Locomotive Lubrication

By

W. J. SCHLACKS

Published by

McCORD AND COMPANY

Chicago New York

McCORD AND COMPANY
Chicago, Ill.

PREFACE

A better understanding of railway devices by the employe handling them, works for economy in railway service. This book on Locomotive Lubrication is written for the express purpose of bringing about a better understanding of this very important subject.

Furthermore, a device such as the Locomotive Force Feed Lubricator, which needs practically no attention from the engineer, reaches the highest efficiency in economy, in that it does not lubricate per unit of time, but in per unit of work done by the locomotive.

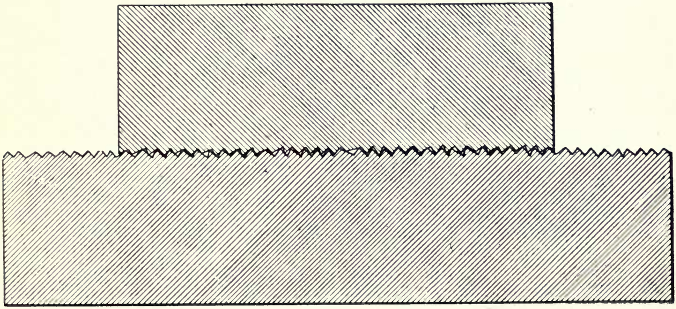
Locomotive Lubrication

The aim of good lubrication is the reduction of friction to a minimum.

The object of this work is to provide motive power men with a basis for design, supervision and regulation of lubrication on locomotives, and it is hoped that the information on this subject, based on the results of experiments, will assist in overcoming some of the obstacles met with in locomotive lubrication.

Friction.

Friction is the force that acts between two substances in contact, opposing their sliding one on the other, and is caused by the irregular surfaces of the two bodies interlocking. Under the microscope these irregular surfaces appear interlocked somewhat as shown in the following illustration:



The coefficient of friction is the ratio of the force, required to slide a body along a horizontal plane surface to the weight of the body.

From the definition of friction it is evident that it is a loss of power in operation of the locomotive, and its reduction, therefore, must be considered primarily in connection with the cost of maintenance, operation and delays, and the safety of transportation.

Conditions Affecting Friction.

The amount of friction depends:

First—On the nature of the substances in contact;

Second—On the pressure with which these two substances are held in contact;

Third—The speed of their moving, one on the other;

Fourth—The temperature of the substances in contact;

Fifth—The substance between the two, put there to reduce the amount of friction.

Established Laws of Friction.

First: With substances in contact variable and all other conditions constant there is no fixed law, the amount of friction depending on the nature of substances in contact.

Second: With varying pressures and all other conditions constant, friction increases directly with the pressure.

Third: With speed variable and all other conditions constant, the friction decreases at speeds from 10 ft. to 100 ft. per minute, but at higher speeds it is nearly directly proportionate to the square root of the speed.

Fourth. With varying temperature, and all other conditions constant, the amount of friction decreases as temperature rises until abrasion takes place.

Fifth: With substances to reduce friction variable and all other conditions constant, there is no fixed law, the amount of friction depending on the nature of substance used as lubricant.

Friction—Lubricants.

The lubricants used in locomotive practice consist of different oils, grease, graphite and lead used separately or in combination. It has been found that each of these has certain advantages over the others for the lubrication of different parts of the locomotive mechanism. The general qualifications of a good lubricant are given by Mr. W. H. Bailey, in Proc. Inst., C. E., vol. xlv., p. 372, and are as follows:

1. Sufficient body to keep the surfaces free from contact under maximum pressure.

2. The greatest possible fluidity consistent with the foregoing condition.

3. The lowest possible coefficient of friction, which in bath lubrication would be for fluid friction approximately.

4. The greatest capacity for storing and carrying away heat.

5. A high temperature of decomposition.

6. Power to resist oxidation or the action of the atmosphere.

7. Freedom from corrosive action on the metals upon which based.

Lubricating material made up of any number of elements having independent qualifications, must be a homogeneous whole and remain so under the conditions surrounding the problem.

In considering qualifications Nos. 1 and 2, the cohesiveness, or viscosity, of the lubricant must be sufficient to prevent the separation of its particles, and the adhesion of the lubricant must be sufficient to enable it to cling to the bearing surfaces. A lubricant having greater adhesion or cohesion than the above conditions require, will increase the frictional resistance.

Considering the friction developed between two surfaces lubricated in one case with grease and in the other with oil, the friction developed with grease is greater than with oil for the following reasons:

FIRST: When the grease is cold, its cohesion is greater than oil, and its adhesion to the bearing surfaces is less, and consequently the coefficient of friction is higher.

SECOND: When the grease is in a fluid, or semi-fluid state, its cohesion, while less than when solid, is again greater than oil, and its adhesion to the bearing surfaces, while greater than when solid, is again less than oil, and consequently the coefficient of friction is higher; and further, additional friction has to be expended to furnish the heat required to reduce the solid grease to a fluid state.

It is an undisputed fact that the generation of heat by friction is an extravagant method.

An abstract of a brief historical review of lubricants, that have been used in locomotive practice, as given in the American Railway Master Mechanics' Proceedings, Vol. 42, 1909, follows:

"In the early years vegetable oils (principally olive oils) were used for machine lubrication in Europe, and, although history is vague on this subject, it is fair to assume that the first steam locomotives were lubricated with oils of this kind."

"There have been times in the history of steam lubrication when anything of a greasy nature was considered a lubricant and experimented with. In the early era of steam locomotives in this country a railway publication, under the caption, 'Pork for Journal Boxes,' stated: Why not use it? We have asked 50 railway men within as many days if they were aware of its success. On the H. R. R. a car was packed with slices of fresh pork, and is today as it was a year ago. The cost per box for pork packing, that will stand at least a year will not exceed 30 cents."

"A railway man who used soft soap as a lubricant seemed, to say the least, eccentric. A standard authority, 'D. K. Clark's Railway Machinery,' published in 1855, said: 'In proportion as the bearing surfaces are fine, hard and polished, the more fluid may be the lubricating material; (thus fine oil may be used instead of soap.) It is probable that concussion was originally the inducement to use soap on railways apart from the difficulty of preventing oil from being wasted.''

''Antedating the use of mineral oil, cotton seed and sperm oil were extensively used, followed by a more general use of lard oil for machine lubrication and tallow for valves and cylinders. As early as 1854 a firm in Philadelphia introduced what they termed a 'lubricating grease adapted to use on all classes of running stock on railways.' They recommended it on account of its 'freedom from gum or glutinous substances and adaptability to all kinds of weather.'

''The mineral oils or petroleums were placed upon the market in the years soon following and on account of their cheapness and superiority as a lubricant their use became general. The natural West Virginia oil, with its notable characteristics of a low cold and a high fire test, immediately found favor and was considered superior to sperm. The production of the West Virginia oil was limited, and as the demand rapidly increased the supply was soon exhausted. A manufacturing concern in 1869 introduced for railway service an oil for external lubrication, combining the excellent qualities of nature's best lubricating product with other ingredients, producing an article which met all of the requirements of the day; an oil of low cold and high fire test, a gravity permitting a ready flow, and the sustaining power for support of the ever-increasing loads upon the bearing surfaces. This lubricant has stood the test of service from the date of its introduction and is now used on the majority of the railways of this country, as well as on many of the English and European lines."

"Prior to the introduction of mineral cylinder oil, tallow was the almost universal lubricant for valves and cylinders. In some few instances lard oil mixed with plumbago was used, and grease introduced through cups with double stop cocks was tried, but melting tallow in the old familiar tallow pot was practically the universal practice for many years. Tallow carrying a high percentage of acid was found objectionable, the acid attacking the metal, pitting and rendering it porous and weakening its structure."

"The superiority of an oil free from acids, with greater viscosity, less liable to gum, and with a higher fire test to meet the increases in temperature was fast relegating tallow to other uses. In 1870 there was placed upon the market a cylinder oil meeting all the desired requirements, furnished from a source of supply that insured uniformity in quality and quantity to meet all demands. This cylinder oil has stood the test through all the gradation of temperature as steam pressures have increased from 120 to 230 lbs., and higher temperatures incident to the use of superheated steam."

Mr. Wm. J. Walsh made a statement in a paper on "Lubrication of Railway Equipment," presented before the New England Railway Club which in part is as follows:

"The average running temperature of freight trains is considered to be 80 degrees, and the average running temperature of passenger trains 125 degrees.

We learn from experience that the proper gravity of oil for the lubrication of all trains should be about 30 degrees, and as a degree of gravity is lost at every ten degrees advanced in heat, it is plain to be seen that should we supply an oil for the lubrication of a freight train at 80 degrees, with a gravity of 30 degrees, and if the same lubricant is used on a fast-moving passenger train at 125 degrees, the gravity of the lubricant would be reduced about 5 degrees; or, to explain further, if this lubricant at 30 degrees gravity is dense enough to carry the load at 80 degrees running temperature, it would not be dense enough to carry it at 125 degrees running temperature.''

The use of grease as a locomotive lubricant has been proved by tests to result in an increase of friction over oil. There have been reasons, however, for its use in locomotive practice.

The successful operation of oil waste driving journals requires the cellars to be dropped every ten to twelve days, at an actual labor cost of 35c per box, to facilitate inspection and repacking when necessary.

The following is quoted [redacted] from a paper by Mr. J. R. Alexander, General Road Foreman of Engines, Pennsylvania R. R., read before the Railway Club of Pittsburg:

''The economical operation of locomotives also demands careful supervision of the methods employed in handling lubricating oils, for surprising as it may appear, there are many men who believe good lubrication can best be obtained by quantity rather than quality.

The ideal condition insuring perfect lubrication on locomotives is to have a lubricant, the globules of which will be sufficiently strong, and the mechanical arrangement such that the load carried on the bearing will not force out the film of oil, thereby permitting metallic contact."

Graphite is a good lubricant, especially under high pressure. It is not adaptable to locomotive lubrication, but its use with water or a light oil as a carrying medium presents possibilities of development. It gives a low coefficient of friction with cast iron or other porous materials by filling the minute irregularities in the surfaces, thus increasing the actual bearing area.

Friction-Bearing Metals.

As has been stated above, the nature of the bearing metals determines the amount of friction between them when other conditions are constant. While there is no certain relation between the molecular structure of the bearing and friction, it is generally true that the harder and smoother or more polished the metals, the lower is the friction developed, due to the surfaces of the metals having fewer irregularities to interlock or overlap each other. With metals harder than brass for bearings, such as cast iron, a journal is more liable to cut and wear. Such bearings do not adjust themselves as readily to irregularities of the journals, and in some cases they are too brittle to withstand stresses.

In the June, 1905, Proceedings of the American Society of Mechanical Engineers, Melvin Price stated his conclusions on this question as follows: "An alloy's resistance performance seems to be peculiar to itself, although there are often partial similarities. Investigation showed that there was no definite law between friction and the structure of alloys."

The desired qualities of soft and hard bearing metals are ably discussed in a report by Prof. R. C. Carpenter in Vol. 27 of the Society of Mechanical Engineers on "Locomotive Bearings," from which we quote the following:

Desired Qualities.

"The qualities which a bearing metal should have in order to be satisfactory are quite varied in nature, and in some respects somewhat contradictory. The bearing metal should first of all be one that has considerable adhesion for a lubricant and is readily wetted by it. It should also be softer than the shaft which it supports, so that in case of lack of lubrication, or in case hard gritty materials get in the bearing, the bearing material would be injured rather than the journal. It should be hard enough, however, to retain its shape under any conditions of pressure or temperature which are likely to be imposed upon it by actual use. The melting temperature of the bearing metal should be less than that of the journal which it supports, but should not at the same time be readily melted by changes in temperature which occur in practice. The bearing metal when melted should not possess the property of adhering or welding fast to the journal."

Soft Metals.

"For many purposes where the pressures are low and temperature not likely to get high, a very soft bearing metal, such, for instance, as may be made from 85 per cent lead and 15 per cent antimony, is excellent. This metal is, however, entirely unsuited for hard service, as it readily changes its form with increases of temperature. The bearing metal known as genuine babbitt, consisting of tin 85 to 89 per cent, copper 2 to 5 per cent, and antimony 7 to 10 per cent, is probably adapted to a wider range of use than any other metal which has ever been designed or invented. On account of the large amount of tin, this metal is expensive, and there is a great temptation to palm off as a substitute a metal containing a considerable portion of lead. As a result of my experience, a considerable amount of lead can be used, provided it alloys perfectly with the other metals and does not render the compound too soft. Lead is, however, a poor conductor of heat; for a given condition of lubrication and work performed, a bearing metal containing much lead is likely to run warmer than one containing other metals."

"The soft metals mentioned above possess the advantage that they can be easily melted and cast into shape in place as desired or as needed for use on the journal."

Hard Metals.

"There are a number of other metals which have a high melting point and quite a large coefficient of contraction which, if used for bearing metals, must be cast in separate moulds and finished on machine tools before applying. These metals vary in hardness to a considerable extent, the phosphor bronze being probably the hardest and the yellow brasses the softest. I made extensive experiments with a bearing metal of this class consisting of an alloy of aluminum, zinc and copper, the zinc being largely in excess of the other ingredients. That alloy was very satisfactory when zinc of the proper purity could be obtained, but was so much affected by the impurities likely to be found in zinc that it was frequently quite unsatisfactory in practice."

"I have found that a mixture consisting of 50 per cent of aluminum, 25 per cent of zinc and 25 per cent of tin forms an alloy which has many excellent properties as a bearing metal. It is light in weight, has a fair degree of hardness, a moderately high melting point, and, so far as I can determine from laboratory experiments and some practical applications, is a superior metal for certain kinds of bearings."

Conclusion.

"From the uncertain nature of our methods of testing and from the varied conditions under which bearing metals are used, it is easy to understand the differences of opinion which are held by various engineers regarding the quality of the same bearing material. This fact also probably explains the reasons why such a variety of prices and grades of bearing metal can be marketed."

"In my opinion there is no possible criterion, no single definition or specification, which can adequately describe a bearing metal which shall be universally satisfactory for all work and conditions."

Different Brass and Babbitt Mixtures.

Very good results are obtained with brass bearings of the following composition:

Copper not less than............	79%	
Lead not less than............	9%	
Total softening elements.......		88%
Tin not to exceed..............	10%	
Zinc not to exceed............	2%	
Total hardening elements......		12%
		100%

A good babbitt metal for lining car journal brasses is:

Lead	78%
Antimony	19%
Tin	3%
	100%

A good metal for piston rod and valve stem packing is:

Lead	86%
Antimony	12%
Tin	2%
	100%

Friction—Hot Boxes.

The following diagram represents the various causes of hot boxes:

Hot Boxes

- Excessive Friction
  - defective lubrication
    - inferior lubricant
    - insufficient lubrication
      - waste not against journal
        - not enough waste in box
        - waste not resilient
      - waste with insufficient capillary power
        - waste not thoroughly saturated with oil
        - oil frozen
        - short fibre waste
      - waste charred
      - oil washed out of box by snow or water
  - excessive bearing pressure
    - insufficient bearing area
      - too small journal
      - presence of abrasive or cutting particles
      - bearing out of alignment
      - bearing too tight or too loose on sides
      - bearing warped or rough
    - inferior bearing metal

Lubrication—Driving Journals.

Tests have been made proving that driving journal friction increases proportionately as the distance traveled after oiling.

The lubrication of driving journals with oil by cups and cellars caused so much trouble in locomotive operation, due to the increase in length of runs, peripheral speeds and bearing pressures combined with the lack of a regular feed of the lubricant, that grease was resorted to by some railroads because it afforded a positive feed, which materially reduced the annoyances and expense of hot driving journals.

When the first experiments were made with grease it was found that the grease cellars, with the usual oil-hole left in the top of box and with the brasses fitting the journal as snugly as was the practice with oil, would not give satisfactory results. In these experiments it was found that the grease was forced out through the hole in the top of the box. In a number of instances wooden plugs were driven in the holes to prevent this, but the pressure exerted by the revolving journal forced these plugs out, demonstrating the magnitude of the pressure thus generated. One explanation of this pressure is that the revolving journal in generating pressure acts like a paddle-fan water wheel reversed in that the minute irregularities on the surface of the journal fill with the lubricant and carry it to the pressure side of the brass where it adds to the amount previously taken up and retained; a kind of cumulative pressure which continues until the pressure has reached a point that will not permit more grease entering between the journal and the bearing.

After these grease difficulties were overcome, the loss of tractive force, with the consequent higher cost of operation per ton mile hastened the perfection of the automatic oil force feed lubricator for journal lubrication.

The following is another quotation from Mr. J. R. Alexander's paper:

"Driving box lubrication is obtained by means of a supply of oil from both top and bottom of the journal, while tender and car journals depend altogether on the supply of lubricant from the under side. In either case, however, it is essential that the packing in journal box cellars be maintained in good condition, and to this end it is necessary that a good quality of wool waste, or other suitable material, be provided and same prepared for use by being submerged in oil for not less than 48 hours, after which the waste should be drained of free oil in excess of 4 lb. oil per pound of waste, and furnished to inspectors well loosened up and not wrapped up tightly in balls. In packing journal boxes it is a great mistake to have the waste contain too much free cil, as this makes it impossible to pack sufficiently tight under the journal to prevent pounding down after locomotive or car is in motion. Dust guards at back of journal boxes should be maintained in good condition and the packing kept firmly set up to the journal at the rear of the box. At the sides the waste should not be allowed to extend above the center line of the journal, for if the waste is allowed to pack against the rising side of the bearing it will soon become glazed and act as a wiper, and is very likely to clean the journal free of oil, preventing it from passing under the bearing. The best results and with considerable economy in the amount of oil and waste, will be obtained by having locomotive and tender journal box cellars not more than 2¼ in. deep, as experience proves that capillary attraction will not bring sufficient oil through waste from a greater depth."

In reference to the above it might be stated that average wool waste under most favorable conditions seldom absorbs over 3 lb. oil to 1 lb. waste.

Lubrication—Valves and Cylinders.

The question of internal lubrication has been given additional consideration in recent years, due to increasing difficulties met with in high steam pressures, and superheated steam with irregular lubrication.

The lubrication of valves and cylinders to be effective must be regular and in proportion to speed and cut-off, because one of the fundamental laws of friction is, as previously stated, that it decreases directly as the speed of the moving parts up to 100 ft. per minute and increases nearly directly proportionate to its square root at greater speeds. This applies to valve and cylinder as well as journal lubrication. Valve and cylinder lubrication should be proportionate to the cut-off at which the locomotive is working because at the longer cut-off the valve travel is greater, and while piston travel is the same the mean effective pressure and consequently the temperature in the cylinder is greater, both of which conditions require more lubricant. In addition to this there is the increased tendency to work water at the longer cut-off when starting.

Driving journal lubrication should be proportionate to the cut-off for the reason that at longer cut-offs the mean effective pressure in the cylinder is increased, thereby increasing the pressure on the working sides of the journal bearing.

Relative to the amount of lubricant necessary the Committee on Locomotive Lubrication of the American Railway Master Mechanic's Association in 1907 made the following recommendation:

"Your committee feels that for internal lubrication 70 miles per pint for large freight locomotives and 80 miles per pint for large passenger locomotives seems to be the amount needed to lubricate properly. The amount to each class depends upon the speed at which the locomotive is running; in bad water districts the oil allowance should be increased about 25 per cent."

Lubrication—Superheated Steam.

Oil must be fed regularly to overcome the difficulty of lubricating valves and cylinders, in the case of superheated steam, beause of the loss of lubrication due to the dryness and high temperature of the steam itself. The fact was emphasized in the 1907 Proceedings of the Traveling Engineers' Association, and automatic force feed lubrication was recommended. The fastest superheated locomotive in the world is lubricated by an automatic force feed system.

Lubrication—Regular or Irregular.

Irregular lubrication necessitates using an excessive amount of oil, causes unnecessary friction which results in most of the hot bearings and cut surfaces, and in the case of valves and cylinders materially affects the proper distribution of steam by overburdening the valve gear.

These conditions increase the cost of operation by increasing coal consumption and by decreasing the available power of the locomotive. The overtaxing of the valve gear also causes more rapid wear of pins and connections and earlier repairs.

Methods of Lubrication—Hand Oiling—Oil Cups.

At the outset the moisture of low pressure steam was depended upon to lubricate valves and cylinders, but soon oil cups were placed on steam chests, and were filled whenever stops were made. The next step was to place the oil cup in the cab of the locomotive, so that it could be operated by the enginemen. This method of lubrication was nothing more than hand oiling, but it was more convenient.

Methods of Lubrication—Sight Feed, Hydrostatic.

The second step in valve and cylinder lubrication, taken about twenty-five years ago, was the introduction of the hydrostatic sight feed lubricator. The principle upon which it operates is, that a column of water under boiler pressure forces the oil floating on top of it into cylinder oil pipes leading to the bearing surfaces. The difference in pressure which forces the oil is equivalent to the weight of a column of water equal in height to the difference in levels of lubricator outlet and bottom of choke plug, less the friction in the pipe, plus the difference between boiler and steam chest pressure.

Method of Lubrication—Force Feed.

Force feed lubricators were perfected first for stationary engines and automobiles, and about five years ago the lubricator with automatic features was finally designed for locomotive service. The European railways have used force feed lubrication much longer, but the mechanical construction of the lubricator did not appeal to American engineers, especially on account of the increased consumption of oil due to the impossibility of fine adjustment of feed.

With the modern American system of automatic force feed lubrication, motion is obtained from some part of the valve mechanism, the motion of which is proportional to that of the valve itself, and is transmitted through a mechanical transformer to the lubricator proper, located in the most convenient place on the locomotive. Individual pumps force the oil through individual pipes to the bearings to be lubricated. The lubricator operates automatically only when the engine is running, and the speed of the plungers in the lubricator is entirely dependent upon the travel of the valve.

Before starting the locomotive, after standing some time, the engineman operates the plungers several times by the hand crank to oil each bearing before moving engine. As the pumps are capable of developing over 3,000 lbs. pressure, the lubrication is absolutely positive, the oil being forced direct to the bearing surfaces. There is no pressure in the reservoir, which is an assurance against accidents, and permits the filling of the reservoir while the lubricator is in operation. The amount of oil delivered to any bearing surface is dependent upon the stroke of the individual pumps of the lubricator and the feed may be adjusted from one drop in 10 strokes to 20 drops in one stroke by changing the stroke of the plungers. The feeds to the different bearings are independent of one another and are regulated to suit the conditions. Adjustment once made, is maintained by locking the adjusting nut.

Foot per Foot Travelled.

The force feed lubricator is regulated on trial of each locomotive. The mileage per pint of valve oil will vary from 70 to 150, depending on type, power and speed of locomotive, steam pressure and temperature, grade of track, etc.

Direct and regular lubrication effects a saving in oil, an increase in engine efficiency and a decrease in the wear of the parts lubricated.

The McCord force feed lubricator does not lubricate per unit of time, but in per unit of work performed, which is not only in direct proportion to the speed, but also in proportion to the cut-off at which the engine is being worked. It is automatically regulated by the speed of the engine and the position of the reverse lever.

Power and Tractive Force-Lubricants.

A good lubricant applied in regular sufficient quantities reduces the internal friction of a locomotive there by increasing the effective tractive force and horsepower. The tests made by the Pennsylvania Railroad at the Louisiana Purchase Exposition demonstrated that the use of grease instead of oil on driving journals, increased the friction per journal by from 75 per cent to over 100 per cent, depending on the peripheral speed.

The report of Prof. W. F. M. Goss, printed in the 1906 proceedings of the American Railway Master Mechanic's Association, is here quoted in part:

"Accepting the oil lubrication as a basis of comparison it appears that at 20 miles an hour the loss of power resulting from the use of grease is slight, so small in fact as to be almost negligible, but as the speed is increased the loss is increased and at 60 miles per hour it amounts to from 140 to 160 horsepower. The equivalent coal loss, assuming four pounds of coal per horsepower hour, is something more than 500 pounds per hour. A summary of results in form permitting easy comparisons is set forth in the accompanying table."

Speed of Engine 20 Miles an Hour.

1. Pounds pull of the draw-bar necessary to overcome friction of the engine.

Cold start	Grease	1,578	Oil	1,435
Hot start	Grease	2,222	Oil	1,549
Average		1,900		1,492

2. Tractive force lost by use of grease 408
3. Horsepower lost 21.8
4. Coal lost per hour run (assuming 4 pounds per horsepower hour) 87.2

50 Miles an Hour.

1. Pounds pull at the draw-bar necessary to overcome friction of the engine.

Cold start	Grease	1,862	Oil	555
Hot start	Grease	1,628	Oil	780
Average		1,745		667

2. Tractive force lost by use of grease 1,078
3. Horsepower lost 143.7
4. Coal lost per hour run (assuming 4 pounds per horsepower hour) 574.8

60 Miles an Hour.

1. Pounds pull at the draw-bar necessary to overcome friction of the engine.

Cold start	Grease	1,727	Oil	655
Hot start	Grease	1,804	Oil	873
Average		1,765		764

2. Tractive force lost by use of grease..........1,001
3. Horsepower lost 160.2
4. Coal lost per hour run (assuming 4 pounds per horsepower hour) 640.8

These tests were made on an Atlantic type locomotive with grease and oil used in each case on driving journals and crank pins.

We are informed that oil was fed to driving journals by gravity through holes in the top of the driving boxes. These holes released whatever pressure the revolving journal generated; thus relying for lubrication on the little amount of oil that, due to its adhesive quality, could not be forced out from between the journal and the bearing.

The modern automatic force feed method forces the oil into the top of the driving box against the pressure generated by the revolving journal and raises the box from the journal as far as the oil packing on the ends of the driving box will allow, thus separating the journal and the bearing with a thick film of oil. This fills all irregularities in the bearing surfaces, so that the actual bearing surface more closely approximates the projected areas. It separates the journal and bearing sufficiently to clear projections on one or the other that would ordinarily cause cutting. There are actual cases of cut journals thus lubricated, running as cool as the smooth journals on the same engine.

In experimenting with a driving box in the laboratory it was found that a gauge piped to the cavity in the top of the brass recorded a pressure as high as four times the bearing pressure per square inch that the weight on the bearing divided by the projected area should have given, which proves that the actual pressure per square inch is a very different quantity from that figured from the projected area. The increasing of the realized area by intervening a thick film of oil between the bearing and journal will overcome troubles due to overloaded journals.

With the modern automatic force-feed method of lubrication, the oil, in being forced through the top of the box, is ready to go to the service or pressure side of the journal whether the engine is backing or going ahead, and does not have to ride up the other side first and be scraped off by the brass before it has reached the surface that most needs the lubricant.

For this reason driving box brasses may be fitted up without side clearance and a tight fitting cellar may be used to prevent any "pinching" of the journal. This method gives the brass more crown bearing and allows that much more side-wear before the journal is as loose in the brass as when driving boxes are fitted for grease lubrication from the under side.

Excessive side clearance or pound between driving journals and brass subjects locomotive machinery and frames to severe dynamic stresses and this clearance together with any looseness in the rods, requires the piston to move a certain distance in taking up lost motion before moving the engine. The volume of steam used in this piston displacement is a dead loss and in the case of a modern 22-inch consolidation engine with

¼-inch total play in the boxes and ⅛-inch on each crank pin, it amounts to about 225 lbs. of coal per hour.

All moving parts in a reciprocating engine should be as devoid of lost motion as possible, for as soon as there is lost motion, the stress to be resisted by the pistons, rods, crank-pins, driving axles and frames, is changed from a static to a dynamic stress, whose magnitude and effects (as was learned from draft gear experiments) are extremely difficult to determine.

A lubricator does not operate perfectly if it fails to feed automatically in accordance with requirements of the service, which is in proportion to speed and cut-off. The automatic lubricator relieves the engineman of the necessity of the care of it and allows him that time for other duties.

Conclusions.

One of the chief aims in modern transportation is a safe reduction in ton mile costs. A very important item entering into this is locomotive efficiency, which depends on a number of conditions, one of which is the reduction of friction. This is accomplished by using the best lubricant with the best method of applying it.

The automatic force feed system of lubrication does not reduce the amount of oil actually needed but does reduce the waste of oil which accompanies other methods. While the automatic force feed system reduces this waste, the principal benefit derived is a more nearly constant coefficient of friction in the bearings lubricated. This is lower than the average of the varying coefficients of friction with any other method.

Advantages Derived by the Use of McCord System of Force Feed Locomotive Lubrication.

1. Lubrication is positive.

2. Lubrication is proportional to valve travel and therefore proportional to the work done by the locomotive.

3. When locomotive stops, lubrication stops.

4. Lubricator pumps against a pressure of more than 3,000 pounds.

5. No pressure in reservoir insures against leakage and accidents to enginemen.

6. Reservoirs can be filled while in full operation.

7. Each feed can be adjusted separately.

8. Feed is adjustable from one drop in 10 strokes to 20 drops in one stroke.

9. Adjustment of feeds once made, they remain accurate and adequate under all conditions.

10. All moving parts are immersed in oil.

11. Oil consumption is reduced and engine efficiency is increased.

Directions for Operating the McCord Force Feed Lubricator.

1. There is no pressure in this lubricator, consequently no steam to be turned off or no draining to be done before filling.

2. To fill, remove the filling cap and pour in the oil after it has been heated sufficiently to pour freely through the strainer at the filling hole. This may be done either when the engine is standing or running.

3. Do not fill this lubricator with oil drained from a hydrostatic lubricator, as it will contain water.

4. Do not allow oil to feed out below gauge line.

5. The feed is increased by screwing down the knurled nuts on the top of the pump plungers, and is decreased by screwing them up.

6. The lubricator body should be kept warm to the touch so that the oil will remain thin enough that the pumps may handle it easily. A heater chamber is provided on the bottom of each lubricator into which a small amount of steam can be admitted in cold weather.

7. This lubricator operates automatically when the engine is in motion, so there is nothing to turn on at the beginning of a run or to turn off at the end of a run.

8. Should it be necessary to give the engine more oil than is obtained by the automatic mechanism, operate the hand crank on end of lubricator.

Directions for Operating and Testing the McCord Locomotive Force Feed Lubricators.

To Put the Lubricator in Service.

Remove the filling cap and fill the lubricator with warm oil; disconnect below all the terminal check valves and operate the hand crank until oil appears at the bottom of each check valve. Then connect up each terminal check valve and driving mechanism and the lubricator will be ready for operation.

To Test Out the Lubricator Should Any Trouble Be Reported.

Disconnect the operating mechanism at the valve stem, operate the ratchet arm slowly by hand, and see that the lubricator shaft revolves with each return movement of the ratchet arm.

Disconnect all oil pipes at check valve joints. The oil pipes should be full of oil. If any pipe is found empty or only partially full of oil, it is an indication that there is something wrong with the check valve or pump on this oil line, or that the oil pipe leaks or is stopped up.

Admit steam under the check valve. No steam should blow out at the oil port connection. If there should be a leak here, remove the check valve and grind in the needle valve seat. Use powdered glass or any grinding compound same as used on air brake work, but be sure that this grinding is done when the valve is hot, as it is under this condition that the valve should be tight. Be sure to clean the check valve and seat thoroughly after grinding so that no small particles can get under the valve seat and cause leak.

If the check valve is Steam tight, disconnect the oil pipe connection at the lubricator pump and turn the hand crank; if oil shows at the pump discharge, the pump is O. K. If the pump does not work, take it out and make sure that the packing around the pump plunger is tight, that there is no waste or other material collected around the pump suction pipes, and that all the ball checks in the pump are in their proper places.

Pump kerosene through the pump to wash and clean the ball checks and seats. The plunger packing should be elastic enough that it will not be necessary to screw the packing nuts down so tight as to bind unnecessarily on the plungers.

To determine if the oil pipe leaks, connect a pressure gauge on to the end of the oil pipe and operate the lubricator by hand. The pipe line should hold a pres--sure of at least 300 lbs. without any variation on the gauge. This is also an absolute test that the ball checks and the packing in the pump are tight. If there is an obstruction in the oil pipe, no oil will appear at the end of the pipe after the lubricator has been operated by hand a reasonable length of time, and further, the lubricator shaft will turn hard on the down stroke of the plunger, and oil will leak out at the packing nut, and at the pump outlet connection.

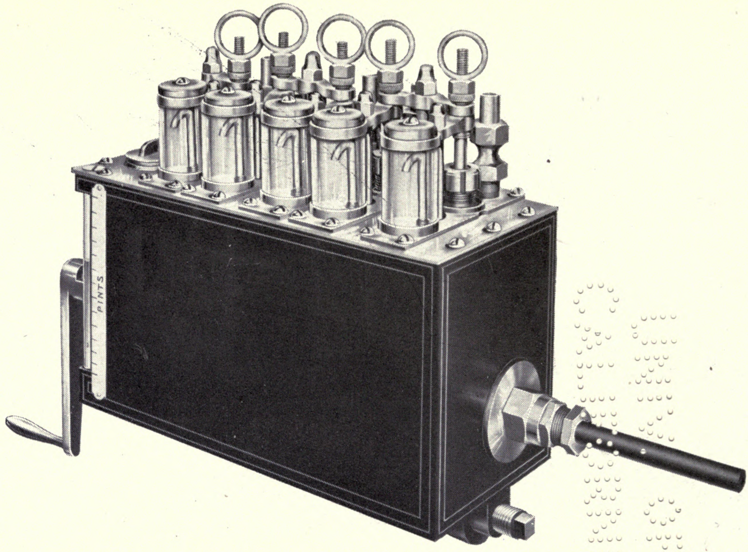
After doing work on any or all of the oil pipes, screw all union joints tight and turn hand crank until the oil pipes are full of oil before the engine goes out. This is important. The slightest leak in the whole system should be avoided, for it will materially affect the regular delivery of oil.

The feed is adjusted by means of the knurled nuts on the top of the pump plunger. Screw these nuts down to increase the feed and screw them up to decrease the feed.

McCORD AND COMPANY

Peoples Gas Bldg.
Chicago.

50 Church Street
New York.



McCord Locomotive Force Feed Lubricator

McCORD AND COMPANY,
PEOPLES GAS BUILDING
CHICAGO

Gentlemen: Please send me ______________________ copies of "Locomotive Lubrication," by W. J. Schlacks.

Name ______________________________

Position ______________________________

R. R. ______________________________

Address ______________________________

____