of such elements in helping one to a knowledge of the character of the person who penned them, or even of the general character of the writer's handwriting is not as great in these cases as it is in the signature and the few formal words which precede it in a letter. There are several reasons for this: one is that these formulas occur in different connections with the accompanying text, indicating

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branchs occurring in the Hamilton and Chemung stages. The strongest lines in the composite correspond nearly with Leptodesma Rogersi.

very different attitudes of mind in the several cases. The sense of what is written must have a large influence in the manner of writing it, and therefore the letters composing these words will be larger or lighter, or more or less quickly and angularly written as the idea of the sentence by reflex action evokes different emotions in the mind of the writer. A circumstance equally noticeable will be the place on the paper which the words occupy, whether there is an abundance of room to write the words, or whether they are cramped in order to bring them into a smaller space. In cases where the words of such a subphrase are divided between two lines, they will almost surely not appear as they would when they follow each other in their natural order. But even more than these is the fact that the signature and its connected words, "Yours truly," etc., are always indicative of the task completed, the information conveyed. They are words of ceremony and endorsement, no matter what the contents of the letter may be. They are invariably repeated and come to be a purely conventional sign, of which the parts resemble more or less the letters in the body of the writing in different people. This symbol usually occupies very nearly the same part of the page—at least as to its distance from the right or left hand edge of the paper—and this tends to fix it as a distinguishing sign. All these facts lead to a distinction between a signature and that writing by the same hand which accompanies original composition.

There are, of course, peculiarities in every hand which can be traced both in the signature and in the body of the text. These are very apparent when the writer labors under a physical disadvantage, such as a maimed or deformed hand or arm, but in lesser degree these peculiarities are present in every handwriting and constitute the general constant of "will-power, nerve sensitiveness, and muscular force" employed by a given individual in this perfunctory habit.

It is not always entirely obvious how signatures with many light flourishes, or accompanied by intricate lines connecting their several parts, should be superposed; for these appendices are so easily affected by minute causes that it seldom happens that two will cover each other exactly. It is not to be expected that such parts will survive in the resulting type signature, but the breadth of the space covered by the blur and parallelism of the faint lines will give evidence of the extent to which these ornaments have grown from caprice to a habit.

As a general rule, there are several places—sometimes as many as eight or nine in a long signature—where the darkening of the lines indicates a general conformity of the pen's path to one direction, and it would seem that these places were not peculiar to any one part of a letter, nor that they were less in a hairline than in a heavy stroke. They appear to be dependent upon the anatomy and muscular structure of the individual taken in connection with his method

of performing the act of writing his signature. For instance, some writers can only form one or two letters without moving the writing hand; only a word or so without shifting the elbow; others describe with the forearm of the writing hand a curve around the elbow, which latter remains stationary; others slide the forearm along into parallel positions while writing. All these habits have different effects upon the handwriting which results, though they are not always to be easily detected, owing to the fact that other habits are cultivated at the same time to counteract the defect which each of these methods, when not so compensated, would have impressed upon the appearance of the chirography.

Thus, he who writes with a definite part of the arm pivoted immovably upon the table must learn to move the fingers over a greater space at some part of the line, to avoid the curve which would unconsciously result. This more vigorous movement of the fingers is naturally likely to produce heavier strokes in the part of the signature where the compensation is applied. So that a fixed forearm and heavy letter in the middle of the signature may stand to each other in the relation of cause and effect.

The Methods of making Composites.—There are two methods of making composites. The first was suggested by Mr. Galton, and consists in exposing the sensitive plate to each of the objects in succession for a fraction of the time necessary to develop a picture,

care being taken to bring similar parts of the images formed by the lenses over the same part of the plate. The plate will be exposed to each object for a time equal to the number of seconds required for a complete exposure, divided by the number of objects.

This plan is preferable, and in fact necessary, where each object supplies details to a large part of the surface of the sensitive plate included by its outline.

The second method, which is equally applicable to linear designs like handwriting, consists in photographing each object on a film of gelatinized celluloid and making a composite by superposing these films, and photographing them all together when thus superposed.

If the number of authentic signatures from which the composite is to be made is very large, they are sorted into different lots, each lot consisting of signatures having approximately the same dimensions, and composites are made from these lots, care being taken to make the resulting composites equally long by altering the distance of the objects from the camera where necessary.

Composites can be made of these first composites again until a final plate is secured representing the composite of all the genuine signatures employed.

Such a final composite will appear as a heavy, thick-lined signature, which, nevertheless, exhibits very strikingly the peculiarities of its writer's hand.

Where extreme precision is required, or, in cases

where the writing is so wide and loose that good composites of the two or more names as a whole cannot be obtained, it will be necessary to make a composite of each name, or even of each letter separately, and to study the suspected writing name by name, or letter by letter.

This plan, while more laborious and expensive, is much more certain to lead to good results, because it deals with each element of the complete signature separately, and not with groups of them together. But in most cases the treatment of the whole signature or each name as a unit will yield important data for deciding its validity. A composite of each name of a signature will obviate the difficulty of dealing with too great a quantity of variables at once; and this method is preferable to the analysis of the elements, because there is a character in the way in which the letters are strung together which is overlooked when they are considered each by itself.

The first composites of signatures were made for the author by Mr. W. Curtis Taylor, now in Tacoma, Washington. To him I am indebted for the composite of the Washington signatures, which accompanied my paper on the process to the American Philosophical Society in 1886, and which is also given here. (Plate IV., Fig. 4.)

This plate was made by Galton's method of exposing each of the objects to the same sensitive plate for less time than is necessary to develop that plate.

More recently Mr. Charles Truscott, of this city, has prepared another composite for me from the same signatures by the method of superposition, and I append his letter on the subject. He favors the plan of superposing positives of signatures taken on celluloid, and photographing them all at one operation.

May 1, 1894.

DR. PERSIFOR FRAZER:

DEAR SIR,—As a person rarely makes two signatures to exactly the same scale, it is necessary to reduce or enlarge each so as to bring them all to a common standard gauge. This must be done by photographic means, and thought and patience are required in no common degree.

Before beginning work on a given signature, it should be decided whether the signature should be made as one composite or two.

If the writing has been done with one sweep of the pen it may make a good composite, as a whole, although composed of two or even three words, but if the words have a break between them any irregularity in this space would prevent prompt registering.

The next point to decide is the scale to use, and still more important the points of measurement to adopt. No rule can be laid down; a little experience will soon develop judgment. It might be pointed out, however, that the capitals had better be left to take care of themselves, or a separate composite made of them, and the points of measurement should be the length rather than the height of the signature, and a point at the bottom line rather than the top of letters, except in the case of an "e" when it is near either end of the word, and when its intersecting line makes a good point.

The next operation is to tabulate the signatures with dates and measurements in decimals between the points of each signature adopted. Then they should be classified, those having heavy lines from those written with a fine pen; or they may be assorted in groups according to their dates, the groups being selected which are most

desirable for a composite. It is well to make a composite of two groups, one heavy line and one light, or one group in one year and another several years apart, noticing the development or evolution of the signature.

It sometimes happens that a disputed signature is simulated from a type long abandoned, hence the advantage of the composites each belonging to the same date, one later and one earlier if possible.

When ready to begin photographing, I use a lens of from twelve to twenty inch focus of the rapid doublet type. A focussing screen of fine texture and more transparent than ground glass is necessary to facilitate the use of the dividers in adjusting the scale with that nicety on which everything depends. A strip of paper is stretched across under the signature on which the date or some distinguishing number is written to be photographed, with the signature for identification. Good, vigorous negatives are now made of all the selected signatures in this way.

The next step is to make transparent positives from these on thin celluloid (Kodak film). These positives should be all made of the same density, otherwise the components will not contribute an equal share in the result. They should not be made very strong, or there will be difficulty in causing the composite to have all the gradations due to the superposed lines.

The films must be accurately superposed, in which operation there will be scope for considerable ingenuity, as on good registration the success or failure of the result depends.

The exposure should be full but not excessive, or the single lines will be lost.

CHARLES TRUSCOTT.

The method of examining by composite photography is recommended wherever applicable, because it includes all the elements of character in a handwriting, and not merely a selected few; because it eliminates the personal error of observation and

measurement, and represents everything in the final result which existed in the separate cases; and because it is a method which can be explained to the jury, and its results left to their judgment.

In this it is even better than the tables drawn up to represent the numerical averages by measurement, because it appeals at once to the eye and requires no previous knowledge of mathematics. It enables the jury to make a direct comparison, and not the expert, with the advantage that instead of comparing one signature with another they can compare the signature in question with the concentrated essence of many signatures of which the adventitious components have been removed.

The method of examining handwriting by the aid of composite photography would seem, therefore, when properly employed, and not abused, or strained to procure results which it cannot give, to be simple and reliable, and, if the photographs have been honestly and wisely prepared, it removes the personality of the expert from the case altogether.

Washington's Signature.—George Washington's signature has been selected as an illustration, because many persons are familiar with it, and there are numerous well-authenticated documents in existence which bear it. It is, however, a severe test of the principle because of its length and the dash and freedom with which it was written.

In writing his signature Washington put pen to the

paper five times. First he wrote the "G W" in one connected line. Second, he raised his hand and made the small "o" between the upper parts of the G and W, and the two dots which appear in all but signature No. 7. Third, his hand and arm were placed in position to write "ashing," these six letters occupying a breadth of almost exactly four and one-half centimeters (or one and three-fourths inches) in every signature except the third, when they are extended to four and seven-tenths centimeters (or one and thirteen-sixteenths inches). This is about as much of the arc of a circle, of which the centre is some part of the forearm pivoted on the table, as one with arms and hands of average length can cause to coincide with the tangent, or the base line of the letters, unless unusual effort be made and a great deal more movement be given to the fingers. The "g" ends in a curved flourish, of which the convex side is turned upward below the right centre of the name.[1] Fourth, he wrote the final "ton." Fifth, he added the very peculiar flourish above the right centre of the name, with the object of dotting the "i" and crossing the "t" at the same stroke.

In examining the composite, the effect of these various separate movements becomes manifest in its strengthened portions. It is hardly possible that any

[1] The lower loop of the "g" in all the signatures and in the composite was cut off in preparing the plate.

one during the period of sixteen years, which these signatures represent, or from 1776 to 1792, should have so schooled his hand to write a long name that the first three or four centimeters of the writing should always occupy the same relative position to the body of the signature. It would take at least that much action for the hand and arm and pen to be brought into normal signature-writing condition; and especially is this so when the part of the writing we are considering is accompanied by flourishes, as it is in this case. The "G W" and the little "o" and the dots at the top were the prelude, after which the arm was moved into position to write the main body of the signature, or the "ashing." Of course, from the manner of making the dots, and the extremely small space they cover, their reinforcement of each other in the composite was almost impossible, and, in fact, like other subordinate characters, they disappear almost completely. This latter is the part of the name which one would have expected to exhibit the greatest amount of uniformity, as in point of fact it does, with the exception of its terminal "g," which shows more variation than any of the other letters, because at this point the limit of coincidence between the tangent line of the writing and the curve, of which some part of the right forearm was the radius, had been passed, and a freer movement of the fingers was compensating for the increasing divergence.

The fourth separate act of the penman was the formation of the "ton" after changing the point of

PLATE IV.

No. 1. G. Washington

No. 2. G. Washington

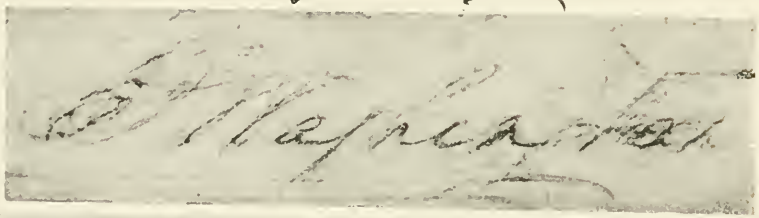
No. 3. G. Washington

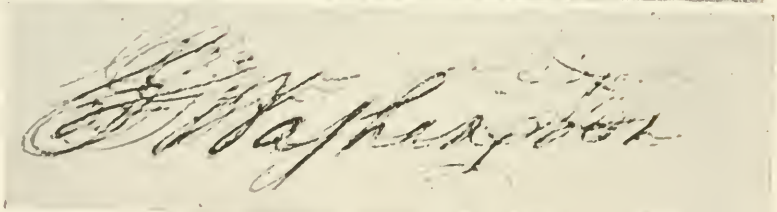
No. 5. G. Washington

No. 6.

No. 7. G Washington

No. 8. G. Washington

No. 4. 

No. 4a. 

rest of the arm. The breadth of the space occupied by these three letters is from 0.75 to 0.87 centimeter (or five-eighths to seven-eighths of an inch), and considerably within the range of coincidence of the curve and straight line before referred to; owing to this fact there is only a moderate degree of reinforcement of the letters in the composite, because these letters might fall into the first or last part of the five centimeters of space which was the limit of movement with a fixed elbow. It is worthy of note that even in this case the middle letter of the three is darker in the composite than either of the outside letters. The fifth and last movement was the flourish which dots the "i" and crosses the "t" by one stroke. This was done in the freest of free hands, often, as it seems probable, without resting hand or arm on the table at all. Therefore there is no coincidence of the lines in this part of the composite, and the *region* of variation is wider than that of any other part of the signature.

All the signatures used in the accompanying plate (IV.) (seven in number) are unquestionably genuine. With the exception of one, which is the property of the writer, they were carefully chosen from a number of authenticated signatures in the possession of the Historical Society of Pennsylvania.

No. 1 is on a letter dated December 18, 1776, from near the Falls of Trenton, and addressed to Washington's brother Samuel.

No. 2 is on a letter dated Head-quarters, November

4, 1777, and is addressed to the writer's great-grandfather, Lieutenant-Colonel Persifor Frazer, then a prisoner of war in Philadelphia.

No. 3 is on a letter dated September 27, 1777, and is to William Henry, of Lancaster.

No. 4 is the composite of all the signatures by Galton's process of using one sensitive plate made by Mr. W. Curtis Taylor.

No. 4*a* is the composite of Nos. 1, 3, 5, and 8, made by Mr. Truscott, who photographed the superposed positives on celluloid strips.

No. 5 is on a letter dated Head-quarters in Morristown, February 22, 1777. The person to whom the letter was addressed is not stated.

No. 6, dated September 26, 1793, is affixed to the commission of David Lenox.

No. 7, of the same date, is affixed to David Lenox's appointment as agent for the relief and protection of American Seamen.

No. 8, May 24, 1799, on a letter to Thomson Mason.

The following statement of the celebrated contest over the Whitaker will is condensed from the paper-book of Mr. Samuel Dickson before the Court of Common Pleas No. 1, Philadelphia County, Sheets *vs.* Whitaker, on the motion for a new trial.

Robert Whitaker was killed on the 23d of August, 1878, and on the evening of the 28th of August a telegram was sent from New York in the name of Wil-

liam R. Dickerson to the Register of Wills, stating that he had a will of Robert Whitaker which he would bring over for probate.

Certain persons were arrested on the charge of forgery. Before the magistrate, testimony was given that these persons drafted a will and had it copied by the former attorney of Robert Whitaker, whom they had associated with them in the conspiracy. The signature of Whitaker was traced by an expert forger from a genuine signature found upon a deed made by Robert Whitaker several years before.

The copy of the signature, seal, and the concluding lines of the last page of this famous document has been made from a photograph kindly loaned to the author for that purpose by ex-Judge F. Carroll Brewster: the original document, now in the possession of the Register of Wills of this city, having been found by the photographer sent to his office to copy it too much soiled and mutilated to admit of a satisfactory copy being taken.

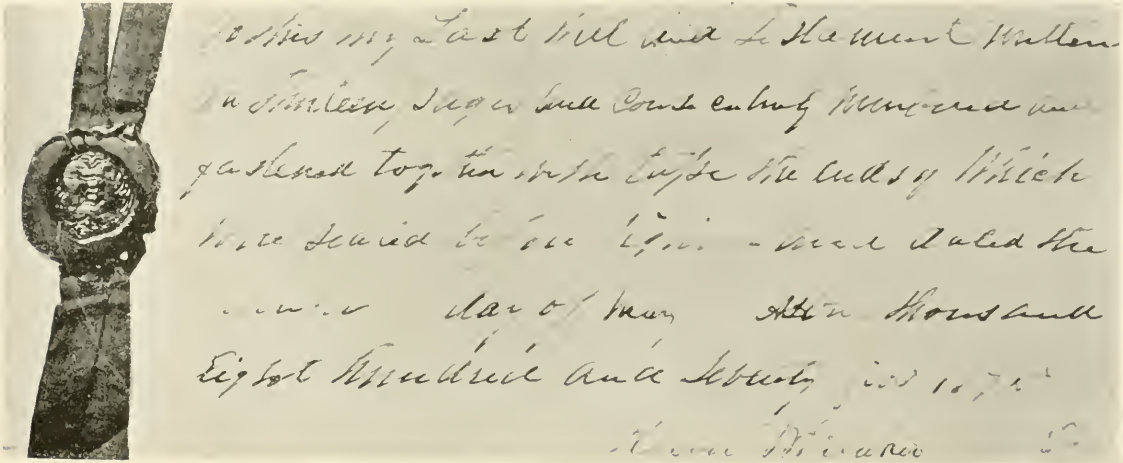
The signature affords a further example of the tremor of fraud,—*i.e.*, that tremor and uncertainty which result from the slow motion of the pen over the paper, necessary to a hand unaccustomed to writing a signature when all the minute details visible in that signature must be repeated. Still it would have been hazardous to pronounce the name a simulated writing in the absence of genuine examples of the writing of the man whose signature it purports to be.

Under a moderate magnification the continual changes in the pressure of the pen on the paper and the constantly recurring deviations in the pen-mark are sufficiently manifest, and with the light which has been shed upon the history of the signature it is impossible not to ascribe them to their proper cause.

But in the absence of such light it would be claiming too much to profess the ability to discriminate with exactness between the halting and uncertainty due to fraud and that due to feebleness, or illiteracy, or other unknown cause.

The composite of the name was obtained from five signatures to letters written long before the period of the will (1849–54). Perhaps among the voluminous testimony taken in this case the observation may be found that Mr. Whitaker had adopted the habit of writing his name "R. Whitaker" for a long time before the date of the will, and that during the period previous to this when he wrote his name "Robert Whitaker" he employed a final "r" different in kind from that attached to the will. The character in the name appears clearly in the composite, and differs from that in the signature entirely.

Each name of the signature was photographed separately for a composite, and the two were joined by careful measurement of the relation between the names in the genuine signatures. The photographs were made by Galton's process of exposures of the successive objects to the same plate, each for its



Robert Whitaker

fraction of the time necessary for complete development.

This is a good illustration of the pitfalls awaiting the forger, who usually leaves evidences of his unlawful work.

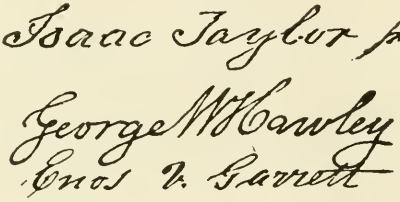
The dragged and manipulated appearance of the tape may be compared with that of the stretched tape shown in a previous chapter, while a close inspection will reveal a scratch across the face of the "D" on the seal, which played an important part in the trial.

When the composite has been made, it should be submitted to the same measurements as the separate signatures, though it will not usually be found so tractable. The portions of greatest value in determining the elements of the given handwriting are those which are the most black, because these indicate the most frequent routes of the pen. It is more difficult to measure spaces between letters in the composite, because its dark kernel is broader and less well defined than the similar parts of a single signature, and it will in fact often cover nearly as much paper as the space itself. In general, wherever a column representing the measurements of the same element in different signatures shows large variations in the numbers, the said element will appear in the composite as a broad blur or as a number of distinct lines.

It is advisable not to attempt to get a measurement

thus obscured from the composite, but to pass it by and rely for the expression of its average on the numerical mean obtained by measuring individual letters or distances between them. In Plate VI. will

Fig. 12.



be found composites of genuine signatures of Isaac Taylor, George W. Hawley, and Enos V. Garrett, which when compared with the forgeries of their names (Fig. 12) illustrate the use of the process in detecting fraudulent writing.

The signature of Thomas J. Morris was made from twenty-seven undisputed examples written by him during a period of eight or ten years. The agreement in these signatures was so great in parts of the name as to almost amount to coincidence. The black line represents the ideal of the writer's signature which he never attained entirely at any one time, and the blur indicates local and accidental deviation of individual signatures from that ideal.

It will be understood from what has been already said that the measurement of the composite is not the only, nor perhaps the most important aid it can render a jury which is to decide upon the falsity or genu-

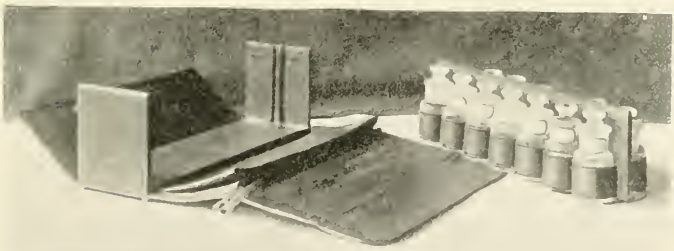
PLATE VI.

Horace Taylor Jr.

George W. Crawley

Chas. D. Garrett

Thos. J. Williams



ineness of a signature. To a jury it furnishes that most valuable of criterions, an authentic pattern of the ideal signature, while to the expert it gives the kinds of variation, their distribution in the separate letters, and their limitations. In Table I. the agreement of the numerical and the graphic methods and of both with a previously unrecognized genuine signature is strikingly shown.

CHAPTER XV.

"GUIDED HANDS."

Character of such Writing.—Cases frequently come before the court where it is admitted that the hand of the person who wrote the signature was guided by the hand of some one else.

The writing produced by two hands conjointly is usually erratic, and, at first sight, hard to connect with the handwriting of any one person. In appearance it changes abruptly from very high or very wide to very low or very narrow letters.

Theory.—This is to be explained by the non-agreement in phase of the impulses due to each of the two writers. If both are endeavoring at the same moment to write a given stroke, the length of that stroke will be measured by the sum of the impulses given by the two writers. If they act in opposition to one another,

one seeking to make a down stroke while the other is trying to make an up stroke, the result will be a line equal to the difference between the stronger and the weaker force.

As these coincidences and oppositions occur at irregular but not infrequent intervals, like the interference and amplification phases of light and sound-waves, the result traced on the paper might be expected in advance to be—and in fact is—a distorted writing where maxima and minima of effect are connected together by longer or shorter lines of ordinary writing.

The tabular statement by numerical average of one case will be shown and more specifically explained farther on.

The only state of things which can justify the guiding of a hand executing a legal instrument is the feebleness or illness of its owner.

Explanations.—When such assistance is required it is usually given by passing the arm around the body of the invalid and supporting the writing hand while the necessary characters are being made.

Both participants in this action are looking at the writing, and both are thinking of the next letter which must be written, and of the motion of the pen necessary to produce it. Unless the executing hand were absolutely lifeless or entirely devoid of power, it would be impossible for it not to influence the guiding and presumably stronger hand; for the least force exerted cannot fail to deflect a hand, however strong, in an

unnatural and cramped position. Nor can the hand of the guider fail to add its contribution to the joint effort, however much the brain which controls it may strive to render the hand entirely passive. Both minds are busy with the same act, and insensibly both hands will write the same letter with the results just described.

Analysis of Guided Writing.—Can the characteristics of each hand be separated from those of the other and the relative amount of the two contributions to the joint signature be stated?

This is a question which is naturally asked during the trial of a case involving the consideration of a guided hand. From the comparatively small number of experiments made by the writer in this direction it would be too hazardous to answer it in the affirmative, but it may be said that some of the characteristics of each hand can usually be made apparent by the system of measurement, and the indications seem to point to the probability of being able to increase the number of characteristics elicited in proportion to the number of observations made. If the significance of every part of every stroke could be properly interpreted, it follows that a complete separation of characteristics would be effected, but this would require an indefinitely large number of observations to be made and a quite unattainable skill in explaining them.

Example.—Table II. contains the data of the study of a disputed signature.

TABLE II.

DOCUMENTS.	1 Length *H—a.*	2 Length *a—t.*	3 Length *t—y.*	4 Length *y—S.*	5 Length *S—h.*	6 Length *h—d.*	7 Length *H—d.*	8 Height of *H.*	9 Height of *H* above line.	10 Average height above line letters of first name.	11 Height of *y.*	12 Height of *S.*	13 Height of *h.*	14 Angle of last down stroke of *y.* α	15 Angle of last up stroke of *y.* β	16 Angle of down stroke of *a.* γ	17 Angle of second up stroke of *y.* δ	18 Angle of first up stroke of *S.* ε	19 Angle of middle of first down stroke of *S.* ζ
	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
Name, 1st line . . .	4	11	8	4	2	14	44	5.5	1	0.7	4 5	4	4.5	68	20	39	9	30	65
Signature at end . .	3	14	9	4	2	14	48	4.5	1	0.6	4	4.5	5	70	30	30	3	40	75
Average	3 5	12.5	8.5	4	2	14	46	5	1	0.65	4.25	4.25	4.75	69	25	34.5	6	35	70
A	5	14	7	7	2	13	49	7	1	α touches 0.5	5.5	7	6	60	30	40	10	25	50
B	6.5	17	7	8	2	12.5	53.5	*6	0	0	5	6	6	60	12	32	8	20	50
C	6	18	8.5	6	3.5	11	52.5	7.5	0.2	0	6	7	7	50	12	30	10	20	40
D	5	15	12	6	3	18	59	8	1	1	†9.5	7	7	60	20	50	30	32	58
E	5	13	9	6	3	15	‡39.5	7 (below line.)	0	0	*y* omitted.	7	6.5	50	20	50	No *y*.	32	60
F	4.5	16	9	7	3	15	54.5	9	1	1	5.5	6	6	50	25	40	10	30	43
G	3	17.5	9	9	3	18	60	7	0	0	5	6	7	50	20	38	20	25	60
H	7	13	10	9.5	3	17	58	6.5 (below line.)	1 (below line.)	Very small.	6	6.5	5.5	50	10	50	5 Too short.	30	50
I	5.5	. . .	8	5.5	3	14	. . .	6.5 (below line.)	0	Very small.	5.5	5	6	50	10	10	Too short to measure.	20	60
J	6	. . .	8.5	6.5	3	15.5	. . .	6 (1.5 below line.)	1	0.5 (below line.)	4 5	5	4.5	50	10	10	Too short to measure.	20	48
K	5	15.5	7	7	3.5	14	51.5	7	0.5	. . . .	6.5	6	5.5	50	10	40	10	20	50
Average	5.32	15.44	8.64	7.01	2.90	14.81	53.05	7.06	0.15	0.31	5.90	6.22	6.09	52.72	15.45	35.45	12.87	24.90	51.72

* Lower stroke of *H* below line 0.5 m. † Tail of *y* below line. ‡ The final *r* in last name omitted.

Columns one to thirteen inclusive refer to measurements between certain selected parts of letters, heights of letters, etc.

Columns fourteen to nineteen inclusive include angular measurements of parts of letters.

The first three horizontal lines represent a name at the commencement of a will, the same name as a signature, and an average of their combined measurements. The following eleven horizontal lines contain corresponding measurements of as many undisputed signatures, with their averages in the lowest line. The first things to strike the eye are the disagreement in the measurements of the name and the signatures in many characteristics and their close agreement in others. These facts alone would indicate that the case was a peculiar one. The variations between close approximation or identity of measurement and wide divergence would lead one to suspect the cause to have been periodical perturbation of a normal hand, and this view is strengthened when one compares the numbers representing the successive measurements of the elements of the disputed signature with the corresponding numbers of the undisputed series.

In columns three, six, and sixteen the measurements of the signature agree fairly well with the averages, but in seventeen, eighteen, and nineteen (all angles), the signature shows the widest discrepancies when compared with the averages of the larger series.

There are too many approximations between the

two to render it probable that the signature was made entirely independently of the hand which made the lower series, and yet the wide divergences in a large number of the components investigated show that another force was modifying the first. It had the appearance of a guided hand, and this appearance was further confirmed when analysis showed that several elements in the signature differed radically from about one hundred and seventy-five instances of the same elements in the hand which was suspected of having forged it, while agreeing very closely with them in the undisputed signatures. This method supported the view (which was afterwards corroborated by direct testimony) that the suspected signature was produced by the hand of the person whose name it indicated, guided by the hand suspected of forging it.

These tables are introduced for the purpose of showing the system by means of which the separate observations are recorded, combined, and employed.

Plate VII. and Tables III. and IV. illustrate an experiment in this direction. The supposititious name "Edwin S. Barley" was selected, and two persons, A and B, practised writing it for some time, in order to attain some facility, at least remotely resembling that which every one has in writing his own name.

In Experiment I., Plate VII., the name was written freely by A. In the group of three experiments, II., *a*, *b*, and *c*, B supported the elbow of A while the

PLATE VII.

I. Edwin S. Barley

II. Group.
a Edwin S. Barley
b Edwin S. Barley
c Edwin S. Barley

III. Group.
a Edwin S. Barley
b Edwin S. Barley
c Edwin S. Barley

IV. Group.
a Edwin S. Barley
b Edwin S. Barley
c Edwin S Barley

V. Group.
a Edwin S. Barley
b Edwin S. Barley
c Edwin S. Barley

VI. Group.
a Edwin S. Barley
b Edwin S. Barley
c Edwin S Barley

VII. Group.
a Edwin S. Barley
b Edwin S. Barley
c Edwin S. Barley

VIII. Edwin S. Barley

latter wrote the name; both A and B, however, in this, as in all but the first and last experiments, together kept their attention fixed upon the writing.

In the group of three experiments, III., *a*, *b*, and *c*, the middle of the forearm of A was grasped by B.

In the Group IV., *a*, *b*, and *c*, the forearm was grasped and supported immediately behind the wrist.

In the Group V., *a*, *b*, and *c*, the wrist itself was grasped and supported and its motion largely hindered.

In the Group VI., *a*, *b*, and *c*, the hand itself was tightly grasped, the wrist motion entirely prevented, and only the fingers and the arm left free to move.

In VII., *a*, *b*, and *c*, the hand and fingers were tightly held and free motion only allowed to the arm.

In VIII., B wrote the name without assistance or interference from A.

The signature was then examined, and seventeen elements selected for measurement, which are indicated at the heads of the seventeen columns ruled on the paper.

The first seven columns refer to horizontal distances in millimeters between certain parts of letters. The succeeding five columns give the heights of as many letters selected from the rest, because it was thought that they would give more significant indications as to character.

The last five data refer to angles with the horizontal, or slopes of the letters.

TABLE III.

Measurements of the Writing of a Guided Hand.

	E—d.	d—n.	n—S.	S—B.	B—a.	a—y.	E—y.	Height.					Angle of d.	Angle of S.		Angle of B.	Angle of l.
								E.	S.	B.	d.	l.		β	γ		
	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Deg.	Deg.	Deg.	Deg.	Deg.
I.	5.5	19	21	13	6.5	28.5	93	9 5	8	8.5	6	6	40	30	50	48	30
II. *a*	9	22	21.5	10	8	28 5	101.5	9.5	8	10.5	5	6	40	20	50	45	25
II. *b*	10.5	28	23.5	8.5	8.5	28	100 5	8	7.5	9	4	4.5	30	12	50	40	30
II. *c*	7	13 5	25.5	9	7	28	101	6.5	6.5	10.5	3.5	5.5	50	15	50	40	30
II. Average	8.83	21.6	23 5	9 16	7.83	28.23	101	8	7.33	10	4.6	5.33	40	15 66	50	41.66	28.33
III. *a*	10	27	22	11	7.5	25	103	9.5	6.5	9.5	5	5.5	40	23	50	50	30
III. *b*	8	24	24	11	6.5	31	105	7	6 5	7.5	4	3.5	50	20	50	42	25
III. *c*	7	24	23.5	10	10	30	105.5	6.5	6.5	9	5	4.5	58	15	40	40	25
III. Average	8.33	25	23 16	10.33	8	28.66	104.5	7.66	6.5	8.66	4.66	4.5	49.33	19.33	46.66	44	26.66
IV. *a*	7	26	21.5	10.5	9	31.5	101.5	7.5	6.5	8	5.5	5.5	58	20	50	48	27
IV. *b*	7	26	21.5	10.5	7	28	99	7	6.5	7	5	4 5	58	15	68	45	30
IV. *c*	8	25.5	21.5	10	8	33.5	104.5	7.5	7	7	5	6	48	20	60	30	30
IV. Average	7.33	25.83	21 5	10.33	8	31	101.66	7.33	6 66	7.33	5.16	5.33	54.66	11.66	62.66	41	29
V. *a*	7	22.5	19	10	7	26.5	96	8.5	8	6.5	7.5	5	70	20	70	50	25
V. *b*	10	23	18 5	10 5	5.5	28	96	8	7.5	8	6	6.5	50	20	70	50	40
V. *c*	8.5	25	20	10 5	8 5	29	100.5	7	8	9.5	6	4	40	20	70	50	40
V. Average	8.5	23.5	19.16	10.33	7	27.83	97.5	7 83	7.83	8	6.5	5 16	53.33	20	70	50	35
VI. *a*	9	28	21	13	8	33	112	10.5	10.5	13	8	7	60	23	70	55	35
VI. *b*	10	21	18.5	13.5	7	27.5	97.5	9.5	9	12	8.5	5	45	25	65	40	30
VI. *c*	8.5	25	22	16	5.5	28	104	9.5	9	12	5.5	6	50	30	60	50	40
VI. Average	9.16	24.66	20.5	14.16	6 83	29.5	103.16	9.83	9.5	12.33	7.33	6	51.33	26	65	48.33	35
VII. *a*	5.5	16 5	16	10 5	5 5	24.5	79	6	8.5	8	6	7 5	60	10	60	70	50
VII. *b*	7	20.5	11.5	13	5.5	21	79	8.5	8.5	8	6	8.5	68	10	58	70	55
VII. *c*	3.5	19.5	11.5	12.5	6.5	19 5	71.5	5.5	6.5	7	5	5.5	70	3	58	65	38
VII. Average	5.33	18.83	13 0	12	5.83	21.66	76.5	6 66	7.83	7.66	5.66	7.16	66	7.66	58.66	68.33	47.36
VIII.	6	15.5	17.5	12.5	4.5	21.5	78	7.5	11.5	11	5.5	8.5	50	35	50	50	40

TABLE IV.

Averages of 320 Observed Measurements of the Writing of a Guided Hand, from Table III.

	E—d.	*d—n.*	*n—S.*	*S—B.*	*B—a.*	*a—y.*	*E—y.*	Height.					Angle of *d*, long stroke.	Angle of *S*, up stroke.	Angle of *S*, down stroke.	Angle of *B*, main stem.	Angle of *l*, up stroke.
								E.	*S.*	*B.*	*d.*	*l.*					
	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Mm.	Deg.	Deg.	Deg.	Deg.	Deg.
I.	5.5	19	21	13	6.5	28.5	93	9.5	8	8.5	6	6	40	30	50	48	30
II.	8.83	21.6	23.5	9.16	7.83	28.23	101	8	7.33	10	4.6	5.33	40	15.66	50	41.66	28.33
III.	8.33	25	23.16	10.33	8	28.66	104.5	7.66	6.50	8.66	4.66	4.5	49.33	19.33	46.66	44	26.66
IV.	7.33	25.83	21.50	10.33	8	31	101.66	7.33	6.66	7.33	5.16	5.33	54.66	11.66	62.66	41	29
V.	8.5	23.5	19.16	10.33	7	27.83	97.5	7.83	7.83	8	6.5	5.16	53.33	20	70	50	35
VI.	9.16	24.66	20.5	14.16	6.83	29.5	103.16	9.83	9.5	12.33	7.33	6	51.33	26	65	48.33	35
VII.	5.33	18.83	13	12	5.83	21.66	76.5	6.66	7.83	7.66	5.66	7.16	66	7.66	58.66	68.33	47.36
VIII.	6	15.5	17.5	12.5	4.5	21.5	78	7.5	11.5	11	5.5	8.5	50	35	50	50	40

To prevent the error which would be likely to result from considering but one series of measurements for each of the seven cases just described, all but the first and last were repeated three times, and the averages of these triple measurements were taken as single observations and compared with each other and with the single signatures at the commencement and the close.

The resulting figures are complicated, but in general they show the greatest divergences from the type furnished by each of the experimenters in the middle spaces III., IV., V., and VI., or where the motions of both A and B had the greatest freedom; and the least divergence in the spaces nearest to the type signatures.

Summary.—If the average of Experiment VII. (Table III.) be compared in numerical results with that of the free-hand Experiment VIII., it will be seen that about half of the results differ by less than fifteen per cent.

To be more accurate, they are as follows, counting the seventeen columns from left to right: 0.11, 0.17, 0.33, 0.04, 0.22, 0.006, 0.019, 0.011, 0.31, 0.30, 0.002, 0.015, 0.32, 0.78, 0.14, 0.27, 0.15. Eight out of the seventeen results differ by fifteen per cent., or less, whereas the results in the middle space III., IV., and V. differ in almost every case by much more than fifteen per cent., which has been arbitrarily assumed as the maximum variation to be generally allowed between any genuine signature and the average of a number of them.

Table IV. gives only the averages mentioned on Table III., omitting the separate measurements for the purpose of obtaining greater simplicity.

The greatest differences between Series VII. and VIII. are found in the angles representing slopes of the letters or inclination to a horizontal line.

This is an additional instance of the value of this element in determining normal signatures.

NOTE.—Since this book was in press the daily papers report some testimony of an expert in a case of guided handwriting.

Whether or not it be considered established that with care the elements of each handwriting can be proven in the guided signature, the expert's opinion was certainly premature if he were correctly reported as stating that "it was impossible for a person holding another's hand to infuse the character of the guider's hand into the writing." (See Philadelphia *Evening Telegraph*, May 22, 1894.

PART II.

CHEMICAL EXAMINATION.

CHAPTER XVI.

THE TESTING OF INKS.

Objects in View.—The testing of inks on documents may have for its object the decision as to whether two different ink-marks give the same reactions; whether certain substances are contained in an ink; or which of two crossed lines is the upper one. These and a variety of other questions belong to the chemical part of an expert's duties, and are here to be considered by themselves. It is evident that, in an important document, it is out of the question to think of making a quantitative analysis of an ink. To do so would destroy the document, and even if by this means a satisfactory analysis could be made (which is doubtful) it would be at too great a sacrifice. But it is not likely that a satisfactory quantitative analysis of the ink could be made from the extremely thin and dried films of its marks on paper, for whether mechan-

ical or chemical means were used to collect it, the substance examined would always be rendered impure by the material derived from the surface of the paper, which could not be entirely separated from it.

Some constituents of inks are volatile, and consequently the result attained by an ultimate analysis of the material which could be secured from a dried piece of writing would be but little more precise in suggesting the original constitution of the ink than such qualitative tests as may be conducted without injury to the document as a record.

Importance of photographing the Document.—While it is perfectly true, as has been said before in this work, that a good photographic copy should be made of every document before it is submitted to chemical examination, the latter is far from the dangerous process which judges and opposing counsel sometimes seem to consider it.

Plea for Proper Chemical Testing.—It is frequently remarkable to observe with what equanimity the court can see an important document soiled by dirty fingers, folded and sometimes torn, pricked with pins, and adorned with "Exhibit" marks, while it forbids the application of a minute drop of a reagent to the ink or paper of which the effects could only be seen by a magnifying-glass, and which would have some real value in the establishment of the truth: as if the act of testing chemically were a sacrilege. This prejudice of the court against permitting a document to be

chemically tested seems not to be shared to the same extent abroad.

If the truth is to be elicited some liberty is to be allowed the expert, but it is not necessary that he should be permitted to mutilate or destroy the paper. On the contrary, in dealing with valuable documents none should be allowed to apply tests of any kind but those known to have the necessary experience to do so safely, and those who have a respect for records.

The tests applicable to a writing are necessarily qualitative,—that is, they are exclusively directed to determining the presence of a substance and not to the quantity of that substance which exists in the ink. The proof of the presence of a substance is obtained by the reactions it gives, which are in these cases usually changes of color or shade on the application of the testing substance. It is not necessary that this should be effected over any considerable surface of the ink-mark tested. An exceedingly small drop applied on a fine point to a given part of an ink line, and then examined carefully under the magnifying-glass, will give the same assurance of the presence of a component as would the entire document if immersed in the reagent. It is seldom necessary to effect so great a change as to be remarked by a casual glance at the document. Nevertheless, it in no way invalidates the authenticity of a document if the color of parts of a few letters has been changed, especially if the exact parts of the document to which reagents have been applied are noted,

and can be recognized and testified to by the expert who makes the experiment. Nor does it deprive the expert who is studying the character of handwriting of the opportunity to pursue his investigation if the lines he is following are occasionally mottled with colors different from that of the ordinary ink, so long as the lines remain in other respects as distinct as before. This should generally be the case, but there are tests which leave the ink spread out in little blots where the reagent has been applied. Tests like these should be avoided wherever possible, and when they must be undertaken the amount of the reagent should be as small as is consistent with a proper observation of the reaction.

For the purpose of examining inks upon written documents, the following are the reagents which it will usually be found sufficient to employ:

Reagents Desirable.—Oxalic acid, three per cent. solution; citric or tartaric acid, ten per cent. solution; hydrochloric acid, ten per cent.; sulphuric acid, fifteen per cent.; nitric acid, twenty per cent.; a solution of one part tin chloride, one part hydrochloric acid, and ten parts of distilled water; saturated solution of sulphurous acid; four per cent. solution of gold chloride; a solution of sodium hyposulphite one part, ammonia one part, and distilled water ten parts; a solution (which should always be freshly made) of potassium ferrocyanide one part, hydrochloric acid one part, and distilled water ten parts; a solution of

potassium sulphocyanate one part, hydrochloric acid one part, and distilled water ten parts; a four per cent. solution in distilled water of sodium hydrate; a two per cent. solution of chlorinated lime; some crystals of iodine; absolute alcohol; aqua ammonia, and distilled water.

Convenient Form of Apparatus.—The writer finds it convenient to arrange these reagents in a portable case, of which a representation is given in Plate VI., Figs. 5 and 6.

The little reagent-bottles, each containing about twenty cubic centimeters, are held in separate compartments, on two sides of a double strip, hinged at the top. In carrying, the two strips are pressed together and slipped into the grooves on the ends of the outside case; while in use, the strips are separated and rested on the table, when they are ready at hand. A broad pocket extending over the entire length of the outside case is useful for carrying the glass rods, feathers, pens, etc., necessary for applying the reagents.

Manner of testing.—Strips of clean, white blotting-paper should always be provided before commencing the examination.

If the document be very old or the ink with which it is written very pale, it is well to apply a drop of distilled water to the place where the reagent has been applied, and as soon as sufficient time has been allowed to judge of the reaction, to remove the surplus fluid at once by means of the blotting-paper.

According to Hager and Holdermann[1] the most frequently employed black inks are prepared from the following substances:

Constitution of the Principal Inks.—1. Gallo-tannic acid (nutgalls), copperas, gum arabic (with or without acetic acid or wood vinegar). This ink is generally called nutgall ink.

2. Alizarine ink is prepared like that of nutgalls, but receives an addition of indigo-carmine, or a solution in water of indigo in sulphuric acid to which iron has been added.

3. Nutgall ink with logwood is prepared like nutgall ink, but instead of water a decoction of logwood is employed.

4. Logwood ink (with potassium chromate) is prepared with one thousand parts of a decoction of logwood and one part of potassium chromate.

5. Unknown inks are brought into commerce under different names, but are chiefly prepared from logwood infusions with various salts (such as, for instance, cupric chloride).

6. Copying-inks consist mostly of the foregoing inks, with glycerin and an addition of sugar, or they are prepared from solution of extract of logwood, with the addition of alum, blue vitriol, glycerin, indigo-carmine, etc.

7. Aniline inks are prepared from aniline colors.

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[1] Hager's Untersuchungen, etc., Dr. H. Hager and E. Holdermann. Leipzig: Ernst Günther's Verlag, 1888.

General Considerations.—It is often important to know the constitution of these universally employed inks, and to pay attention to them in the examination of supposed forgeries.

The testing of a writing demands every precaution, for often only one written letter, a simple stroke, constitutes the object of the examination, and it must be proved from this stroke whether it has been made with other ink than that used in the rest of the document. Again, sometimes the proof must be furnished whether a written character is of later date than the remainder of the document.

When it concerns important documents, and especially in legal cases, as has been reiterated, it is advisable to have a photographic copy taken of the writing, or the suspected part of the writing.

Preliminary Investigation.—At the commencement of the investigation one should use a lens or a magnifying-glass in order to determine whether several adjacent characters have been apparently made with the same ink. They should be viewed with a magnifying-glass in reflected and transmitted light in order to recognize a variation in color, lustre, or thickness of the ink-film. Many inks blot on bad paper,—that is, the written characters surround themselves with a paler border; other inks which contain, for example, much gum do not possess this characteristic.

The lens determines this easily, but it must not be overlooked that many papers are badly sized, or have

individual spots which are not sufficiently sized, and hence cause the ink to flow. An ink rich in gum, or an ink concentrated by evaporation in an inkstand, gives a more lustrous and thicker stroke. Many inks sink deeper into the material written on, so that the character can be seen and observed on the other side of the paper with the lens. At the place where written characters cross, and these written characters have been made at different times, or with different inks, it can often be recognized, with the aid of a lens, which character lies under or over the other, and therefore which was made first or last. If it be necessary to employ the microscope, a magnifying-power of tenfold linear measure with a lateral illuminating lens is generally strong enough.

Next comes the use of reagents.

Oxalic Acid ($C_2H_2O_4 + 2Aq$).—With a soft quill or gold pen which has been dipped in solution of oxalic acid (one part acid to ten or fifteen per cent. of distilled water), minute dots are made on, or cross-strokes are made through the broader and narrower parts of some of the written characters, and these are examined by the naked eye after drying, and with the lens. With iron-holding inks a fading or paling will occur more quickly in fresh writings, and more slowly in old writings. Fresh characters traced in nutgall ink one or two days before the observation disappear under oxalic acid easily, or become light gray; older

characters become a little paler or gray, and the same is true of nutgall ink with logwood; the characters written with alizarine ink become by solution of oxalic acid bluish or blue; characters made with logwood inks, on the other hand, orange red, raspberry red, or brownish red. Aniline ink is not materially changed.

Hydrochloric Acid (HCl).—Hereupon the pen is dipped in twelve and a half per cent. hydrochloric acid, and strokes are made as before through separate parts of the writing, and allowed to dry without warming. Writings of nutgall ink, if not more than a day old, become yellow; if older, yellowish-gray; those with nutgall ink containing logwood, reddish or reddish-gray; with alizarine ink, greenish; logwood inks, more or less red; aniline ink, more or less reddish or brownish-gray.

Ammonium Hydrate (NH_4OH).—This substance, known in commerce simply as ammonia or hartshorn, is one of the three strongest alkalis. It is preferable as a reagent to potassium or sodium hydrates, because it is entirely volatile, and any excess which may be left on the substance to which it is applied may be entirely expelled by moderate heat. Ammonium hydrate is very subject to the capillary action of the paper, and runs over a large space outside of that to which it is applied. The use of parallel strips of blotting-paper

is to be recommended when it is applied to a written instrument.

In moist ammoniacal air, or by touching with caustic ammonia, the places in the writing which have been changed in color by acids become darker (even blackish violet, like the logwood inks), frequently with blurred outlines; but the writings least of all or not at all darkened are those made with nutgall ink and bleached by acids.

Potassium Ferrocyanide.—Ferrocyanogen forms with most metals compounds insoluble in water, and usually exhibiting characteristic colors. Its compound with iron, even when an infinitesimal amount of the latter is present as a sesquioxide or sesqui-salt, produces an intense blue—Prussian blue—which is not effected by hydrochloric acid, but is dissolved by potassium hydrate.

In using this reagent on a document for the purpose of proving the presence of iron in the ink unusual precautions are necessary. In the first place, as has been stated in the remarks on the constitution of paper, a small drop of the reagent should be applied to the paper of the document at parts where there is no ink, and left there for a minute. If no change of color take place, the drop should be removed by soft blotting-paper, and its traces still further obliterated by successive drops of distilled water on the same spot also removed by blotting-paper.

The reagent should then be applied in a minute drop to the ink. If, at the expiration of sixty seconds no change of color appear in the drops or on the paper under it, the solution should be removed by bibulous paper, and the place washed by successive drops of distilled water, which should be allowed to stand for an equal time, and removed in the same way. If the solution be exposed to the light and air it will suffer decomposition, and part of its iron contents will furnish the very reaction for iron which is sought in the material to which it is applied.

Documents which have been tested by the reagent without having been subsequently freed from it, as above suggested, invariably exhibit blue spots which ignorant or designing persons may ascribe to reactions with the iron in the ink or paper when no such iron was present.

While this reagent is invaluable, it requires more care than all the rest to avoid leaving a stain on the document. It should not be applied in drops broader than the ink lines it is meant to test, but in very minute drops lying wholly within the lines, and the reaction, if any, should be observed with a glass magnifying four or five diameters. If no reaction for iron is observed on the blank paper, while a reaction is seen when the reagent touches the ink, the proof that the color is due to the iron in the ink is convincing.[1]

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[1] An actual instance where this test proved of great value was in the Whitaker will trial.

Potassium Sulphocyanate (KCNS).—This reagent when acidulated, as recommended in the table of reagents, or, indeed, in all but distinctly alkaline solutions of iron sesquioxide salts, produces in them an intense red color, although not a precipitate.

This test is one of the most delicate in qualitative chemistry, and, in the absence of molybdenum dioxide and hyponitric acid (of which the presence in the subject of examination is excluded), is convincing as to the presence of iron in the ink. Indeed, its very delicacy, which takes note of the adventitious existence of the minutest particles of ferriferous substances in paper or ink, is almost a drawback to the formation of an opinion when it gives the reaction for iron; but when even this substance fails to show the slightest trace of iron, it is useless to seek proof of such a trace

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A will, purporting to have been made by Robert Whitaker, on the 7th of May, 1875 (a copy of the last page of which will be found among the illustrations of this book), was presented for probate upon his death in 1878. The appearance of the ink with which the signatures were written was of that peculiar reddish-brown assumed by iron inks after the lapse of several years. If it were an iron ink, therefore, it must give, with potassium ferrocyanide, the blue color characteristic of this element. If, on the contrary, it gave no reaction for iron, it was no common writing fluid, but a coloring matter chosen to imitate an oxidized iron ink. So thought the writer, who was requested to examine the will, and preparations were made to test this. The writing fluid was proved to be an unusual one containing no iron but simulating old iron ink, and it was stated to be probably Winsor and Newton's brown, which was subsequently corroborated by the confession of the forgers.

by any other. It has also the advantage over potassium ferrocyanide of not containing iron within itself, which may by internal change produce the very reaction it is employed to show in other substances.

Tartaric Acid ($C_4H_6O_6 = H_2\overline{T}$).—That of commerce is sufficiently pure for purposes of testing. It is to be kept as a powder and a solution made when required, for it decomposes by exposure to light and air, as can be observed when a white film forms on its upper surface.

Citric Acid ($C_6H_8O_7 = H_3\overline{Ci}$).—Like tartaric acid, is useful in preventing sesquioxide of iron solutions from precipitation by alkalis; it dissolves sesquioxide of iron, and therefore bleaches an ink of which the dried film contains this substance.

Sulphuric Acid (H_2SO_4).—The reactions of this most powerful of all the acid reagents are too well known to need recapitulation here. It readily dissolves the sesqui-salts of iron in an ink-film and produces characteristic color reactions with the various inks.

Nitric Acid (HNO_3) is equally with the preceding well known to chemists and non-chemists. It is a powerful oxidizing agent and solvent, and its salts are generally easily soluble in distilled water.

Acidified Tin Dichloride ($SnCl_2.HCl$).—This is a powerful deoxidizing or reducing agent.

It extracts the oxygen present in the ink-film, and breaks up the compounds, while the free hydrochloric acid removes the iron.

This reagent is difficult to preserve for use, and should be made when needed. It should be kept in a well-stoppered bottle slightly acidulated with hydrochloric acid, and some metallic tin should be added. Its tendency is to form tin perchloride, which destroys its value as a reagent.

Gold Terchloride ($AuCl_3$).—This solution is used as a strong oxidizing agent. In the act of raising the stage of oxidation it precipitates metallic gold as a reddish-brown powder.

It is not so subject to change in the reagent-bottle as the substances just considered.

Ammoniacal Sodium Hyposulphite ($Na_2S_2O_3 + NH_4OH + Aq$).—This well-known reagent, employed extensively in photography, has powerful reducing properties, and reacts on the various constituents of inks with characteristic color effects noted in the table at the end of this chapter.

Sodium Hydrate ($NaOH$).—This is one of the two strongest alkalis, and is employed both for neutralizing acids previously applied to portions of the paper,

and for its decomposition and color-indications on the materials to which it is applied. (See table.)

Chlorinated Lime ($CaOCl_2$).—This is simply the bleaching powder of commerce dissolved in water. It has a bleaching and an oxidizing effect, the two being due to the same characteristic, the release of oxygen by the free chlorine and the destruction of coloring matter by the former. Like all the other reagents, but with greater reason than for any but strong sulphuric and nitric acid, it should not be left in contact with the document longer than is necessary for the observation of the reaction, otherwise it is liable to destroy the paper with which it comes in contact.

Iodine (I_2—crystals).—This element is volatile, even at ordinary temperature, and is characterized by its strong blue color when brought in contact with starch. Its uses are more particularly set forth in the two succeeding chapters. This reaction was supposed to be merely physical, but the best authorities now regard it as a true chemical combination, and Mylius finds it to contain eighteen per cent. of iodine, of which part is hydrogen iodide, and gives the formula $(C_{24}H_{40}O_{20}I_4)$ HI (*Sadtler*).

Alcohol ($C_2H_5(OH)$).—The use of this substance as a test on portions of a paper where writing has been erased, and the bare place has been re-sized by means of resin, soap, and paste, or other like substances, has

been already alluded to. Besides this, however, it is of value in causing the reappearance of writing which has been rendered invisible, as described in the experiments of Chevallier and Lassaigne in a succeeding page. Care is necessary in using alcohol on documents on account of its strong tendency to spread and run over a large area of the sheet, carrying its stain and coloring materials to a considerable distance from the spot to be tested. Where this would interfere with the investigation, it is recommended to place strips of blotting-paper on either side of and close to the spot to be treated with alcohol, and to press them firmly upon the document before applying the small drop of alcohol between them.

Superposition in Crossed Lines.—To distinguish the ages of two ink-films which cross each other, whether, for instance, a crossing-out, a writing, or a blot was first made (if nutgall was the ink used), the place is touched with a brush dipped in the above-named solution of oxalic acid, because it can be assumed that the upper ink-film will bleach sooner than the under and older, which has penetrated deeper into the paper fibres. If a logwood ink has been used for crossing out, it can be made to disappear by touching with ammonia. If the overlying ink is nutgall ink, and the writing logwood, the proper place should be repeatedly moistened with oxalic acid or solution of fluoride of potassium acidified by sulphuric acid until

it has become so pale that the lower writing can be read.

During this operation the moistened part should be frequently observed in a good light. If the ink-film to be removed is very thin, and if the writing covered by it consists of fine strokes, it is recommended to saturate blotting-paper with the acid or the ammonia and by tapping and pressing upon it to take up the ink-film. When the covering ink-film is removed, if the writing be more or less attacked, it is allowed to dry without warming. In the case of nutgall inks, it is touched with a small quantity of a solution of gallic acid, and in the case of logwood ink with very dilute solution of chloride of copper, and is allowed to dry without warming.

Approximate Age of Writing.—To assist in determining the ages of writings by one and the same ink, it is to be observed that the older the writing the less soluble it is in dilute ammonia. If the writing be lightly touched with a brush dipped in ten per cent. ammonia, the later writing will always give up more or less soluble matter to the ammonia before the earlier. In case of inks of different kinds this test is not serviceable, for characters written in logwood ink, for instance, will always give up their soluble material sooner than nutgall inks, even if the last named be later applied. To estimate the age of writing from the amount of bleaching in a given time by hydrochloric or oxalic acid is very precarious, because the

thickness of the ink-film in a written character is not always the same, and the acid bleaches the thinner layer sooner than the thicker.

(See later to determine the age of a writing according to Carré.)

CHAPTER XVII.

HAGER'S METHOD.[1]

Reagents used by Forgers.—The forging of papers or the removal of written characters occurs, according to experience, in two ways. Either by erasure or by washing with chemical reagents.

The erased place is usually covered by rubbing with sandarach powder, an alum powder, or a partial sizing.

To the chemical washing reagents belong oxalic acid, citric acid, hydrochloric acid, potassium oxalate, chlorine, chlorinated lime solution, and acid sodium sulphite. For the purpose of establishing a forgery of writing of this kind, observe the surface of the paper, whether it is rough or smooth, whether the particular place exhibit any difference in reflected and in transmitted light, as well as by feeling with the fingers. The place in question is either rough or smooth, or rubbed with the previously-mentioned powders, or it possesses a greater transparency and is thinner.

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[1] Hager's Untersuchungen, Zweiter Band: Leipzig, Ernst Günthers Verlag, 1888.

In hand-made paper (which at present is but rarely met with, and is only superficially sized) the erased places are easier to detect than in machine-made paper.

The sizing which is applied to ordinary writing-paper is a paste holding resin soap. In order to heighten the white of the paper a blue material, either ultramarine or Berlin blue, is added. On the other hand, almost every paper contains traces of iron derived from the water which is used in its manufacture.

If the forgery of the writing have been effected by the aid of chemical means, certain changes in the color of the paper will be noticeable. On the places in question will be found gray, yellow, or white spots, recognizable in reflected and transmitted light.

Reagents in the Cold.—A piece of slightly moist litmus paper is laid on the suspected place and pressed strongly. If acid still stick to the document's surface (oxalic, citric), the litmus paper will be reddened. After this test the suspected area is exposed to the action of ammonia gas, by laying it on a beaker glass in which is some spirit of sal ammoniac. In an hour the parts of the paper where the ink-decomposing reagents acted will have shown themselves changed, or the written characters which have been disturbed will appear in some color or other. If the change have taken place in consequence of the action of ammonia gas, but is only moderately distinct, the place is touched over gently with a mixture of equal parts of dilute ammonia and ninety-per-cent. alcohol. If nothing

appears by this method the moistened place is allowed to become dry and then is painted over with a solution of one part gallic acid or gallo-tannic acid in twenty parts of forty-five-per-cent. alcohol. If parts of oxide of iron from the decomposed written characters are found in the mass of the paper fibre they will now appear perhaps somewhat blurred. If the paper contain in itself oxide of iron (recognizable by the yellow or brownish-yellow color), it is advisable, instead of gallic acid or gallo-tannic acid, to employ a dilute solution of ferrocyanide of potassium in water. This latter is to be recommended if the above acids have given no result.

If the ink with which the decomposed letters were made contained copper salts, or iron and copper salts, this should insure a result.

Heating in Presence of Reagents.—Heating the paper with chemical reagents is recommended (by Chevallier & Lassaigne) in forgeries. The paper, previously moistened with alcohol, should be heated directly at the fire, or laid between two paper sheets and pressed by a hot iron until the upper sheet browns feebly, or becomes the color of chamois skin. This operation must be conducted with the greatest caution.

Another experiment recommended consists in the action of iodine vapor on the paper. A few iodine crystals are placed in a flat glass vessel which is covered by the suspected parts of the paper. In fifteen to thirty minutes the paper will have been colored yel-

lowish, and the erased portions, or the places which contained writing, will appear surrounded by a colored border.

It is, nevertheless, advisable that a previous experiment be made with the same paper in order to ascertain its behavior to iodine. If it be colored very deeply by iodine vapor the color can be again removed by vapor of ammonia.

Whether the one or the other reagent be employed, a preliminary experiment with the same paper is always to be undertaken in order to observe its behavior to the reagent.

Cases can very well occur where a reagent cannot be employed if the paper thereby will be darkly colored.

For documents the paper should be manufactured from a pulp which has received an addition of ferrocyanide of potassium, caustic ammonia, and protochloride of iron.

Determination of Age.—The determination of the age of a written paper is a problem difficult of solution. According to F. Carré the age can be approximately determined if the characters written in iron ink are pressed in a copying-press, and a commercial hydrochloric acid diluted with eleven parts of water is substituted for water; or, if the written characters are treated for some time with this diluted acid.

The explanation is that the ink changes in time, its organic substance disappears little by little, and leaves

behind an iron compound, which in part is not attacked even by acids.

An unsized paper is impregnated with the described dilute acid, copied with the press, and a copy from a writing eight or ten years old can be obtained as easily as one by means of water from a writing one day old.

A writing thirty years old gives, by this method, a copy hardly legible, and one over sixty years old, a copy hardly visible.

In order to protect the paper against the action of the acid, it should be drawn through ammoniacal water.

Sympathetic Inks.—The discovery and proof of the use of sympathetic ink are sometimes required of the expert. Solutions of salts of cobalt, nickel, lead, copper, ferrous oxide, mercurous oxide, ferrocyanide of potassium, besides solution of iodide of potassium, diluted sulphuric acid, onion-juice, solution of tannic acid, gallic acid, and radish-juice, furnish material for sympathetic inks.

First, heat must be applied, and measures taken to hold the paper over a lamp with a glass cylinder until a slight browning occurs.

Characters made with cobalt salt appear blue, those with nickel salt are green, those with the sulphuric acid and plant-juice are gray or blackish.

If the warming produce no result, cross-lines are made across the paper sheet by means of a very soft-cut goose-quill dipped in a reagent.

Reagents.—The appropriate reagents are: 1, gallo-tannic acid; 2, ferrocyanide of potassium, acidified with a little sulphuric acid; 3, hydrogen-sulphide water; 4, ammonium sulphide; 5, copper vitriol; 6, iron vitriol; 7, solution of potassium iodide; 8, caustic ammonia; 9, lime-water.

Procedure.—Blotting-paper is saturated with that particular reagent which produces a color reaction, and pressed strongly on the paper containing the invisible writing, or the latter is drawn quickly through a dilute solution of the reagent. If neither heating nor any reagent produce a result, vapor of iodine is allowed to act upon it, by laying the paper in a saucer or plate, of which the bottom is covered with iodine crystals; and if in this way no result be obtained, the paper is strewn with burnt ivory or fine charcoal powder, and a sheet of paper is laid over it and pressed. When the charcoal powder is removed by light tapping, enough dust remains in contact with the written characters, which have been made with some indifferent substance (dextrine, india-rubber, glue, etc.), to render the writing legible.

Writings with sympathetic ink are not always to be sought on simple white paper; more frequently they are found on the margins or between the lines of epistles written with black ink, on the margins of printed documents, or the parts of notes uncovered by writing.

If the piece of writing be observed in an obliquely

falling daylight, the usually duller written characters can be recognized, if not deciphered.

The paper can also be laid between glass plates, and observed in transmitted sunlight.

CHAPTER XVIII.

BAUDRIMONT METHOD.[1]

Reagents needed.—The reagents needed are alcohol, reagent papers, silver nitrate, and some others.

Distilled water is very useful in many cases to ascertain whether the paper has been scratched and partially sized or treated with resin. If it have not been altered by chemical agents, this partial sizing and the resinous matter used, give to the paper a peculiar appearance. Sizing takes away from the whiteness of the paper, and, thinned by the scratching or washing, it absorbs water much more quickly even when it has been partially sized.

Mode of Operation.—Place the document suspected of being a forgery on a sheet of white paper or, better still, on a piece of glass; then moisten little by little with a paint-brush all parts of it, paying close atten-

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[1] Dictionnaire des alterations et falsifications des substances alimentaires, etc., par E. Baudrimont. Paris: Asselin et Cie, 1882.

tion to the behavior of the liquid as it comes in contact with the paper.

Water.—By means of water one can discover what acids, alkalis, or salts the parts of the paper with colored borders or white spots contain.

With the aid of a pipette cover these spots with water and let it remain for ten or fifteen minutes; then with the pipette remove the liquid and examine the products it holds in solution. Afterwards make a comparative experiment on another part of the paper which is neither spotted nor whitened.

If the original writing have been done with a very acid ink on a paper containing a carbonate, such as calcium carbonate, the ink, in attacking the calcareous salt, stains the paper, so that if the forger have removed the ferruginous salts this removal is denoted by the semi-transparence that water gives to the paper.

To study carefully the action of the water it is necessary to repeat the experiment several times, allowing the paper to dry thoroughly before recommencing it.

Alcohol.—According to Tarry, it is necessary to have recourse to alcohol to discover whether the paper has been scratched in any of the parts and then covered with a resinous matter to prevent the ink from blotting.

Place the document on a sheet of white paper and with a paint-brush dipped in alcohol of specific gravity 0.86 or 0.87 cover the place supposed to have been

tampered with. It may be discovered if the writing thickens and runs when the alcohol has dissolved the resin.

Hold the paper moistened with alcohol between the eye and the light: the thinning of the paper shows the work of the forger.

Some more skilful forgers use paste and resin at the same time to mask their fraudulent operations; in this case luke-warm water should be first employed and then alcohol; water to dilute the paste, and alcohol to dissolve the rosin. The result is that the ink added on the places scratched out spreads, and the forgery is easily seen.

Test-papers.—Test-papers (litmus, mauve, and Georgina paper) serve to determine whether a paper has been washed either by the help of chemical agents, acids incompletely removed, or the surplus of which has been saturated by an alkali, or by the help of alkaline substances. The change of the color to red indicates an acid substance; an alkali would turn the reddened litmus paper to blue, and the mauve and Georgina test-papers to green.

Take a sheet of test-paper of the same dimensions as the document to be examined, moisten it, and cover it underneath with a sheet of Swedish filter-paper. These two sheets together (the filter-paper underneath) are then applied to the document which has been moistened already. The whole is then laid between

two quires of paper, covered by a weighted board, and left in contact for about an hour.

At the end of this time examine the test-paper to see if it has partly or altogether changed color. This examination finished, put the test-paper in contact with distilled water, to be afterwards removed and tried by appropriate tests to discover the nature of the alkali or acid present. Instead of test-papers, tinctures of litmus, mauve, or purple dahlia may be used.

Silver Nitrate.—Silver nitrate is used to discover whether the paper has been washed with chlorine or chlorides. A paper in that way becomes acid. The chlorine changes to hydrochloric acid, which dissolves in the water with which the suspected document is moistened, and at the contact of silver nitrate little spots of silver chloride appear.

Various other Tests.—Certain reagents, such as gallo-tannic acid or infusion of nutgalls prepared a short time before, potassium ferrocyanide, alkaline sulphites, and sulphuretted hydrogen, may all be used with advantage to restore writings that have been removed by washing. Place the document on a sheet of white paper and moisten the whole of its surface with a paint-brush dipped in the reagent, taking care not to rub it or strongly press it. When the surface is well impregnated allow the solution to act for an hour, and at the end of this time examine the document again. Then moisten it a second time, and the follow-

ing day examine the results. Repeat the moistening several times if necessary, for it often takes some time to make the traces of writing reappear.

Use of the Vapor of Iodine.—Chevallier and Lassaigne experimented together on the effect produced by the vapor of iodine on the surface of papers or documents upon which the alteration of writing was suspected. Take a bottle with a wide mouth from ten to eleven centimeters in height, and the opening from five to six centimeters in width. This last is covered by a disk of unpolished glass. Into the bottom of this vessel introduce from twenty to thirty grams of iodine in crystals.

Place the portion of paper on which the vapor of iodine is to act at the opening of the bottle, and cover it with the stopper of unpolished glass, on which put a weight so as to exert a slight pressure, and in order that the aperture may be hermetically closed. Then allow the vapor of iodine to act on the dry paper for three or four minutes at the temperature of 15° to 16° (Cent.) and examine it attentively. When the surface has not been spotted by any liquid (water, alcohol, salt water, vinegar, saliva, tears, urine, acids, acid salts, or alkalis) a uniform pale-yellow or yellowish-brown tinge will be noticed on all parts of the paper exposed to the vapor of iodine.

Otherwise a different and easily-distinguished tinge shows itself on the surface that has been moistened and then dried in the open air.

Machine-made papers with starchy and resinous sizing give such decided reactions that sometimes it is possible to distinguish by the color the portion of the paper treated with alcohol from that moistened with water. The spot produced by alcohol takes a bistre-yellow tinge; that formed by water becomes a violet-blue, more or less deep, after having dried at an ordinary temperature. As to the spots produced by other aqueous liquids, they approach in appearance (though not in intensity) those occasioned by pure water. Feeble acids, or those diluted by water, act like water; but the concentrated mineral acids, in altering more or less the substances of the sizing, produce spots that present differences.

The spots which become apparent in using the vapor of iodine are due to chemical agents whose strength has altered either the fibres of the surface, or the paste uniting them. For this reason stamped papers, whose preparation and sale are superintended by the French government, are less easy to falsify than ordinary machine-made papers.

In a word, the test of a paper by vapor of iodine has the double advantage of indicating the place of the supposed alteration and operating afterwards with appropriate reagents to bring back the traces of ink. It is only the reappearance of former letters or figures written or effaced that demonstrates forgery.

The difference of the action of the vapor of iodine on the surface of a paper which is not homogeneous

permits one to judge whether or not it has received, in certain parts limited in area, a fine layer of some glutinous matter (gum, gelatin, or flour paste) to make it adhere to other sheets of paper.

This method of testing may be tried at the same time with that which consists in proving this addition, either by the reflection of incident light on paper inclined at a certain angle or by the transmission of daylight or artificial light through the same paper.

Machine-made papers and stamped papers take a violet-blue color in the parts covered by starchy paste, but with the first a more intense color is produced in the parts treated with a thin layer of gum arabic, fish-glue, or gelatin, whereas these same substances spread on certain parts of the surface of stamped papers become neither darker nor yellower than the parts free from it. But on looking at the light incident to the surface of the paper held obliquely, it is easy to distinguish the parts to which these various substances have been applied.

Table V., from the *Journal of the Society of Chemical Industry*, of October 31, 1892, is a useful compendium of the more usual tests which may be applied to the inks of written documents. It was published originally in the *Pharmaceutische Central-Halle, Neue Folge*, 1892, No. 13, p. 225, by A. Robertson and J. Hofmann.

TABLE V.—TESTS FOR INKS.

Draw a moistened quill or gold pen over the ink-mark, and observe with a magnifying-glass.

REAGENTS.	INKS.					
	Iron Tannate. "Nutgall."	Logwood with $K_2Cr\ O_4$.	Logwood with $Cu.SO_4$.	Nigrosin.	Vanadium.	Resorcinol.
Oxalic Acid 3 per cent.	Disappears.	Violet.	Orange-yellow.	Unaltered.	Bleached and runs slightly.	Bright red.
Citric or Tartaric Acid 10 per cent.	Bleached.	Violet.	Orange-yellow.	Runs and becomes dark blue.	Bleached and runs.	Disappears.
HCl. 10 per cent.	Disappears, leaving a yellow color.	Purple-red.	Blood-red.	Little altered.	Bleached slightly, runs slightly.	Bright rose.
H_2SO_4 15 per cent.	Disappears.	Red.	Purple-red.	Unaltered.	Bleached slightly.	Bright red.
HNO_3 20 per cent.	Disappears.	Red.	Purple-red.	Runs slightly.	Bleached slightly.	Bright rose.
$SnCl_2$ 1 pt. HCl 1 pt. Water 10 pts.	Disappears.	Red.	Magenta-red.	Unaltered.	Bleached slightly.	Disappears.
SO_2 (sat. sol.).	Bleached.	Gray-violet.	Red.	Unaltered.	Bleached slightly and runs.	Bleached.
$AuCl_3$ 4 per cent.	Bleached slightly.	Red-brown.	Brown.	Unaltered.	Unaltered.	Becomes brown and runs.
$Na_2S_2O_3$ 1 pt. Aq. Ammonia 1 pt. Water 10 pts.	Dark red.	Unaltered.	Dark blue.	Becomes dark violet and runs.	Runs freely.	Brown.
KFe.Cy 1 pt. HCl 1 pt. Water 10 pts.	Blue.	Red.	Brick-red.	Unaltered.	Unaltered.	Rose.
NaHO 4 per cent.	Dark red.	Brown.	Becomes dark red and runs.	Becomes dark violet and runs.	Becomes dirty brown and runs.	Unaltered.
Chlorinated Lime 2 per cent.	Disappears.	Disappears.	Disappears, leaving a yellow color.	Brown.	Unaltered.	Brown.

CHAPTER XIX.

CONCERNING THE LAWS RELATING TO THE TESTIMONY OF EXPERTS ON HANDWRITING.

It was the original intention of the author to cause to be made a short compendium of the laws governing the testimony of expert witnesses in forgery cases in the various courts of this and other countries, but lack of space and of the ability to even properly edit such a chapter have caused him to forego this attempt.

In the absence of such a compilation the following extract from Stephen's Law of Evidence[1] is appended for the benefit of those who are interested in looking up the authorities cited for themselves.

STEPHEN'S LAW OF EVIDENCE. PART I., CHAPTER V.

ARTICLE XLIX.

OPINIONS OF EXPERTS ON POINTS OF SCIENCE OR ART.

"When there is a question as to any point of science or art, the opinions upon that point of persons specially

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[1] A Digest of the Law of Evidence, by Sir James Fitzjames Stephen, K.C.S.I. A Judge of the High Court of Justice, Queen's Bench Division. Fourth English edition. American Edition with annotations and references to American cases, by George Chase, LL.B., Professor of Criminal Law, Torts, and Procedure in the Law School of Columbia College. New York: Printed for the editor, 1890.

skilled in any such matter are deemed to be relevant facts.

"Such persons are hereinafter called experts.

"The words 'science or art' include all subjects on which a course of special study or experience is necessary to the formation of an opinion, and amongst others the examination of handwriting.

ILLUSTRATION.

"The question is, whether a certain document was written by A. Another document is produced which is proved or admitted to have been written by A.

"The opinions of experts on the question whether the two documents were written by the same person, or by different persons, are deemed to be relevant.[1]

ARTICLE LI.

OPINION AS TO HANDWRITING, WHEN DEEMED TO BE RELEVANT.

"When there is a question as to the person by whom any document was written or signed, the opinion of any person acquainted with the handwriting of the supposed writer that it was or was not written or signed by him, is deemed to be a relevant fact.[2]

"A person is deemed to be acquainted with the handwriting of another person when he has at any time seen that person write,[3] or when he has received

[1] "28 Vict. c. 18, s. 8; see Art. 52, and note.

[2] "For a valuable article on this subject, see Am. Law Rev., xvi. 569.

[3] "Having seen him write once is enough; this effects the weight,

documents purporting to be written by that person in answer to documents written by himself or under his authority, and addressed to that person,[1] or when in the ordinary course of business, documents purporting to be written by that person have been habitually submitted to him.[2]

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not the competency, of the testimony. Hammond *v.* Varian, 54 N. Y. 398; Comm. *v.* Nefus, 135 Mass. 533; McNair *v.* Comm., 26 Pa. St. 388. So a person's mark may be proved in this way. Strong's Exers., 17 Ala. 706; Fogg *v.* Dennis, 3 Humph. 47; Jackson *v.* Van Dusen, 5 Johns. 144; contra, Shinkle *v.* Crock, 17 Pa. St. 159. But a person who sees another write, or examines his handwriting, expressly for the purpose of being able to testify, is, in general, an incompetent witness. Reese *v.* Reese, 90 Pa. St. 89; Board of Trustees *v.* Nusenheimer, 78 Ill. 22; Hynes *v.* McDermott, 82 N. Y. 41, 53. A witness may testify as to handwriting who cannot read or write himself. Foye *v.* Patch, 132 Mass. 105.

[1] "Chaffee *v.* Taylor, 3 Allen, 598; Clark *v.* Freeman, 25 Pa. St. 133; Cunningham *v.* Hudson River Bk., 21 Wend. 557; Empire Mf'g Co. *v.* Stuart, 46 Mich. 482. But this is sometimes not sufficient authentication. McKeone *v.* Barnes, 108 Mass. 344. So if the witness has received letters or other writings of a person, who has afterwards, by words or acts, acknowledged their genuineness (Gr. Ev. 1, § 577; Johnson *v.* Daverne, 19 Johns. 134; Snyder *v.* McKeever, 10 Bradw. 188); but not if he has only seen letters to strangers, purporting to be those of the person in question. Phila. etc. R. Co. *v.* Hickman, 28 Pa. St. 318; Nunes *v.* Perry, 113 Mass. 275.

[2] "See Illustration; Titford *v.* Knott, 2 Johns. Cas. 211; Comm. *v.* Smith, 6 S. & R. 568. Thus public officers who have seen many official documents filed in their office, having the signature of a certain justice, may testify as to an alleged signature of his. Rogers *v.* Ritter, 12 Wall. 317; Amherst Bk. *v.* Root, 2 Met. 522; Still *v.* Reese, 47 Cal. 294. As to signatures upon ancient writings, a person may

ILLUSTRATION.

"The question is, whether a given letter is in the handwriting of A, a merchant in Calcutta.

"B is a merchant in London, who has written letters addressed to A, and received in answer letters purporting to be written by him. C is B's clerk, whose duty it was to examine and file B's correspondence. D is B's broker, to whom B habitually submitted the letters purporting to be written by A for the purpose of advising with him thereon.

"The opinions of B, C, and D on the question whether the letter is in the handwriting of A are relevant, though neither B, C, or D ever saw A write.[1]

"The opinion of E, who saw A write once twenty years ago, is also relevant.[2]

ARTICLE LII.

COMPARISON OF HANDWRITINGS.

"Comparison of a disputed handwriting with any writing proved to the satisfaction of the judge to be genuine is permitted to be made by witnesses, and such writings, and the evidence of witnesses respecting

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testify who has gained his knowledge by inspecting other ancient authentic documents bearing the same signature. Jackson *v.* Brooks, 8 Wend. 426, 15 id. 111.

[1] " Doe *v.* Suckermore, 5 A. & E. 705 (Coleridge, J.); 730 (Patteson, J.); 739–40 (Denman, C. J.).

[2] " R. *v.* Horne Tooke, 25 S. T. 71–2; see Brachmann *v.* Hall, 1 Disney, 539.

the same, may be submitted to the court and jury as evidence of the genuineness or otherwise of the writing in dispute. This paragraph applies to all courts of judicature, criminal or civil, and to all persons having by law, or by consent of parties, authority to hear, receive, and examine evidence."[1]

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[1] "17 & 18 Vict. c. 125, s. 27; 28 Vict. c. 18, s. 8. There are diverse rules on this subject in different States. A rule substantially like the English rule prevails in all the New England States, in New York, New Jersey, Mississippi, Texas, Ohio, Iowa, and Kansas. Woodman *v.* Dana, 52 Me. 9; State *v.* Hastings, 53 N. H. 452; but here the *jury* judge whether the writing used as a standard is genuine; State *v.* Ward, 39 Vt. 225; Costello *v.* Crowell, 133 Mass. 352; Pub. St. R. I., c. 214, § 42; Tyler *v.* Todd, 36 Ct. 218, Peck *v.* Callaghan, 95 N. Y. 73; Laws of 1880, N. Y. c. 36; N. J. Rev., p. 381; Koons *v.* State, 36 O. St. 195; Singer Mf'g Co. *v.* McFarland, 53 Ia. 540; Macomber *v.* Scott, 10 Kan. 335. But in many States, collateral and irrelevant writings cannot be introduced for comparison: Williams *v.* State, 61 Ala. 33; First Nat. Bank *v.* Robert, 41 Mich. 709; Hazleton *v.* Union Bank, 32 Wis. 34; State *v.* Clinton, 67 Mo. 380; Brobston *v.* Cahill, 64 Ill. 356; Burress's Case, 27 Gratt. 946; Herrick *v.* Swomley, 56 Md. 439; Hawkins *v.* Grimes, 13 B. Mon. 260; Yates *v.* Yates, 76 N. C. 143; so in the Federal Courts: U. S. *v.* Jones, 20 Blatch. 235; generally, however, in these States genuine writings properly in evidence in the case may be used for comparison by the jury, and in a number of them such comparison may be made by experts to aid the jury (Id). In Indiana comparison may be made by experts with writings admitted to be genuine: Shorb *v.* Kinzie, 80 Ind. 500. In Pennsylvania comparison with writings proved to be genuine may be made by the jury as corroborative evidence, but not by experts. Berryhill *v.* Kirchner, 96 Pa. St. 489. See this general subject fully treated in Am. Law Rev. xvii. 21; Gr. Ev. 1, §§ 576–582.

The opinion of one who saw another write twenty years ago is relevant (p. 188); and a witness may testify as to handwriting who cannot himself read or write (p. 187, n.); but a person who sees another write expressly for the purpose of being able to testify, is in general an incompetent witness (*Ibid.*).

Handwriting Evidence in Pennsylvania.—The law in Pennsylvania applicable to expert testimony on handwriting has been very ably and fully summed up by the late Chief-Justice Woodward, of the Supreme Court of Pennsylvania, in an opinion in the case of Travis *vs.* Brown, reported in 43 Pennsylvania State Reports, page 9. This opinion avowedly restricts itself to expounding the law as it exists, and if the latter be

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"A person's signature or other writing made in court at the trial will not generally be allowed to be used for comparison. Comm. *v.* Allen, 128 Mass. 46; Gilbert *v.* Simpson, 6 Daly, 29; Williams *v.* State, 61 Ala. 33. But this is something permitted upon cross-examination, or when the writing is made at the request of the opposite party who offers it for comparison. Chandler *v.* LeBarron, 45 Me. 534; Bronner *v.* Loomis, 14 Hun, 341 King *v.* Donahue, 110 Mass. 155.

"Letter-press copies cannot be used for comparison. Cohen *v.* Teller, 93 Pa. St. 123; Comm. *v.* Eastman, 1 Cush. 189. But photographic copies may be when the originals are also before the court. Hynes *v.* McDermott, 82 N. Y. 41; Marcy *v.* Barnes, 16 Gray, 162; but see Tome *v.* Parkersburgh, etc., R. Co., 39 Md. 36.

"Experts in handwriting may also testify to other matters; as, *e.g.*, whether a writing is forged or altered, when a writing was probably made, etc.: Travis *v.* Brown, 43 Pa. St. 9; Withee *v.* Rowe, 45 Me. 571."

little in keeping with the age it is no fault of the learned jurist.

This opinion recurs so frequently in cases involving the kind of investigations which have been considered that it is given here at length, except the concluding sentences which are concerned with the application of the principles just announced to a particular case before the court, and which throw no additional light on those principles.

SUPREME COURT OF PENNSYLVANIA.

43 Penna. State Reports, page 9.

(TRAVIS *vs.* BROWN.)

(The opinion of the court was delivered, May 22, 1862, by Woodward, J.)

All evidence of handwriting, except in the single instance where the witness saw the document written, is in its nature comparison of hands. It is the belief which the witness entertains, upon comparing the writing in question with the exemplar in his mind derived from some previous knowledge. Any witness, otherwise disinterested, who has had the opportunity of acquiring such an exemplar, is competent to speak of his belief. It is one of the few instances in which the law accepts from witnesses belief in facts, instead of facts themselves. No prudent witness will undertake to swear that any signature or document was written by the person by whom it purports to have been written, unless he saw it written; but if, from having seen the party write, or from correspondence or business with him he has become familiar with his hand, he may testify to his belief as to the genuineness of the writing in question. This is the ordinary every-day rule of practice in the trial of causes.

But though it is in its nature a comparison of the writing under investigation with the exemplar in the witness's mind, it is not what

is technically called comparison of hands. Still less is it that peculiar kind of proof which is known in the books as the testimony of experts. Comparison of handwritings was defined by Judge Duncan, in Commonwealth *vs.* Smith, 6 S. & R., 571, to be "when other witnesses have proved a paper to be the handwriting of a party, and then the witness on the stand is desired to take the two papers in hand, compare them, and say whether or not they are the same handwriting. The witness collects all his knowledge from comparison only: he knows nothing of himself: he has not seen the party write nor held any correspondence with him." Starkie's definition is more condensed, though to the same effect: "By comparison is meant," he says, "a comparison by the juxtaposition of two writings, in order, by such comparison, to ascertain whether both were written by the same person:" Metcalf's Starkie on Ev., part 4, p. 654.

Now this is as distinct and separate a thing from that comparison which a witness called to testify to handwriting makes between the writing in question and the exemplar in his mind, as an external, visible, and tangible object is distinct from a mental impression or memory. It is the distinction between what is objective and what is subjective.

A few words now as to experts. In Bouvier's Law Dictionary, they are derived from the Latin *experti*, which signifies instructed by experience, and are defined as persons selected by the courts or the parties in a cause, on account of their knowledge or skill, to examine, estimate, and ascertain things, and make report of their opinions. See also note to 1 Greenl. Ev., pl. 44, p. 572. Thus when professional men give evidence on matters of skill and judgment, their evidence frequently does not and cannot, from the nature of things, extend beyond opinion and belief. An engineer may be examined as to his judgment of the effect of an embankment on a harbor; a seal-engraver as to whether a particular seal has been forged; a ship-builder as to the seaworthiness of a ship from a survey made by others; and the testimony of medical men is constantly admitted with respect to the cause of disease or of death, and as to curing insanity, although they found their opinions entirely on facts, circumstances, and symp-

toms established in evidence by others: Sharswood's Starkie on Ev., p. 152, and the cases collected in notes.

The propriety of admitting the evidence of experts in investigating questions of forgery is now recognized by statute with us in the 53d section of the Criminal Procedure Act, and it is a necessary rule of evidence on general principles. Common sense dictates that in all investigations requiring special skill, or when the common intelligence supposed to be possessed by the jury is not fully adequate to the occasion, we should accept the assistance of persons whose studies or occupations have given them a large and special experience on the subject. Thus, such men of experience or experts are admitted to testify that work of a given description is or is not executed with ordinary skill; what is the ordinary price of a described article: whether described medical treatment or other practice was conducted with ordinary skill in a specific case; which of two colliding vessels, their respective movements being given, was in fault; whether one invention was an infringement of another, looking at the models of both; and other cases already mentioned.

This is as near to an exact definition of who are admissible as experts as it is possible for us to come. In all these cases it is to be observed that the expert is to speak from no knowledge of the particular facts which he may happen to possess, but is to pronounce the judgment of skill upon the particular facts proved by other witnesses. Of course the court must be first satisfied that the witness offered is a person of such special skill and experience, for if he be not, he can give no proper assistance to the jury; and of course, also, very much must at last be left to the discretion of the court, relative to the need of such assistance in the case; for very often the matter investigated may be so bunglingly done that the most common degree of observation may be sufficient to judge it.

Where a witness is called to testify to handwriting, from knowledge of his own, however derived, as to the hand of the party, he is not an expert, but simply a witness to a fact in the only manner in which that fact is capable of proof. Nor is he an expert who is called to compare a test writing, whose genuineness is established by others,

with the writing under investigation, if he have knowledge of the handwriting of the party, because his judgment of the comparison will be influenced more or less by his knowledge, and will not be what the testimony of an expert should be, a pure conclusion of skill.

But when a witness, skilled in general chirography, but possessing no knowledge of the handwriting under investigation, is called to compare that writing with other genuine writings that have been brought into juxtaposition with it, he is strictly an expert. His conclusions then rest in no degree on particular knowledge of his own, but are the deductions of a trained and experienced judgment, from premises furnished by the testimony of other witnesses.

According to many authorities, these forms of proof are admissible in appropriate circumstances, in cases both civil and criminal; but when evidence by comparison of hands should be received; whether the witness making the comparison should be qualified by personal knowledge of the party's handwriting; when mere experts should be admitted to make the comparison; and what degree of evidence is required to establish the genuineness of test papers, are questions that have been debated in a multitude of cases; from the attainder of Algernon Sydney and its reversal, in the reign of Charles II. and the case of the Seven Bishops, in the time of James II. See 3 State Trials, 802, and 4 Id. 338. The English and American authorities will be found collected in the notes to Starkie and Greenleaf, and whoever will undertake to go through them, will be struck with the confusion, obscurity, and contradiction which have arisen almost entirely from disregard of the distinctions above stated. Questions have been discussed as belonging to the law of experts, and of comparison of hands, which belonged to other heads, and judges and compilers have often written loosely even when these subjects were legitimately before them. Every one knows how essential it is to all scientific discussions that terms be first correctly defined, and then always used in the defined sense. If this rule had been reasonably observed in treating of the branch of the law we are now upon, we should not have so many inconsistent cases in the books, and it would not have been, as it is now, exceedingly difficult for judges and lawyers to know what the

mind of the law is touching proof of writings by comparison of papers. Without detaining ourselves to make a minute analysis of the cases in England and our sister States, I propose to examine our leading cases in Pennsylvania, and to state as clearly as I can, the rule which is fairly deducible from them.

McCorkle *vs.* Binns, 5 Binn. 348, involved a comparison of printed papers. The law of written papers came in only incidentally by way of illustration, and Chief-Justice Tilghman simply stated the rule in the most general terms, that "after evidence had been given in support of a writing it may be corroborated by comparing the writing in question with other writings, concerning which there is no doubt." By whom compared, whether by the jury or a witness, and if by a witness, what qualifications he must have, were points which the Chief Justice did not touch.

In the Farmers' Bank *vs.* Whitehill, 10 S. & R. 110, Whitehill was sued as endorsee of a promissory note, and the genuineness of his signature was the point in question. Matthiot and McClure both swore to their belief that the endorsement was in Whitehill's handwriting. They had both seen him write, and Matthiot had Whitehill's signature to a receipt in his possession. Of course they were both qualified to prove the endorsement according to the ordinary rule of evidence. But to corroborate their opinions, an original administration account was offered in evidence, which Whitehill and his mother had settled, signed and sworn to in the presence of the register who proved it. This account, the genuineness of which was thus indubitably established, was the test paper that was brought into juxtaposition with the endorsed note, and it was offered in evidence by the plaintiff to the jury "that they might compare the signature of the defendant thereto with the handwriting of the note." The Judge of the Common Pleas rejected the evidence, but this court ruled that it ought to have been admitted. The doctrine which this case established, therefore, was that, in corroboration of antecedent testimony of a signature, a test paper, clearly proved, might be submitted to the jury to make comparison of the two papers. This was evidence by comparison of hands, but it was comparison by jury instead of a witness.

In Lodge *vs.* Pipher, 11 S. & R. 334, the effort was to prove that a receipt of Reuben Haines had been forged by one William Shaw, and for this purpose several papers were produced, and fully identified as Shaw's writing. Instead of submitting them to the jury to compare with the receipt, Israel Pleasants was called as an expert to make the comparison, and to give his opinion of the signature of the receipt. He had never seen Shaw write, but he had been a man of business for many years, had an extensive correspondence, and was accustomed to see a great deal of writing. The court admitted him to testify, but this court reversed the ruling in an emphatic opinion by Chief Justice Tilghman.

This case is entirely consistent with the Bank *vs.* Whitehill, and the two taken together establish the rule that comparison of hands may be made by a jury but not by a mere expert.

Bank of Pennsylvania *vs.* The Administrators of Samuel Jacobs, deceased, 1 Penna. Rep. 178. The genuineness of a certain check, purporting to have been drawn by Samuel Jacobs in his lifetime, was in question in this case. After several genuine checks had been given in evidence on the part of the defendant, three witnesses were called who had seen Jacobs write frequently, and had for a long time done business and carried on correspondence with him, and they were permitted to compare the genuine checks with the doubtful one, and to give their opinion that it was a forgery. Then, on the part of the Bank, three cashiers of other banks were called to testify as experts. They had all the experience in judging of writings which cashiers of banks usually acquire, but they had never seen Jacobs write. Their testimony was also admitted. This court, in a very satisfactory opinion by the late Judge Smith, decided that the three witnesses on part of the defendant, were rightly admitted, but that the testimony of the three cashiers on the part of the plaintiff ought to have been excluded.

It is manifest that, according to general rules, the three witnesses were competent to speak of the signature of the check, because they had seen Jacobs write. They had exemplars in their minds, and comparing the check with these, they had a right to speak. The point of the ruling was that they might also compare the check with the

accredited tests that were in evidence; but the learned judge fell into error when he cited Bank *vs.* Whitehill as an authority on this point, because, as we have seen, that case ruled that the jury, not witnesses, were to make the comparison. He more accurately quoted Pipher *vs.* Lodge, as an authority against admitting the experts. I do not think the court meant to advance a step in this case beyond the doctrine of the prior cases. The testimony of the defendant's witnesses was admissible, without reference to the peculiar doctrine of comparison of hands, and I hold that the comparison which the case in 10 S. & R. had decided was to be made by the jury, was as much the rule after Jacobs's case as before it.

Callan *vs.* Gaylord, 3 Watts 323, is not a very intelligible case. Though a civil action for libel, the opinion of Gibson, C. J., is a good deal occupied with an argument to prove that the rule of evidence in regard to comparison of hands is the same in civil and criminal cases. The account books which were produced as tests were proved by witnesses who were acquainted with the defendant's writing, and we understand the chief justice to have ruled that they were admissible for the jury to make comparison of them with the alleged libel. This was consistent with Bank *vs.* Whitehill, which he cited, and doubtless meant to follow.

Baker *vs.* Haines, 6 Wh. 291, states the general principle of the admissibility of comparison of hands, without intimating whether the comparison is to be made by witnesses or the jury, and then rules that very strict proof should be given of the genuine or test paper,—such as would leave no reasonable doubt on that point. And the proof of the test papers in that case was held insufficient, though it was made by witnesses who had seen the party write. This is a very important case in regard to what is sufficient to establish a test; but who is to apply the test when established, whether jury or witness, is not decided in the case. So when, Depue *vs.* Place, 7 Barr, 429, the question related to the sufficiency of the authentication of the test papers rather than to the application of them.

In Power *vs.* Frick, 2 Grant's Cases, 307, there was no test paper in question. The ruling related entirely to the knowledge of a party's

handwriting which a witness must possess to enable him to prove a lost note.

So in Fulton *vs.* Hood, 10 Casey, 366, there was no test writing, and therefore, strictly speaking, no comparison of hands. The question was upon the alteration of the date of the bond in suit. McKinney, the subscribing witness, was the scrivener who prepared the bond, and he swore that the alteration in the date and the addition of the concluding words were made before the bond was executed. After the defendant had given evidence to contradict him, the plaintiff was permitted to prove by experts, in corroboration of the subscribing witness, that the whole bond, including the additional date, appeared to be written by the same hand, with the same pen and ink, and at the same time. We sustained this ruling. There are not wanting cases in the books to show that experts may be called to testify whether a particular handwriting is natural and genuine or forged and imitated. See Sharswood's Starkie, p. 152, in notes. And such cases sustain our ruling in Fulton *vs.* Hood; but it is only necessary to recur to the distinctions which I stated at the outset of this opinion, to see that this case bears no relation to the cases on evidence by comparison of hands.

Taking Bank *vs.* Whitehill, 10 S. & R., Lodge *vs.* Pipher, Id., and Baker *vs.* Haines, 6 Wh., as the leading cases in Pennsylvania on this branch of law, the following summary may be stated as fairly resulting from them.

1st. That evidence touching the genuineness of a paper in suit may be corroborated by a comparison, to be made by the jury, between that paper and other well-authenticated writings of the same party.

2d. But mere experts are not admissible to make the comparison, and to testify to their conclusions from it.

3d. That witnesses having knowledge of the party's handwriting are competent to testify as to the paper in suit; but they, no more than experts, are to make comparison of hands, for that were to withdraw from the jury a duty which belongs appropriately to them.

4th. That test documents to be compared should be established by the most satisfactory evidence before being admitted to the jury.

5th. That experts may be examined to prove forged or simulated writings, and to give the conclusions of skill in such cases as have been mentioned, and their like.

Our cases are all reconcilable with these conclusions, though the language of judges has not always been as guarded as would have been well. No doubt inconsistent authorities may be found outside our borders, but it is not worth our while to discuss them, for if we have got a settled rule of our own it is enough for us to adhere to it, etc.

* * * * * * * *

This decision prevents the expert from placing the genuine and disputed signatures in juxtaposition, and drawing the attention of the jury to their resemblances or differences, although the learned judge very truly says in the first sentence of his opinion that a comparison of one kind or another, whether it be with an actually visible pattern or with an ideal stamped upon the memory, is necessary to the formation of any judgment.

Conforming to the Law.—With the purpose of conforming strictly to the law, which makes the jury and not the expert compare the genuine and suspected signatures, the writer has devised the plan of preparing a table in which each horizontal line is devoted to the description of a particular signature, while each of the vertical columns into which the paper is ruled is dedicated to one element of the signatures. The expert thereupon reads separate descriptions of signatures and their averages by reading in succession the horizontal lines, while the jury, by reading the columns

vertically downward, observes at once the differences between the separate signatures and their averages.

This method, as well as the application of composite photography, to effect the same purpose, are briefly explained in Chapters XIII. and XIV.

Both these methods enable the expert to prepare the work for the jury's consideration, and to leave it to the judgment of the members of that body without obtruding an opinion at all,—unless counsel should happen to ask for it.

Best Method of Presentation.—It is really not infrequently practicable to explain to a jury of intelligence the methods by which tabular or graphic results have been reached, and to leave entirely in its hands the decision as to what these results show; and when this is done the jury's decision must carry greater weight than when it may be asserted that they have been influenced by the words or manner of the expert witness.

But it is unjust to be obliged to evade the letter of a bad precedent, having the effect of a bad law, in the attempt to further the interests of that very justice in behalf of which the decision itself was undoubtedly made; and it is to be hoped that the present law will soon be relegated to the limbo of all those laws and decisions which have hampered progress and stood in the way of eliciting truth. It may be said that if one who is an expert be forbidden to juxtapose and make comparison before a jury of a handwriting admitted

to be genuine with one in doubt, it is in consonance with the spirit of such a law that he should be forbidden to use such comparison in forming an opinion. It is certain that without *a* comparison he can form no opinion, and the statement that in his belief the writing in question is or is not a forgery implies that he must have made such a comparison; it can have no other basis. Of course it is immaterial whether the genuine and the questioned writings be placed side by side, whether the expert carry in his mind the peculiarities of the one when he views the other, or whether he produce tables of the two writings. In either case this judgment can only be the result of comparison and the detection of differences.

Either the decision of genuineness must be left to the fortuitous impressions of those who have not given scientific study to the subject, or those who have made handwriting a serious study must be allowed the use of the tool with which they do their work, and that tool is comparison, no matter how the task be undertaken.

One of the palpable anomalies of the present practice is that a person who has seen another write, no matter how ignorant the observer may be, is competent to testify as to whether or not certain writing is by the hand of the person he has once seen engaged in the act of writing, while an expert in handwriting may only testify that the hand appears to be simulated, but may not point out the differences between speci-

mens of genuine writing and the instrument in controversy.

It is safe to presume that the apparently unreasonable position of the law was assumed with a good object in view, and it is probable that the object was the protection of the court from the swarm of *soi-disants* experts which might be hatched by a laxity in the wording of the law. Few things would be easier for a dishonest person than to swear he was a competent expert, and then to swear that a document was, in his opinion, forged or genuine, according to the requirements of his hirer. The framers of the practice in reference to expert testimony on documents seem to have had in mind that the only possible kind of testimony as to documents was that based upon impressions; and that the only method of coming to a conclusion was by giving words to the first mental effect produced on a witness after he has looked at a writing.

For this reason the practice has grown up in many trials of preparing carefully-forged signatures and producing them before the witness as a test of how far he is able to distinguish genuine from forged signatures.

However expert a witness may be, however successful in discriminations of this kind, self-respect and a becoming modesty should induce him to refuse to answer them without distinctly stating that his answer, which gives his best judgment at the time, must be subject to reversal if by longer and more thorough

investigation it appear that the opposite view were the true one.

It is doubtful if the present practice in Pennsylvania would have been inaugurated had there prevailed a system of exact measurement, and a method of carefully explaining all the steps which led to an expert's conclusions, and it will probably cease as soon as the courts are convinced that the principles involved in the examination of handwriting are as purely scientific as those employed in the researches of ethnology or philology.

Some of the extraordinary consequences resulting from the decisions of other courts than those of Pennsylvania, as well as the peculiar features of the present law in this State, will suggest the inquiry whether it would not be advisable to bring them more into conformity with the spirit of the age. As long as there were no other means of establishing the genuineness or falsity of handwriting but by the vague impressions or guesses of persons more or less "accustomed to handwriting," the restrictions of the law in Pennsylvania may have been useful in reducing the number of sham experts by narrowing the field in which their testimony was competent; but there can be no excuse for such curtailment if the study be admitted to stand on the same basis as other studies which involve the application of scientific principles to specific and useful purposes.

If it be true, as Chief-Justice Woodward said, that

comparison of some sort must form the basis of all opinion as to genuineness, why should the expert be prevented from directly comparing a suspected signature with a genuine, or, still better, with the *type* of a number of genuine signatures, instead of with a mental image; and pointing out to the jury wherein the differences between the two are unimportant, and wherein they are essential. The very act of doing this intelligently would offer the best guarantee of the witness's title to be called an expert.

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THE END.