

Automobile Lubrication—II*

How to Test, and How to Use Various Classes of Oils and Greases

By C. W. Stratford

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CONDITIONS UNDER WHICH MOTOR OILS WORK.

THESE may be treated under three headings: (1) Division of lubricating system; (2) Operating temperatures of motor parts; (3) Requisite physical properties and their effect upon motor operation.

Division of Lubricating Systems.—A thorough analysis of the lubricating systems of automobile motors, with all their peculiarities of design, in connection with exhaustive tests made with oils in each, shows that practically every lubricating system in use to-day can be included in the following distinct types:

- | | |
|------------------------------------|-------------------------------|
| (1) Full Splash. | (6) Separate Force Feed. |
| (2) Splash, with Circulating Pump. | (7) Force Feed. |
| (3) Pump Over and Splash. | (8) Full Force Feed. |
| (4) Force Feed and Splash. | (9) Knight Slide Valve Motor. |
| (5) Pump Over. | (10) Oil Fed with Fuel. |

The reason for choosing such a fixed number of lubri-

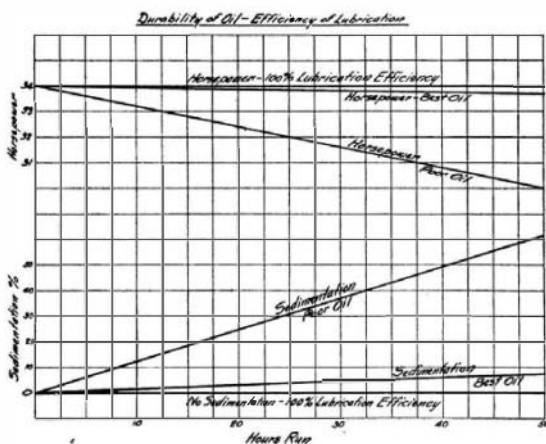


Fig. 11.—Durability of oil and efficiency of lubrication.

ating systems is to facilitate their proper classification and because of the effect which the details of these lubricating systems exert upon the flow of oil to the moving parts. Insofar as the principles involved go, lubricating systems, without exception, can be divided into two general groups, "Circulating" systems and "All-loss" systems. By "all-loss" system is meant a lubricating system in which oil is fed directly into the crankcase, or through the bearings into the crankcase, from an outside source. Oil thus fed into the case never returns to its source. In "all-loss" systems the lubrication of the parts in contact is accomplished by (a) splash only from the connecting-rod ends, and by (b) oil under pressure as well as by splash from the connecting-rod ends. In motors employing "all-loss" systems oil is filled up to a fixed level in the crankcase. The lubrication of all parts is then made continuous by splash and by feeding oil from an auxiliary source into the crankcase, where it is consumed at or about the same rate as the feed. "All-loss" systems are, however, much less fool-proof in many ways than are the circulating. There is a possibility with the former of feeding an excess of oil into the crankcase, which may cause a rapid carbon deposit in the cylinders, or, on the other hand, of feeding too little oil, thereby causing unduly rapid wear, or, perhaps, serious injury to the parts from want of lubrication.

By circulating system is meant a lubricating system in which a quantity of oil is filled to a fixed level into the crankcase sump, whence it is circulated by some type of pump or by the flywheel to all parts requiring lubrication. In circulating systems the oil is applied to the moving parts by (a) splash alone from the connecting-rod ends, or by (b) pressure, and splash from the connecting-rod ends. A drain pocket or cavity should be provided at the lowest part of the crankcase sump in circulating systems so that all metallic sediment, carbon, heavy carbonaceous or foreign matter will settle and not re-enter the circulating pump. Fine mesh metallic screens are regularly fitted between the main crankcase and the oil sump below, or over the inlet side of the circulating pump, as a positive means of separating solid matter, cotter pins, nuts and wrenches from the lubricating oil.

Before leaving the subject of lubricating systems, I wish to state that during my own experience as a designer of internal combustion engines I have frequently been called upon to solve many vexatious and baffling problems most of which had to do with the proper form and

arrangement of the lower crankcase, oil sump and its accessories. Very careful attention here to details invariably pays in the long run. The very success or failure of a motor in the hands of a careless public may depend wholly upon their excellence.

OPERATING TEMPERATURES.

Automobile motor oils are exposed continuously to much higher temperatures in an internal combustion engine than they were in the heat test already mentioned. Especially is this true within the explosion chambers, upon the upper surfaces of the cylinder walls and upon the lower surfaces of the piston heads. For clearness let us examine only the functions performed by the oil and the changes which it undergoes above and below the piston.

Oil for the lubrication of pistons and cylinders is splashed on the lower cylinder walls and from there it is carried upward and spread over the cylinder wall surface by the pistons and piston rings. A certain quantity as well is thrown off the pistons on their ascending stroke and projected onto the entire explosion chamber walls. If the latter quantity is small, and the fuel mixture is set on the lean side, it will be flashed off, leaving no appreciable deposit. But when an overabundance is thrown up, the heat of explosion can only vaporize the exposed surface or outer layers so to speak, of the oil film, because of its poor heat conductivity, and blow it out with the exhaust gases in the form of smoke, leaving behind heavy end-products of destructive distillation. These are rapidly reduced by the intense heat of open-throttle explosions into a cumulative incrustation called carbon deposit in common parlance. The actual free carbon content of this carbon deposit may vary from less than 1 to as high as 75 per cent. Other constituents present are metal oxides, mostly iron, from a trace to approximately 5 per cent, large percentages of inactive earthy matter (road dust) and solid black carbonaceous or asphaltic compounds, according to the oil used. An analysis of crankcase sediment, taken from a laboratory motor, showed free carbon under 2 per cent, metal dust less than 1 per cent, the remainder being nearly equal quantities of carbonaceous matter, (1) soluble in naphtha and (2) soluble in carbon disulphid. And the analysis of deposit taken from the crankcase side of the piston heads showed approximately the same percentage of the above constituents, excepting a slight increase in free carbon.

Given an oil of good quality, carbon deposits resulting from its use, up to the point where trouble occurs, can and should be easily avoided between annual overhauls by the manufacturer's proper design of motor parts. While it is a fact that much can be done toward the suppression of mechanical defects, omissions of design and carbon deposits accruing therefrom, by correct oil specifications to suit the case in hand, it is decidedly unfair to suppose that oil alone can satisfactorily replace leaky piston rings, or to burden motor oil with a more exacting task in the cylinders than that of good lubrication with its helpful seal against slight gas leakage.

Below the piston heads, though the heat conditions there are somewhat less severe than above, chemical reactions within the oil are just as inevitable and continuous. No lubricating oil exists that will not undergo a chemical and, naturally, a physical change when exposed to the high temperatures on both sides of the pistons of automobile motors. In other words, there is no motor oil known that will not deposit sediment in the crankcase. A very marked difference does, however, exist in the rate of sedimentation of oils of good and of poor quality, used in the same motor under the same operating conditions. It seems logical to conclude, therefore, that the rate of sedimentation must be a dependable measure of durability and efficiency.

SERVICE TESTS.

For the purpose of the following tests, let us assume that two yellow oils of the same viscosity, say, between 200 and 300 seconds Saybolt at 100 degrees, be used.

Good Oil—Reactions.—When a motor is run on the test stand or in a car for a few hours with a filtered oil of the highest quality and a sample taken for examination, it will be seen that the oil has changed from its original yellow to a grayish-blue by reflected light. After running several days it will be found that the oil has turned entirely black and become opaque. A sample drained from the motor into a long narrow tube and allowed to stand 24 hours will show a black sediment at the bottom. The oil floating above the sediment is red in color by transmitted light and is equally as ser-

viceable as when fresh. The volume of this sediment depends upon the operating temperatures of motor parts with which it has come in contact, particularly the temperature of the piston heads, upon the presence or absence of mechanical defects (leaks) in the motor, and upon the quality, i. e., degree of purity and stability of the oil used.

Poor Oil—Reactions.—Let a poor oil be run in the same motor under like conditions of time and temperatures and samples examined. At the end of a few minutes

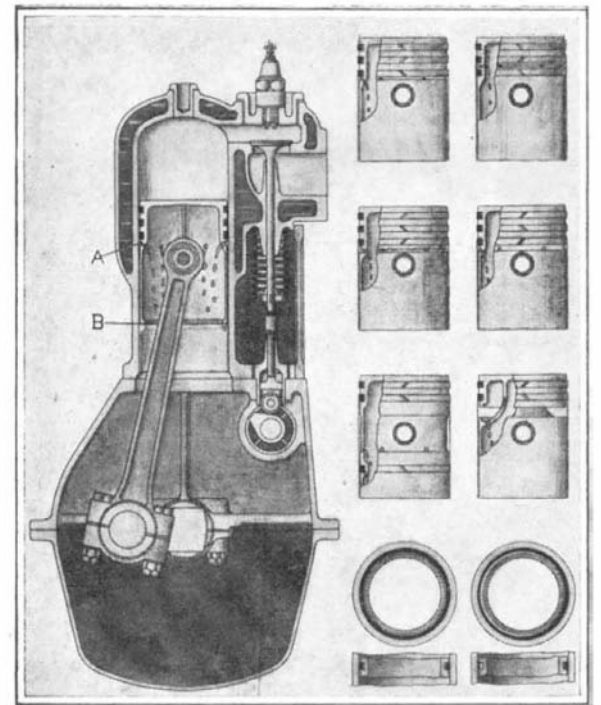


Fig. 12.—Proper design for good lubrication.

the oil will turn to a dense and lustrous black. After standing 24 hours the sample used several days will show a voluminous black sediment, several times greater than that of the good oil.

In the interpretation of these results, let us assume the most favorable case for the poor oil—that the portion remaining above the sediment is still usable, though more often it is not. The good oil is still vastly more durable and economical than the poor. (Fig. 11). Chemically, this low resistance to heat shown by poor oils is again traceable to the nefarious and destructive effect of "sulpho" compounds present. Regarding the probable effect which their presence might have upon the bearings and other parts within the motor, when decomposed by heat into free sulphuric acid, it may be expected that corrosive action would be almost negligible. The effect of hot sulphuric acid gas upon highly heated exhaust valves and seats is very noticeable, however, causing rapid pitting of the surfaces and leakage.

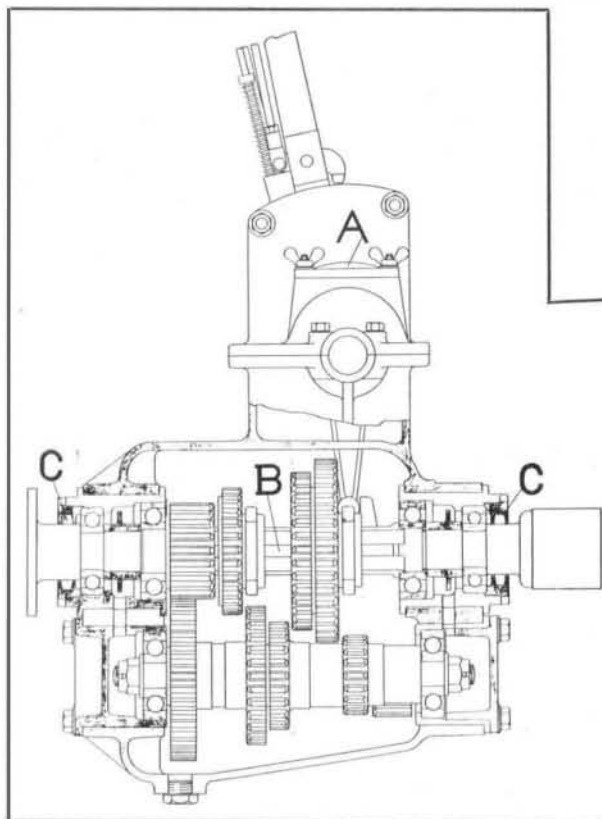
SUGGESTIONS RELATIVE TO DESIGN.

The maximum mileage per gallon of oil in the best modern automobile motor is rarely above 1,000, as compared to that of the average motor which probably never exceeds 200. Why such a wide difference in efficiency? The answer is not hard to find. An examination of the 1,000-mile motor discloses the use of tight piston rings, large centrifugal rings on the crankshaft where it passes through the case, ample cooling fins in the pistons, vents between the crankcase chamber and the valve enclosures, etc. Briefly put, cooling of the oil in this motor has been properly cared for and leakage reduced to a minimum. The result speaks for itself.

To be specific regarding details of design: Oil surplus can be kept out of the explosion chambers by leaving the lower edge of the piston skirt sharp and by the use of a shallow groove just below the lower piston ring (Fig. 12). Small holes are bored through the piston walls at the base of this groove and communicate with the crankcase. The similarity of the sharp edges of piston skirt and piston ring to a carpenter's plane bit, makes their operation plain.

Faulty piston rings are not to be tolerated any more than is their careless fitting. Concentric rings are to be preferred with a maximum clearance between back of ring and bottom of groove, of 0.010 inch. The thickness of piston heads should not only be sufficient for strength but also for good heat conduction. If the bore exceeds

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tion of fatty oil with sodium or potassium hydroxide in the presence of water. When the saponification is completed, all of the water is boiled out and a hydro-carbon oil is then added. Variation in the quantity of the constituents makes possible the manufacture of light, medium and hard grease. This grease when heated up becomes entirely fluid and upon being allowed to cool returns approximately to its former consistency.

Graphite Grease.—Finely divided graphite is mixed

a material loss in power transmission and are not to be advised.

When cup greases are used alone, the friction heat soon causes a voluminous foaming and, later, a permanent separation of the oil from the soap which occludes it. For this reason cup greases should never be used for transmission or rear axle lubricants in any other form than semi-fluid oils. For leaky cases gear compounds only should be used, due to their high adherence, good

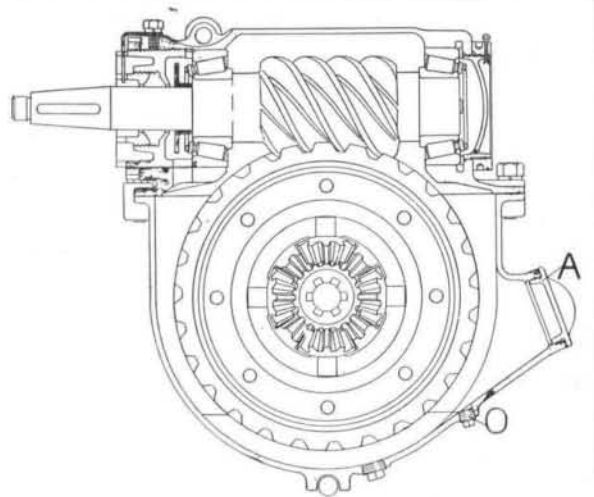
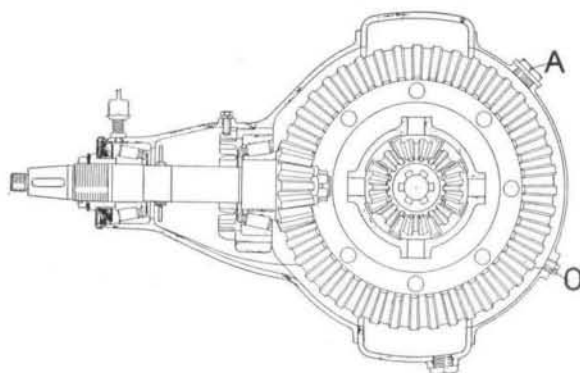


Fig. 13.—Proper design for good lubrication.

4 inches, thin cooling webs should be provided in the head so as to fully utilize the cooling effect of the oil. The ideal piston, from the viewpoint of cooling, is of course that made of aluminium alloy.

The cooling of oil in the sump can be accomplished most effectively by radiating fins on its outer surface. The lower crankcase should be fully exposed to the outer air. A settling basin for sediment should be provided, having a cubic content of not less than one tenth of the total oil capacity. The depth of this basin should be at least 3 inches and its walls vertical to reduce the mixing of sediment with the oil in circulation. The inlet to the oil pump should be near and above the top of the settling basin. Concerning filtering screens there is little to be said, save that their areas should be ample and the mesh coarse enough (one sixteenth of an inch) to offer no serious resistance to the free flow of cold or heavy oil through them; otherwise the oil in the crankcase may build up above them to an undesirable level. The necessary frequency of draining and flushing out the oil sump differs greatly with the age (condition) of the motor and the suitability of the oil used. In broad terms, the oil sump of a new motor should be thoroughly drained and flushed with kerosene at the end of the first 200 miles, next at the end of 500 miles and thereafter every 2,000 miles.

Now, to answer a leading question that cannot be passed over lightly, namely: "What is the best type of lubricating system for automobile motors?" Without hesitation I would say force feed, i. e., a circulating system with feed under pump pressure to all crank and camshaft bearings. This system furnishes a copious supply of oil for carrying away the friction heat of bearings and for cooling the piston heads. In fact, the large body of oil in constant circulation offers the best conveyance for surplus heat to the outer air. Once the oil sump has been filled, no further attention is required. There is no danger of burning out bearings or scoring cylinders from lack of oil, fouling of plugs or carbon troubles. Furthermore, so long as there is water in the cylinder jackets and oil above the oil pump inlet, no amount of punishment by hard work on the road or high motor speed can injure any of the moving surfaces in contact.

TRANSMISSION AND REAR AXLE.

In the early days grease of medium consistency was thought to be the only proper lubricant for use in transmission and rear axle mechanisms (Fig. 13), but improvements made in the design of different devices for retaining the lubricants where the drive-shafts pass through the case have fortunately made possible the introduction of more efficient semifluid lubricants.

CHEMICAL CONSTITUENTS OF TRANSMISSION LUBRICANTS.

Cup Grease.—Cup grease is manufactured, first, by the saponification of fatty oil with calcium hydroxide ($\text{Ca}(\text{OH})_2$) in the presence of water. When saponification is complete, hydro-carbon oils are added to the soap formed to make the homogeneous mixture known as cup grease. Light, medium and hard greases are readily made by varying the quantities of the constituents. Finished cup grease always contains more or less water and for that reason when heated it foams and a permanent separation takes place between the soap and the hydro-carbon oil.

Fiber Grease.—Fiber grease is made by the saponifica-

with cup grease to form different grades of graphite greases.

Semi-fluid Oils.—These are made in the same manner as cup greases, the only difference being that a smaller quantity of saponified fatty oil is combined with the hydro-carbon oil.

Gear Compounds.—The so-called gear compounds are generally manufactured by blending fiber grease with a hydro-carbon oil. Inferior grades are made from a mixture of paraffin wax and heavy oil. Paraffin not being a lubricant, the lubricating efficiency of such compounds is therefore reduced in proportion to the quantity present.

Transmission Oils.—These oils consist either of a heavy straight cylinder stock (hydro-carbon oil) or of a blend of same with a small percentage of fatty oil, and are used for the most efficient lubrication of both transmission and worm- and bevel-gear rear-axle mechanisms. For the lubrication of worm-driven rear axles, chemically pure castor oil is sometimes used, in spite of the fact that it offers no noticeable advantages over transmission oils and in the face of an almost prohibitive cost.

LIMITING CONDITIONS OF OPERATION.

Doubtless were it not for the frequent serious leakage of lubricant which occurs from the average commercial transmission or rear axle, no other medium would be used than transmission oils. The best body of these oils for use in both winter and summer lies around 140 seconds at 212 degrees (Saybolt universal instrument). Leakage does, nevertheless, occur and is consequently one of the chief factors, if not the leading factor, governing the specification of lubricants for these mechanisms. It is generally recognized to-day that even a medium cup grease is unsatisfactory because of the fact that the gears cut "tracks" into its body, thus preventing anything more than momentary contact with their teeth, and the other parts requiring lubrication. On the other hand, a thin oil rapidly leaks out through the joints of the case and along the shafts. As a solution, a compromise lubricant is chosen which offers the least resistance to movement and shows a minimum loss from leakage. Often a heavy grease mixed with wood fiber, asbestos or other solid matter, is used to suppress the irritating noise of poorly cut gears. Such substances cannot fail to show

lubricating properties and slight tendency to leakage. They may be had in consistencies sufficiently heavy to suit conditions of the leakiest case, without possessing any of the disadvantages of straight cup or fiber greases. Leakage with any lubricant can be reduced to a minimum by the application of centrifugal rings to all shafts, or if the space be too limited for the application, by felt packing, and by providing air vents at the top of the case so as to maintain atmospheric pressure above the lubricant within the case. All lubricants possess a fairly high coefficient of expansion and when filled cold up to the center of the shafts, will be expanded by friction heat and the level raised thereby to such an extent that the hot air above, also expanded, will force them out, even through tight joints.

As to the necessary frequency of inspecting the level of the lubricant in transmission and rear axles, or of draining and flushing out same, it would be merely a waste of words to give any definite figures. There are entirely too many variables involved. Suffice it to say that reasonably frequent attention should be given to maintain a uniform level in these mechanisms, and to drain them whenever a sample of the lubricant shows the presence of considerable metallic dust when examined by reflected sunlight. A thorough cleansing of the case between every three to five thousand miles will richly repay what it costs in lubricant by the increased life of the parts.

CHASSIS.

Cups.—Commercial cup grease of a grade suiting the season should be used, exception being made only of the grease cups feeding the water-pump bearings and glands, where graphite greases give better service.

Steering Gear.—The worm and sector in the steering-gear housing require a cup or fiber grease or a heavy gear compound, depending upon the tightness of the housing. Preference should be given the latter wherever its use is possible.

Wheels.—With anti-friction bearings, a medium grade of fiber grease will give entire satisfaction. In case the wheels are fitted with plain bearings, a suitable grade of semi-fluid oil should be used.

Suspension Springs.—The blades of suspension springs where they come into contact with each other can be

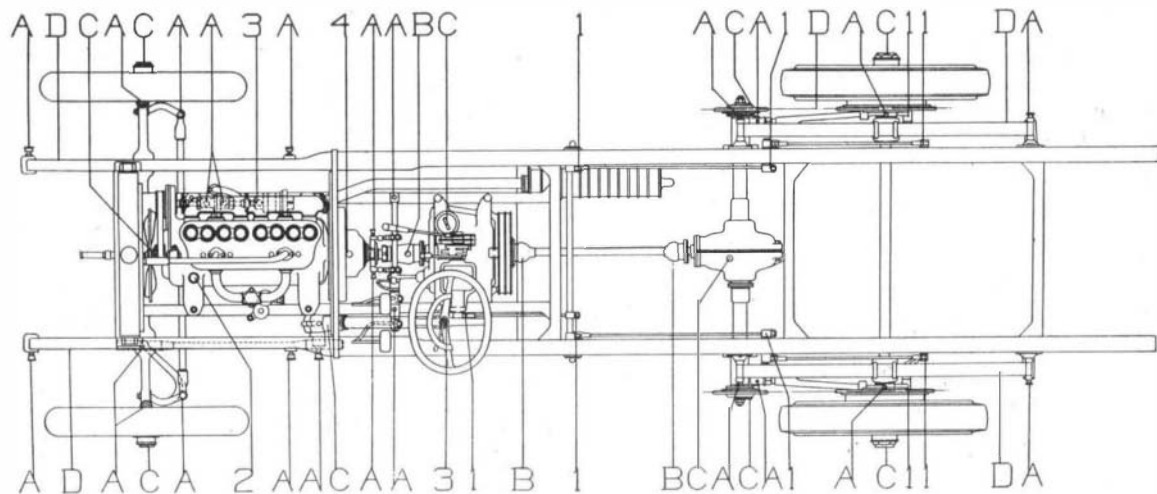


Fig. 14.—Suggested form for lubrication chart, letters designate parts to be supplied with grease at fixed intervals of time or distance traveled. Numerals designate parts to be supplied with oil.

lubricated most effectively by painting their surfaces with a heavy graphite grease. One application only will be necessary between annual overhauls; the improvement in the riding qualities of the car cannot fail to be appreciated.

Moving Parts Exposed to Dust.—Miscellaneous moving parts exposed to dust can best be lubricated by the application of a suitable grade of graphite grease.

CONCLUSION.

There is no valid reason why much greater economy and efficiency of lubrication cannot be attained in all automobile motors, by the simple application of a knowledge of cause and effect of oil destruction. Neither is there any insurmountable difficulty in the way of suppressing useless and costly leakage from all automobile mechanisms. Certainly the almost unbelievable drop in yearly maintenance costs and the total elimination of all lubrication annoyances should make the study and successful solution of this problem one of absorbing interest and profit to every manufacturer and to his customers. Intelligent co-operation between oil refiners and automobile manufacturers would surely do much along this line.

Measuring Growth of a State

First Enumeration Solely to Provide for Political Reapportionment.

THE census enumeration of New York State promises to be, next to that of the United States, the largest and most expensive single statistical enterprise in the country. In no other State are there so many people to be enumerated; while the fact that the number and complexity of the interrogatories will be more extensive this year and a completion within the short space of two months set by the Constitution is necessary, a large number of supervisors and enumerators, clerks, and interpreters will be required.

The task, in its simplest phase, involves the counting of upwards of the 11 millions of inhabitants now estimated to be in this State.

FIRST STATE CENSUS IN 1782.

Under the first State Constitution a census was taken in 1782, when the Sheriff was required to direct the local constables to take the number of white inhabitants, including refugees, victims of the invasion of the enemy, at the expense of the counties. These returns were to be summarized and filed with the Secretary of State, to be transmitted by him to Congress. A similar enumeration was taken again in 1786, but it was not until the third State census was taken, in 1795, that the law required the Secretary of State to prepare the blanks containing the questions covered by the enumeration. This State first inaugurated the decennial or periodical system of enumeration of the population and resources. In order not to conflict with the Federal system, the State Constitution provided that an enumeration could be taken in the years in which the unit figure five was present.

During the colonial period the provincial governors were required to give account of the progress of the settlements, and in New York colony at least fourteen different counts of population were taken before the Revolutionary War. Since the provision for periodic measurements of the State's growth was inaugurated by the framers of the first Constitution, many foreign countries, States and Territories have adopted similar systems, and at the present time the laws of at least two foreign countries require an enumeration of the population every five years.

BASIS OF POLITICAL REAPPORTIONMENT.

The first census enumeration in New York State was intended solely for political reapportionment. Consequently, the electoral census of 1782, 1786, 1790, 1795, 1801, 1807, 1814, and 1821, taken under the constitutional provision of 1777, limited the scope of such inquiries, in fact, the first three of these were for the counts of these electors distributed into four property classes. The census of 1914, however, was the first to depart from this rule of mere enumeration of the electors and to procure other social information. At that time over a dozen inquiries were added concerning property qualifications, age, sex, number of slaves, etc.

The census of 1821 required additional inquiries, including agricultural and manufacturing questions and other matters considered of relative importance at that time. In 1825 other questions were added to the census of that year, which was the first to be taken under the second Constitution of 1821. These inquiries concerned the enumeration of defective and dependent classes, such as the deaf, dumb, blind, insane, and paupers and since that time care has been taken to obtain information concerning physically and mentally defective classes. Another item included marriages, births, deaths, and in the next census of 1835 little change was made in the scope of this inquiry excepting that certain questions were added concerning the factory and manufacturing interests.

TRADE INQUIRIES INCREASE.

The census of 1845 introduced many inquiries concern-

ing trade, commerce, newspapers, and periodicals. It increased the number of questions relating to agricultural interests. The census of 1855 under the third Constitution of 1846 differed radically from all previous ones in that for the first time the Secretary of State was called upon to undertake the direction of all the work. In the previous enumerations the returns were tabulated by the local enumerators, who were required to report the totals to the county clerk, who in turn forwarded a summary to the Secretary of State's office.

The next two censuses were taken in 1865 and 1875, when the enumerators, acting in the places of the marshals, were called upon to count the population. These census-takers were allowed \$3 per day, to be paid by the county, and this was the last occasion in which the census was taken at the entire expense of the locality, although the State at that time contributed \$62,555, while at the census of 1875, the first to be undertaken by the State alone, the appropriation was doubled, totalling \$138,037. The census of '65 provided for a large number of inquiries concerning soldiers and sailors engaged in the Civil War. There was opposition against the enumeration because of the fear that such information would be used to draft soldiers. In 1885 and 1895 no census was taken, although in 1892 a mere count consisting of seven questions on population was made, when an appropriation of \$205,000 was allowed. Since the publication, however, of the last census taken in 1905, the importance of the subject has been more fully recognized, and the amount of attention paid to the census cannot be better shown than in the figures for the number of inquiries made since this last census.

The constitutional provision limiting the time during which census returns are to be made has frequently proved to be insufficient to complete the task, though it is expected that the coming enumeration can be completed within the months of May and June, as the Constitution requires. The system usually adopted in this country of extending the period of enumeration over one month has been termed the census *de jure* as compared with the English system, which is called the census *de facto* method, which latter system begins and completes the enumeration within one day after a previous distribution of the blanks to be filled out by each householder. Such a method, while reducing the number of errors caused by duplication to the minimum, could not be employed in this country, because many sections are thinly populated and difficult of access.

As stated, census enumerators originally were the local constables. Later the law provided for special takers, who were called "marshals," and appointed by the Secretary of State. At the present time these individuals are called supervisors and enumerators, and the law now provides that the Secretary of State shall appoint and prescribe their duties, and have direct control over their work. Circulars of instructions are provided, and all returns are to be tabulated and arranged according to the numbers of inhabitants, exclusive of aliens, and the number of aliens in each village, town, county, city, borough, and the ward of the State.

MACHINE TABULATION.

Tabulating to-day's population statistics within a reasonable length of time would be practically impossible were it not for the modern machine methods necessary for tabulating the different characteristics of the population for which inquiries are made and which must be presented in various combinations with one another. By the method now in vogue all the numerous facts appearing upon the schedules are transferred to the cards, each being represented by a punched hole, the significance of which is determined by its location on the cards, which are run rapidly through tabulating machines to register the data in a variety of combinations.

With this mechanical aid it is possible to complete the tabulation of all the data within the time specified by law. The Constitution in about one half of the States requires the enumeration of the population every ten years, but less than half of the States completed this work in 1905. The original returns of the enumerators during the past century were deposited in the State library, but unfortunately these were destroyed in the fire of 1911, although the summaries made from these returns are now on deposit in the office of the Secretary of State.—*N. Y. Post*.

Porous Boiler Settings

THE heavy brick setting of a steam boiler looks so solid and substantial that not only is the average user of steam deceived as to its ability to keep out air, but the expert, who should know better, has his attention easily diverted from a very important feature in successful boiler operation. To insure efficient and economical operation all air reaching a boiler furnace should be admitted at the proper place, and in the proper quantities, if economical combustion of the fuel is to be secured; and any additional air that finds its way into the furnace through casual entrances simply interferes with both the draught and

the proper combustion. It has come to be recognized that brick boiler settings are by no means airtight, but are actually decidedly porous; and this fact was recently visibly demonstrated at an electric power plant in the Middle West. Men were set at work painting a boiler setting with extra heavy stack paint, and before one side had been covered an improvement in the draught could be seen at the draught gage. When both sides had been painted the natural draught had increased by 0.15 inch.

That this point is so commonly overlooked is not surprising when we constantly see the ruinously cracked brickwork around boilers that is allowed to stand year after year without attention.

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