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Facts About The "Silent Knight" Motor

BY

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THE TOLEDO LEGAL NEWS CO.
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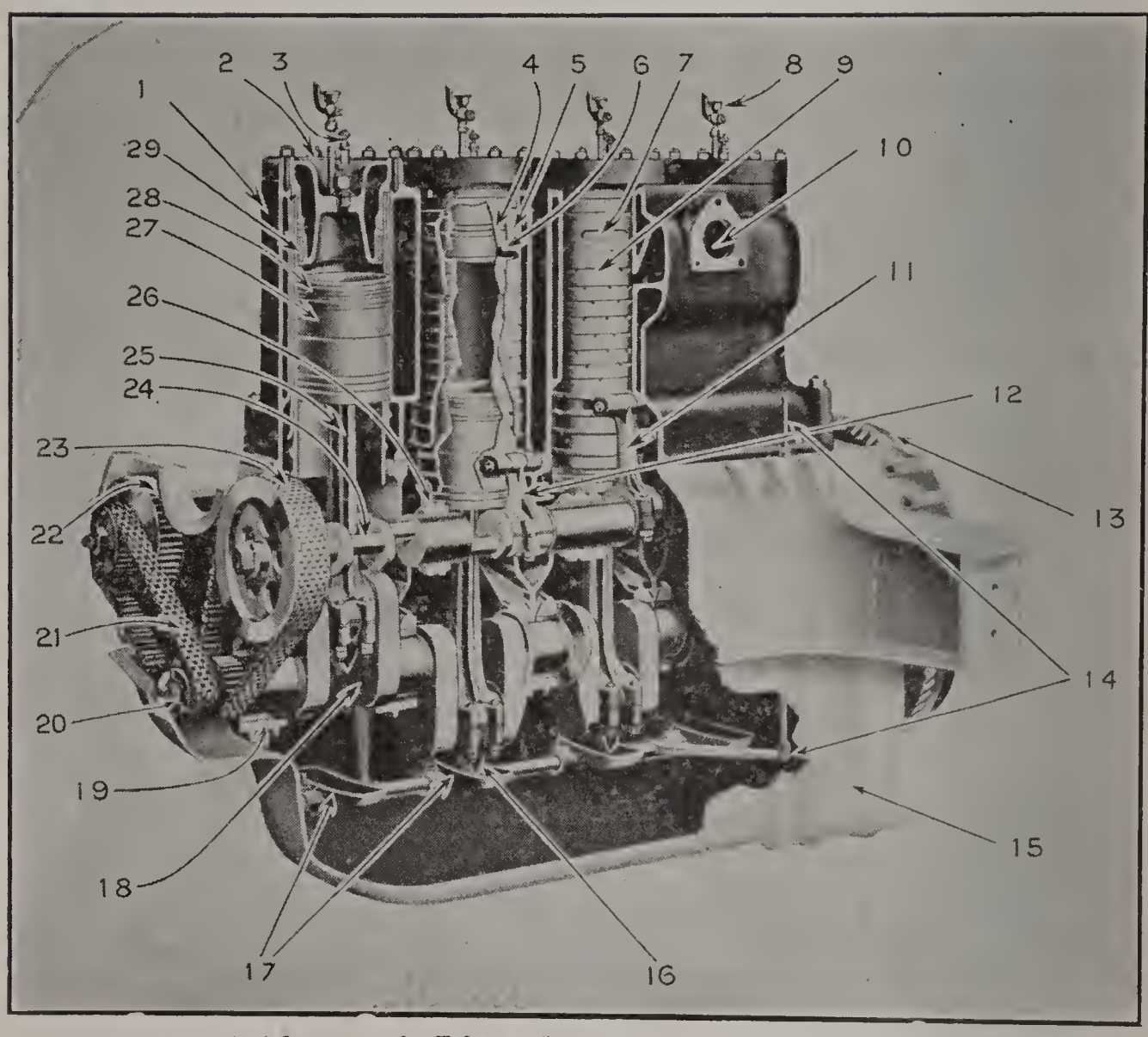
INTRODUCTION.

This edition in hand book form has been prepared for those interested in the operation of the Silent Knight Motor, showing the elements of construction and giving a detailed explanation of all its most important features. Every endeavor has been exerted to make the book comprehensive, while yet not unduly technical. It will serve as a reference as well as being instructive to those interested in the operation of this truly wonderful motor. It is not the intention of the writer to praise or belittle the makers or any type of engine but the claims set forth in this book are to more fully uphold my contention of the merits of this motor.



Sectional View of Silent-Knight Four-Cylinder Motor

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FACTS ABOUT
THE "SILENT KNIGHT" MOTOR.

By Eugene Ballou

IT is surprising at this late date in the development of The "Silent Knight" Motor, considering all that has been said in lecture, advertisement and demonstration, the number of people one finds in traveling about this country, and Europe as well, where the sleeve valve motor was first taken up and put on a commercial basis, that do not understand its simple construction and principles of operation.

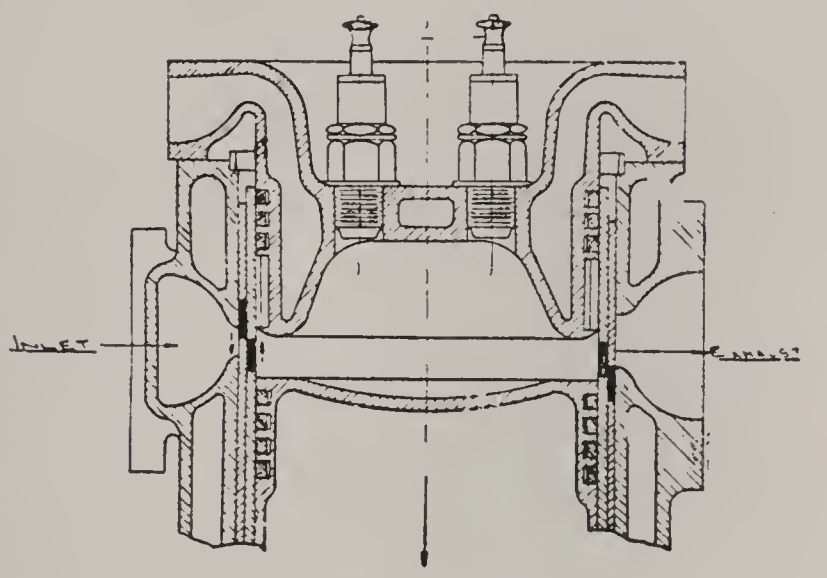
Therefore the object of this book is to set forth in clear, non-technical language a treatise that will be understood by the most unmechanical minded.

The invention of the silent sliding sleeve valve is undoubtedly the most wonderful stride in advance and improvement since the advent of the internal combustion engine. Owing to its simplicity and absence of small parts and its remarkable reliability under the severest tests, this motor has a very bright future. The facts and data herein compiled have been collected by myself, and I am very much indebted to Mr. C. Y. Knight, the inventor of the sleeve valve motor, The Daimler Motor Car Co. and The F. B. Stearns Co. for the privileges of making observations while at their plants. Through the courtesies of The Knight and Kilbourn Patents Co. I have been able to obtain much reliable and authentic data, records, and evidence to substantiate my arguments.

Mr. Knight realized the faults and short comings of the poppet valve type motor in the early days, namely, pitting of valves with the result of lost power and inefficiency, noisy operation, variation in spring tension and numerous other disadvantages which the old motor possesses. After many unsuccessful attempts to silence the tappets or commonly called valve jumpers, Mr. Knight began experiment along altogether different lines; that is, to depart from the beaten path and produce something altogether different, and the result was his first single sleeve engine, early in 1902. This led to the present type of efficient double sleeve motor. The advantage of having two sleeves is evident as when the ports open the sleeves are traveling in opposite directions and vice versa, so giving a very fast opening and closing, whereas with the single sleeve there would be but a single movement. The Silent Knight engine does not differ from other motors only in the valve mechanism. The different cycles of operation, of which there are four, namely, induction, compression, combustion and exhaust, take place in the same manner as any four cycle engine. The changes in the Knight which constitute the great improvement over existing types, are these silent, tremorless, sliding sleeves working away without care or attention. They make no noise, for they strike nothing. They merely slide up and down in perfect lubrication, and silently. Take in your hand two smooth pieces of metal, oil them well, then slide them one upon the other—this is the simple, noiseless, vibrationless, silent action of the sleeves in the Silent Knight engine.

Two concentric cylinders or sleeves encircle the piston and form the outer walls of a combustion cham-

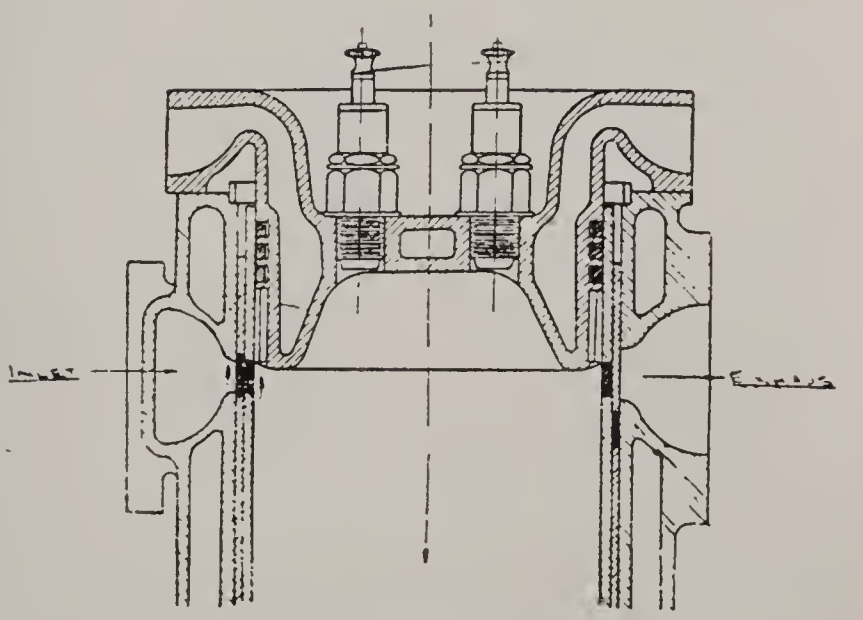
ber. These sleeves are operated from an eccentric shaft or in other words, a small crank shaft, by means of short connecting rods attached to the lower end of the sleeves. These sleeves are made from a good grade of grey iron, the same as that employed in cylinder casting.



(1) Inlet Opening.

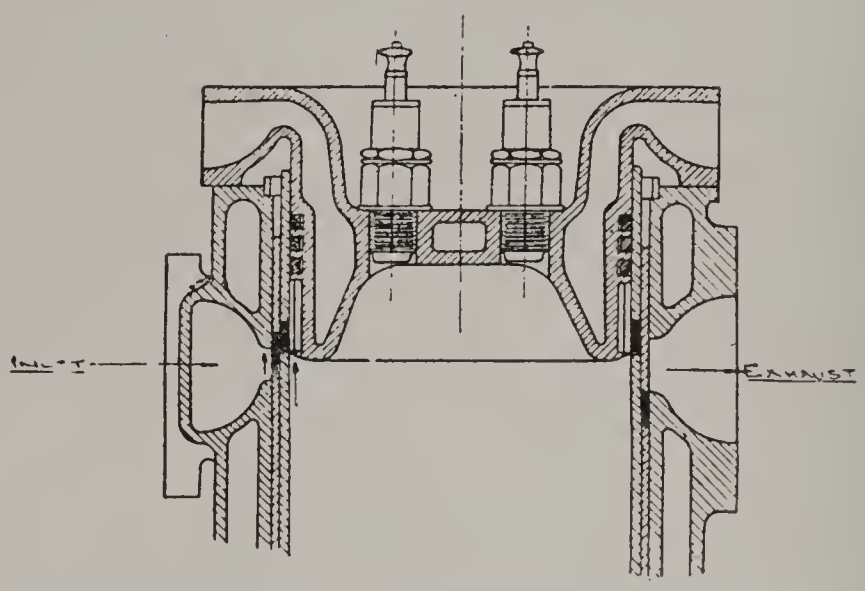
The Movements of the Sleeves.

It will be observed that the inner sleeve is moving upwards, and the outer sleeve downwards, and the two sleeve ports are rapidly coming into line with the inlet port of the cylinder. The piston is, of course, descending.



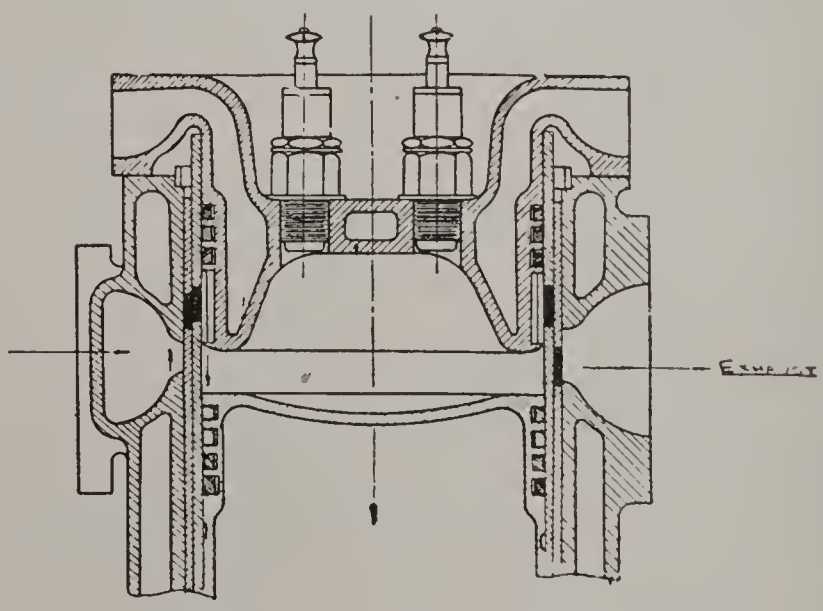
(2) Inlet Full Open.

The inlet ports in the sleeves have come fully into line with the cylinder port, and now there is a clear opening for the gas to be drawn in. The piston is halfway down on its stroke.



(3) Inlet Closing.

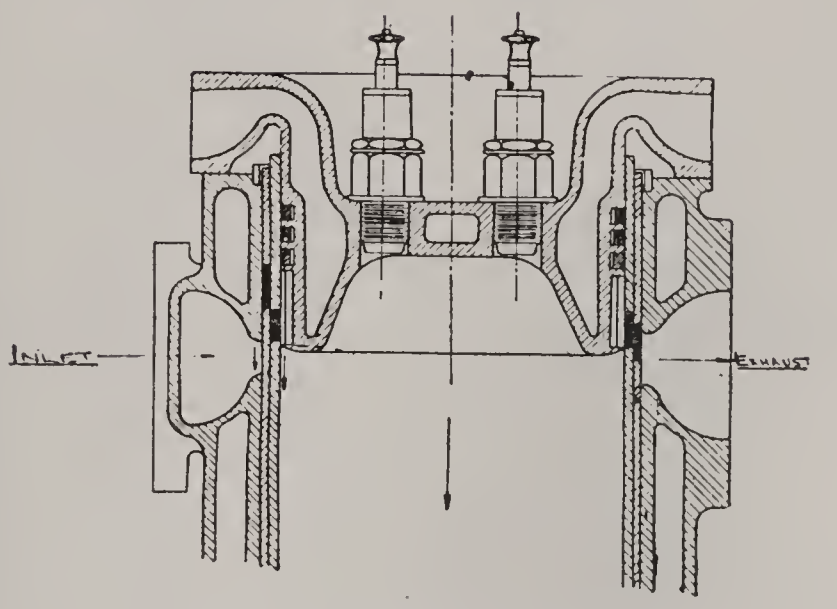
As the piston reaches the bottom of its travel and begins to return on its compression stroke, the sleeves have moved upwards so that the port in the inner sleeve is no longer in communication with the cylinder. The exhaust port is also closed, and therefore the gas is compressed by the rising of the piston.



(4) Explosion Point.

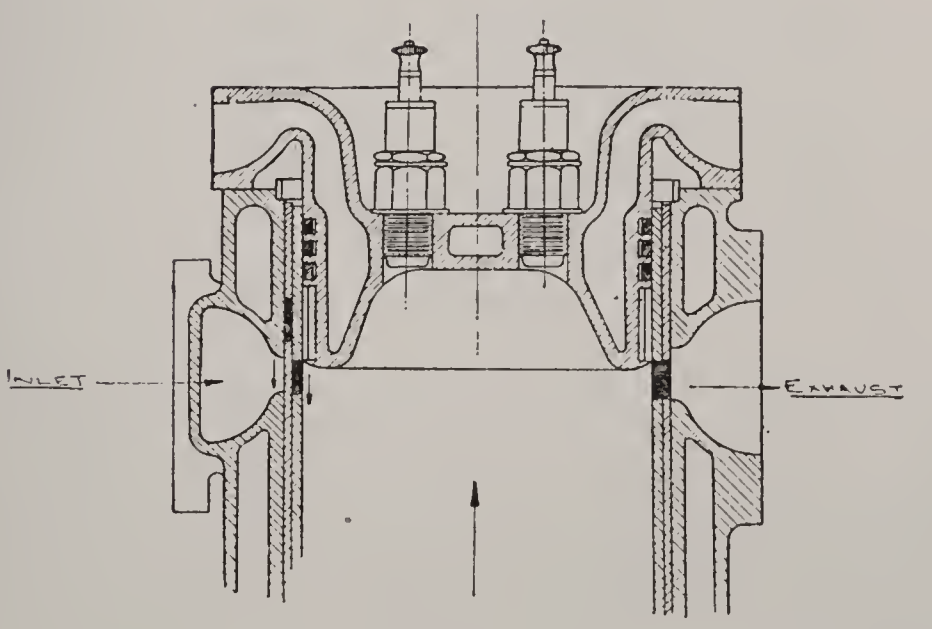
Both of the ports in the inner sleeve are securely sealed by the pressure of the broad junk ring situated

at the bottom of the cylinder head. In this way the explosion expends its full energy in driving the piston downward.



(5) Exhaust Opening.

When the piston has descended about three-quarters down on the power stroke, the downward movement of the sleeves brings the inner ports from behind the junk ring in the cylinder head, and as the exhaust port in the outer sleeve is already in line with the cylinder exhaust port, the waste gases can escape from the cylinder.



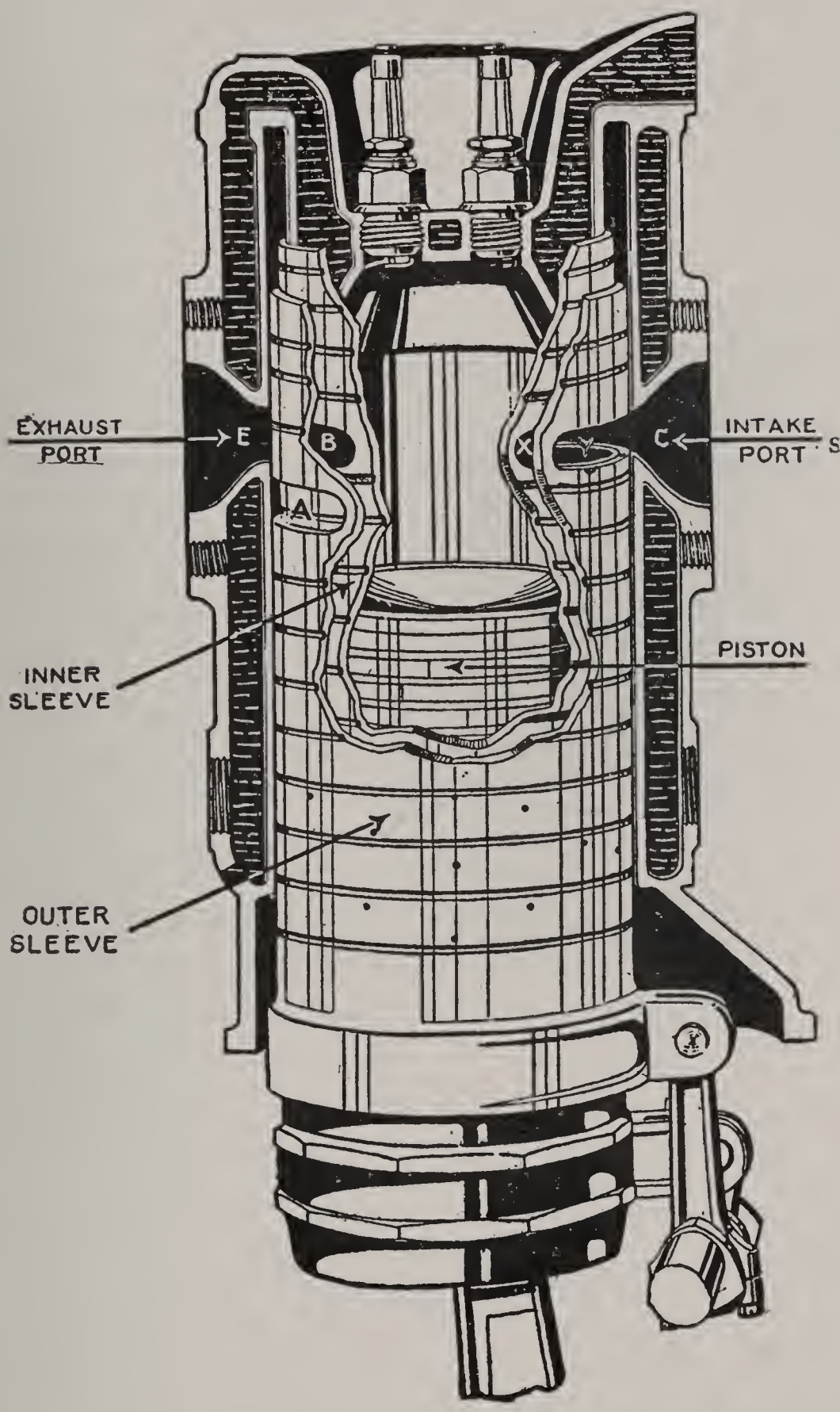
(6) Exhaust Full Open.

The exhaust ports in the sleeves soon come fully into line with the cylinder exhaust port, and before the piston begins to ascend on its exhaust stroke the major portion of the burnt gases has already escaped from the cylinder. When the piston reaches the top of the stroke, the outer sleeve has moved down so far that the exhaust port is closed and the inlet is again opened, as in figure 1.

The previous drawings give a fair idea of the operation of opening and closing the ports for the different functions.

These sleeves are machined to exactly the same thickness and ground inside and out. Slots are cut near the upper ends, and these form the ports for the gas passages. These slots or valve openings are larger than is possible with any other style of valve, so that greater power is attained through the induction of a fuller charge of gas, as also, through a more complete scavenging of the cylinder chamber after explosion.

You will note that the cylinder contains ports on each side which form a passage to the inlet and exhaust manifolds. In the bottom of the cylinder head is a large packing ring. This packing ring is of orthodox piston ring construction. except for its greater width; owing to this width it bridges the ports without catching on the edges. It has been named the junk ring and its use is most important as it seals the ports against leakage during explosion. Another nicety of this design is the detachable heads to the cylinders, consequently the combustion chamber can be machined and polished so there is no possibility of pre-ignition owing to carbon or small projections of metal. It is owing to this construction that it is pos-



Fitting the engine cylinder closely, one within the other, with a film of oil between, are these two sliding sleeves, and within the inner one slides the piston. Each sleeve has two slots in it, one on each side. When slit Y in the outer sleeve comes opposite slot X in the inner sleeve, and opposite the intake port C, a charge of gas is drawn into the cylinder. After the explosion has taken place, the sliding of the sleeves brings the slot B in the inner sleeve opposite slot A in the outer sleeve, and right opposite the exhaust port E, forcing the burnt gas out through the exhaust manifold.

sible to have every combustion chamber of exactly the same size, which contributes to smoother running. It is a well-known fact, conceded by engineers, that a motor with valves in the head develops more power than a T head that has its valves set in offset pockets at the side of the engine. It is possible to combine this ideal construction without the disadvantages of long push rods and the valves operating against high pressures and the fierce heat of combustion.

The gas enters the cylinder on the suction stroke, when the piston is going down, and the inlet slots in the inner sleeve are in register with the inlet slots in the outer sleeve; this always happens midway of the inlet port to the cylinder. On the return stroke of the piston, which is the compression stroke, both sleeves move up so that the inlet slots slide by the edge of the junk ring, thus sealing the port. The inner sleeve continues to go up and does not start down until the piston has started on the next, the explosion stroke.

Before the piston reaches the bottom of this stroke the exhaust slot in the inner sleeve begins to open, passing the edge of the junk ring (previous to this the outer sleeve has already moved down), thus allowing the gases to pass through its slot and escape into the exhaust port of the cylinder and out to the muffler. The piston on the return stroke continues to force the burnt gases out the exhaust port until the slot in the outer sleeve moves down past the port in the cylinder, thus cutting off this passage.

Just before this cut-off takes place, the slots on the opposite (the inlet) side have begun to open to start again over the four cycles just mentioned.

Please note that up to the time the exhaust gases are allowed to escape, both the inlet and the exhaust

slots of the inner sleeve are still up and sealed by the junk ring. This sealing of the cylinder chamber continues throughout the whole working stroke and prevents any gases from leaking out of the cylinder and thereby lessening the explosive pressure, which would mean loss of power.

The advantage of the Knight type of engine over the ordinary type is simplicity, economy, power and silence. There are fewer parts to this engine over the poppet type—I should say about one-third less. The parts are very easy to machine.

The Knight engine runs at a very high efficiency, as 20 per cent less heat is carried off by the water circulation. This 20 per cent, instead of being lost as wasteful heat, is utilized as useful energy. The combustion of the gas is directly over the piston, while the point of ignition is in the center of the compressed gas.

Another reason for the abnormal power developed by this motor is the fact that the walls of the sleeves which the piston travels upon are exactly the same thickness and do not distort or expand unequally with heat and let the explosive gases past the rings. As every one knows it is a physical impossibility to set a core so straight that a cylinder wall will be absolutely the same thickness from top to bottom without machining the outer diameter. As this is out of the question it must be left in that condition and naturally distorts unequally under heat. If this amounts to but a thousandth or two it is enough to permit the gases to blow by the rings with a consequent loss of power. As I said before this is all quite impossible with the Knight.

The Knight engine may not develop much more power than any other engine at low speeds, but at high speeds the Knight Motor is far in advance.

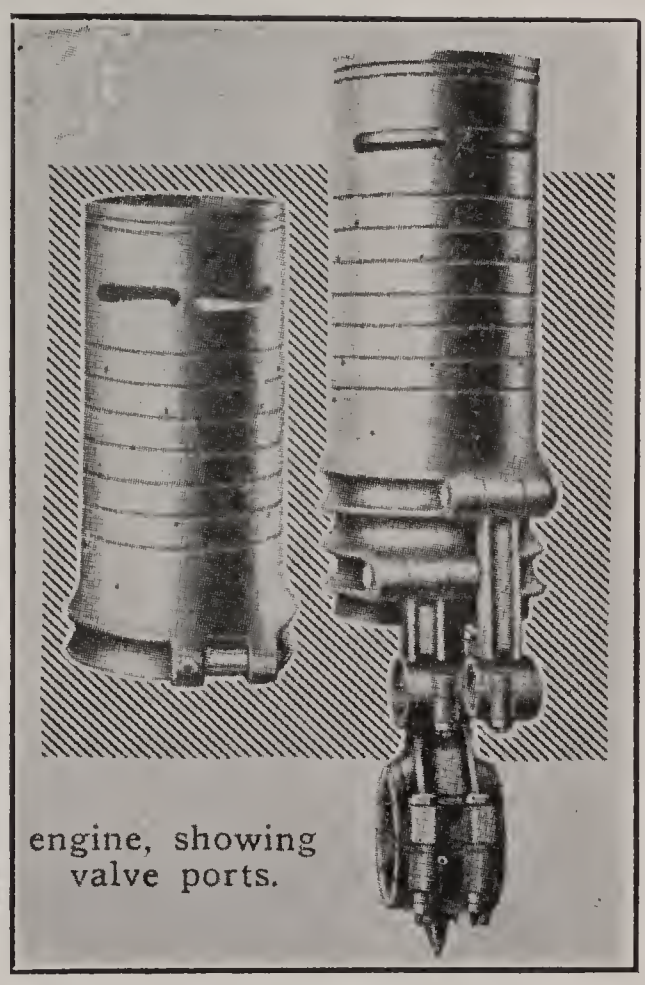
Silence is one of the inherent features in the Knight type motor without unduly muffling it. Since the advent of the sleeve motor, I dare say a thousand different types of valveless engines have been patented including the rotary valve, from which engineers hoped so much, but in every instance they were failures, for none of them showed the efficiency of the poppet, let alone an increase from 25 to 50% as in the case of the Knight. The poppet manufacturers have succeeded in silencing their motors by fitting cover plates over the valve stems and lighter springs, as well as altering the shape of the cams, so as to get a gradual opening. All this serves to quiet the motor at slow speeds, but at high speeds there is very little difference. All this tends to make a sluggish motor as the valves will naturally open slower with the altered cam profile and it has been proven beyond doubt that poppet valves do not always close at excessive speeds with heavy springs so what good are lighter ones?

Another feature which makes for added quietness is the use of silent chains for driving the eccentric shaft as well as magneto and pump instead of gearing. The pull being constant the use of the silent chain is permissible. The ordinary type of spur gear timing wheels could be used to even better advantage on a Knight than on a poppet valve engine where the pull is intermittent owing to the use of cams and high tension springs, but the humming of the gears would be very much out of place on a motor naturally so quiet. The noise on the Knight is confined to a few

rotating parts, such loose bearings, fan and magneto. At high speed the noise is no more noticeable. This is where the "silence" on the Knight scores.

When driving a Knight engined car, one gets the impression of being pulled along by some unseen force; the absence of noise at high speed is indeed pleasing. It happened to be my good fortune to drive two Knight engined cars a distance of nearly 25,000 miles over all conditions of roads and it was indeed a pleasure, this mileage being covered without the slightest trouble with the sleeves.

Piston sleeves of Stearns - Knight

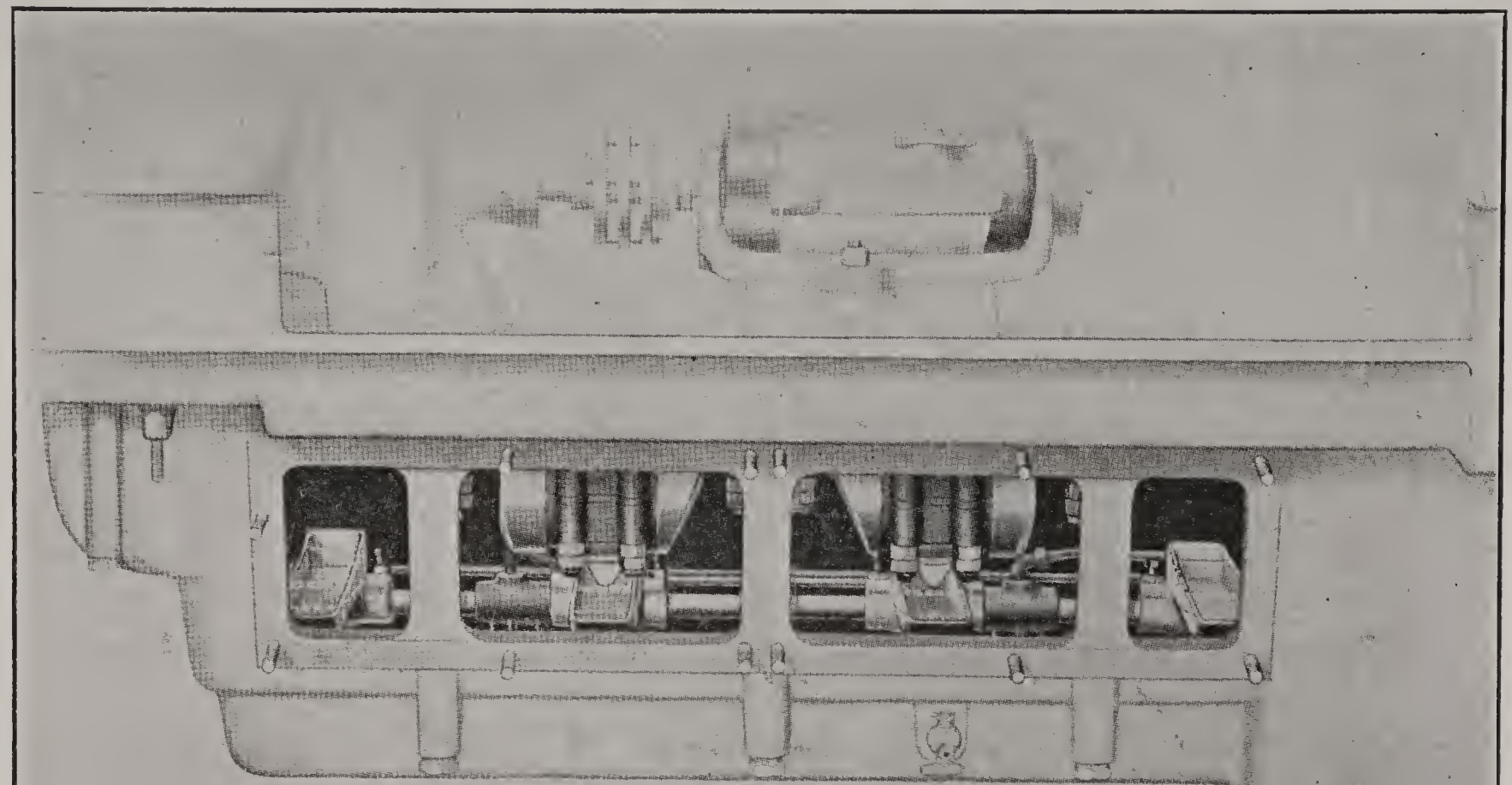


engine, showing valve ports.

LUBRICATION.

Do the Sleeves Properly Lubricate?

There has been enough said about the lubrication of this engine to fill a book of a thousand pages. Skeptical people and competitors have often said that the sleeves would sieze up, that it is impossible to lubricate them, that carbon finds its way between the sleeves and scores them, that the ports burn and a hundred and one other things that ought to happen to it. As a matter of fact nothing of the sort does happen. The truth of the matter is that the early Daimler engines smoked excessively—that would indicate too much oil—so they abandoned the direct oil leads to the tops of the sleeves, and the motors still had too much oil, so the level was lowered until the proper quantity was supplied. As it is impossible to fit baffel plates beneath the cylinders, the Knight motors run with a much lower oil level than most motors. The automatic splash system is used almost without exception. Oil is pumped into troughs which lie beneath the crank shaft, one under each connecting rod. Small scoops attached to the connecting rods dip into the oil and splash the oil to all parts of the motor. These troughs are connected to the throttle lever and when the engine is accelerated the troughs are raised, supplying more oil and less when throttle is closed. This is very simple and economical, the oiling varying not only with the power, but also with the speed of the engine. It has been known for engines of this type to average four and five hundred miles to a gallon of oil over a distance of 10,000 miles, the motor being 4⅞″ bore by 5⅛″ stroke. In one instance a 6-cylinder Knight motor, 4½ x 5½, was



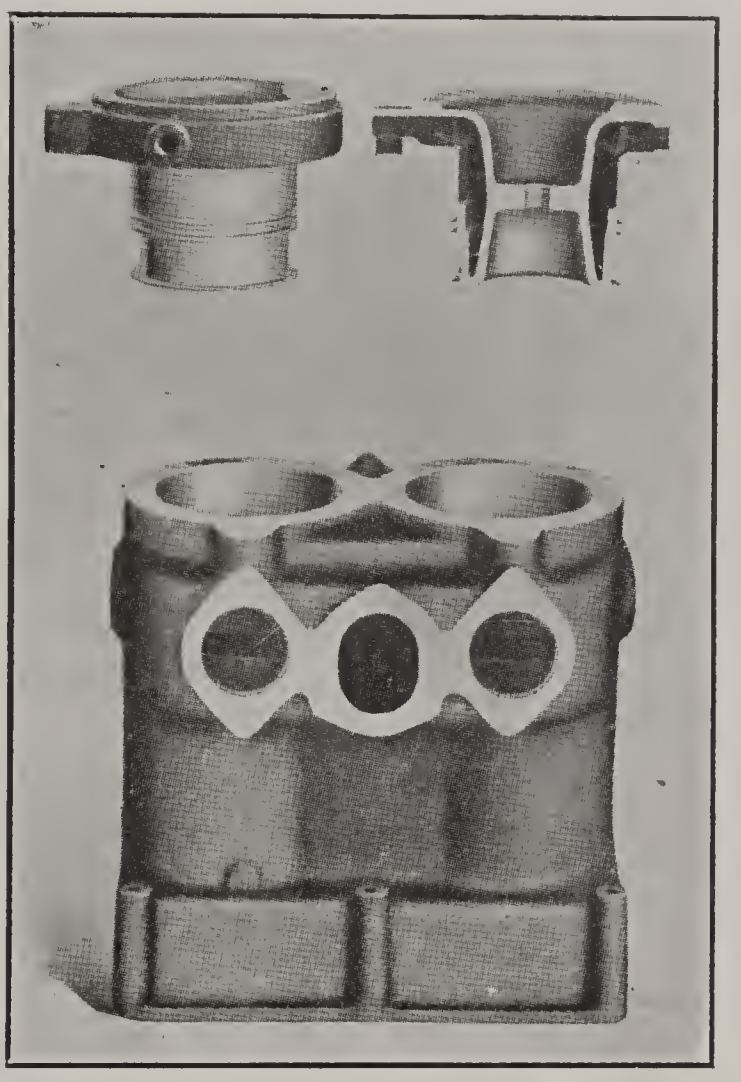
Oil Troughs in Bottom of Crank Case seen by Removing Inspection Plates

run idle 9½ hours at 2100 revolutions per minute, and with the motor still running at this speed the oil was drained off to see what would happen to the motor. The connecting rod bearings went first and threw some of the rods out through the crank case, but upon dismantling the motor the sleeves were found to be in perfect condition as far as lubrication was concerned, for owing to great surface and the many oil grooves it is possible to retain oil for a considerable period. On one occasion I saw a Knight engined car driven a mile and a half with no oil in the crank case.

If you will examine a sleeve of a Knight you will notice these oil grooves cut right around them, also that the piston has been drilled with small holes to return excessive oil to the base again.

The most difficult surface to lubricate is a sliding surface subjected to intense heat, combined with high pressure. Two flat surfaces working together strongly, and when conditions are such that the viscosity of the oil may be preserved to a reasonable extent, resist the squeezing of the oil from between them. But increase this pressure, heat the surfaces to a point where the oil thins up like water, and it soon finds its way to the outer edges as a result of the reciprocating movements essential to the functioning of the valve. In rotating surfaces, particularly when the rotating action is supplemented by the pumping action of the stopping and starting of the reciprocating parts, the oil which is squeezed out at one impulse through high pressure could be automatically replenished by the succeeding shock of the return movement of the reciprocating masses, such is the action present in the operation of the flat slide valve, and the tendency is wholly to squeeze the oil out. In the con-

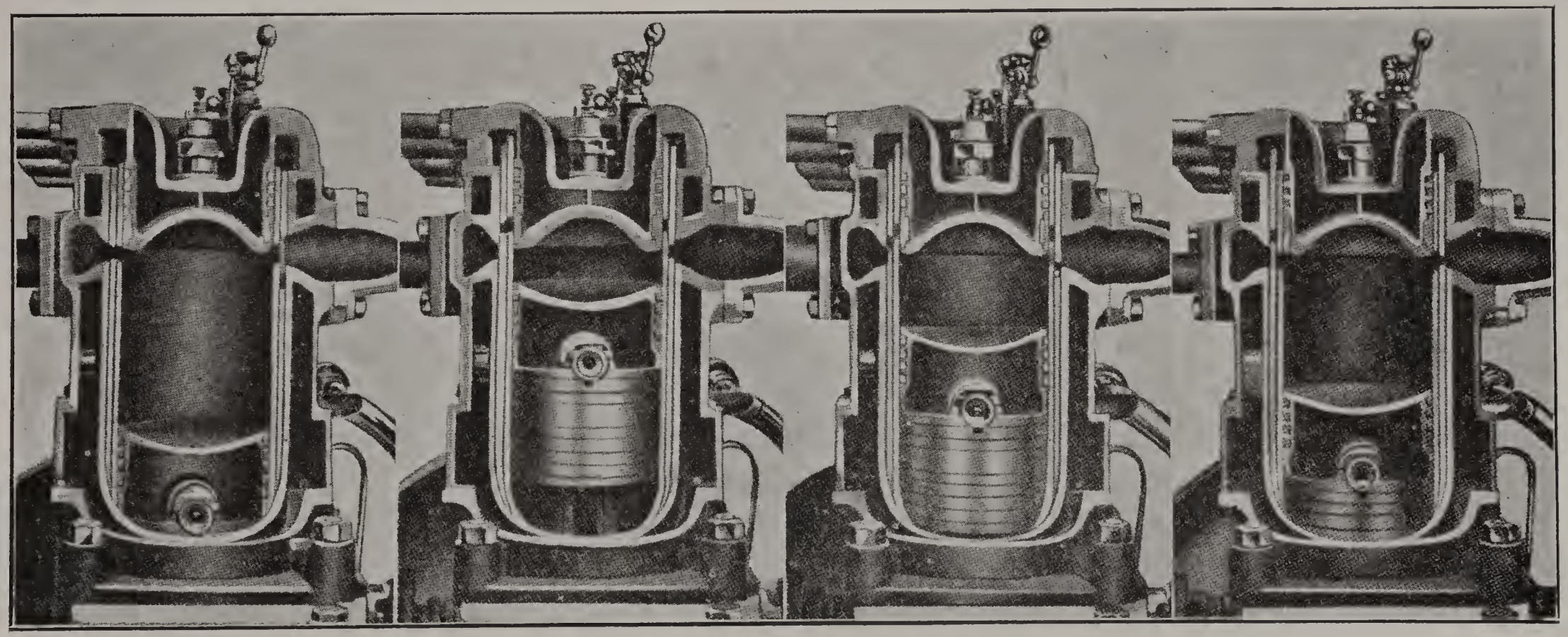
centric sleeve valve of the "Knight" motor, these conditions are almost wholly eliminated since the sleeve valve wholly encircles the piston and forms the side walls of the explosion chamber, these valve seats are not subjected to high pressures, as the explosions against the walls of the valve are entirely balanced.



Cylinder Casting, with Cylinder Head Sectioned, showing Top of Combustion Chamber.

The cylindrical walls, as a result of their form, are not in the least affected as to position by the explosion. In other words, were it possible one could put their fingers between the walls of the sleeves and suffer no ill effects from the explosion itself, the only side thrust or pressure at the firing point being caused by the angularity of the connecting rod. This pressure figures out at only 20 lbs. to the square inch.

ILLUSTRATIONS SHOWING POSITION OF PORTS DURING CYCLE OF OPERATIONS.



Induction. Compression. Firing. Exhaust.

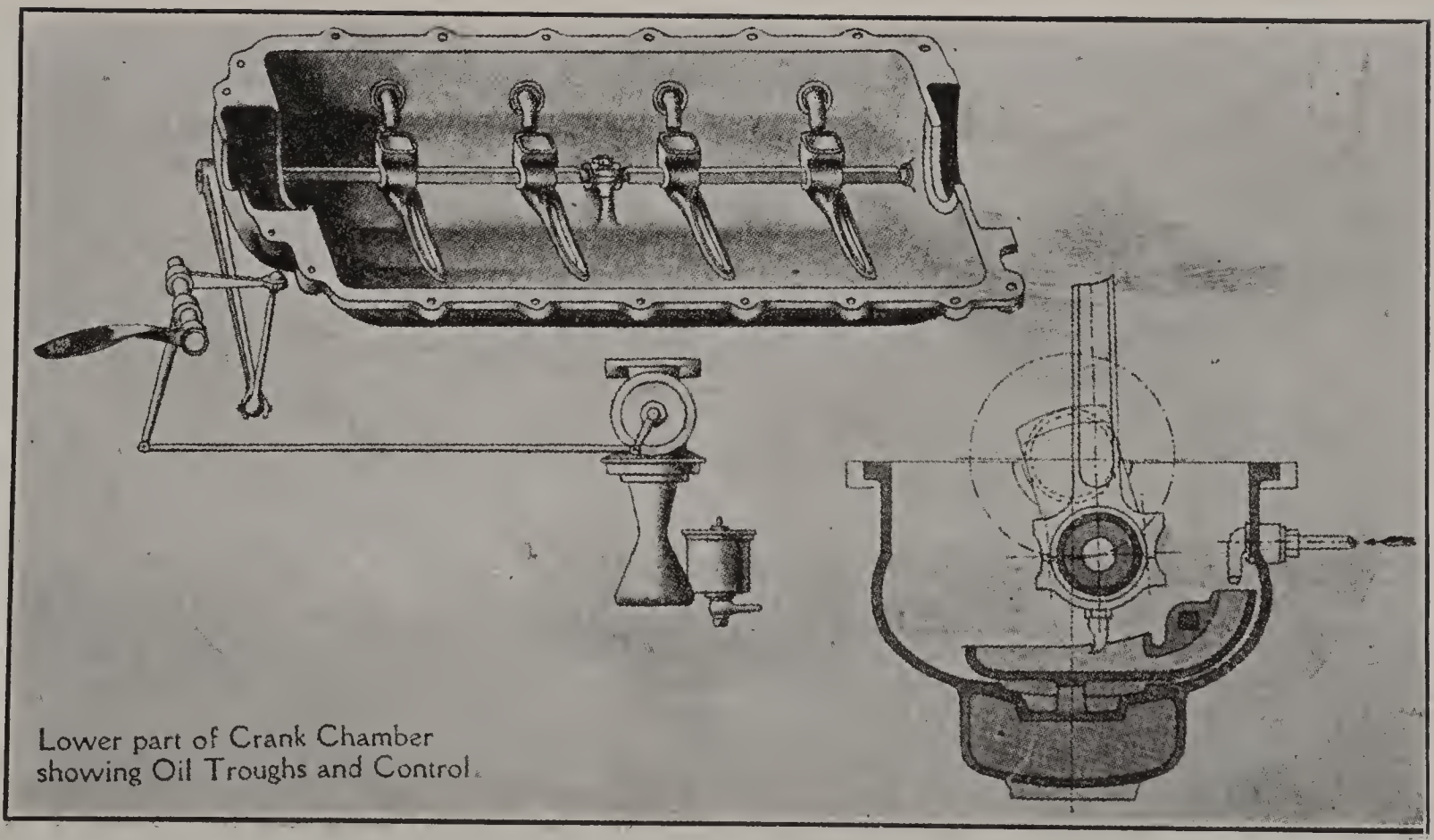
Another unfounded fault is that of criticising the operation of the sleeve from one side, some saying that it would not wear uniformly owing to the tipping action.

For illustration, draw an imaginary line from the point of operation to the opposite side at the top, and it will readily be seen that the angularity of operation is practically nil. At any rate the weight of the piston working inside and the long surface in contact with the stationary cylinder wall would be enough to correct the slight angularity.

Vacuum Distributes Oil.

There is always from four to seven pounds to the square inch of vacuum at the intake ports which extend nearly a third of the way around the cylinder. Any oil that clings to the base of the sleeves is exposed to this vacuum. Every time the intake ports open oil is gradually drawn up the sleeves and then distributed around the entire surface of the sleeve by the grooves and capillary attraction. That this suction is present and does draw the oil from the base between the sleeves and cylinder walls is most easily proven by placing a motor on a bench and running it for half an hour from power through a belt with a plate bolted over the induction port. It will be found upon removing the plate that the port will be full of oil. This proves conclusively that the motor is self-lubricating.

Mr. Knight said in one of his lectures: "If I had tried to invent an automatic lubricating system instead of a silent engine it would appear as if I had succeeded very well indeed."



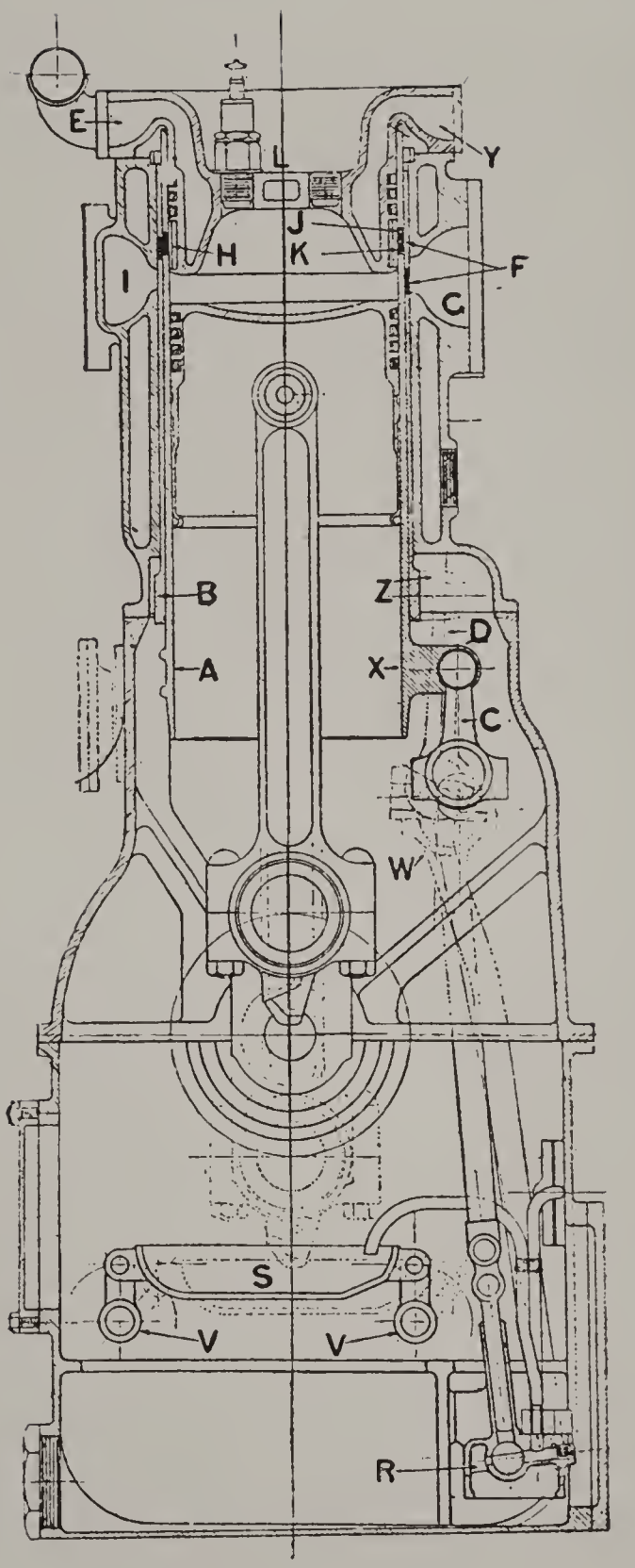
Lower part of Crank Chamber
showing Oil Troughs and Control.

SLEEVES MOVE WITH PISTON WHEN UNDER PRESSURE.

With regard to the operation of the sleeves I desire to call your attention to a most important feature of the motor. At the time the explosion occurs in the cylinder, both piston and the sleeves are at the top of the stroke. They start downward simultaneously and move together until the piston has reached the bottom of the stroke and the pressure in the cylinder has been practically reduced to atmospheric. Now, it will be seen that instead of the sleeve requiring power from the eccentric shaft to drive it downward, the friction of the piston against its walls would have done so had no other means been provided. During the explosion we have the maximum side thrust of the piston stroke.

While the piston returns, the sleeve continues downward, and the two elements are driven by their mechanism in opposite directions. But upon this stroke there is no lateral pressure upon the sleeve, because the piston is only dispelling the exhaust gases. Therefore there is no resistance to the travel of the sleeve.

When the piston reaches the top, the sleeves have reached the bottom of their stroke, and they start moving in opposite directions. But as this is the suction stroke, again there is no friction of consequence. There being no pressure upon the piston it now starts on the return stroke, the compression stroke, and the sleeve continues upward. Here there is the lateral pressure of the piston which meets the resistance of the compression gases, and the sleeves are again under pressure. But here again the friction side pressure aids them in their upward movement.



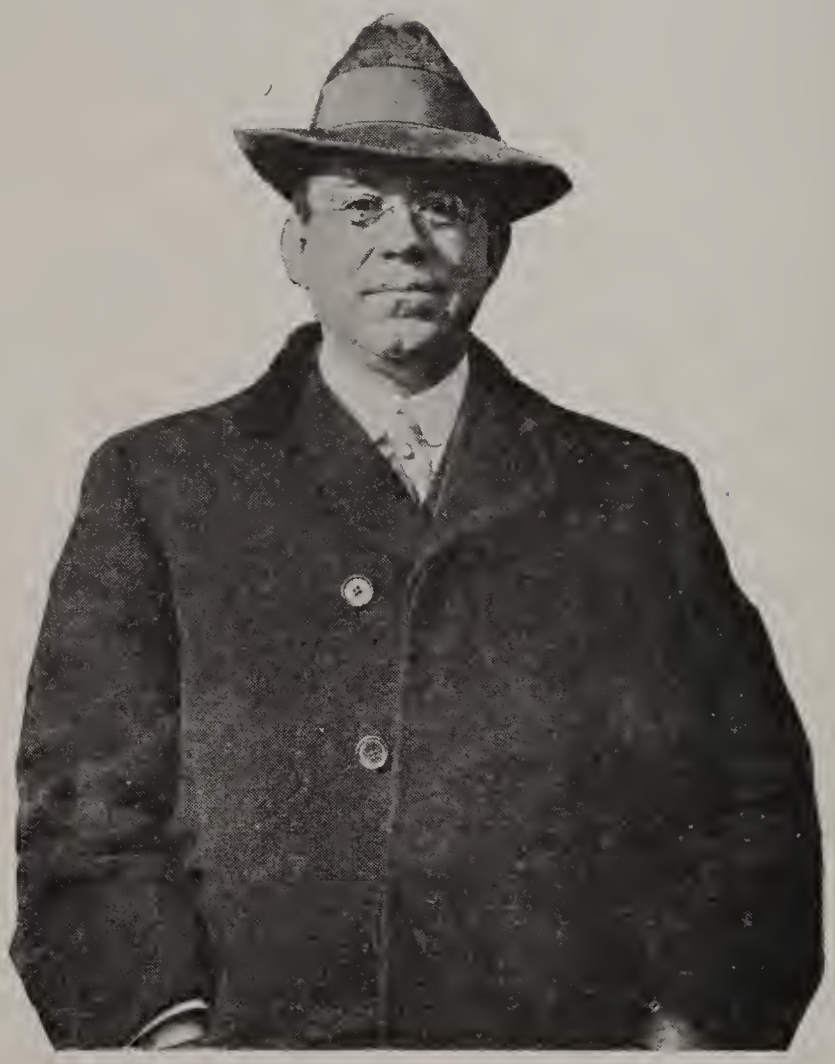
Sectional View of Daimler Engine.

This sectional view of the motor will show the easy method of retiming the sleeves in relation to the piston. First, for illustration, take number one cylinder and turn the piston to the top dead center with the crank up as in cut. Then take hold of eccentric shaft gear and turn same until the inner sleeve reaches its highest point of travel at top dead center, as in cut. Then put on silent chain and the motor will be properly timed. These sleeves, or valves as they might be called, require no attention or adjustment whatever once they are properly timed when the engine is assembled.

BURNING OF THE PORTS.

One of the first false impressions under which a great many labored was the burning of the ports in the sleeve valve. It might suffice to state that they do not, but inasmuch as the cause of their immunity from damage from heat is easily explained, I shall dwell to some extent upon this feature.

The ports in the sleeves are sealed by overlapping of their opening with the junk ring. Underneath the junk ring there is placed a second, or spring ring for the purpose of insuring perfect contact with the interior of the inner sleeve. Both rings are split like a piston ring. Above them are two or three ordinary piston rings to guard against leakage of gas that might pass the junk ring. These rings are all set in the water cooled detachable head that extends down into the cylinder. The water reaches within a fraction of an inch of the bottom of the inside of the head. The cylinder surrounding the sleeves and head is also waterjacketed so that the sleeves reciprocate between water cooled walls, and the sleeves, junk ring and slots are cooled upon both sides. At the time



Mr. C. Y. Knight.

of the explosion the slots of the inner sleeve are central with the junk ring. Hence, from the time of the greatest heat until the temperature in the explosion chamber is reduced to at least half, the slots through which the exhaust gases pass are not exposed to heat at all. Therefore, their lips and surfaces are not only immune from the fierce heat of combustion, but the entire section of the sleeve carrying them is pushed up after every explosion and rubbed against the water cooled surfaces, thus serving to prevent the accumulation of heat at this important point. None of the valve mechanism is ever brought in contact with the heat, as are poppet valves, whose heads are always subjected to the highest temperature generated in the explosion chamber, and which heat reaches almost the melting point of steel.

With regard to the wear of the sleeves. The sleeves present an enormous surface for taking the bearing pressures. This pressure amounts to 20 pounds per square inch, against the piston pressure of 80 pounds or more per square inch.

For instance, take a motor with a stroke of 5½ in. and the travel of the piston at crank shaft speed based on a thousand revolutions a minute will travel approximately 916 ft. per minute. Now take the sleeves with a stroke of 1⅛ inches, and traveling half the speed of the crank shaft, based on a thousand revolutions of the crank shaft per minute, will travel 93 ft. or nearly a tenth as far and as fast.

A foreign taxicab company noted the wear between piston and cylinder on 50 of their cars and the average was five-thousandths of an inch for 50,000 miles. Now then by dividing five-thousandths by ten, which will give the wear on the sleeves, it will readily

be seen that the wear in 50,000 miles is practically nothing as after a few hundred miles they take on a glass-like finish. Several instances have occurred where sleeves have been run in a motor for 100,000 miles with no evidences of wear after the first few hundred miles. As I said before, after the fitted surfaces have become smooth the interior of the inner sleeve where the rings and piston works, of course, will show wear just the same as the stationary wall of a poppet valve cylinder. By fitting a new inner sleeve it eliminates the necessity of regrinding the old cylinder and fitting new pistons and rings. The power absorbed in driving a set of sleeves in a six-cylinder of 4½ x 5½ was found to be only two horse power when the engine was developing 75 horse power.

Compare this absorption of power with that required to operate poppet valves. The springs necessary to seat the poppet valves of a motor developing power equivalent to that given off from a 4⅞ x 5½ sleeve valve type, require at least 100 pounds tension. Not only this, but on the exhaust side the cam shaft is compelled to lift against an explosion pressure which amounts to at least 150 pounds upon the valve head at the end of the firing stroke, when the pressure of the explosion is somewhere about 50 pounds to the inch at the time the exhaust valve should open. Thus we will see that fully 250 pounds pressure is required to lift the exhaust and 150 to raise the intake valves, at every second revolution, in the case of poppet valves.

In the Knight engine the inertia of the inner sleeve, when the motor is turning 1,200 revolutions per minute is something like 60 pounds while that of the outer sleeve is less than 50. Taking the inner

sleeve as the one subject to the greatest stresses because of its greater weight, there is 96 pounds of weight to raise; 90 pounds of friction to overcome at one point only; 60 pounds of inertia to counteract at the outer and inner ends of the stroke; a total of only 150 pounds as against 250, in the case of the poppet valve.

COOLING.

Will the motor cool? is another question often asked, and might be answered by repeating the fact that over 26,500 of these motors are now in the hands of the general public, doing the most drastic service in cars operating upon European roads with stretches hundreds of miles in extent where unrestricted speed is possible, as well as on American roads where road conditions are much worse. Not only this, but official tests are available which will leave no doubt in the mind of the disinterested seeker of the truth as to the perfect cooling of this type. Complete water jacketing encircles the cylinders, cylinder heads, circulation areas enclosing the spark plugs, and also the gas ways, so that a uniform heat is maintained the entire length of the piston travel The water passages are all large, and the piping simple. Those eager to criticize the construction raise the point that between piston and water cooled cylinder wall of this motor there are three films of oil as against one in the poppet type, and that oil, even in these very films, is a most inefficient conductor of heat. Here again exist peculiar conditions of which he has not taken account.

Were it a fact that these sleeves while under heat remain stationary, I would concede the correctness

of the theory. What do you do with a quantity of liquid in a vessel when you desire to drive the heat from it? Naturally you stir it in order that each particle shall gradually be brought into contact with either the open air or against the sides of the walls which are so exposed. A vessel of hot fat left undisturbed will congeal at the edges of the vessel and remain liquid at the center. So with the oil films between the sleeves. If they are left undisturbed they will retain their heat to a greater or less extent. But if the patricles are rolled and tumbled about, by being rubbed between the sleeve surfaces, there is no chance for any heat remaining away from contact with the metal slides. Each reciprocation changes the position of these heat particles and serves to remove them from local heat spots which otherwise might cause a section of the surface to become too hot for proper lubrication. The average person may readily understand that the transfer of heat from one surface to another is tremendously facilitated by rubbing them together.

But, if the Knight motor possessed only one feature in which it differed from all other motors it would forever be famous. This one feature is its valve timing, which is positive and mechanical. It cannot be deranged by ignorance, neglect, or wear. In fact, the valve timing in the Knight motor can never become deranged because there is a definite opening and closing of the intake and exhaust ports no matter at what motor speeds the car may be operating. Two years ago one of the leading American engineers experimented with poppet valves and discovered that frequently at the high speeds the exhaust valves did not seat, there not being sufficient time because of the

inability of the valve spring to close the valve in the interval before a cam returned to open it again. With such a condition it is certain that the most powerful mixture was not obtained. Said the engineer: "It is a well-known fact that with poppet valves the tension of the springs on the exhaust side varies after five or six weeks' use and consequently the accuracy of opening and closing is interfered with. In fact it has been proven that they do not close at all at certain speeds. Carbon gets on the valve seating and also prevents proper closing of the valve, with the result that the compression is interfered with and the face of the valve injured."

With the sliding sleeve valve as on the Knight such failure of operation cannot be, because no matter how fast the motor is operating there is a definite opening and closing for both intake and exhaust valves. With the positively-operating valves it is a fact that they will not operate unless they are right, and when they are right they go on indefinitely without trouble, and in fact go better after a certain amount of usage, and these motors gain instead of losing power as numerous tests have shown. This is a feature to be greatly appreciated by operators or owners. The four-cylinder Knight engine with its few parts and balancing features is able to hold its own against the best six-cylinder poppet valve engine. Its smooth running and soft pull on the car, together with its rapid acceleration with the throttle open, make an ideal motive power. Of course, this ideal is enhanced in its application to a six-cylinder engine.

Numerous tests have been made for power on the Knight engine, the most interesting of these are

those of long duration. Some engines have run continuously 400 hours developing their maximum horse power and maintaining it throughout the whole run. This is a feat practically impossible for a poppet engine to duplicate.

The tests made by the Royal Automobile Club of Great Britain on the Knight engines some time ago are well known, and the fact that the challenge they made to poppet valve manufacturers for the duplication of this test was never taken up, proves that the test was rather difficult.

The Panhard people of France, before taking out a license for this type of engine made tests of the Knight engine in their laboratories. They not only ran the engine 150 hours continuously at maximum horse power, but ran the test 400 hours. Their entire testing of these motors extended continuously over a period of 15 months. They must have been satisfied with the performance of this engine or they would not have placed the cars on the market.

The Mercedes concern in Germany made similar tests, the results of which were never given out, but inasmuch as they are now marketing the Mercedes cars with the Knight engine, it must be taken for granted that the tests were satisfactory.

When the Daimler Company first allowed a Knight motor to be installed in their factory, to observe its performances, they ran it continually every day for six months. They made no comment, but simply kept it under the daily eye of their entire engineering force. At the end of six months, they said "they were interested." But, before they would express themselves further as to their opinion of this motor, they wanted to construct a half dozen motors

and subject them to the same severe six months' testing that this one motor had received. At the end of three months, however, the performances of these motors were so marked, that the Daimler people were ready to conclude their arrangements with Mr. Knight.

Mr. Knight's experience with the Panhard Company was even more exasperating, after what his motors had actually accomplished for the Daimler Company. The Panhard people ran one of these Knight motors for 15 months. Every day for 400 days, this motor was submitted to continual testing. They tried to kill it in every way possible. When they found that it withstood all the rough treatment they had given it, they told Mr. Knight they wanted it.

I have endeavored here to make clear the reasons why the sleeve valve type of motor has proven a practical success. I take it for granted that every one fully appreciates the advantages of an explosion chamber free from pockets or vestibules, the merit of liberal and direct and unobstructed port openings, the absence of unenclosed working parts and the advantage of a valve system which compels the positive opening and closing of ports which cannot get out of synchronism, and also of the general cleanliness and symmetry of design possible with this construction, as well as the absence of any surfaces except the piston against which the explosion can act. In every automobile factory where experiments on the Knight were conducted, the engineers making the tests, have always stated that the Knight engine does show results and, in the words of a well-known American automobile engineer, "The sliding sleeve valve engine has made good." In viewing this motor from every

angle and analyzing it thoroughly, then comparing it point for point, it would be impossible to arrive at any other conclusion.

The accessibility of this motor should appeal to every one interested from an economical point of

THE TRIUMPH OF THE SLEEVE VALVE.

"Poppet" Acknowledges the Superiority of the Sleeve.

view, both in time and labor to make an overhaul. For instance, on all cars it is advisable to clean the deposit of burnt oil out of the cylinders at regular intervals. To do this, it is usually necessary to have the engine completely dismantled before the cylinders can be removed.

The method of fitting detachable cylinder heads renders the operation much more simple. After disconnecting the sparking plug wires, loosen the nuts which connect the water pipes on each side of the cylinder head, and remove the six nuts which hold the head down on the cylinder. The head will then be quite free and may be lifted straight off. If, however, the head is tight in place, it is convenient to leave a couple of the holding down nuts loosely on their studs and then to turn the starting handle gently. When the piston rises on the compression stroke the pressure will move the head off its seat, so that it will be quite free when the nuts have been removed.

When replacing the detachable heads after they have been removed for any reason care must be taken to properly enter the junk ring and the rings above it by forcing the split ends of the rings together into their grooves, just the same as replacing a piston in a cylinder.

This operation is quite simple and requires a fraction of the time necessary on a poppet valve motor with the necessity of valve grinding, lifting heavy cylinder castings and dismantling everything, spoiling gaskets and disturbing the different piping and connections. No matter what in theory may be against the Knight principle, everything works out admirably in practice.

The last 500 mile race at Indianapolis where a Knight engined car finished fifth is wonderful evidence of its staying qualities and sleeve valve regularity. The motor in question was of 25 H. P. with a bore and stroke of 3 15/16 x 5⅛ inches and was capable of a speed of 85 miles per hour and made an average of 70 miles per hour for the entire 500 miles

without replenishing cooling water and the temperature was 86° in the shade, this little motor defeating 20 cars nearly all of greater horse power. It was the smallest car in the race and had been driven 9,000 miles as a touring car and was borrowed from the owner for the race.

The regularity of its running may be gathered from the fact that the difference in the average of each hundred miles for 300 miles being only a few seconds. While on the subject of reliability I might state that the London General Omnibus Co., which has 2600 motor omnibuses on the London streets, has been so thoroughly satisfied with the service given by 300 Knight engined buses which have been running for twelve months past that they have decided to replace gradually all the poppet engines in their 2600 buses with Knight engines. The buses in question are greatly favored by the public on account of their silence and smooth-running qualities, while the great power of acceleration enables the driver to pick his way through traffic to very best advantage, with the result that the Knight motor has now been selected as standard for future work. In view of the fact that the daily run of a London bus is 110 miles of very strenuous work, it must be admitted that the success achieved here is very notable indeed.

The American Auto Club recently completed a test of a well-known poppet valve engine which recalls and causes to stand out conspicuously in point of reliability and superior performance the test of four years ago of the Knight motor, officially observed by the Royal Auto Club of Great Britain. All of these important evidences and many more which I might enumerate go to show to what state of per-

fection and power this wonderful invention has been brought. However, it has never been seriously put forward by any responsible authority that the sleeve valve motor is capable of greater power or speed than **any** poppet valve motor of **whatever** design or **type.** The poppet valve motor may be, and is generally, built to suit the occasion. If great power and high speeds are desired, high compression, large valves, strong springs, and precipitous cams are employed. This high power and great speed produce an uncontrollable, noisy and unreliable motor. The large valves and their seats are very susceptible to warping; because of their large area and the increased heat of high compression they do not cool properly, and the strong springs necessary to seat them at high speeds soon weaken or actually pound the head of the valve out of shape. This spring action, seating with a force sometimes as great as 300 lbs. pressure, has the same effect when the valve is red-hot (as it becomes under hard work) as pounding the head in the center with a hammer, as the large head "gives" in the center where the spring is pulling through the stem, the clearance between valve tappet and cam decreases, the timing undergoes change, and adjustment is necessary to bring back the decreased power. To remedy this defect racing motors are often built with two exhaust valves to the cylinders, so they can be kept small and cool.

In order to produce a quiet, reliable poppet valve motor, low compression, small valves, weak springs, and a gradual opening cam are necessary on account of the difficulties enumerated above. With small valves and weak springs go decreased efficiency, both in the matter of power and fuel consumption. The

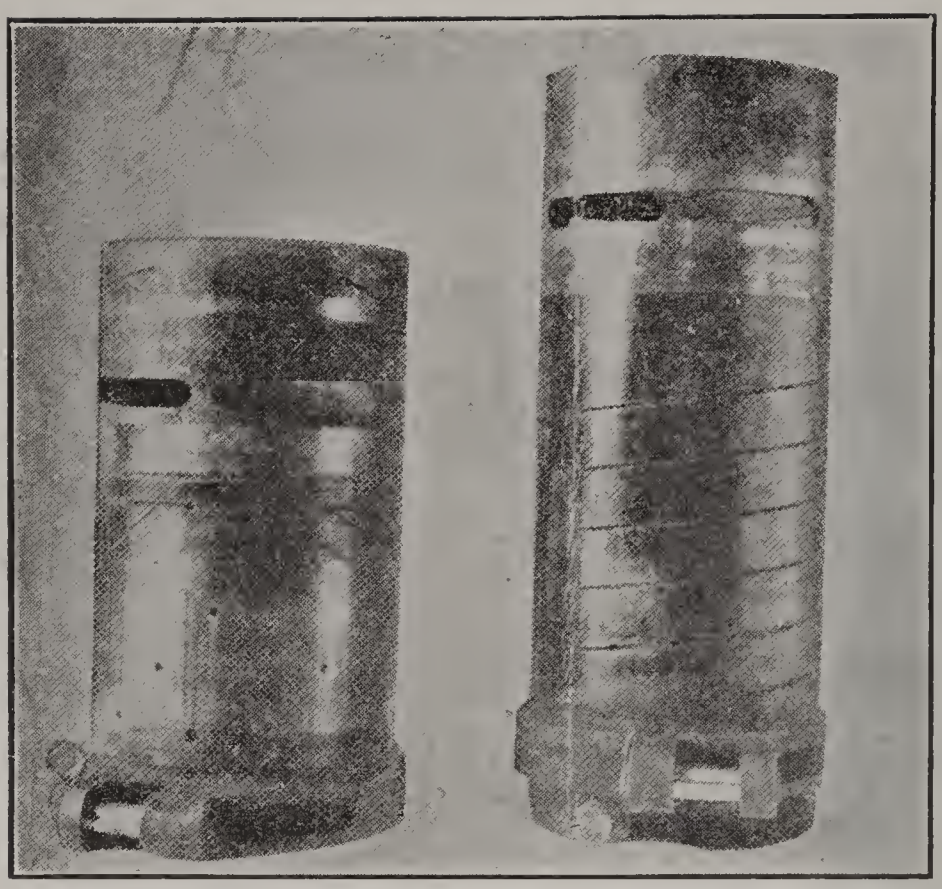
small valves do not admit sufficient gas to generate high pressures behind the piston, and the weak springs will not properly seat the valves at high speeds, but cause them to lag and foul the mixture by permitting the piston to draw back into the cylinder exhaust gases through the exhaust ports when the spring fails to close this port at the proper time. The powerful poppet valve motor requires a cam capable of opening the valves suddenly and wide, and the very nature of this operation prohibits quietness, because the opening must be more or less in shape of a hammer blow. Also poppet valves of large area require much more power to lift against the exhaust pressure at the end of the power stroke, the weight required to be lifted by the cam increasing in proportion to the area of the valve head exposed to the gas pressures in the explosion chamber.

When a poppet valve advocate talks power and efficiency his argument is invariably based upon that type of motor which is noisy and unreliable. When he talks smooth running and reliability, he seeks his evidence from the type of motor with small valves, weak springs, inefficient cam contour, and low compression, and the inexpert, knowing nothing of these differences, but believing one poppet valve motor to be the same as another, is deceived by race track performances of special engines into believing that he has its efficiency in the quieter type especially designed for quietness and smooth running for touring cars. The superiority of the sleeve engine over the poppet type lies in the fact that the efficiency and durability of the sleeve system is not affected by high pressures.

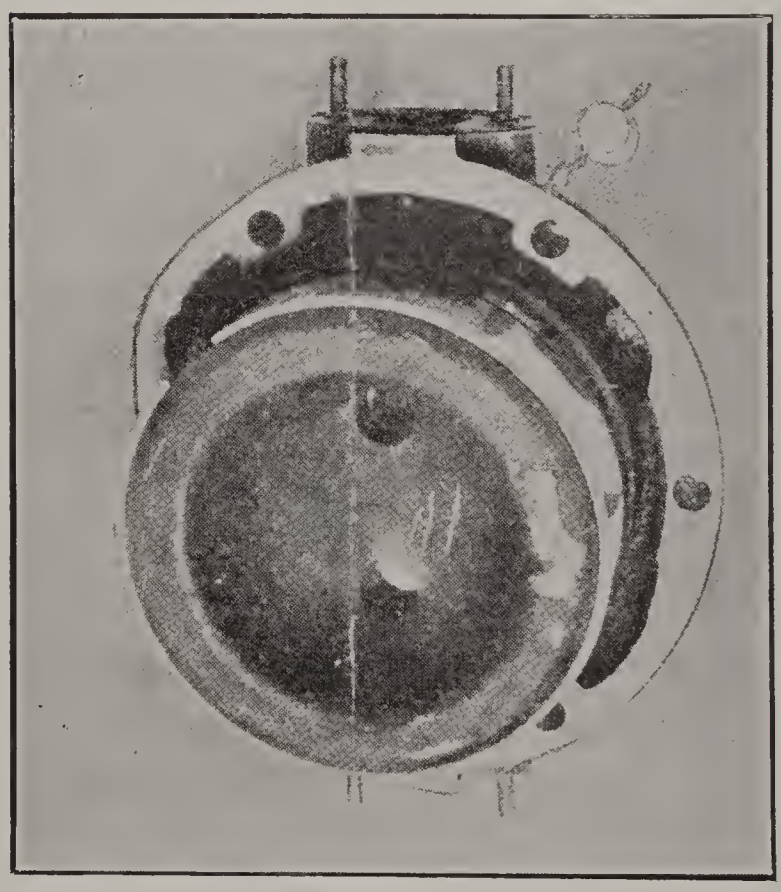
The sleeve valve is balanced against lateral pressure, and the explosion does not affect or shock it at any point. The ports are large, the inlet and outlet most effective for their area, and the action of the motor is not affected adversely by their increased size. Increase of compression up to the pre-ignition point is no disadvantage, because the explosive pressures developed are expended in useful work upon the piston, and the valves are no more difficult to open under high pressure than low, because they slide without resistance past their port openings, instead of being made to lift against pressure.

In the sleeve valve, therefore, it is possible to combine the advantages of both types of poppet valve motors. In the sleeve valve is combined the silence, endurance and reliability of the small poppet valves and low compression with the high efficiency of the high compression, large valves, powerful springs, and precipitous cams of the racing poppet valve motor, and the operator has in the one sleeve valve all the advantages of both types. A standard sleeve valve motor is capable, so far as efficiency is concerned, of delivering all the power of the racer with all the softness and quietness of the inefficient poppet, and the operator has within his control a surplus of power which he can call into service when needed in emergencies. Of course, with standard bodies, wind resistance, and weights of touring cars nobody expects extreme racing speeds upon country roads, but the power is there when required for acceleration and hill work, as thousands of users testify.

The accompanying photographs are of two sleeves and a detachable head that came through the Royal Auto Club test of four years ago. I was for-



Two of the Sleeves After the Test—Both in Perfect Condition.



Cylinder Head at Finish of Test—Note Absence of any Carbon Deposit.

tunate to be in London at the time they were on exhibition and had an opportunity of examining them. They were truly in perfect condition as the Club's seals attached to each part will testify.

It would probably not be out of place in conclusion to make a few comments upon the early discouragements of the inventor and the eventual adoption of the motor. An English Daimler car fitted with one of these motors under the supervision of the Royal Automobile Club of Great Britain, won the Dewar trophy in March, 1909,—the result of the greatest engine test on record. Incidentally this trial established so high a precedent that no engine of the poppet valve type has ever equalled or surpassed this performance. Other well-known companies in all parts of the world have acknowledged the unquestioned supremacy of the sleeve valve engine.

A STORY OF BURIED GENIUS.

But back of the series of triumphs attending the sleeve valve motor is a story of many years of toil and discouragement, a story of buried genius, a story of a man who for years sought recognition for an invention destined to revolutionize motor building. The story of that man—Charles Y. Knight of Chicago—reads like a romance of business fiction. Away back in 1896, when automobiles were just beginning to attract attention in this country, Mr. Knight brought forth a new type of motor radically different in many ways from the ordinary engine. He was laughed at by engineers and designers—at that time they were "too busy" to investigate. In those days manufacturers were chiefly concerned in making their cars

run—they had no time to experiment with new motors. The questions of maximum efficiency, silence, high power and smooth operation were not vitaily important. Those were the days when the principal thing necessary was to make the car run—not how or why—but just keep it running.

"But," Mr. Knight would argue, "my motor is not only superior theoretically, but practically. Cars with my motors are running successfully today right here in Chicago."

It made no difference—no one would pay any attention to the "Silent Knight." "Just a freak," was the almost universal comment.

KNIGHT GOES ABROAD.

Discouraged, but firm in the belief that ultimately the world would recognize the merits of his motor, Knight persisted. Finally, on the invitation of the English Daimler Company, Knight sailed for England in 1907. It was during this year that I had my first ride behind a Knight motor. The trip made was from London to Windsor and back a distance of forty miles. Since then I have been an enthusiastic supporter of the principle, for as crude as the motor was then, it was a revelation.

At that time England and the continent were far ahead of this country in automobile manufacture. Even then, tests and experiments had become chiefly devoted to improving, refining and silencing the machine—the one aim being "the quiet car."

Straight to the Daimler Company at Coventry went Knight—to the oldest manufacturer in Great Britain. Quietly the engineering staff listened to him and carefully watched the performance of his sleeve

valve motor. Comparison with their own highly developed and efficient motors showed an immense margin in favor of the Knight type.

For a year the experimental department tested and tried the new engine. Not only was the Daimler motor very efficient in itself, but the company was licensed under the German Mercedes patents and had access to all the developments worked out by that well-known firm, consequently they were loth to admit the superiority of a new motor, but months of gruelling tests proved true all the claims made for the Knight Sleeve Valve Engine.

Daimler adopted the Knight motor. Finally in 1908, after combining the best points in design as practiced in their power plant with the Knight sleeve valve principle, the English manufacturers announced to the world that they had adopted the new motor, convinced that it was far in advance of any other type of engine. So in England the invention was first publicly recognized.

Then came the storm of criticism—a blast from many sources. "The new motor was only good in theory—it had not been proven—it was a freak. Why weren't poppet valve engines good enough? Why hadn't America recognized this engine?" And a hundred and one other criticisms. In short, Knight and the Daimler Company faced the same biting blasts of denunciation and ignorance that was borne by Alexander, Graham, Bell, Morse, Prof. Langley and every other true discoverer and inventor.

But service in the hands of the public soon proved the Knight motor. It more than fulfilled the claims made for it. But the critics, lacking any tangible proof of the claims made against the Knight motor,

but secure in the belief that it could not be as good as represented, they demanded a test—an official trial by the Royal Automobile Club, the highest technical authority on motoring in Great Britain, and a body composed of engineers for whom designers the world over have profound respect. It seemed impossible for this motor to "make good"— that it must prove false.

The Daimler people at first did not care one whit whether their motors were tried by the R. A. C. or not; their sales had never been so good in all the history of the company; their stock was advancing by leaps and bounds. Still in a way they were glad of an opportunity to prove to the world just how good the new motor really was.

Daimler Accepts the Challenge.

The longer they thought over the idea of a test the more willing they were to enter it, but not on the terms prescribed by the Club. "No," said the Daimler people. "If we submit these engines to test, we will make it worth while and impose conditions more stringent than any ever heard of in the history of motoring. We will prove our motors conclusively, and we will set a standard that nobody else will attempt to equal."

They handed in such a revision of the specifications and conditions that no one could believe that they were in earnest. "You surely don't want us to submit your new motors to these rules?" said the Royal Automobile Club in effect. "Why, it would be suicide for you—no motor ever made could stand up under such a test—we won't do it." "Yes, you will," came the grim response from the makers. "You will

try our motors in this way or we will not hesitate to publish the fact that the Royal Automobile Club refuses to put our motors to such tests."

The result of that trial is history. Not only was it never attempted before, but no poppet valve motor has ever attained anywhere near the results of that test. The following is a reproduction of the two certificates issued by the Royal Automobile Club, printed in their entirety. Notwithstanding the severity of this test there was no perceptible wear noticeable on any of the fitted surfaces.

ROYAL AUTOMOBILE CLUB.

(I.) Certificate of Performance (No. 118) in a Test of a

38.4 R. A. C. Rating.

"New" Daimler Engine. March 15th to 28th, 1909.

This is to Certify that a "New" Daimler Engine, bore 124 mm., stroke 130 mm., was submitted for the following test by Messrs. the Daimler Motor Company (1904), Limited.

1. That the engine shall be tested on the bench for a period of 132 hours continuous running.

2. That the horse-power given off shall at no time during the test fall below the R. A. C. rating multiplied by 1.3, the piston speed to be 1,000 feet per minute. If a higher piston speed is used the minimum horse-power shall be increased proportionately.

3. That the water temperature of the inlet shall be kept at 50° C. during the test.

4. That upon completion of the bench test, the engine, without any of its vital parts being disturbed, shall be installed in a standard touring car, and run for a distance of 2,000 miles on Brooklands Track, this distance to be completed in not more than sixty hours of running time.

5. That upon completion of the track test, the engine shall be again placed on the bench, and run for five hours under the same conditions as the previous bench test referred to in paragraphs 1, 2, and 3.

6. The Certificate shall show, **inter alia**—

(1.) A chart giving the horse-power readings to be taken not less than once every hour during the endurance test at the declared speed.

(2.) A record of repairs or adjustments, if any. The following, however, while they may be recorded on the certificate, will not debar the engine from continuing its test; the time for the necessary repairs being noted, and the motor being called upon to make good such time under the general conditions governing the test:

Defects in—Petrol supply.
Water circulation.
Ignition system.
Exhaust piping.
Brake system.

(3.) The fuel consumption per horse-power on the bench.

(4.) The degree of wear shown at the finish, on examination of the parts by the judges.

The speed entered for in the Trial was 1,200 revolutions per minute, giving a limit of 50.8 h. p., below which the horse-power was at no time to fall.

The engine was observed throughout the Trial, and readings were taken and recorded every half-hour. These records are shown on the chart accompanying this Certificate.

Part I.—First Bench Test.

Duration of Test.	Stops incurring Penalty.		Stops not incurring Penalty.		Total Time during which the Load was eased for Brake Adjustments (Engine not stopped).	Average Horse-power Recorded.	Petrol Consumed	Consumption per Horse-power Hour.	
	Number	Duration	Number	Duration					
d. h. m.				Mins.	Mins.		Galls.	Pint.	lb.
5 14 15	Nil	—	5	116	19	54·3	614·75	.679	.613

During this and the final bench test there were no stoppages caused by any failures other than those of the description mentioned in paragraph 2 of clause No. 6 of the conditions of the trial.

On completion of the above test, the engine was removed from the bench to the chassis, under observation, without any of the vital parts being disturbed, and the car was fitted with a standard touring body.

Part II.—Running Test.

Nature of Mileage.	Mileage.	Average Total Weight of Car and Passengers	Petrol Consumed.	Distance per Gallon Miles.	Ton-miles per Gallon.
		lbs.	Galls.		
Coventry to Weybridge...	112	4085	Not taken	—	—
Brooklands (track)	1930.5	3805	93	20.57	34.94
Track to lock up.....	5	3805	—	—	—
Weybridge to Coventry...	112	4085	5.75	19.48	35.97

The total mileage run was, therefore, 2159.5. The 1930.5 miles on Brooklands Track were completed in 45 hrs. 32 mins., giving an average speed of 42.4 miles per hour.

On returning to Coventry the engine was replaced upon the test bench without any of its vital parts being disturbed.

Part III. Final Bench Test.

Duration of Test.	Stops incurring Penalty.		Stops not incurring Penalty.		Total Time during which the Load was eased for Brake Adjustments (Engine not stopped).	Average Horse-power Recorded.	Petrol Consumed	Consumption per Horse-power Hour.
	Number	Duration	Number	Duration				
h. m.					Mins.		Galls.	Pint. lb.
5 15	Nil	—	Nil	—	15	57·25	22·5	·599 ·541

Judges' Remarks.

The engine was completely dismantled, and no perceptible wear was noticeable on any of the fitted surfaces.

The cylinders and pistons were found to be notably clean.

The only visible wear in any part was caused by two point pins rubbing against adjacent parts.

The ports of the valves showed no burning or wear.

(Signed) J. W. ORDE, Secretary.
(Date) 7th April, 1909.
119 Piccadilly, London, W.

FRANCIS OF TECK, Chairman.
MERVYN O'GORMAN,
Chairman of Technical Committee.

(II.) Certificate of Performance (No. 117), in a Test of a

22.85 R. A. C. Rating

"New" Daimler Engine. March 15th to 28th, 1909.

This is to Certify that a "New" Daimler Engine, bore 96 mm., stroke 130 mm., was submitted for the following test by Messrs. the Daimler Motor Company (1904), Limited.

1. That the engine shall be tested on the bench for a period of 132 hours continuous running.

2. That the horse-power given off shall at no time during the test fall below the R. A. C. rating multiplied by 1.3, the piston speed to be 1,000 feet per minute. If a higher piston speed is used, the minimum horse-power shall be increased proportionately.

3. That the water temperature of the inlet shall be kept at 50° C. during the test.

4. That upon completion of the bench test, the engine, without any of its vital parts being disturbed, shall be installed in a standard touring car, and run for a distance of 2,000 miles on Brooklands Track, this distance to be completed in not more than sixty hours of running time.

5. That upon completion of the track test, the engine shall be again placed on the bench, and run for five hours under the same conditions as the previous bench test referred to in paragraphs 1, 2, and 3.

6. The Certificate shall show, inter alia—

(1.) A chart giving the horse-power readings to be taken not less than once every hour during the endurance test at the declared speed.

(2.) A record of repairs or adjustments. The following, however, while they may be recorded on the certificate, will not debar the engine from continuing its test; the time for the necessary repairs being noted, and the motor being called upon to make good such time under the general conditions governing the test:

Defects in—Petrol supply.
Water circulation.
Ignition system.
Exhaust piping.
Brake system.

(3.) The fuel consumption per horse-power on the bench.

(4.) The degree of wear shown at the finish, on examination of the parts by the Judges.

The speed entered for in the Trail was 1,400 revolutions per minute, giving a limit of 35.3 h. p., below which the horse-power was at no time to fall.

The engine was observed throughout the Trial, and readings were taken and recorded every half-hour. These records are shown on the chart accompanying this Certificate.

Part I.—First Bench Test.

Duration of Test.	Stops incurring Penalty.		Stops not incurring Penalty.		Total Time during which the Load was eased for Brake Adjustments (Engine not stopped).	Average Horse-power Recorded.	Petrol Consumed	Consumption per Horse-power Hour.
	Number	Duration	Number	Duration				
d. h. m.				Mins.	Mins.		Galls.	Pint. lb.
5 12 58	Nil	—	2	17	41	38.83	476.5	.739 .668

During this and the final bench test, there were no stoppages caused by any failures other than those of the description mentioned in Paragraph 2 of Clause No. 6 of the conditions of the trial.

On completion of the above test, the engine was removed from the bench to the chassis, under observation, without any of the vital parts being disturbed, and the car was fitted with a standard touring body.

Part II.—Running Test.

Nature of Mileage.	Mileage.	Average Total Weight of Car and Passengers	Petrol Consumed.	Distance per Gallon Miles.	Ton-miles per Gallon.
		lbs.	Galls.		
Coventry to Weybridge...	112	3612.5	Not taken	—	—
Brooklands (track)	1914.1	3332.5	85.5	22.44	33.37
Track to lock up.....	5	3332.5	—	—	—
Weybridge to Coventry...	112	3612.5	5.75	19.48	31.19

The total mileage run was, therefore, 2143.1. The 1914.1 miles on Brooklands Track were completed in 45 hrs. 42 mins., giving an average speed of 41.88 miles per hour.

On returning to Coventry, the engine was replaced upon the test bench without any of its vital parts being disturbed.

Part III.—Final Bench Test.

Duration of Test.		Stops incurring Penalty.		Stops not incurring Penalty.		Total Time during which the Load was eased for Brake Adjustments (Engine not stopped).	Average Horse-power Recorded.	Petrol Consumed	Consumption per Horse-power Hour.	
		Number	Duration	Number	Duration					
h.	m.					Mins.		Galls.	Pint.	lb.
5	2	Nil	—	Nil	—	1	38.96	18.25	.749	.677

Judges' Remarks.

The engine was completely dismantled, and no perceptible wear was noticeable on any of the fitted surfaces.

The cylinders and pistons were found to be notably clean.

The ports of the valves showed no burning or wear.

(Signed)
J. W. ORDE, Secretary.
(Date) 7th April, 1909.
119 Piccadilly, London, W.

FRANCIS OF TECK,
Chairman.
MERVYN O'GORMAN,
Chairman of Technical Committee.

COMMENTS.

The following extracts, comments and replies to criticisms will no doubt be found interesting as well as instructive:

There is no reason why this motor should not be an economical engine to build, as it is all round work and easy to machine and being cast iron it should prove much easier to work than steel and possible to keep the tools in a better state of perfection. The class of machinery for this work, although special in many ways, is simple nevertheless.

This motor should be, if anything, less expensive to produce in a commercial way after the necessary alterations in equipment are made. It seems to me that an enormous saving can be affected in the final assembly and test as this is a cut and dried proposition from start to finish. There are no valves to seat, or regrind; no valve covers to leak; no valve jumpers to adjust, etc. So including the royalty it should compare favorably with the poppet type as regards production cost.

A further convincing evidence of the increasing popularity and unusual reliability of Knight engined cars is contained in a book entitled "The Knight Motor and How the World Has Received It," which has just been compiled by Mr. Knight, which is made up entirely of hundreds of personal letters and testimonials from satisfied owners in all parts of the world.

A frequent criticism lodged against this motor is that it is hard to crank in cold weather owing to the oil becoming congealed between the sleeves. This

condition, however, contributes little, if anything, to the tendency to crank harder. The ability of a Knight engine cylinder to hold compression is the true reason for being somewhat harder to turn over. Instead of this being a fault, it really constitutes one of the great improvements over the older type of motor. The various poppet valve motors which I have operated it was actually possible to hear the compression leaking around the valves. Naturally this condition acting as a compression release should contribute to easy starting as well as an inefficient motor. The only way to temporarily remedy this fault is to grind valves. It is not uncommon to find poppet valve motors in the final test to have a variation of 20 pounds per cylinder in compression. This is an unknown quantity in the final tests shops of sleeve valve manufacturers. For instance, a poppet valve motor may be put in the pink of perfection but its efficiency steadily diminishes with use whereas the efficiency, smoothness and power of a Knight motor steadily increases with use. Slower progress in the development and adoption of the Knight principle in this country than abroad may be accounted for in various ways. Failure of Amercian engineers and manufacturers to realize its merits, larger market for their output, litigation, stubborn prejudice, and lack of capital being among the main reasons. However, I predict some big developments for this motor in the near future. The increasing tide of sales is turning in favor of those manufacturers of Knight engined cars, just as surely as the backbone of the poppet valve situation is being broken.

(Extract from page 1020.)
(The Auto Car, Saturday, June 7, 1913.)

A THREE HUNDRED HOUR ENGINE TEST.

An American Demonstration Run. A Feeble Exhibition.

An event which has been attracting a good deal of attention in American motor circles lately is the recently concluded laboratory test by the Automobile Club of America of a 4 in. x 5½ in. (102 x 139.7 mm.) six-cylinder poppet valve Packard engine. According to the rules of the test the engine was to accomplish a 300 hour run at more than 70% of its best brake horse-power. This test the engine successfully accomplished, but analysis of the figures of the A. C. A.'s report shows that the performance was not so remarkable as at first sight appears. For instance, the best recorded h. p. that the engine gave was 44 h. p. at 1,533 r. p. m., which for an engine of approximately 6,864 c. c. cannot be considered good, as the horse-power of an engine of these dimensions according to the Dendy Marshall formula of $\frac{D^2 S N R}{12{,}000}$ should be 67.45 h. p.

The test was run at an average of 35.7 h. p. at 1,208 r. p. m. Here, again, the showing is poor, as by the same formula the engine should have shown 53.152 h. p. at 1,208 r. p. m.

With regard to petrol consumption, this worked out at 1.072 pints per brake horse-power hour, which is about double what is usually considered a fairly good consumption, i. e., .6 pint per horse-power hour. A further remarkable figure is the consumption of lubricating oil given as 1.07 gallons per hour, which,

taken in conjunction with the standard gear ratio of the chassis from which the engine was taken, is equivalent to a consumption of 1.07 gallons of lubricating oil for 37 miles. During the test it is only fair to state that the adjustments made were trivial, and that only one stop of 47s. was made to rectify an air lock in the petrol feed pipe. But then, we should not expect trouble with such a small output of power from an engine of these dimensions.

Compared with the Daimler sleeve valve test at Coventry four years ago under the official observation of the Royal Automobile Club, the Packard performance takes rank as a rest cure. This is borne out by the volumetric efficiencies of the two Daimler engines and the Packard, which are as follows: Packard 6,864 c. c., 35.7 h. p. giving 1 h. p. per 192.2 c. c.; 38 Daimler 6,272 c. c., 54.3 h. p. giving 1 h. p. per 115.5 c. c.; and the 22 Daimler 3,764 c. c., 38.83 h. p. giving 1 h. p. per 96.9 c. c., the volumetric efficiency of the last engine being almost double that of the Packard.

(The Daimler Bulletin.)

Mr. C. Y. Knight's Reply to an Anonymous Criticism of the Slide-Valve Engine.

(Which appeared in The Autocar, on October 15th, 1910.)

When first I read "Some Criticisms of the Slide Valve," by "A Manufacturer of Poppet Valve Engines," I exclaimed, "An enemy hath done this." I canvassed the motor engineering field of the United Kingdom in a vain endeavor to identify a member of the profession who, in view of the facilities for information afforded today, should be so ill-formed regard-

ing such an important subject as to venture into print with this mass of misleading statements and absence of tangible data, and I failed to call to mind the name of a single engineer whom I could reasonably charge with the act.

Then a sudden light dawned upon me, and I said to myself, "How stupid not to have thought of this before. There are tricks in all trades. This mysterious communication throws light upon a whole lot of queer things which have been going on in the Daimler Company's advertising department of late. It is not the work of an enemy. It's the deep laid plot of some one interested in the sale of slide valve cars to draw this subject again into the limelight of publicity, and force me to help make the people sit up and take notice at show time." Being of a retiring disposition, I have for the past year turned a deaf ear to all the entreaties of the Daimler advertising staff to "write something for the Bulletin, or some other paper," and all sorts of "jollying" and soft words of persuasion have failed to turn me from my avowed purpose to "Keep mum and saw wood." But the able director of the Daimler Company's publicity department is artful and wily. He fully appreciates the fact that there's more than one way to kill a cat. He has evidently read from the ancient philosophers that "Whom the gods would destroy they first make mad," and in order to destroy my native modesty, and force me and the motor into the public eye, has concocted a a conglomeration of insinuations and suppositions purposely wide of the mark to goad me on to the rhetorical demolition of this straw man. Then I thought—

"It's just like Instone!"

And I will say that, so far as I know, up to the hour of writing Instone hasn't denied its inspiration! He even admits that such a controversy, started right upon the eve of Olympia, is likely to draw prospective purchasers in droves to the stands of those firms who sell cars equipped with sleeve-valve engines, and makes no effort to conceal his joy over the matter. And I more fully believe it's Instone, because I do not think an engineer would say some of the things which are said in this article, and Instone isn't an engineer. Then I'm sure, after a close study of the article, that the Editor of The Autocar is mistaken in his assurance that the author is "chief engineer of a leading firm of poppet valve engine makers," because, surely, no such person, informed as one in his position must be, would permit himself to rush into print with such a mass of undigested statements, affording an antagonist opportunity for laying before the public numerous facts favorable to the sliding sleeve engine that would otherwise have no excuse for publication.

The mysterious author must have donned false wig and beard, thrust a "T" square under his arm, rubbed some Indian ink upon his finger tips, and invaded the sanctum of The Autocar thus disguised. Those familiar with his wiles must in one voice acclaim with me:

"It's just like Instone."

Publicity he will have for Daimler at whatever cost!

I positively know it isn't my old and esteemed friend, S. F. Edge. There is no mistaking his efforts. When he used to take up his pen to write upon the sleeve-valve question he dipped it in vitriol instead of ink, and I could always divine the fact when a publica-

tion contained one of his caustic effusions from the warmth which permeated even to the outer cover thereof, and had it emanated from this well-known champion of the six-cylinder propaganda, the signature S. F. Edge would have shone, even as the warmth of the language permeated through the many pages and outer cover. Mr. Edge knows too well the value from an advertising standpoint of three pages pure reading matter well forward to neglect, if opportunity affords, to secure the benefit thereof.

Efforts have been made to lead me to believe that the article emanated from the chief engineer of another leading company which produces six-cylinder cars exclusively. It is positively known that the Rolls-Royce Company did some time ago purchase a 38 h. p. Daimler chassis for the purpose of studying the motor; that they did make certain tests with the silencer removed; that they did claim at the time to have arrived at certain results which exactly tally with those which the writer of this article states he secured.

But I thought it would scarcely be reasonable to suppose that a well-known concern with standing would make public the results of a test made of a rival's production, with no opportunity for that rival to be present and see that the tests were fair. I know when it was suggested that, inasmuch that no maker of poppet valve engines has seen fit to subject his productions to the same official test that the sleeve valve Daimler had successfully withstood, the question arose of going out into the market, purchasing a motor manufactured by a firm which has been particularly active in circulating public statements to the effect that the new motor would not stand up under work, putting it on the bench, calling in disinterested

witnesses, and seeing just how long it would last pulling one and a half times its rated horse-power.

But this was at once frowned down as not being "cricket," even in view of the exasperating provocation of continuous defamation of the new motor upon the part of this concern.

However, the facts concerning this reported test at Derby were known to Mr. Instone as well as to myself, and it is barely possible that reference to it has been introduced for the purpose of misleading me. For, as I previously remarked, Mr. Instone is, in an advertising way, wily, and his ways are sometimes past understanding.

Possibly I owe the reader an apology for discussing to such length the probable authorship of this article. But it does make a difference. You don't see the point? Well, as Harry Lauder would say:

"I'm a tellin' ye."

Once upon a time an old German Professor was greatly annoyed by the unearthly ear-splitting noise produced by a boy who, under his very window, was belaboring an empty wooden crate with a board.

"Poy, poy!" he indignantly exclaimed out of his window, "what for you do dot?"

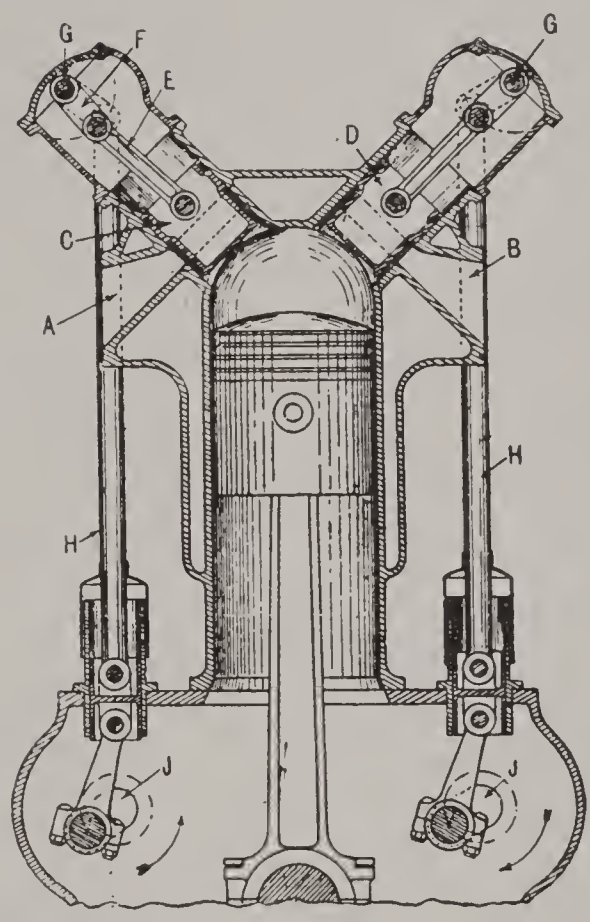
The boy, assuming the very personification of innocence, replied: "Why, to make a noise, of course."

"Oh," replied our German friend, now mollified, "dot vas all righdt; I thought you do dot to annoy me."

Now if this emanates from Instone, it is certainly done for the purpose of "making a noise"; if it comes from the pen of Mr. Royce, of the Rolls-Royce Company, whom the title as given by The Autocar fits, then I must take it for granted that it is done for the

same purpose that the Professor feared the boy was pounding the box—"to annoy me."

There are times when anonymous communications may be justified, when a great public good is to be served in an unselfish manner. But I am sure Mr. Royce, even though he saw fit anonymously to attack the interests of a competitor, would not in the same



Drawing from Fred Royce's New Motor as shown in British Patent Specification, No. 20,063 of 1909.

breath, with hidden identity, urge the merits of his own product, as is therein done. Such procedure savors too much of putting the husband out of the way and proposing to the widow before the funeral.

Maybe I owe Mr. Royce an apology for making this a personal matter. But I desire to assure him that, inasmuch as quite a number of people really believe his firm to be responsible for this effort, it is in

his interests that I take the subject boldly in hand and clear him from suspicion as far as it is possible for me to do so with the evidence at hand.

Not only do I believe this conclusion of some people to be unreasonable, but I think I can demonstrate from this gentleman's own signed utterances that he does not entertain the views expressed in this article, which says under the heading "Silence":

"It has been written that silence is golden, and silence in connection with the engine of a pleasure car is worth much gold.

"How far will an engine having the large and rapidly opened exhaust ports which are a peculiarity of the sleeve valve engine fulfill this requirement? The answer is that the exhaust would be exceptionally noisy, and that, in order to smother it sufficiently to satisfy the present demands of users of pleasure motor cars, a manufacturer might consider it necessary to fit exhaust pipes and silencer which would reduce the h. p. of the engine by twenty per cent. at 1,000 revolutions per minute, and by thirty per cent. at 1,500 revolutions per minute."

As a matter of fact, the exhaust of the sleeve-valve engine is much less difficult to silence than its poppet-valve predecessor. In the latter, not only has the noise of the escaping gases to be cared for, but the exhaust branches and pipes afford as ready a conductor of the noise caused by the seating of the valves as they do for the flow of the gases, as their effect is producing a mechanical noise at one end of the pipe, the other end of which opens out to the air. Consequently, the silencer in the case of the poppet valve has a double function to perform.

Strange to relate, all experience is contrary to the conclusions of this writer in relation to the noise made by the open exhaust from a slide-valve engine.

On March 28th, 1909, a very novel competition was held in Paris, called "An Exhaust Guessing Contest."

This was a contest in which the silencers were removed from various motors, and the contestants, who were out of sight, were required to judge from the sound of the exhaust the identity of the motor.

In speaking of this the Paris correspondent of The Motor, in its issue of March 30th, 1909, says:

"The Knight-Daimler engine, the dark horse of the competition, and the one that probably not one of the competitors had heard running before, proved to be the easiest of the lot. The exhaust was so much softer than that of any of the French cars that nearly all correctly named it."

I can scarcely believe that Mr. Royce could have entertained such an idea regarding the effects of large exhaust ports, as he has spent valuable time and much money in an effort to perfect a motor possessing those exact qualities.

In the application which he executed as the basis for British Patent No. 20,063, of 1909, for a piston-valve engine, the drawing of which is shown herewith, Mr. Royce says:

"This relates to an internal combustion engine in which the inlet and exhaust ports are opened and closed rapidly and silently, and remain open for a considerable period giving a large port area and free passage for the incoming gases and exhaust products so that high speeds can be efficiently obtained, and also in which the combustion chamber assumes a regular shape, preferably hemispherical and without any pockets, also in which the noise caused by the poppet valves dropping on their seats, which is present in the ordinary type of engine, is absent."

One would think Mr. Royce had borrowed the phrasing of his patent claim from that portion of the

catalogue of some maker of a sleeve-valve motor in which the advantages of the Knight engine are set forth!

I am further led to believe that those who suspect Mr. Royce of the authorship of this article must be mistaken, because he, being well informed regarding motoring matters, would not endeavor to secure credit for an article of his production to which it is not entitled. The writer of this article says, under the heading of "Fuel Efficiency":

"It has yet to be shown that the sleeve valve engine when adapted for use in a luxury car, can equal the poppet valve engine in fuel efficiency. Such records as the performances of the four-cylinder Vauxhall car and the six-cylinder Rolls-Royce car in the 2,000 miles trial of the Royal Automobile Club, in 1908, remain unbroken, and until they are beaten the poppet valve may well claim superiortiy in the fuel economy of pleasure cars."

Surely Mr. Royce would never have placed such a statement in black and white. He would know that a Minerva-Knight 38 h. p. motor driven by Mr. Hugh Kennedy in the 1909 Scottish Trials officially knocked this Rolls-Royce fuel consumption record sky-high. The record of the Rolls-Royce, as shown by the report of the R. A. C. Trials of 1908, was 40.98 ton-miles to the gallon. The Vauxhall spoken of was but 37.2, and why it is mentioned is something of a mystery, as there were others in the same trials standing higher.

In the 1909 Scottish Trials, however, the standard "luxury car" Minerva-Knight, covering a distance exceeding 1,000 miles, established 44.57 as the world's record, 3.57 ton miles per gallon higher than the Rolls-Royce, and 8.37 ton-miles better than the Vaux-

hall record referred to, and its average time on the hills was rather better than that of any other of the sixty-eight cars in the contest. This won the Minerva the Scottish Cup for consumption, and so far as I know the record has never been eclipsed.

Best official road records for fuel consumption, so far as I have been able to ascertain, are as follows:

H.P.	Car	Under auspices.	Date.	Miles covered.	Ton-Miles per gal.
38	Minerva-Knight	S.A.C.	1909	1,007	44.57
59.9	Napier ..	R.A.C.	1910	799	42.57
24	Vauxhall ..	S.A.C.	1909	1,007	41.65
20	Vauxhall ..	S.A.C.	1909	1,007	41.16
48	Rolls-Royce ..	R.A.C.	1908	2,000	40.98

Not only does the sliding-sleeve engine hold the record for road trials consumption, but its high speed track performance has never been beaten in this respect.

During the past year there have been numerous consumption trials at Brooklands under the auspices of the R. A. C. upon the part of manufacturers who believed the performance of their products would be creditable.

Not one anywhere near approached the performance of the two Daimler sleeve-valve engines in their 2,000 mile track part of the great engine test of the spring of 1909, which they covered at an average speed approximating 42 miles per hour.

This record, as taken from the R. A. C. records, is as follows:

H.P.	Car.	Miles covered.	Miles per hour.	Ton-Miles per gal.
38	Daimler-Knight	1,930.5	42.4	34.94
22	Daimler-Knight	1,914.1	41.88	33.37
10.8	De Dion	13.8	40.17	28.54
38	Napier	13.8	60.14	21.95
25	Napier	13.8	51.55	18.08
15.9	Sunbeam	13.8	48.60	18.26

Then again, Mr. Royce certainly would not have made the error of characterising this Rolls-Royce R. A. C. trial car as a "luxury car," because his firm was most solicitous that the public should know that this trial car was not standard, but built especially for efficiency, and that its makers were heartily ashamed of its performance compared with their standard product. Regarding this, they wrote The Automotor Journal under date of November 7th, 1908, as follows:

"May we be allowed to call attention to the fact that the 'Silver Rogue' referred to in the above comparison was a car built specially for the 2,000 Miles Trial of the Royal Automobile Club, and that on June 1st last we addressed a letter to the Press, which was published in many papers, stating that as in this trial everything was to be gained by efficiency, power, and high speed, and that the silence was not a merit, we had decided to abandon in these particular cars the methods by which noise has been eliminated in standard Rolls-Royce cars. We pointed out that these methods had not prevented a speed of over sixty miles an hour on the flat being obtained with ordinary touring cars carrying four persons, but that it was evident that for the purpose of this trial nothing was to be gained by the employment of such methods. We stated that we regarded these two cars as somewhat fast and not altogether to be admired offsprings of the Rolls-Royce house, and that the 'twins' instead of being christened (as had originally been intended) the

'White Ghost' and 'Silver Silence,' would be known as the 'White Knave' and the 'Silver Rogue.'

"It is therefore no surprise to us whatever to find that Lord Montagu thought that perhaps the Daimler engine had a slight advantage over the 'Silver Rogue' in respect of silence, because so noisy is she that our standard Rolls-Royce cars when they pass her in the street turn their heads as it were, stop their ears, and turn color with shame."

Then again the following, taken from the article published last week:

"The employment of sliding sleeves, which must be peculiarly dependent upon construction and efficient lubrication, would not be contemplated by any sound engineer unless their employment were to bring about some astounding increase in the qualities in a motor car for which the public craved, and which would govern the buying public in the selection of their car."

Most assuredly it would not. Surely Mr. Royce, as the maker of a poppet valve engine, never would have suggested this conclusive argument and evidence that the sleeve valve engine does "bring about some astonishing increase in the qualities in a motor car for which the public craved."

I can see that Mr. Instone would throw out such a suggestion to bring out evidence that such is the case. He well knows that I have a copy of a cable message forwarded by the engineers of three leading American concerns to their superiors, under date of October 23rd, 1908, as follows:

"All three believe Knight principle valuable; some extraordinary results; advise send representatives at once."

And Lord Montagu, whom the Rolls-Royce concern characterises as a most competent judge and

conscientious man, in his comments at the R. A. C. meeting upon the behavior of the Daimler Company's first 38 h. p. model, which he drove several hundred miles in France, said, as officially reported:

"The characteristics of the engine seemed to be great flexibility, exceeding that of any other four-cylinder engine with which he was acquainted; noiselessness, especially marked when under way and running at high speed, and great power of picking up when a hill had to be negotiated, or when, after a slack of traffic, speed had to be attained again to get out of traffic. Those were the results of his quite unbiased tests and experience. He was not interested in the least in the success of Mr. Knight's engine, and he was not interested in any motor car company whatever. He thought, therefore, that those tests and those experiences might be of benefit to the discussion, and he could honestly say, that he thought it was a remarkable engine. Whether it would attain the great success that some people prophesied was not for him to say; all he could say was that he had been charmed with the running of the car that he had taken to France, and he thought that it was, for a four-cylinder engine, the best he had ever handled."

Mr. Instone knows also that I can show that the Daimler Company during the first year of its production of the sleeve-valve motor sold nearly twice as many sleeve-valve cars as it did poppet-valve cars the year previous; that during the past year (its second) it sold nearly three times as many sleeve-valve cars as it did the previous year; and that for the past two months its sales have been about double what they were for the corresponding months of 1909. He knows that as a result Daimler shares have trebled in price since the sleeve-valve engine was taken up; he knows that the Minerva Company is right now sold up for 1911 without half filling the demand on the Con-

tinent, and that shares in that company have considerably more than doubled in value during the past year as a result of its unprecedented prosperity, and he knows just what I had to demonstrate to the engineers of such experienced and conservative concerns as Panhard of France, and Mercedes of Germany, in order to induce them to link their world-wide reputations and names with that of the Knight Engine, and to exhibit them as a standard product after two years of exhaustive tests at their works. Therefore, it is plainly evident that it is to his advantage to have these most valuable points emphasized upon the eve of Olympia.

It is only natural that the advertising department should be interested in goading me on to produce something that will bring in Press notices. Therefore I can understand why such a taunt as reproduced below from this article should be inspired by our friend Instone:

"No excessively large horse powers for size and weight have been forthcoming in the sleeve-valve system. One would, therefore, conclude that this engine is unsuitable for running at high speed power tests. I believe that all the records for power and track speed are as yet held by engines of the poppet valve type."

I do not believe that any chief engineer of a concern making poppet-valve engines would venture such a suggestion, because, as I remember it two years ago, these gentry loudly and incessantly (until the matter became tiresome) clamoured for a bench test of the sleeve-valve motor. What they got now occupies a very conspicuous place in internal combustion engine history, since which time those who got their fingers

burned have steered clear of the fire. However, the fact that the sleeve-valve does not now hold the high-speed track records signifies little. Little was it thought two years ago that the sleeve-valve motor would to-day hold both the record for the longest continuous run under load ever accomplished by the internal combustion engine, and the official road and track record for fuel consumption in a pleasure car as well. At the present time, however, those manufacturers holding licenses to manufacture sleeve-valve engines do not find it necessary to seek speed records upon the track in order to bring customers to their sales rooms.

However, in this connection, I am rather at a loss to know what the writer is driving at. Here is what Lord Montagu said at the oft-quoted R. A. C. meeting of the speed of the 38 h. p. engine he drove in France, previously alluded to in another connection:

"As regarded the trial for speed, possibly he ought not to give the figures lest it should be thought that he was a 'road-hog,' but they would understand that it was in France. (Laughter.) It was in October, on an absolutely straight and empty road, without any hedges and without any traffic whatever. On the road between Chartres and Le Mans he had let the car out for forty-five minutes consecutively on a hot day on a somewhat undulating road, and he had covered in that time about thirty-two miles. At the end of it the tyres were so hot that he deemed it advisable to slow down. Such a test would not be possible in England naturally. There was no sign of heating in the engine, and the radiator was certainly cooler than with an ordinary Daimler, such as the one he had driven for a great many years—cooler than a 45 h. p. or 40 h. p. or any other existing Daimler type. On another occasion, between Argentan and

Bernay, he had run eighteen miles in 20½ minutes. Allowing for two slacks past cottages, a speed approximating to a mile a minute had been kept up for the whole distance. There was no sign of engine heating, and the explosions were as distinct and regular at the end as at the beginning. The engine, in fact, seemed to gather power on those long trials, and seemed to be working almost better at the end than at the beginning."

Is there any sane man who desires to travel any faster than this upon the public highways? Is there any demand, legitimate or otherwise, for a standard touring car to be any speedier than this standard 38, even though "restricted at carburettor and silencer," if what this writer says be true? If there is such a demand it has not shown itself at Coventry, and I am pretty certain it would be little welcomed at Derby.

If The Autocar article were written for the purpose of giving me an opportunity to call attention to certain evidence of an expert character, I would say under this heading that when one attempts to describe or measure "silence" in words, one has undertaken a big order. This is a question which, like the choosing of a wife, must be left to the personal impressions of the one most interested. No one can deceive a purchaser in this matter. All have ears and are capable of deciding for themselves whether or not one motor is more silent than another. The one thing the makers of poppet-valve engines have striven to do is to make their motors as silent as possible when running idle at slow speeds. This is merely a matter of low compression, good distribution of gases, rich mixture, and a design of cams which permits the valves to seat as quietly as possible. It is true that the lower the compression, the less vibration at all speeds of the

poppet-valve engine, which, when boiled down, means that the less power this type of motor produces the less it will vibrate.

This does not hold good with reference to the sleeve valve. If there is excessive vibration at any period in this motor under load, it is the result of lack of perfection in design or construction, except on the four-cylinder type at the very lowest of speeds. It is characteristic of these motors that they will pick up a loaded touring car on top speed without undue acceleration of the motor, and fairly "walk away" with it without any resort to the change-speed lever. Naturally a motor which delivers this sort of power at low speeds must produce powerful impulses, and any four-cylinder engine which pulls powerfully at slow speeds must, as a result of the design, show slightly more vibration at these very slow speeds than one which does not possess that power. But this unobjectionable feature disappears at a speed of 10 m.p.h. upwards, and between 20 and 50 m.p.h. I will pit a well designed four-cylinder against the best six-cylinder of the same power ever produced, either for quietness or absence of vibration.

Lord Montagu said in this connection, referring to the six-cylinder Rolls-Royce:

"At high speeds he honestly thought that Mr. Knight's four-cylinder engine was possibly the more silent, and the absence of engine vibrations at high speed was a very remarkable feature."

It might be interesting in this connection to refer to some expert and unbiased testimony in connection with the silence of the sleeve-valve motor as compared with that of the poppet valve. In America it is

an open secret that the Pierce Company, who are conceded to stand at the head of the industry there, have for two years been experimenting with the Knight sleeve-valve engine for six-cylinder cars. This concern builds nothing but six-cylinder cars, most of which are more expensive than the highest priced cars upon this side, and their output it probably equal in volume to the output of all the six-cylinder works in England and the Continent combined.

The chief engineer of this company is Mr. David Ferguson, an Englishman by birth and training, and recognised to be one of the most able and most conscientious members of the profession. At a meeting of the American Society of Automobile Engineers, held at Detroit, Michigan, a few months ago, Mr. Ferguson was called upon for information regarding the Knight sleeve-valve engine. His reply is officially reported and published as follows:

"The Knight engine has certain advantages. It is delivering the goods, and the Daimler Co. can sell more than it can manufacture. The motor is giving excellent results, and is more silent than you can get with poppet valves. The public want actual silence in motors, and if they demand such conditions we must redesign the poppet valves or use other types. The Knight engine has made wonderful strides and has created the demand for a quiet motor. I do not know that this motor gives extra power at low speeds, but it gives much more at high speeds. The perfect water-jacketing of the Knight motor as compared with the poppet valve type is excellent. One big advantage in conjunction with the sliding sleeve motor is lack of variation. In the poppet valve type the strength of the exhaust valve spring decreased .35% after six months' use, and after one year the valves are found sticking up as well as carbonising. This does not happen in motors with sleeve or rotary valve."

It may be said by way of explanation that the Pierce Company is not a licensee, as terms have not been agreed upon for various legitimate reasons which do not interest the public. But they have, in addition to having purchased a Daimler-built 38 h.p. four-cylinder motor, built for themselves, using their own practices regarding piston clearances, crankshaft design, and lubrication, a six-cylinder sleeve-valve motor to compare with their poppet valve type of practically the same size, and therefore their chief engineer speaks from experience, not supposition or rumour.

The article is so full of contradictions and inconsistencies that it is impossible either to credit it to a competent engineer such as we know Mr. Royce to be, or believe that it was intended to be taken seriously.

In one place the writer says:

"They (the poppet-valves) do not, as I believe Mr. Knight stated some little time ago, strike their seats like hammers," etc., etc.

Then a few lines further along:

"If an engine be thus improperly accelerated, the rollers actuating the valves are thrown off the face of the cams and a rattling is set up which warns the boldest chauffeur to desist. In the sliding sleeve engine no such warning is given."

In short, this is a confession that, despite previous claims to the contrary, the poppet-valve does jump off its cams at high speeds, and "the rattling warns the boldest chauffeur to desist." If, as claimed, the poppet-valve engine is the only one that will stand high speeds, why the necessity of a warning to desist?

And if the sleeve-valve doesn't give this warning, it's because it doesn't make the noise, isn't it?

Then again, under the heading "Fool-proofedness," the so-called engineer says:

"Another essential of a motor for pleasure cars (which are often in the hands of men who have little or no mechanical perception) is that it should be so constructed as to put it out of their power (so far as possible) to injure or destroy it."

It is then charged that the carburettor of the sleeve-valve engine is so restricted as to guard against this contingency, and that in order to silence the "barking" of the exhaust through the large ports a silencer which greatly reduces efficiency has been employed.

To my certain knowledge there is no foundation whatever for either assertion. So far as I am aware, all four licensees on this side are employing practically the same principles and openings in their carburettor for the sleeve-valve engine that were previously used for the poppet-valve type, and in every case the sleeve-valve equipped car of the same rating is much more economical in fuel, as well as much quieter and more flexible than its poppet-valve predecessor.

So far as restriction at the silencer is concerned, it may be said that as a result of over lubrication upon the part of some drivers made timid by the clamour set up about the difficulty of lubricating the sliding sleeves, many cases were brought to light where silencers had become choked as a result, and thus unduly restricted, reducing the power of the motor greatly. The remedy was simple—clean the silencer.

I suppose the heading "Engine Vibration," was inserted for the purpose of giving me an opportunity

to give vent to my pronounced ideas upon this subject.

I hold that nothing tends to cause vibration in a motor car so much as the constant lifting of poppet valves against the gas pressure and valve springs. The inner sleeve of a 38 h.p. Daimler motor weighs 10 lbs., and requires but 10 lbs. to start upward, as no resistance in shape of pressure is offered to it. While the mushroom valve of the poppet type of motor weighs but a fraction of a pound, it is held upon its seat by a spiral spring offering a resistance of at least 80 lbs. for this size engine, and when under full load at the opening of the exhaust stroke (estimating the pressure of the gases in the cylinder at 40 lbs. to the inch), there is further resistance of anywhere from 80 to 120 lbs. to the action of the cam, so that, despite all the care that can be taken in design and construction, these valve tappets are always giving trouble. In the 1908 R. A. C. 2000 Miles Trials, it is recorded that a car to which such great attention as had been devoted to the design of these tappets as that of the Rolls-Royce, found it necessary to break an otherwise clean engine record by a stop for the adjustment of a valve tappet.

But let us see what Lord Montagu said in regard to this at the now celebrated R. A. C. meeting in 1908, when giving his experience with the first 38 h.p. Daimler sleeve-valve engine ever produced, of which the Daimler Co. would now be as much ashamed as Rolls-Royce ever could be of the Silver Knave.

"The absence of engine vibrations was a very remarkable feature."

I say, and can demonstrate, take two motors of the same power (not dimensions), one of the poppet

and the other of the sleeve-valve type, produced by the same firm, using the same pistons, connecting rods, piston big end and other clearances, same length and diameter crankshaft and flywheels, mount them upon the same chassis, so they may be similarly sprung and working through the same universal and slip joints, and I will guarantee that the sleeve-valve type will have so much of the best of it that no impartial judge would hesitate for one moment so to decide.

This tendency alluded to of motors to emit smoke upon being accelerated after running idle for some time is by no means confined to the sliding-sleeve type. Such tendency may be charged against the lubricating system, which must, of course, be suited to the motor. If such is not the case, why do the Rolls-Royce engineers find is desirable to connect the lubricating system with the accelerator, so that an extra supply of oil is supplied when the motor is given heavy work? The answer is obvious. A motor does not consume the lubricant when not under load. If oil in the same quantity continues to be supplied when the motor is running light, the heat in the cylinder not being sufficient to consume it permits accumulation in various portions of the motor, and when the throttle is opened and a greater supply of gas is admitted, which in turn produces the necessary heat for the combustion of this less inflammable matter, the motor emits smoke until the accumulated oil is consumed.

Simplicity.

The arguments against the sleeve-valve engine as compared with the poppet-valve type seem to have been narrowed down to two contentions.

First, that the former is more likely to be subjected to breakages than the latter.

Second, that it does not hold any long-distance high speed track records.

Concede for the sake of argument the first claim (which is not a fact), where does it lead to? Simply to this: As there are some 3,000 sleeve-valve motors on the roads of England and the Continent at the present time, it is the easiest matter in the world to verify from the owners thereof our claim that the sleeve-valve engine requires by far less attention to keep going sweetly than the poppet-valve. Nothing but palpable neglect or defective construction, materials, or workmanship in the beginning will cause it to make trouble for the owner. Satisfied owners by the hundreds testify that the driving of these motors has brought them renewed delight in motoring, and the fact that four of the most sagacious engineering staffs upon this side of the Atlantic have endorsed, and not without considerable expense adopted it, is in itself evidence that there is something in the claims of superiority urged by its inventor. Are motorists, who are seeking for the greatest returns for the great amount of money they must spend for the enjoyment of motoring, going to be deterred from experiencing this new and admitted delight afforded by the new engine simply through fear created in their minds by competitors that one in a thousand may at some time during the life of a car experience a breakage that is covered by guarantee? If the other type were wholly free from such possibilities, there might be something in the argument. But it happens that the element, and practically the only element, which is likely to cause trouble with the sleeve-valve engine is also

a necessary feature of the poppet-valve motor as well, namely, the piston. One Rolls-Royce motor, for instance, in 1907 completed a 15,000 miles test with a clean record as to breakages. In the next competition a motor of the same make and type was put out of business through the seizure of a piston. It is claimed that the seizure of a piston in the sleeve-valve engine is likely to be more disastrous to the motor than if a similar accident occurs in the poppet-valve motors. Concede for the sake of argument only that this is a fact, the difference would be but a matter of degree. In either case, the result is likely to be a broken connecting rod, crankshaft, or perforated base.

If the public could be scared off through such arguments, where would the pneumatic tyre be today? It is recorded that the much heralded 15,000 miles trial of the Rolls-Royce car cost for labour, materials, and repairs £281 8s. 4½d., of which £187 12s. 6d. was for tyres alone. Think of the money saving that would have been made through the use of steel tyres, or even solid rubber tyres. Not only this, but consider if you will the matter of pneumatic tyres from the standpoint of roadside troubles. So absolutely certain are these difficulties recognised to be that time allowances are made for them in practically every competition, and, in some cases, are unlimited. Why not dispense with them and eliminate nine-tenths of the motor car's disadvantages and expense?

You will say at once, it is the pneumatic tyre which makes motoring sufficiently attractive to induce people of means to take it up. They are willing to accept the pneumatic tyre with the positive knowledge that it is the source of both enormous trouble and expense, because the additional pleasure it affords off-

sets with an enormous margin to the good its great disadvantages.

One lady, among the first purchasers of the new Daimler cars, put the matter very aptly when she delightfully exclaimed after a demonstration: "I would by that car if I knew positively that it would wear out in three months."

If the article were written for the purpose of affording me an opportunity of placing before an interested public upon the eve of Olympia a lot of information concerning the sleeve-valve motor, its author can certainly consider that he has accomplished his purpose.

If it were written, as some are uncharitable enough to suspect, by a competitor as the opening up of a systematic campaign of malicious misrepresentation (such as brought about the six days' bench test and the 2,000 miles tract test of April, 1909), for the purpose of endeavouring to divert from the sleeve-valve the tremendous tide of patronage which its two years' performance in the hands of the public has turned in its direction, the effort will fail, because the people who two years ago refused to be misled are now in a hundred times better position to judge the merits and demerits of this system, and less likely to sympathise with such tactics.

The Six-Cylinder Question.

The author, in touching the six-cylinder question, says, among other things:

"Indeed, there is good reason to doubt whether it is possible to build a satisfactory six-cylinder engine on the sleeve-valve system."

I might reply that there are dozens of designers and manufacturers who doubt very much if it is possible to build a satisfactory six-cylinder engine upon any system, particularly if such engine is permitted to develop power commensurate with its piston displacement. The problems of a six-cylinder of the sleeve-valve type are no different from those of the poppet-valve type, and in the past have been the cause of dozens of designers dropping the matter after a few attempts to make a six-cylinder motor both silent and efficient. This assertion can be most clearly substantiated by reference to the letter which Messrs. Rolls-Royce addressed to the Press November 7th, 1908, in which they, with elaborate care, advised the public that the two cars specially constructed for the 1908 Trials (one of which survived the competition) "being built for efficiency, power, and high speed, they had decided to abandon for these particular cars the methods by which noise had been eliminated in standard Rolls-Royce cars," and that "the survivor is so noisy that our standard Rolls-Royce cars when they pass her in the street turn their heads, as it were, stop their ears, and turn color with shame."

Any manufacturer who sees fit to "abandon efficiency" and build a six-cylinder motor possessing only about two-thirds the power of a four-cylinder engine of the same piston displacement, can secure a fair amount of silence. But silence purchased at such cost does not find a large market, especially in England, where there is room for not more than one such concern of comparatively modest pretentions.

But this silence is not obtained alone at the expense of efficiency, if the selling price of the car is any index to the time and labor required to produce

such results. Making a silent six-cylinder poppet-valve motor is a tremendously extravagant process, both from the standpoint of efficiency and pounds, shillings and pence.

The reason why a six-cylinder, when efficient, is in certain particulars more noisy than a four-cylinder of the same type is well understood by advanced motor engineers, who well know that the entire question is one of vibration aggravated in proportion to the explosion pressure, the result of the great length of crankshaft necessary. In a poppet-valve engine these vibrations are drowned by the valve clatter if through an effort to secure efficiency these explosive pressures are not too great. But permit sufficient compression to be employed to ensure efficiency and these vibrations make themselves heard and felt even above the din of the valve clatter.

Until within the past few months no manufacturer has ever succeeded in wholly overcoming this vibration in an efficient six-cylinder motor. It has remained for the sliding-valve engine within the past few weeks to demonstrate that this can be accomplished, and the successful achievement will mark an epoch in six-cylinder motor construction, and, I predict, be the sensation of Olympia, at which time such a motor will for the first time be demonstrated although not exhibited.

Large Sized Engines.

The writer further says:

"I am sure that no manufacturer building internal combustion engines would think of building engines of large size with the sleeve system, and what is objectionable in a large size of engine is also objectionable to a less degree in a smaller size engine."

Upon what authority, I ask, does the writer pen the above paragraph? Certainly he must have a most remarkable gift for divining thoughts of others!

Permit me to say, however, that he was never more mistaken about anything in his life. The Daimler Company, for instance, have made all arrangements to build slide-valve engines of large capacity for stationary work, and the only circumstance which has held them back is the fact that so tremendous has been the demand for cars equipped with these motors that, despite their more than doubling the capacity of their works, and employing, according to the Chairman's statement at the recent general meeting, 4,290 men, they have not been able to keep abreast of this demand, let alone branching out into new fields.

Suffice it to say, this company have replaced the poppet-valve type of engine with the sleeve-valve in every line of its present production. The Renard trains, weighing from sixteen to twenty tons, which proceed along the highways at a rate of four miles per hour with the engine turning under full load at 1,200 per minute, are equipped with sleeve-valve motors; the railway cars which they have constructed for service on the London and Brighton Railway are similarly equipped; and their new combination petrol-electric 'bus, which requires an engine which can be depended upon to work constantly up to 2,000 revolutions per minute, is also equipped with the sleeve-valve motor.

In the cases of the Renard trains and railway cars the poppet-valve motors which were previously in service have been scrapped and the sleeve-valve type substituted.

What more is necessary to demonstrate the faith in the sleeve-valve type of the concern which has produced up to date more than 3,000 motors of various sizes from 6 horse-power up to 57?

Records Held by Poppet-Valve Engines.

Isn't it asking considerable to expect that in the short period of two years, with, up to within very recently, only two manufacturers in a position actually to deliver cars, both of whom have been up to their eyes in profitable orders—isn't it rather too much to expect that these two could during this short space of time march forth and wrest from the grasp of the hundreds of makers of the old type every record, particularly when it is realized that the makers of the other type, thanks to a large proportion of the public's preference for the sleeve-valve, are not generally so closely confined to their works, and have plenty of time fairly to "live on the job" of high-speed track competitions.

But I have demonstrated, I believe, that there are at least two most important records which the poppet-valve does not hold, viz., the fuel consumption record and the record for the ability to run continuously under a thirty-three per cent. overload for a period of five and a half days, then 2,000 miles in a standard car upon Brooklands at an average of over forty miles per hour, equivalent all round to more than 10,000 miles of track work at a speed close upon fifty miles per hour; then, returning to the bench for a final five hours' test, show increased power, without a single adjustment or repair of any kind to the mechanism, and at the end of the competition the judges pronounce both motors free from perceptible wear.

Compared with such work as this, 15,000 miles

upon the road at the legal limit is mere child's play. In the case of the 15,000 miles road trials, the 48 h. p. motor need develop not more than an average of 20 h. p. in order to pull the car an average of twenty miles per hour. This small power at the rate of consumption secured would require a cooling ability of the motor to care for less than one gallon of petrol per hour!

Place this same 48 h. p. six-cylinder motor in the position of the sleeve-valve engine on the bench, require it, in order to conform to the rules of the test requiring 1.3 times the rated h. p., to develop 62.4 h. p. as a minimum, and in order to come up to the sleeve-valve excess over this requirement, actually to develop 70 h. p. for 132 hours straight, requiring an ability to cool the motor through which is passed seven gallons of petrol per hour instead of one, as on the road, in this 15,000 miles trial, and keep it up day and night, what would result? Dare the makers attempt it? Where is there any comparison between the performance of these two motors—one under the easiest possible conditions, the other crowded into the severest test that could be devised?

I fear our friends, the enemy—assuming for the nonce that the article came from an enemy—are likely to be as much surprised at the result of their efforts to discourage the public from purchasing cars equipped with sleeve-valve engines as was the American professor at the decision of his class of young men, to whom he was endeavoring to convey an awful warning.

"Young men," quoth he, holding aloft a large photograph of the world's leading billionaire, "here we have an example of the evils of a constant desire

to acquire this world's goods in great quantities. Here is a man worth a billion dollars. His income is so great that he couldn't shovel it away in gold sovereigns. But look at his face; note the deep furrows which years of anxiety have impressed thereon; see, he hasn't a single hair upon his head; he has, I am told, no teeth; he has no close friends because he fears no one loves him except for his money. His health isn't the best.

"Now" (eyeing with great pride and satisfaction his class of a score of stalwart, bright-eyed and vigorous American young men)—"Now, I say, how many of you would change places with this man?"

There was no hesitation upon the part of his class. With one accord they sprang to their feet to a thunderous acclaim shouted—

"I WOULD!"

It seems to me that some of the advocates of the poppet-valve motor have undertaken to impress an awful warning upon the motoring public of the United Kingdom. They have said in effect to the people:

"Here we hold up in front of you an awful example in the shape of a new motor which several companies who ought to be more considerate to us are endeavoring to market. We don't know much about it except from the picture; it is evidently quiet; it looks as if it would produce power; it is said to be charming to drive, and affords the motorist a new pleasure in life; but we hear it won't lubricate; it has been known to smoke when suddenly accelerated; and while it has undergone an official endurance test which none of us dare undertake, that doesn't amount to much, and it doesn't hold any high speed records, and it might seize if you try to run it a hundred and twenty miles an hour.

"Now, we say, who of you, in face of all these grave allegations, would exchange your old reliable but noisy poppet-valve motors, which give no end of trouble, but never, NEVER, NEVER break, for one of these new-fangled inventions?"

And to judge from the crowded condition of all the works producing the sleeve-valve engine, the motoring public have risen almost to a man, and with thunderous acclaim shouted—

"I WOULD!"

Charles Y. Knight.

Coventry, October 18th, 1910.

The Knight Engine

and

The Packard Motor Car Company

FOREWORD.

No inventor of an epoch-making improvement having commercial value, it is popularly believed, has been entirely free from attempts on the part of others to appropriate the fruits of his labor. Recent developments indicate that the inventor of the Silent Knight internal combustion engine is no exception to a custom which would be "More honored in the breach than in the observance."

The adoption of the Knight engine by such leaders in the Automobile world as Mercedes, Panhard, Daimler and Minerva created such a stir in the European Trade Journals as to attract the attention of leading American manufacturers, some of whom sent representatives abroad to make an investigation. Among these was the Packard Motor Car Company, and so well were they pleased with what they saw and learned that they made an effort to secure it in a manner which we shall not characterize, but leave for the judgment of the reader.

The different stages of this little story are given in chronological order, beginning with an article by the Packard Motor Car Company, published in the Motor Age of February 10, 1910, followed by a reply on our behalf by Mr. F. E. Lonas, who is carrying on the negotiations for the granting of licenses in the United States for us, which appeared in the same publication on February 17, 1910. A brief article by the inventor of the Reeve steam engine, acquired by the Packard Motor Car Company, is also given. This we have not deemed of sufficient importance to dignify with a reply. A short article from the Automobile is also included, as well as two articles published in the

London, England, Autocar, the whole being preceded by a brief description and drawings showing the general construction of the Knight engine.

We have put this little story in pamphlet form for the benefit of our customers and present and prospective Licensees in the hope that they will find it an interesting contribution to the history of a phase of our American commercial ethics which it is sincerely to be hoped will soon disappear.

KNIGHT & KILBOURNE.

Chicago, Ill., April 20, 1910.

DESCRIPTION OF KNIGHT ENGINE.

In order that a proper understanding may be had of the Knight engine we give the following description:

Figure 1 is a sectional elevation of the engine cylinder.

Figures 2 and 2[a] are views showing the position of the ports at four points of the cycle.

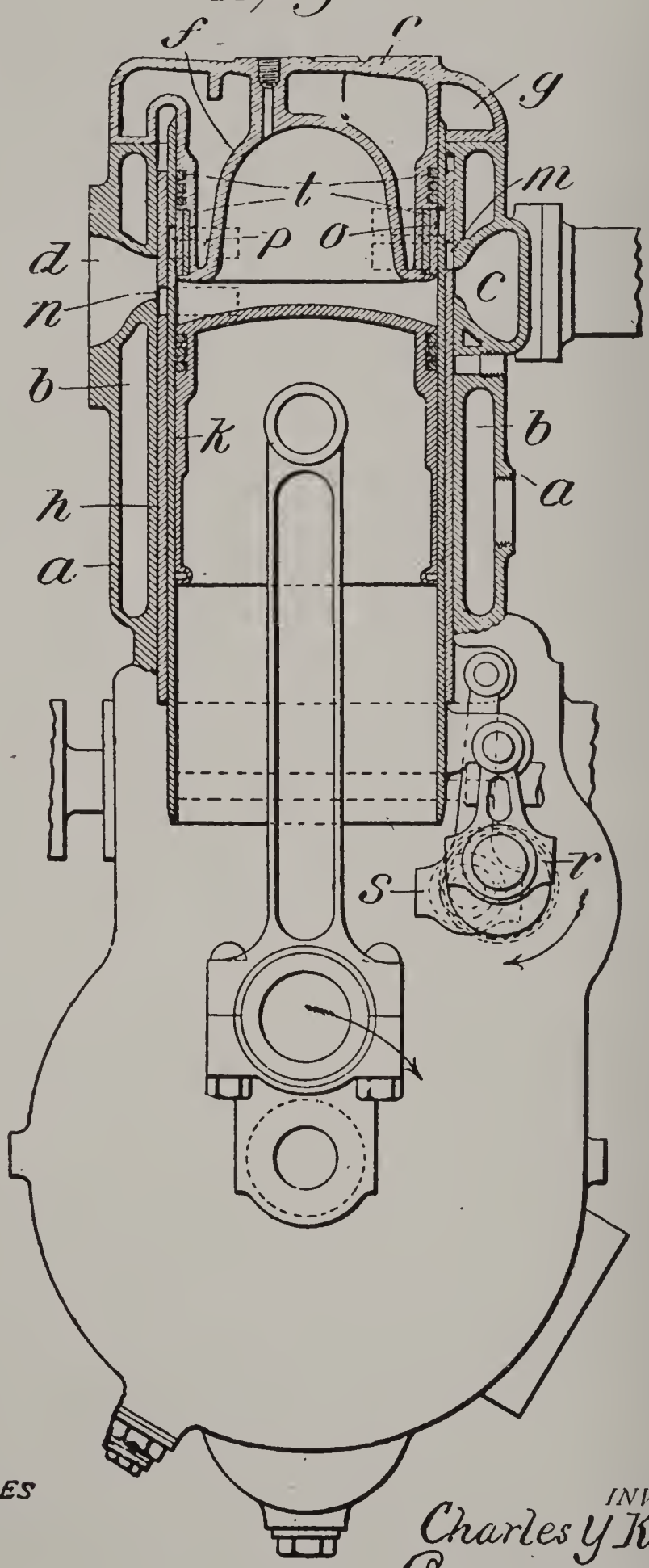
In the construction shown in Figure 1, suitable for a petrol engine working on the ordinary four stroke cycle, we construct the straight part *a* of the cylinder with a water jacket *b* along its whole length, and form the inlet and exhaust ports *c d* respectively, through the water jacket at the combustion chamber end of the straight part *a* of the cylinder. The end of the cylinder is closed by a water cooled head *e*, having a water cooled part *f* projecting internally, forming a groove *g* with the straight part of the cylinder. In this groove the ends of sleeves, *h*, *k*, slide. These sleeves are provided with ports *m*, *n* and *o*, *p*, adapted to register with the ports *c* and *d*, respectively, in the cylinder at parts of their movement for the purpose of obtaining the inlet and exhaust to the cylinder, as hereinafter described. The sleeves *h*, *k*, are actuated by means of a pair of eccentrics, *r*, *s*, one of which operates the outer sleeve *h*, while the other operates the inner sleeve *k*. The eccentric *r* in this form is placed 90 degrees ahead of the other eccentric *s*. Rings *t* are provided in the internal projection *f*, from the head of the cylinder, and bear against the inner sleeve *k*, forming a gas tight sliding contact. The eccentrics actuating the sleeves rotate once every two revolutions of the main shaft.

The cycle of operation of the engine is as follows:

Supposing an explosion has taken place in the engine, and the piston is moving in its working stroke from the position shown at A, Figure 2, when the piston has moved to within about 50 degrees of the end of its out stroke, the port *n*, in the outer sleeve *h*. is almost in exact register with the port *d* in the cylinder, but is still moving slowly upwards, while the inner sleeve *k* is moving downwards rapidly, as shown at B. Figure 2. The port *p* in the inner sleeve *k* quickly passes the edge *u* of the water cooled projection *f*, on the head of the cylinder, opening a straight exhaust passage through the two sleeves and the cylinder. During the rapid downward movement of the inner sleeve *k*, and outer sleeve *h* passes its dead center and begins to move slowly downwards. When the piston has moved through about 90 degrees from its out center on the exhaust stroke, the downward movement of the outer sleeve *h* becomes rapid, quickly reducing the opening for exhaust, until it cuts off the exhaust at the cylinder edge *v*, which is water cooled, just after the piston has passed its in center, the inner sleeve *k*, during this period having passed its lowest position, and begun moving slowly upwards, as shown at C. Figure 2[a]. The rapid downward movement of the outer sleeve *h* also brings the inlet port *m* in that sleeve into register with the inlet port *s* in the cylinder. The straight through inlet is thus open to practically its fullest extent when the piston is in the middle of its downward stroke. At this position the upward movement of the inner sleeve *k* is at its greatest velocity quickly cutting off the inlet, the cut-off being effected by the travel of inlet port *c* over wide head ring *t*, after the piston has

passed its out center, as shown at D, Figure 2[a]. The compression stroke then commences, the inner sleeve *k* moving slowly to its upward position, while the outer sleeve *h* moves upwards. At the end of the compression stroke the outer sleeve is moving rapidly upwards, while the inner sleeve just reaches its highest position coming back to the position shown at A, Figure 2. During the explosion stroke, the exhaust port in the outer sleeve moves down into position to register with the exhaust port in the inner sleeve which is gradually moving downwards, its velocity increasing to rapidly open the through exhaust passage, as above described.

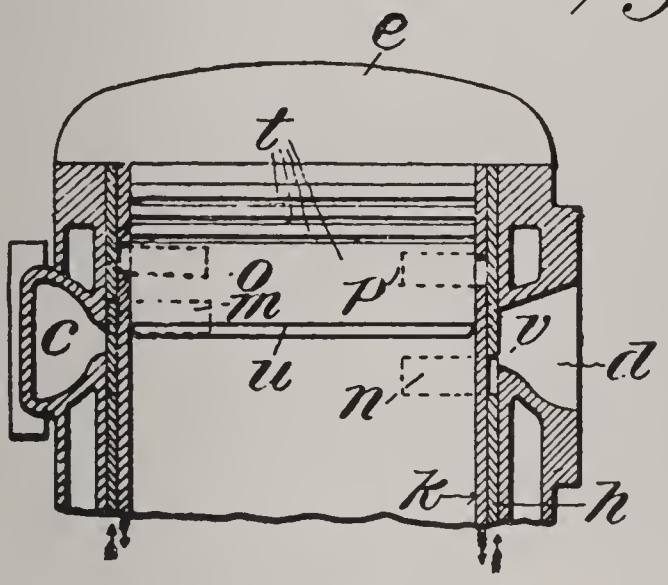
Fig. 1.

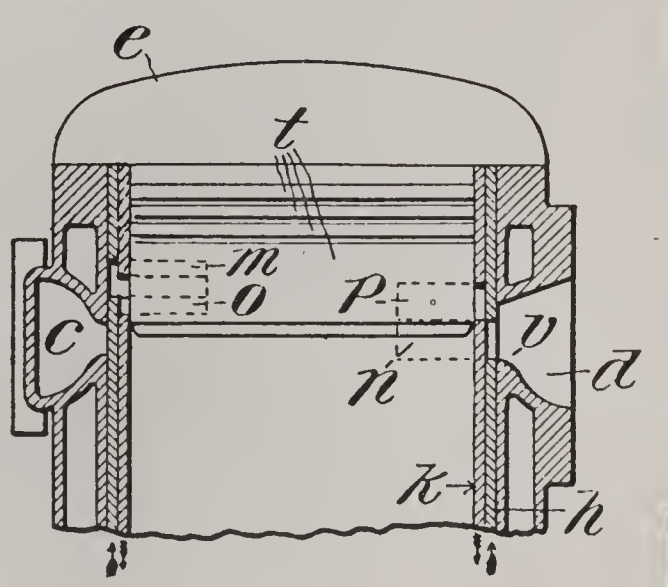


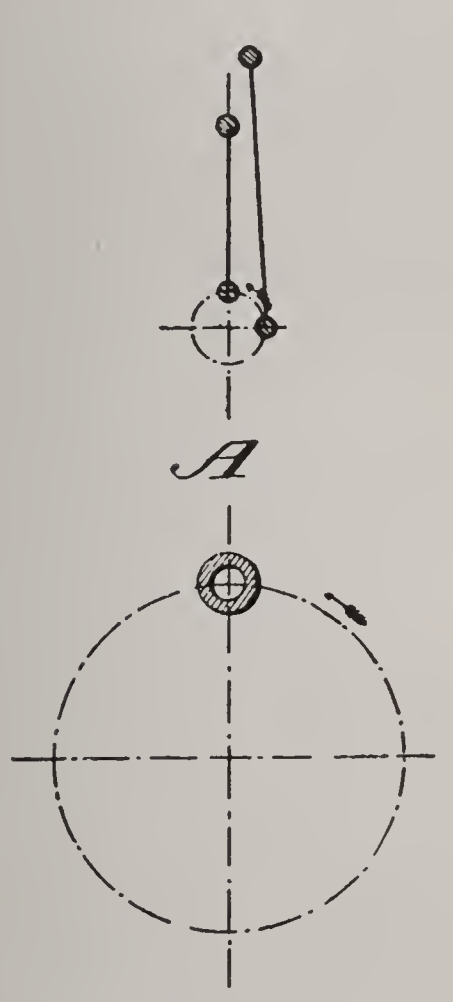
WITNESSES

INVENTOR.
Charles Y Knight.
Brown Hopkins
Attorneys

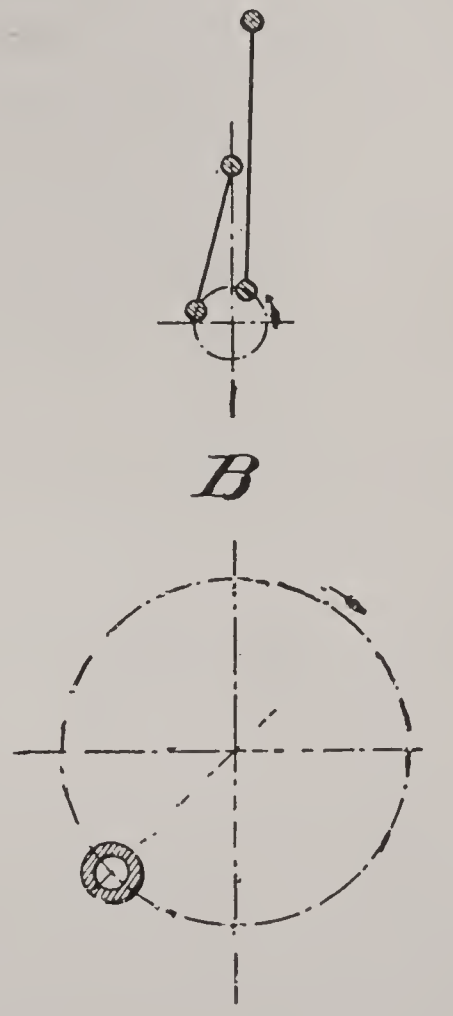
Fig. 2.







A



B

WITNESSES

INVENTOR
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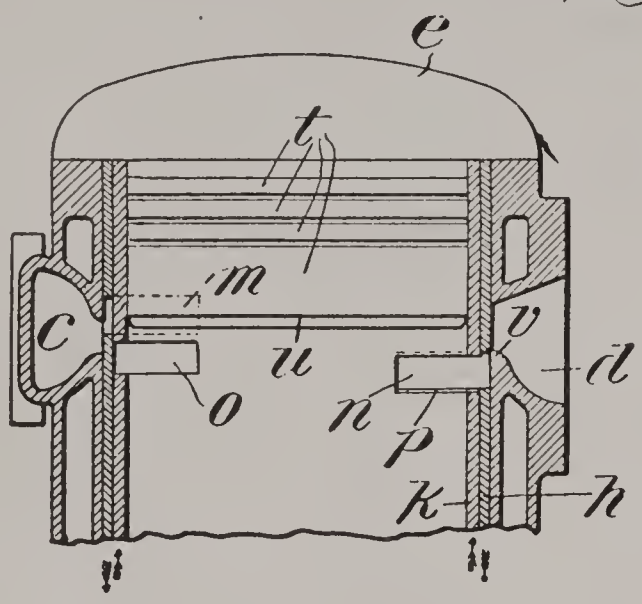
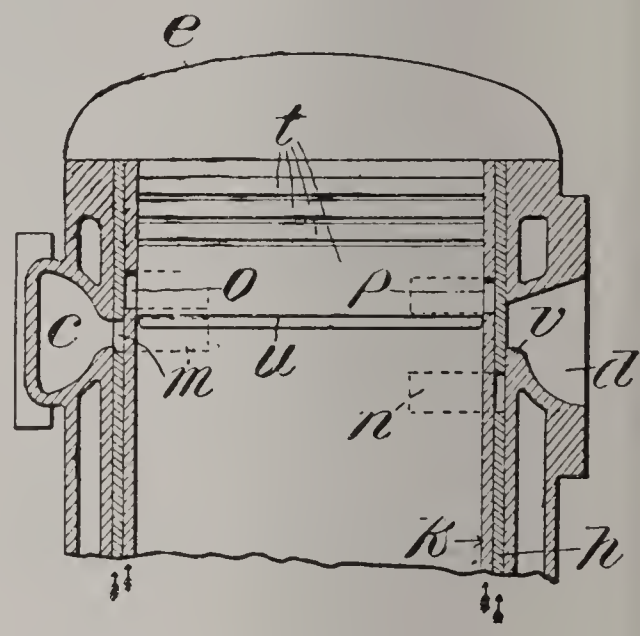
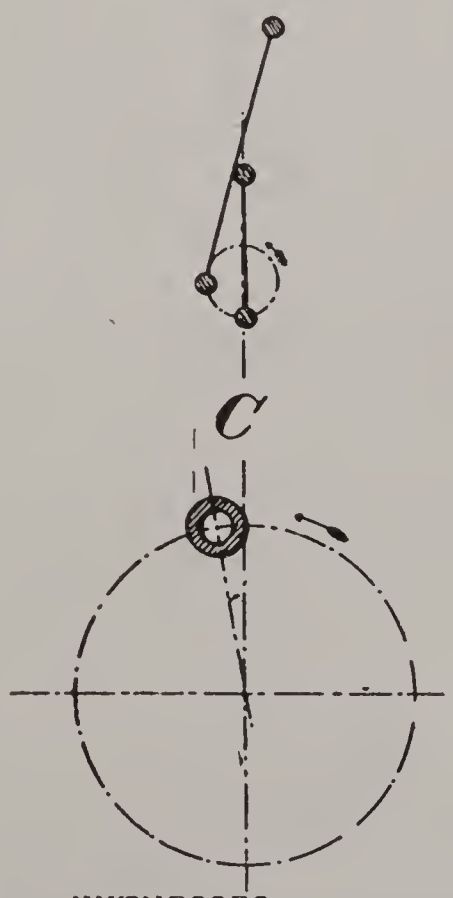
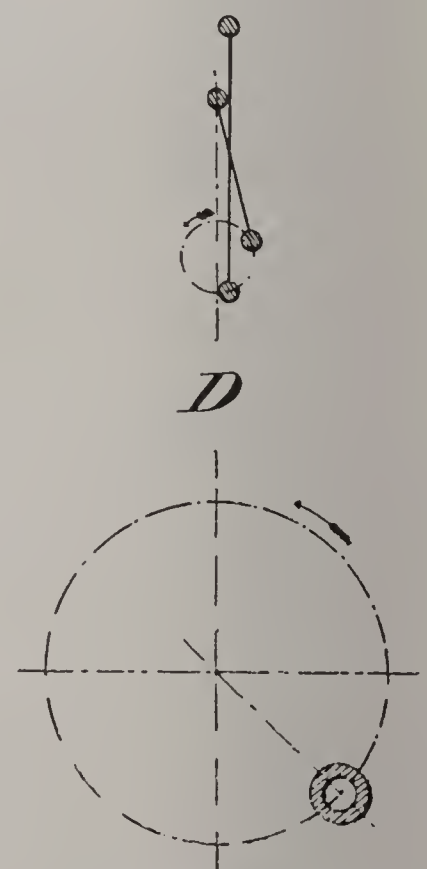
Fig. 2a









WITNESSES

INVENTOR
Charles G Knight
Brown & Hopkins
Attorneys

PACKARD CLAIMS SLIDING-VALVE PATENTS.*

Detroit, Mich., Feb. 9.—A considerable furore in motoring circles was occasioned here today by the announcement made by a representative of the Packard Company to the effect that that concern controls basic patents covering the slide-valve or double-sleeve-valve type of motor, the report going still further to state the Knight motor is an infringement of the patent the Packard Company controls. It appears that the patent in the possession of the Packard Company was one for which application was made in 1901 by Sidney A. Reeve and which patent was reissued Letters Patent No. 12,991. The report further states that Charles Y. Knight, inventor of the Knight motor, which has been introduced in England, France, Germany and Belgium, controls no United States patents covering the construction of the motor.

Development of Knight Motor.

The Knight motor was introduced commercially in America in 1905 by Knight & Kilbourne, Chicago, which concern engaged in the manufacture of this motor up to the present. In November, 1907, Inventor Knight took his motor to England, where license for its manufacture has been purchased by the Daimler Company, which concern is now manufacturing this motor and using it exclusively in all of its models. The motor was later adopted by the Panhard Company, of France; the Mercedes Company, of Germany, and the Minerva Company, of Belgium. The success following the use of this motor abroad as a

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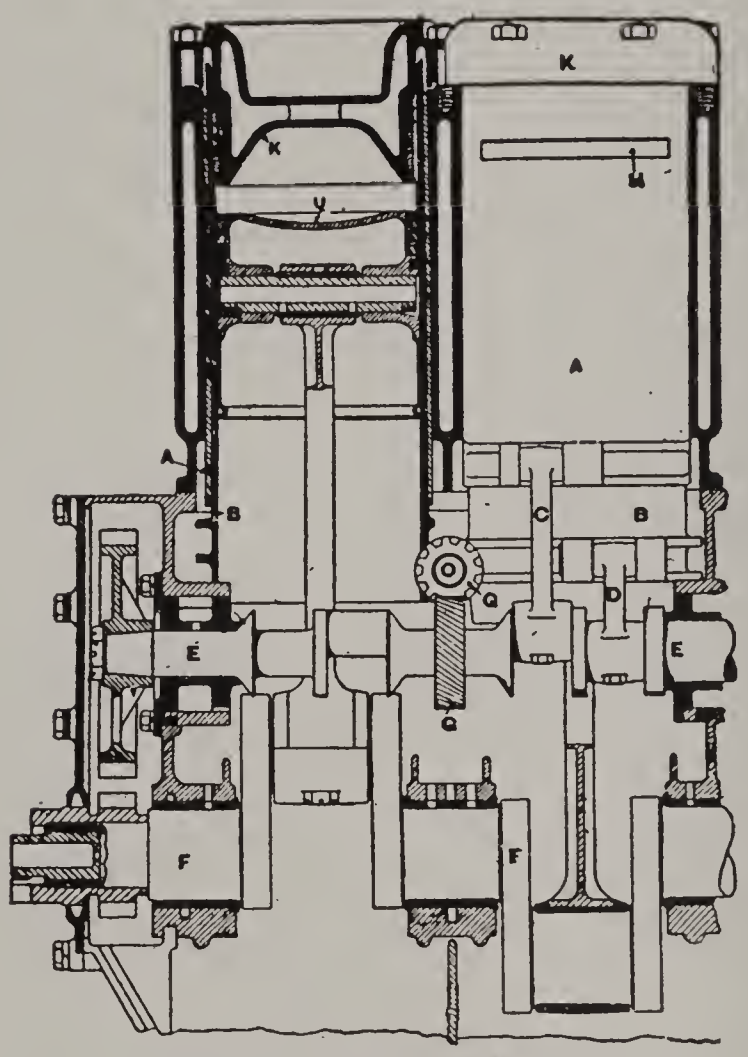
* Reprint of article from Motor Age of Feb. 10, 1910.

substitute for the standard form of poppet-valve engine resulted in an effort to introduce the motor into this country and it is a matter of apparent rumor that several of the larger American concerns have investigated the matter carefully with this object in view.



Knight Daimler Motor.

Claims No American Patent.

The exact basis on which the Knight interests wish to introduce the engine among American motor car manufacturers has never been publicly stated. It is known, however, the Packard representative states that no United States patents on this type of motor have been granted to Charles Y. Knight, although it is generally understood that applications for patents are now pending. Such patents necessarily would be subordinate to the Reeve patent.

Now comes the surprising fact that among the numerous patents in the control of the Packard Company is re-issued letters patent No. 12,991, granted to Sidney A. Reeve and for which the original application was filed September 20, 1901. The claims of this patent, it is reported, not only broadly cover engines of the double-sleeve-valve type, but the actual construction of the Knight engine as it was made in this country and the later improved design of the Daimler Company.

The Packard Company, naturally conservative in the matter of publicity, is reticent upon the subject. A representative interviewed by Motor Age said that the facts in the case speak for themselves and that there was little to add except that the Packard Company is not greatly interested in sleeve-valve motors beyond general experiment such as has been applied to a whole lot of things that were never adopted.

Features of the Motor.

The essential features of the sleeve-valve motor, such as the Daimler, are the outer cylinder, the piston and the two sleeves operating between the cylinder and the piston and having ports adapted to register at the proper times to permit the charge to enter the cylinder and the exhaust gases to be expelled. These valve-sleeves are moved up and down by eccentrics on a shaft arranged parallel with the motor crankshaft and this eccentricshaft is driven by half-time gearing, similar to the camshaft of an ordinary poppet-valve motor.

The sleeves are so timed in their operation that when the piston starts to descend on the intake stroke, the ports on the intake side of the sleeve are just com-

ing into register with each other and with the inlet port of the cylinder. These three ports remain in register during this entire stroke of the piston. On the compression stroke the sleeves have moved sufficiently, relative to each other and to the inlet port, so that none of the ports of the motor are in register during the compression stroke and the greater part of the firing stroke. At the end of this period, the ports on the exhaust side of the sleeves come into register with each other and with the exhaust port in the cylinder and remain so until the end of the exhaust stroke, allowing the exhaust gases to be expelled by the piston. The cycle is then repeated. In function, it is exactly the same as the cycle of the ordinary poppet-valve motor.

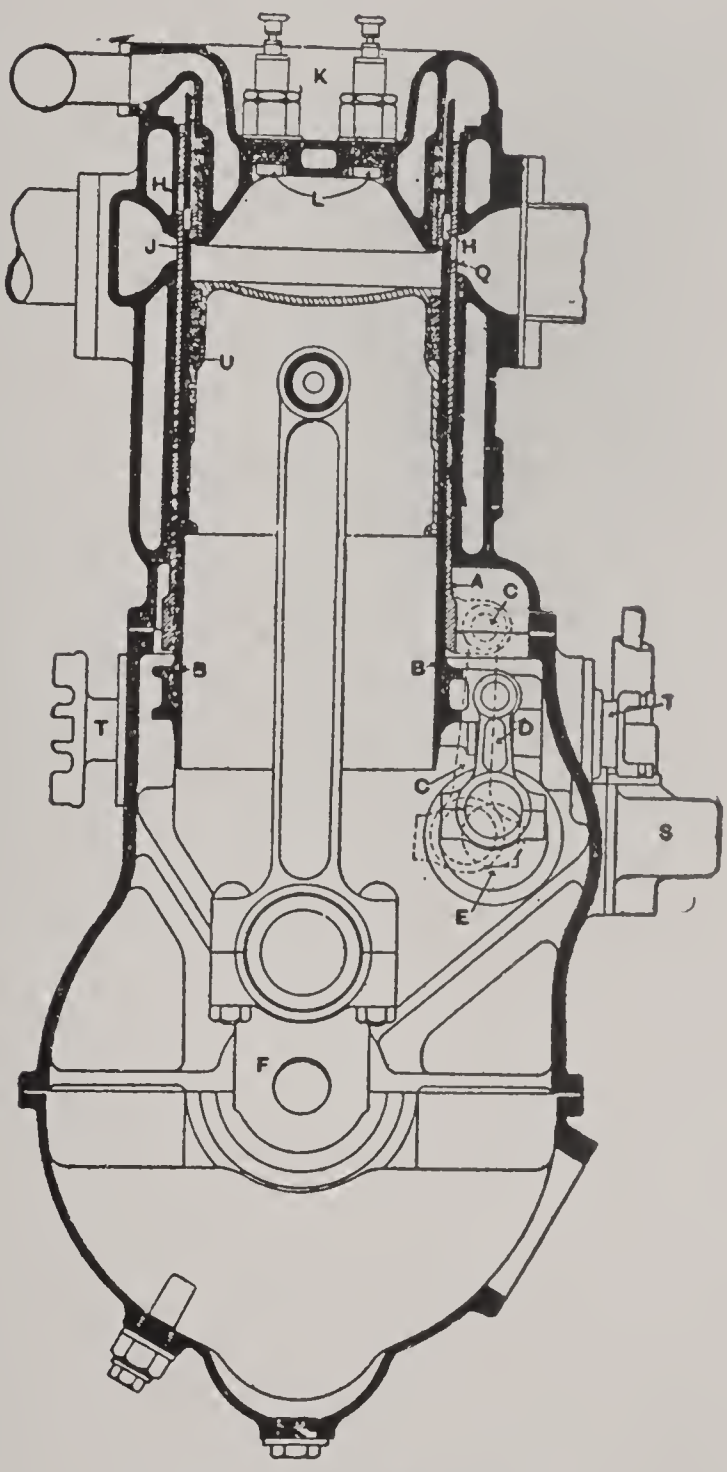
As compared with the motor built by Mr. Knight in this country in 1905 and described in Motor Age of October 26, 1905, the Daimler motor has omitted the offset crankshaft feature of the earlier model and uses but one exhaust port, where the earlier model used both main and auxiliary exhaust ports. Aside from these differences there are detail changes of refinement which are unimportant.

The Reeve Patent.

Referring now to the Reeve re-issued patent No. 12,991, the original application for which was filed September 20, 1901, it seems that twenty-five or more of the sixty-four claims in the patent cover practically all motors in which there are two sleeves sliding between the piston and the cylinder and controlling the inlet and outlet ports of the cylinder. One of the simplest of these claims is No. 36, as follows:

"The combination of a casing, a reciprocating piston, and two cylindrical valves surrounding the piston and operating one upon the other."

Referring to the drawing of the Daimler motor, it may be noticed that the "casing" of this claim is



Section of Knight Motor.

represented by the cylinder of the Daimler motor; the "reciprocating piston" by the piston U, and the "two cylindrical valves surrounding the piston and operating one upon the other" by A and B.

Claim No. 39 reads as follows: "The combination of an axially-movable cylinder-valve, a piston reciprocating therein, and a sleeve-valve movable on the outside of the cylinder-valve."

The "axially-movable cylinder-valve" of this claim is represented by the inner sleeve-valve B, of the Daimler motor; the "piston reciprocating therein" by U, and the "sleeve-valve" by the outer sleeve A.

Another simple claim is No. 62, as follows: "The combination of a casing and a reciprocating piston therein, a plurality of non-seating annular valves arranged between the piston and the casing, and means for independently moving said valves."

The "casing" is represented in the Daimler motor by its cylinder and the "reciprocating piston" by U. The "plurality of non-seating annular valves" are represented by the sleeve valves A and B, these sleeve valves being "arranged between the piston and the casing." The "means for independently moving the valves" are represented by the Daimler eccentricshaft and the gearing and small connecting rods.

KNIGHT ANSWERS PACKARD PATENT CLAIM.

EDITOR'S NOTE.—This defense of the status of the Knight sleeve-valve motor is by F. E. Lonas, attorney for Knight & Kilbourne, owners of the Knight patents, and is in reply to a statement given out by a Packard representative and published in last week's Motor Age to the effect that the Packard Motor Car Co., by owning the Reeve patents governing slide valve mechanisms, controls the slide valve situation in America.

Chicago, Feb. 15.—Editor Motor Age.—Claims made by a representative of the Packard Motor Car Company in Motor Age last week that it owns basic patents on sleeve-valve engines for the United States and that the Knight engine is an infringement of patent No. 12,991, reissued to Sidney A. Reeve on July 13, 1909, contains so much that is untrue and omits so much that is true, and the intention to intimidate and deter other manufacturers from taking licenses to manufacture Knight engines in the United States is so manifest, following, as it does, a veiled threat of the Packard attorneys, in their letter to us of October 30, 1909, that they "should prevent the issuance of any claims to Knight by the United States patent office" if Knight & Kilbourne did not accede to its demands, that in justice to Knight and Kilbourne and the motor industry of the United States I cannot permit it to pass without giving a history of the entire transaction.

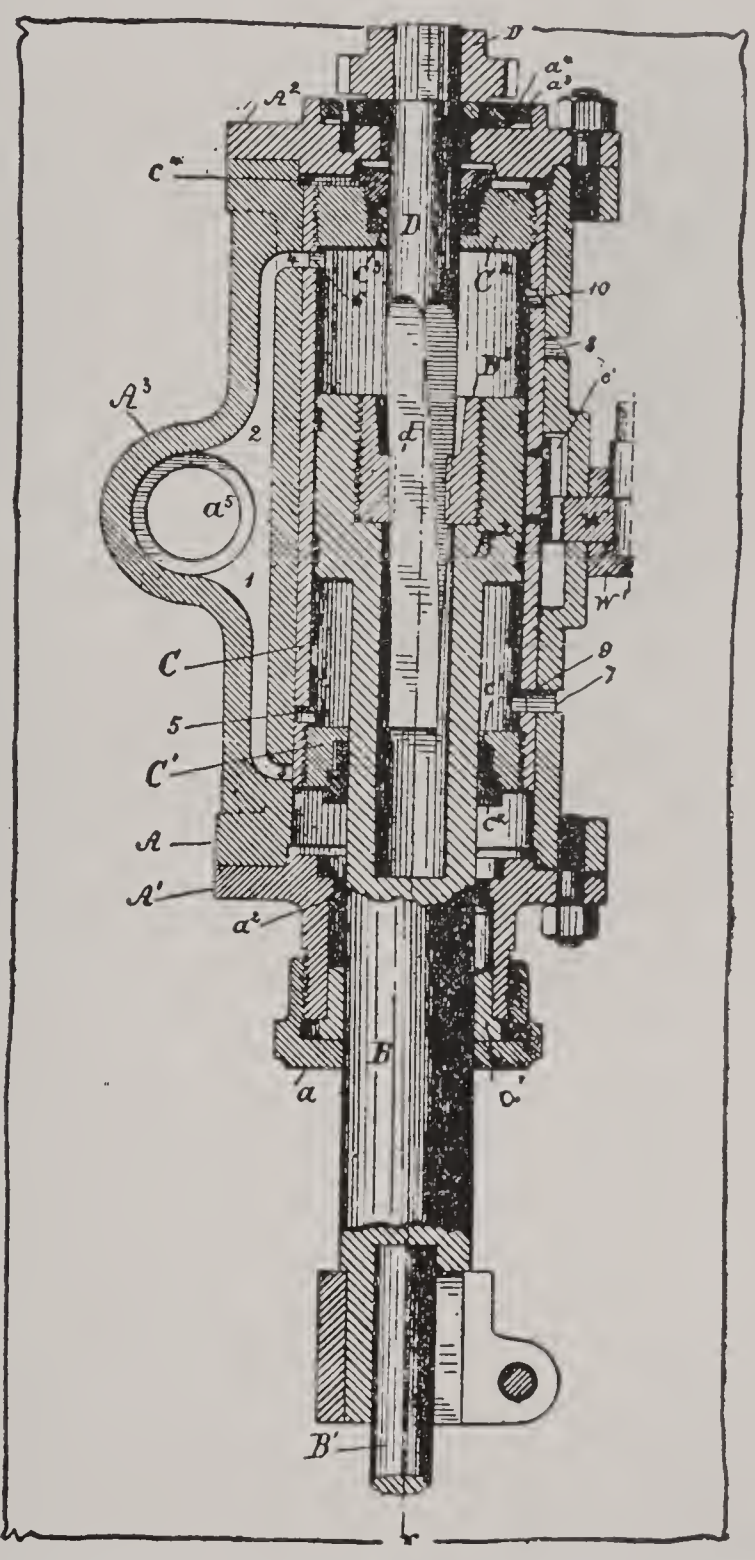
Mr. Knight, at the time this Packard interview was published, was on the ocean bound for England. In the absence of Mr. Knight the duty devolves upon me to answer this attack, and while I cannot hope to do the subject the justice that Mr. Knight could, I will endeavor to show the attitude of the Packard Company by a plain statement of what transpired between it and Knight & Kilbourne. For a proper understand-

ing of what has occurred a brief history of the Knight engine and its success, is, I think, essential.

First Announcement in 1908.

The formal announcement of the adoption of the Knight engine by the Daimler Motor Co. of England was made in September, 1908. Within 60 days after this announcement a number of leading motor car manufacturers of the United States had representatives in England to investigate the merits of the Knight engine. One of these representatives was the chief engineer of the Packard Company, who was received and entertained by Mr. Knight at his home in Coventry. Through the kindness of the Daimler Company Mr. Knight was permitted to take him through its plant and show him every process in the manufacture and testing of Knight-Daimler engines. Mr. Knight and the Daimler Company believed he would treat the information as confidential and respect the rights of Knight & Kilbourne. Arrangements were made by which the Packard and other interested companies should be supplied with engines for test by the Daimler Company at cost, at a time when it was in need of every engine it could build to supply its own customers. The sample engine was shipped to the Packard Company early in January, 1909, its chief engineer having returned to the United States in December, 1908. While in England he visited the motor car show in London, where he saw the tremendous sensation created by the exhibition of the Daimler and Minerva cars equipped with Knight engines, these two companies monopolizing the attention of all visitors. He also was informed that Panhard & Levassor had secured an option for the French

rights to the Knight engine, and that negotiations were under way with the Daimler Motoren Gesellschaft, the famous German firm founded by Gottlieb Daimler, and the manufacturer of the Mercedes car, for the German rights.



Uren U. S. Patent No. 303,334, August 12, 1884.

A Significant Fact.

Particular attention is directed to the significant fact that, according to the certified copy of the Reeve

reissued patent, Reeve, on February 9, 1909, within less than two months after the return of the Packard engineer from England, and within less than one month after the receipt of the Knight engine, made affidavit to an application for a reissue of his patent No. 880,824, of March 3, 1908. The fact, admitted to us by the attorneys of the Packard Company who had charge of the matter, that this application for a reissue was made by Reeve at their instigation, and under their direction and supervision, through a New York patent attorney in order that the connection of the Packard Company might not be known, furnishes illuminating evidence as to the reason for Reeve's assertion that he had not claimed in his original patent all that he had invented. It also furnishes illuminating evidence that he had not discovered, until then, what Knight had invented. As to the validity of the Reeve reissue and the methods by which it was secured I call attention to the facts, and a few decisions of the United States supreme court which, I think, will show a reader unlearned in the law the Packard claims are unfounded.

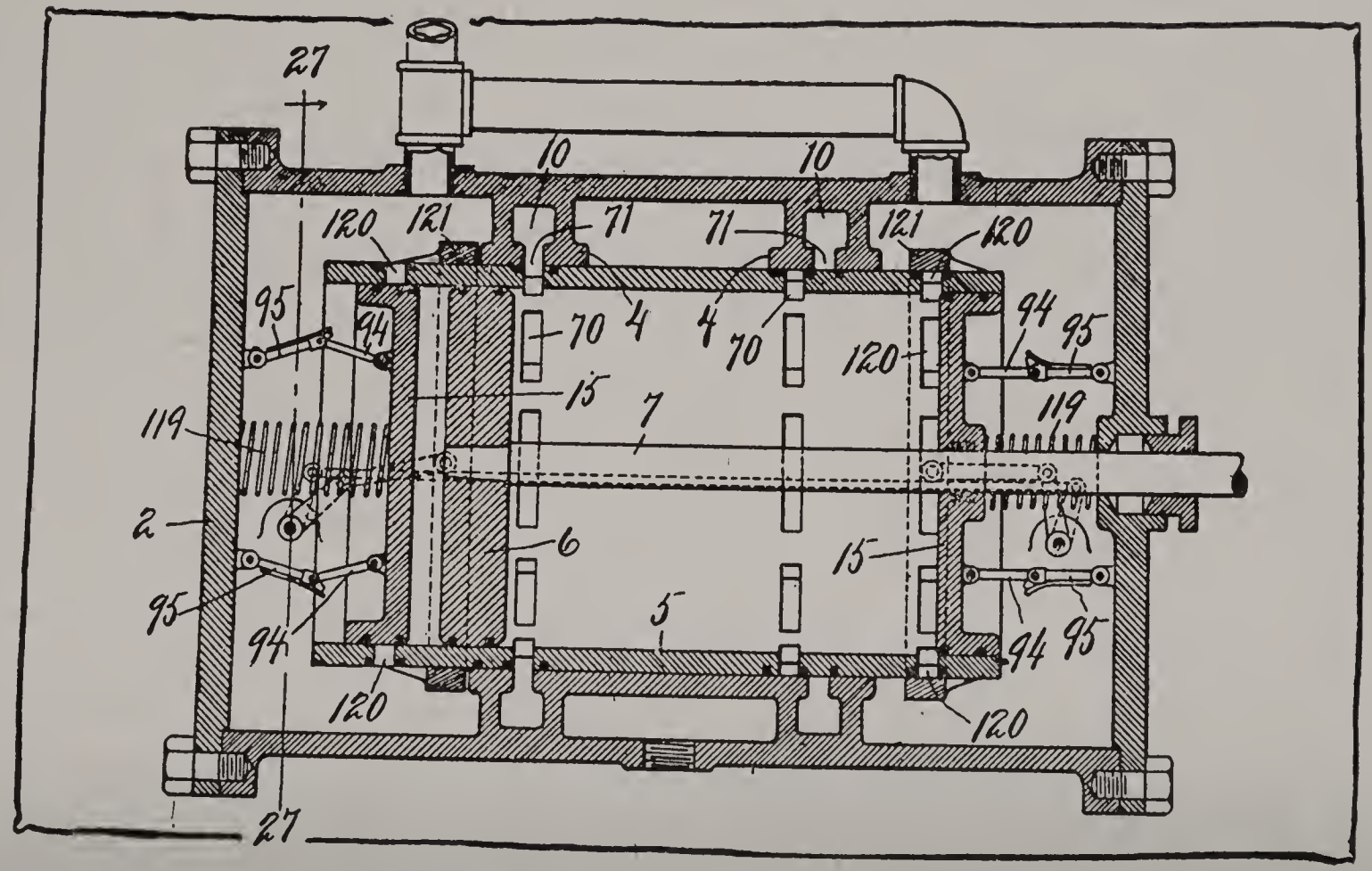
It is a significant fact that when the Packard Company advanced its claim to the Knight invention, under the Reeve patent, it did so in connection with the Knight drawings instead of the Reeve drawings. In order that the public may judge for itself, we furnish herewith a photographic copy of Knight's patent office drawing and a copy of the main drawing of the Reeve patent.

Descriptions of the Knight engine have been published. In a word, it consists of two telescoped sleeves, both having ports, and each receiving a definite valving motion from an eccentric properly

timed according to the four-cycle principle and operated from the crankshaft. Both sleeves slide within the main cylinder, which has a fixed head projecting down into the inner sleeve and carrying the spark plug. This head closes both the intake and the exhaust ports of that sleeve. The piston performs its usual working stroke entirely within the inner sleeve. During the compression and explosion strokes, the inner sleeve is hermetically closed above by the fixed head and below by the piston, so that the charge is fully compressed without loss, and when the explosion occurs its full force is exerted directly against the piston in a perfectly cylindrical combustion chamber having neither side chambers nor crevices to detract from the force of the explosion or to catch accumulations of carbon.

The Reeve Device.

The Reeve device is described as a steam engine of the double-acting horizontal type. The piston 6 works in a sliding cylinder 5 arranged in a casing 1 which constitutes the steam chest or head chamber. This sliding cylinder is not operated by an eccentric or other positive means, like the Knight inner sleeve, but is caused to slide endwise by the friction of the piston, so that when the piston starts to move in one direction the sleeve will slide therewith and cause its exhaust port 70 in one end or the other to register with one of the exhaust ports 10 in the casing or steam chest to permit the steam to escape from the forward side of the advancing piston. All this is common practice and well known in the steam engine and hydraulic engine arts. In the outer ends of this sliding cylinder 5, however, Reeve places two piston valves 15, which are adapted to close the inlet ports 120 of



Reeve Re-Issue No. 12,991, July 13, 1909.

the sliding cylinder when a spring 119 behind each piston valve forces it inward, and the sliding cylinder 5 is forced towards it by the friction of the piston as the piston moves in that direction. The pressure for moving the piston is exerted between the piston valve 15 and the piston, and during the working and exhaust strokes the piston valve is held from moving outward by a latch device which is supposed to let go at the proper time during the return stroke of the piston to permit the steam that has been compressed between the piston and piston valve to force the piston valve outward against the spring and cause the piston valve to slide out from under and again open the inlet port in the sliding cylinder 5. Whether or not such a contrivance would work even as a steam engine never has been demonstrated, for according to the admission of the patentees an engine made upon this principle never had been built.

Reeve shows two forms of his device, one of which is constructed as above described. The other is the same, excepting that he has supplied the sliding cylinder 5 with an auxiliary valve 121 at each end for the common purpose of co-operating with the piston valve 15 in cutting off the cylinder admission more economically than could be done by means of the piston valve alone. This auxiliary cut-off valve is found in the steam engine art in various forms; that is, as piston valve, flat side valve, ring valve and sleeve. Reeve has chosen the ring form, which he places around each of the protruding ends of the sliding cylinder 5, and which he says he operates from the crankshaft by an eccentric in the usual way, although he does not show the eccentric or operating means. A detailed comparison is unnecessary to convince the

thinking engineer that whatever merit the Reeve device may possess as a steam engine, it could not, even by any possible distortion, be converted into an internal explosion engine, nor could the terms which have been applied to the elements of the Knight structure possibly mean the same thing when applied to the Reeve structure, or vice versa.

Has Attracted Attention.

The combination of elements which constitute the sleeve-valve internal explosion motor apparently has caused the world to sit up and take notice, but there was no new result or effect produced by the alleged improvements Reeve made in the steam engine. It was common in the steam engine art years before Reeve's invention, as shown by the United States patent of Uren, No. 303,344, issued August 12, 1884, to have the main piston B^2 slide in a sliding cylinder C contained within a casing or main cylinder A and having ports adapted to register with ports in the casing for controlling the cylinder admission and exhaust, the internal sliding cylinder being moved by the friction of the piston, as in the Reeve patent, and it was also old in hydraulic motors, as shown in United States patent No. 352,797 of Baldwin, November 15, 1886, to provide the internal sliding cylinder K with an auxiliary cut-off valve, 1, 2, 3, 4 encircling each end in the form of a ring and controlling the admission ports, *i*, *i'* in the sliding cylinder K. In this Baldwin patent these cut-off valves are connected together so as to move in unison by a cylinder W surrounding the internal cylinder K, and both of these cylinders are contained within a main cylinder of casing G having an inlet port Z. The cutoff valves 1, 2, 3, 4 receive

definite motion from a valve operating rod N, just as in the Reeve patent. The piston in this Baldwin patent is shown at J, and while it is the main piston it

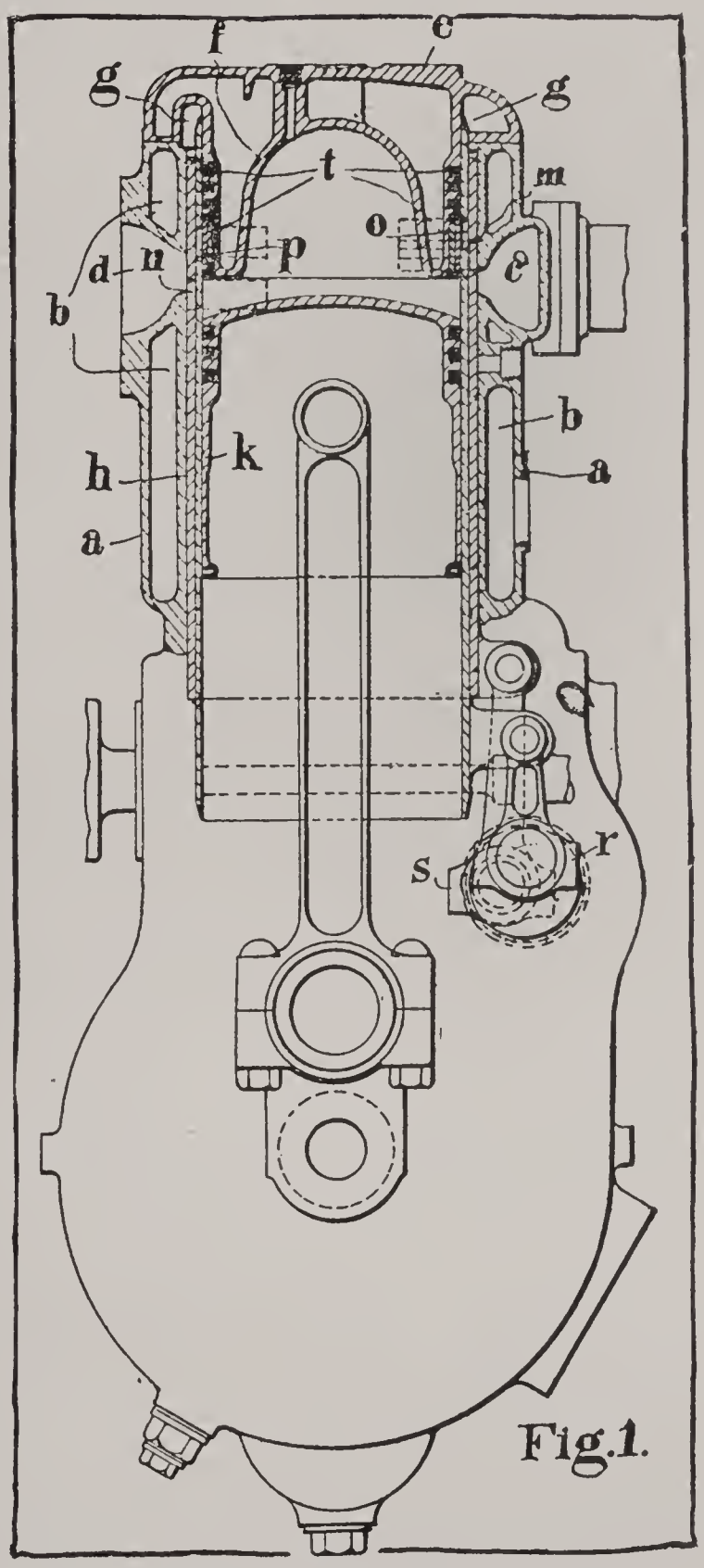


Fig.1.

Knight's Pending Application.

also serves as two piston valves for controlling the exhaust ports M, M′ in the internal sliding cylinder.

To apply these cut-off valves of the Baldwin patent to the Uren steam engine, or to use steam in the Baldwin engine instead of water was mere child's play. Every steam engineer understands the uses of the cut-off valve, and should any steam engine structure require one, he has a large number of examples in the art from which to choose, and there could be no possible invention in his choosing the ring form of Baldwin for use on the Uren form of steam engine, nor for importing into the Baldwin engine Uren's specific form of sliding cylinder and working piston for Baldwin's special form of sliding cylinder and working piston. These are only some of the examples in the prior art of Reeve's alleged improvements in steam engines.

Other Reasons Given.

But these are not the only reasons why the Reeve reissue patent is of no force and effect to cover the Knight invention. When we examine into the conduct of the present owners of the Reeve patent their efforts to obtain a reissue for the express purpose of covering the Knight engine after they were aware that the rights of Knight and Kilbourne had intervened and that a large fortune had been expended by these gentlemen in the development of the Knight motor, and when we examine the records of the patent office relating to the Reeve original and reissue patents and find that the reissue covers a different invention from what was covered in the original, there is nothing left to be said in favor of the Reeve reissue patent, even if it be assumed that it is not completely anticipated or void in view of the prior art. The law on this subject of intervening rights and the reissu-

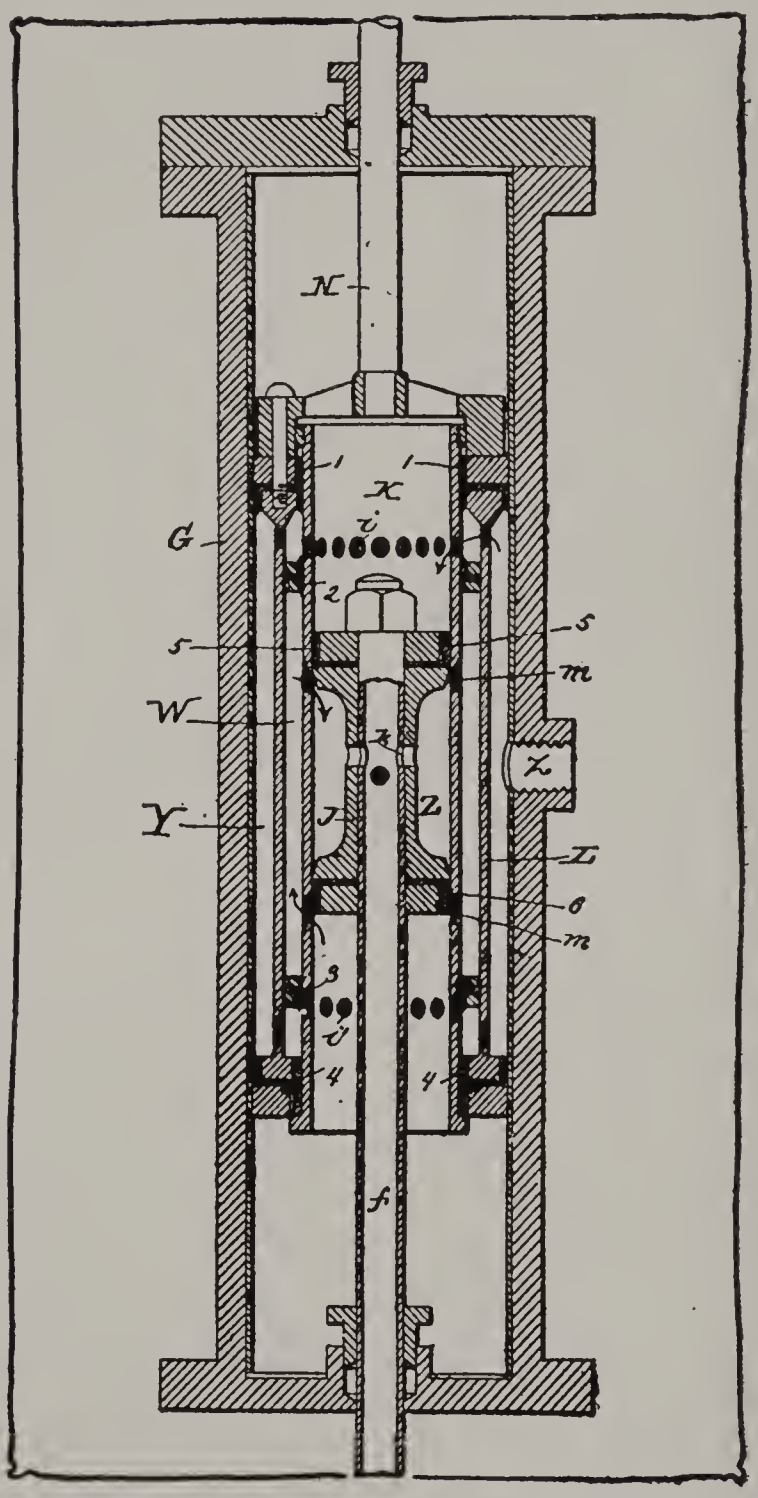
ance of a patent to cover an invention not originally intended to be covered in the original patent, is so clear and the points have been so repeatedly decided by the United States supreme court and the United States circuit courts of appeal as to leave no room for even a shadow of doubt.

As we have before pointed out, Reeve shows in his drawings two forms of the steam engine. In one of these he employs the ring valve around the main cylinder valve as an auxiliary cut-off. In the other form his cut-off valve is omitted entirely. It is important here to note that the form employing the cut-off valve is the only form using an eccentric for the operation of either valve, and in that form it is used for operating the cut-off valve. Now, Reeve in his original patent made this statement:

The principal advantages of my invention as applied to steam engines are * * * —6—The elimination of eccentrics as transmitters of power for operating valves.

It is seen from this statement that any steam engine having an eccentric for operating the valve would not possess the advantages of the Reeve invention. The present owners of the Reeve reissue also saw this and fully appreciated the fact that the Reeve original patent claimed a structure in which no eccentric was employed, and consequently must have claimed the form of the Reeve engine which does not contain the outside auxiliary or cut-off valve. Therefore when applying for the reissue patent they adroitly omitted from the specification the statement of advantages above quoted so as to be able to direct the claims of the reissue to the form of the engine having the outside cut-off valve operated by an eccen-

tric. Consequently the reissue is for a different invention from that which the patentee intended to cover by the original. The United States circuit court at Chicago in the case of Chicago Railway



Baldwin U. S. Patent 352,797, November 15, 1886.

Equipment Co. vs. Perry Sidebearing Co., 170 Fed. Rep., 968, recently has settled these questions in a very exhaustive opinion, and this decision has been sustained by the United States circuit court of ap-

peals and enforced against the reissue even to greater limits. In this decision the court said:

Thus it is sought by the language of the reissue claims to broaden the limited claims of the original patent into claims covering the whole field. * * * It seeks to bring within the monopoly of its patent side bearings not apparently in mind at the time of filing the original application. * * * It can hardly be claimed that the original patent was not a complete device. It was operative just as completely as that of the reissue patent. For all that Wands was seeking, it was in itself a finished side bearing arrangement. Later he thought he could just as well claim the resilient centering device and make it apply to every friction side bearing which is centered by a spring. Undoubtedly he made the mistake of not claiming the larger invention, if it be such, in his first application; but this is not the mistake the statute and the courts have in mind, authorizing the grant of reissue patents.

Supreme Court Decision.

In Campbell vs. James, 104 U. S., 356, the United States supreme court said:

When a patent fully and clearly without ambiguity or obscurity describes and claims a specific invention complete in itself so that it cannot be said to be inoperative or invalid by reason of a defective or insufficient specification, a reissue cannot be had for the purpose of expanding and generalizing the claim. * * *

The United States supreme court, in Burr vs. Duryee, 1 Wall, 531, 17 L. Ed., 650, said:

The surrender of valid patents and the granting of reissue thereon with expanded or equivocal claims, when the original was clearly neither inoperative nor invalid, and which specification is neither defective nor insufficient, is a great abuse of the privilege granted by the statute and productive of great injury to the public. This privilege was not given to the patentee or his assignee in order that the patent may be rendered more elastic or expansive, and therefore more available for the suppression of all other invention.

The United States supreme court in Corbin Lock Co. vs. Eagle Lock Co., 150 U. S., 42, in condemning the practice of broadening the claims to include an element not originally covered, but merely described and shown in the drawing states:

It is settled by the authorities that to warrant new and broader claims in a reissue, such claims must not be merely suggested or indicated in the original specification, drawings or original patent that they constitute parts or portions of the inventions which were intended or sought to be covered or secured by such original patent.

The force of this decision is clearly apparent, since Reeve intended by his original patent to cover a steam engine in which there would be no eccentric for operating the valves, whereas in his reissue patent it became necessary to claim the eccentric operated valve in order to establish a color of right to the Knight invention.

Re-Issue Held Invalid.

In Huber vs. Nelson, 148 U. S., 270, the United States supreme court held the reissue invalid because it left out one of the elements of the original claims.

In Chicago Railway Equipment Co. vs. Perry Co., above referred to, the United States circuit court at Chicago, in speaking of the effort of the reissue patentee to enlarge his claim by omitting an element originally described as important, states:

These two things are vital elements of that patent. Now it is sought by reissue to drop out the distinctive feature of the patent as described in the claims and substitute another element.

This comment is pertinent because Reeve seeks by his reissue to drop out the statement contained in the original making essential the form of his engine in which no eccentric is employed for operating the valves, and then to specifically cover this eccentric form by his reissue claims.

The United States circuit court of appeals in New York in the case of Carpenter Co. vs. Searle, 60 Fed. Rep., 82, laid down the rule to be the same rule as announced in the Chicago Railway Equipment Co. case, that:

Unless the court can find that the invention of the reissue is described as the invention in the original, and that the patentee intended to secure it as his invention in the original, the reissue is invalid. It is not for the same invention.

The United States supreme court, in Miller vs. Brass Co., 140 Otto., 350, said:

These afterthoughts developed by the subsequent course of improvement, and intended by an expansion of claims to sweep into one net all the appliances necessary to monopolize a profitable manufacture, are obnoxious to grave animadversion. * * * But it must be remembered that the claim of a specific device or combination and an omission to claim other

devices or combinations apparent on the face of the patent are, in law, a dedication to the public of that which is not claimed.

Regarding intervening rights, or the rights of a party to continue to make that which was not covered by the original patent, but is covered by the subsequent reissue, the United States supreme court holds that:

When complainant delayed six months and in the meantime the subject of the reissue claims has gone into general use, such reissue is void. Parker vs. Yale, 123 U. S., 87.

The explosion engine expert, Dugald Clerk, of London, England, who testified for the successful party in the Selden litigation, in passing upon the Reeve reissue states it to be his opinion as follows:

The Reeve devices are, in my view, utterly incapable of being applied to any internal combustion engine, and indeed there is not suggestion of any such application in any way found in the Reeve patent. * * * In my view, it could be freely contended that the reissue claims do not properly cover the same invention as was found in the original patent before reissue, * * * and in my view no action for infringement on the Reeve patent as reissued, could be successful in restraining the use of the Knight engines; * * * and in my view, the owners of the Knight patents have nothing to fear from the Reeve reissue, which may be entirely disregarded in dealing with licenses under the said Knight patents.

In speaking of the Reeve structure and the reissued claims advanced by the Packard Company, he further says that the same are:

Invalid for want of novelty, and in my view no action for infringement on the Reeve patent, as reissued, could be successful in restraining the use of the Knight engine.

Opinions of Lawyers.

In the opinion of eminent American counsel:

The Reeve reissue patent No. 12,991 is invalid and void and of no force and effect to cover the Knight internal combustion engine, for four reasons: First, the reissued claims are not for the same invention as that intended to be covered by the original claims; second, the very extensive rights of Knight & Kilbourne have intervened since the granting of the original; third, the claims of the reissued patent, wherever sounding in terms like the Knight construction, are old in the steam engine and hydraulic engine arts, and fourth, the claims of the Reeve patent do not mean the same thing, when read with reference to the construction of the Knight engine, as they do when read with reference to the Reeve steam engine, and when attempt is made to construe them so broadly as to cover the Knight invention, which did not exist until years after Reeve applied for his patent, they became so general as to be readily anticipated by prior steam engine devices.

While the Reeve reissue was pending I called on the Packard Company two or three times and met its president, general manager and chief engineer, all of whom seemed greatly interested in securing information regarding the Knight engine and its progress in Europe, but they did not drop a hint that they were using the confidential information given them in formulating claims covering the Knight construction for the Reeve reissue.

Foreign Deals Made.

During the summer of 1909 I returned to Europe, where arrangements were made with the Daimler Motor Co., Minerva Motors Limited of Belgium, Panhard & Levassor of France and Daimler Motoren Gesselschaft of Germany, all of which had options for exclusive licenses for their respective countries, by which if they subsequently exercised their options and took final licenses, which all have since done, they would accept a uniform license then agreed upon, which provided that all licenses should pay the same royalties, and in the event of any reduction in the rate to any licensee all should immediately receive the benefit of such reduction. This license, with a few modifications to make it conform to American legal conditions, was mailed to the Packard Company on behalf of Knight & Kilbourne early in August, 1909, with a request that further negotiations be taken up with Mr. Kilbourne at Chicago. About the same time I returned to the United States to participate in the anticipated negotiations with the Packard and other companies. No word was received from the Packard Company until October 19, 1909, when it wrote Mr. Kilbourne it had received a copy of the proposition relative thereto and asked if he could come to Detroit on October 26. Mr. Kilbourne and I called at the Packard works in Detroit on October 26, and were received by its chief engineer, and introduced to its local patent counsel, Milton Tibbetts, and its general patent counsel, James S. Watson, of Washington. Both the president and general manager of the Packard Company were out of town.

Mr. Watson stated that, on behalf of the Packard Company, they had made the most exhaustive

search they knew how, and that this search revealed nothing that affected the Knight construction except the Reeve patent. I said to Mr. Watson that I did not see how an internal combustion engine could be built in accordance with it which would work. Mr. Watson said that probably was true.

I asked whether he was speaking for the other companies which originally had invited the Packard Company to join in the negotiations for the Knight patents, and he replied he was not; that he represented the Packard alone and that it was the sole owner of the Reeve patent, and none of the others knew of it. Mr. Watson said they would be willing to turn the Reeve patent over to us for a half interest in all royalties received in the United States.

Mr. Hoff, Packard engineer, thought it eventually would be found necessary to permit other manufacturers to have licenses for such a valuable thing, as it would seriously injure their business if they did not have it, and in the event of our refusing licenses many would use the Knight engine anyway and risk the chances of litigation, and we would have the Selden situation repeated. Neither Mr. Kilbourne nor I gave any intimation of our attitude toward their proposal, and stated we would have the Reeve patent examined by our patent attorneys and see them again. Mr. Huff told us he intended leaving for England on November 3 to attend the Olympia show in London and would see Mr. Knight. This he did, and, as I was informed by Mr. Knight, he again came to Coventry and was entertained at Mr. Knight's home, shown the same courtesies at the Daimler works, given the freedom of the plant and much confidential information, and at the Olympia show again saw the success of the

Daimler and Minerva exhibits with Knight engines. He was also given the information that the Daimler Company had, during the first nine months of its use of the Knight engine sold and delivered about 850 cars, and in the six weeks between the end of its fiscal year, September 30, 1909, and the opening of the Oylmpia show, November 12, had sold more cars for delivery this year than its entire sales last year; that the Minerva Company had sold its entire output for next year before the opening of the show, and that Panhard & Levassor had exercised their option to take a final license and were straining every nerve to get cars with Knight engines on the market at the earliest possible moment, and that before exercising their option they had sent one of their directors to England to ascertain how the public regarded the Knight engine after a year's use by purchasers of Daimler cars, and that when he asked their English agents, Messrs. Ducros, how many cars they would order if they adopted the Knight engine, the latter replied they did not care to specify any definite number, but would take all the factory could produce, but could not sell any more cars with poppet valve engines. Mr. Huff cabled his company that Panhard & Levassor had taken a final license and obtained a copy of this for the Packard Company.

Premiums Offered in Europe.

Mr. Huff, as I believe, also was informed that so great was the demand that Messrs. Ducros were charging a premium of $300 for Panhard cars with Knight engines above the price of cars with poppet-valve engines, which Panhards were compelled to manufacture until they could prepare plans and pat-

terns for other Knight models. He was also told by Mr. Knight that the option held by the Daimler Motoren Gesselschaft would be exercised before its expiration on January 1, 1910, which was done early in December, 1909. With all this information as to the success of the Knight engine in Europe, Mr. Huff came back to the United States. I state this to refute the intimation contained in the statement of the Packard representative that it has no special interest in sleeve-valve motors more than as a matter of experiment such as with many other things that have never been adopted. On the page immediately following the interview with the Packard representative in the Motor Age of February 10, 1910, in an article from the Belgian correspondent of Motor Age on the Brussels show, appears the following:

The car which is undoubtedly the feature of the show is the Minerva, with its American motor, the Silent Knight. Last year for the first time this valveless motor was shown and attracted a good deal of attention. It was, however, an untried novelty. During the past year a large number of Minerva cars with this motor were sold and their success is almost beyond belief. As a result the 1910 Minerva output already is disposed of, and considering the fact that 600 cars, or rather chassis, are being constructed, it is a fact well worth mentioning, considering this small country. While plenty of native makers only laughed at the American Knight last year and predicted a failure for the Minerva, there are many who would be glad to pay a fortune this year in order to be allowed to fit the Knight to their chassis.

"We have to refuse orders from now on," said a Minerva agent to the Motor Age correspondent.

"Premiums of 1,000 francs are offered in order to get cars, but we cannot accept them. The plant in Antwerp will turn out 600 chassis this year, by far the biggest output of any Belgian motor car builder, and it is not possible to hope for more. We could sell several hundred more, but it is a question of quality and not quantity with us."

Quotes a Packard Letter.

But let us see what the Packard Company had to say on this subject. I quote from a letter written by Mr. Watson to the Packard Company, dated January 4, 1910, a copy of which he sent me:

At the end of our interview Mr. Lonas asked if the Packard Company was interested in securing a license under the Knight patents, or only interested in disposing of the Reeve patents. We assured Mr. Lonas that the Packard Company are interested in obtaining a license under the Knight patents if a suitable license could be had upon reasonable terms and the Reeve patent negotiated as a consideration in whole or in part for the license.

As to the intimation that Knight can obtain no United States patents, I quote from a letter from the chief patent counsel of the Packard Company under date of November 4, 1909, as follows:

We have asked Messrs. Brown & Hopkins to give us some assurance in writing that they will not bring the Knight United States application to allowance while our negotiations concerning the Reeve patent are pending. You understand fully the reasons for this request, and we will be obliged if you will authorize Messrs. Brown & Hopkins to give us this assurance.

To this I replied on November 9 that Mr. Hopkins had written that no further action on our applications was due for two or three months, during which time we would have ample time to examine the Reeve patents and discuss the matter with him and his clients. On November 24, 1909, I wrote the Packard Company as follows:

Referring to the conference we had with Mr. Watson and Mr. Tibbetts regarding the Reeve patent, we beg to advise that Messrs. Brown & Hopkins, our patent attorneys, have proceeded far enough with their examination to enable us to form an opinion as to the value of the reissued patent, and we confess to some disappointment as to its having much, if any, value in affording us broader protection. The circumstances under which it was reissued, and the fact that it seems to be in greater part anticipated, leaves little hope that it will be of any assistance in this respect.

On November 26, the Packard Company wrote, asking an appointment for December 4 in Detroit, and it was suggested that we send the Packard attorneys authority to examine Knight's patent office files, which authority was duly mailed. Mr. Kilbourne, Mr. Hopkins and I went to Detroit, December 4, and met the Packard attorneys. Mr. Hopkins showed them an English patent which had been sent us by Marks & Clerk, our London patent counsel, to whom copies of the Reeve original and reissue patents had been delivered by Mr. Knight with instructions that they make a search to ascertain the validity of the Reeve patents. This patent anticipates a large number of the Reeve claims, and we informed Mr. Watson that others were on the way. It was admitted at this

conference, which lasted a couple of days, by Messrs. Watson and Tibbetts that immediately after the return of Mr. Huff from Europe in December, 1908, they began their search at the United States patent office, and that this examination was made principally by Mr. Tibbetts, who discovered the Reeve patent, and that negotiations were at once commenced with its owners for an exclusive license provided a reissue could be secured with claims covering the Knight construction. Mr. Watson frankly admitted that the circumstances under which the Packard Company had obtained it, and the use of the information we had furnished as the basis for the preparation of the claims incorporated in the reissue would not meet the approval of a court of equity; he stated that while it might not be strong as a weapon against us in their hands it would be a powerful club in our hands to use against others, and an additional protection for the Knight patents. He said the defenses we could make to it could not be made by others if we held it, and that we could use it as a basis to make licenses and collect royalties at once from American manufacturers, and hold your own patents in the patent office as long as possible. Mr. Hopkins said he had not yet made a search for anticipations of the Reeve patent, but that the circumstances under which it had been reissued were such that the same defenses could be urged against it in our hands as in theirs, because their connection with it would have to come out. Mr. Watson said their license had not been recorded in the patent office, and he suggested that they destroy their license and all evidence of it and cause a conveyance to be made direct to us from the owners of the Reeve patent. Mr. Hopkins said he would not ask

anyone to pay royalties under the Reeve reissue, nor did he believe that anyone would be foolish enough to do so. He said that it could not be used to construct an internal combustion engine, was never intended as such, and that in the reissue the original specification and purpose had been changed and greatly broadened and that the courts would be sure to declare it invalid, even if it were not clearly anticipated by others, which he felt sure was the fact.

The Packard attorneys at this conference wanted us to give them a free license and 10 per cent. of all American royalties for the Reeve patent. We replied that we could not do that even if we were satisfied the Reeve patent was good, which we certainly were not, because, as they knew we had opened negotiations with three companies in America, which were acting with them, and that our European licenses, as well as those submitted to the American companies contained a clause that all licenses should pay the same royalties and that this situation would have to be divulged, as they were all entitled to see the contracts made with others. Mr. Watson suggested that they would execute the same form of license, and we could arrange to repay through a trustee the royalties paid by them or they would put it in any way we might suggest in order to conceal the real facts from other licensees.

Dugald Clerk's Report.

On December 30, 1909, the Packard attorneys came to Chicago, a copy of Dugald Clerk's report on the Reeve patents having been previously furnished them. At this meeting they were told the Reeve patent was wholly anticipated by prior patents which

were submitted, and the claims were taken up one by one by Mr. Watson and Mr. Hopkins, the most of which even Mr. Watson admitted were anticipated.

As to whether the Packard Company is interested in sleeve-valve motors and desires a license from Knight, I quote from Mr. Watson's letter of January 11, 1910:

"We submit the following proposition:

1—The Packard Company to assign to Knight & Kilbourne all of its right under the Reeve reissue patent and to receive as a consideration 5 per cent. of the gross royalties derived from licenses under the Knight and Reeve patents, plus an amount equal to 75 per cent. of all royalties which the Packard Company shall have to pay for its licenses under the Knight and Reeve patent, the minimum royalty payable to the Packard Company under this arrangement to be $10,000 per annum for the first five years or an amount equal to the minimum royalty provided in the license which the Packard Company shall take under the Knight and Reeve patents.

Or

2—The Packard Company to assign all of its right under the Reeve patent to Knight & Kilbourne and to receive 20 per cent. of the gross royalties received by Knight and Kilbourne from licenses under the Knight and Reeve patents or any of them; the minimum royalty payable to the Packard Company under this arrangement to be $10,000 per annum for five years, or an amount equal to the minimum royalty which the Packard Company shall be required to pay to Kilbourne and Knight by the license under the Knight and Reeve patents."

On January 14, 1910, Mr. Watson and Mr. Tibbetts called on Mr. Knight, Mr. Hopkins and I at the Herald Square hotel, New York, and endeavored to secure further concessions. Mr. Hopkins, meanwhile, had made a search which disclosed a number of American anticipations which in his opinion completely destroyed the validity of the Reeve patent, and we therefore declined to make any concessions or accede to their demands.

Conference in New York.

Balked in its attempt to secure a free license and a share of American royalties, the Packard Company next appeared in the person of Mr. Joy at a conference in New York which was arranged between Knight & Kilbourne and the other companies who, together with the Packard Company had been originally negotiating for the American rights, he having been invited, as I am informed, by one of the other parties. We had, in the meantime, disclosed to these other companies, one of whom had originally invited the Packard Company to join in the negotiations for the American rights under the Knight patents, what had happened with regard to the Reeve patent. At this meeting, while Mr. Joy was present, Knight & Kilbourne were asked to name a price at which they would sell their American patents, which they declined to do. The next we heard from the Packard Company was the statement by a representative in last week's Motor Age. The policy of the Packard Company in trying to not only acquire a free license under the Knight patents but to make the other manufacturers pay tribute to them through Knight & Kilbourne having failed, it has resorted to attempted in-

timidation. I may say for its information that contracts have been made by Knight & Kilbourne with foreign licensees which will bring them an income of about $300,000 per year, and I can assure it that such part of that amount as may be necessary will be spent in protecting their American rights.

Welcome a Suit.

In conclusion, I am expressly authorized by Knight & Kilbourne to say that they wish to make it extremely easy for the Packard Company to carry out its implied threat of bringing suit for infringement, and testing its alleged rights under the Reeve reissued patent, and for that purpose they authorize me to say on their behalf that they are now and since the year 1904 have been continuously engaged in manufacturing and selling Knight engines, and since July 13, 1909, the date of the Reeve reissued patent, have been engaged and are now engaged in manufacturing and selling, and since that date have manufactured and sold Knight engines of the type shown by the drawings in last week's Motor Age, and they propose to continue doing so. That such manufacture and sale has been and is now being carried on at 1238 and 1240 Michigan avenue in the City of Chicago, County of Cook and State of Illinois, and in the seventh judicial circuit of the United States, whose courts have jurisdiction of patent litigation and infringements, and at the above address Knight & Kilbourne will be pleased to accept service in a suit for infringement brought by the Packard Company under the Reeve reissue patent No. 12,991, and if such suit is brought will afford the Packard Company every facil-

ity in their power to bring same to a speedy hearing and determination. I am further authorized to say on behalf of Knight & Kilbourne that not only is the Packard Motor Car Co. invited to bring such a suit, but it is challenged to do so, and its failure so to do will be construed by Knight & Kilbourne, as it doubtless will be by the public, as an admission on its part that it has no rights that are being infringed by Knight & Kilbourne, and that it has not the courage to present such a flimsy case to a court of competent jurisdiction.

F. E. LONAS.

REEVE ANSWER IN THE KNIGHT CASE.*

Boston, Mass.—Editor Motor Age—There appeared in the columns of Motor Age recently a letter on behalf of the manufacturers of the Knight slide-valve motor which indicates the existence of a controversy over the claims of the Reeve reissue patent No. 12,991. The Packard Motor Car Co. has license from us under this patent for certain construction, but, as owners of the legal title and of full rights for all other uses, we feel impelled to correct what may become a wrong impression on the part of those not fully informed of the facts as to the validity of the patent.

We obtained this reissue through our regular attorney, and applied for it promptly on discovering the grounds for reissuing the original, just as the law requires. We are further able to state that the reissue was not granted until after a thorough and conscien-

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*Reprint of article in Motor Age of March 10, 1910.

tious examination on the part of the patent office officials, which failed to reveal any participation or other reason for denying the claims.

In the published communication from Mr. Knight's representative certain acts were alleged and certain opinions of counsel quoted to give the impression that a hold-up was being attempted on the basis of an improper assertion of claims dominating the use of a pair of slide-valves coaxial with the motor piston.

We have no knowledge of our responsibility for the policy which may have been adopted by our licensees but we desire to point out what any one may ascertain who is sufficiently interested to investigate, namely, that Professor Reeve filed his claims in 1901 for the combination, in a motor, compressor or pump, of two co-operating cylindrical or piston slide-valves, in one of which the working piston is mounted to reciprocate and his patent as originally issued claimed substantially that subject matter. An alleged grievance in any quarter is no warrant for an infringement. Although we respect the opinion of so eminent an English authority as Dugald Clerk, he is in error as to our patent—probably because he is misinformed. So far as we are informed by the communication mentioned above, or otherwise, no patent or publication prior to 1901 anticipates the combination of working piston and concentric sliding valves as claimed by Reeve.

It is true that the patent shows several different arrangements of valves for compressions, motors, etc., including steam engines, and it has been hastily alleged by its detractors that the expedients illustrated could not be applied to an explosion motor. That, however, is an error, for it manifestly is entirely prac-

ticable to embody the essential elements of the valve structure shown and claimed by the patent in a gas motor.

It detracts nothing from an inventor's rights that he has not at once started to manufacture under his patent. Such delay usually happens when one is ahead of the art and, for this reason, many of the most valuable patents have not gone into extended use until nearly the time of their expiration. It not infrequently happens in such cases that later inventors suppose, erroneously, that they are entitled to the broad idea.

We take the liberty of asking Motor Age to publish this statement for the purpose of correcting any impression that may have been created to the effect that the Reeve reissue patent is not entitled to respect as constituting a valid monopoly for what it purports to claim.—C. P. Power Co.

REEVES DIFFERS WITH KNIGHT'S ATTORNEY.*

In The Automobile issue of February 17th, Charles Y. Knight, through his attorney, discussed the merit of the Reeves Reissue Patent No. 12,991, which the Packard Motor Car Company has a license to use, and according to the Knight version of this reissue, it is of little value because in the process of obtaining a reissue the claims were enlarged and the scope of the patent was so altered that as a reissue it is in conflict with court rulings bearing upon this subject.

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*Reprint of article from The Automobile, March 17, 1910.

It is now claimed by the owners of the Reeve Reissue Patent, that Dugald Clerk in his discussion of the situation failed to consider all the facts and reached erroneous conclusions in consequence. The Reeves representatives go on to say that it is true of the reissue that it shows several different arrangements of valves for compressors, motors, etc., including steam engines, and an examination of the reissue will of course show that it differs in material respects from the preamble and claims as originally included. The Reeves interests are authority for the statement that it is entirely practicable to employ the essential elements of the valve structure, shown and claimed by the patent, in a gas engine. The Knight attorneys, on the other hand, base their contentions upon the rulings of courts, some of which were given in The Automobile, and they stoutly maintain that the Reeves Reissue is not in conformity with these rulings. It is anticipated that opportunity will be afforded the lawyers on both sides of this situation to exercise their talents and acumen.

SLIDE VALVE ENGINE PATENTS.*

An Alleged American Anticipation of the Knight Engine.

In the American Motor Age of February 10th, just to hand in this country, appears an announcement of considerable importance in relation to the Silent Knight engine manufactured in this country by the Daimler Motor Company.

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*Reprint of article in Autocar, London, England, March 5, 1910.

This is broadly to the effect that an anticipation of the Knight engine exists in the U. S. A. in the form of an American patent to S. A. Reeve, reissue No. 12-991, and dated 1901, and that the Knight engine is held to infringe this patent in America, which is stated to be owned by the Packard Motor Company, one of the largest American manufacturers.

The patent in question is a long one, with a large number of illustrations and claims. We give herewith a short description of one of the most pertinent constructions, with longitudinal sectional views. The actual construction illustrated is that of a steam engine, but the specification states that the invention is applicable to motors broadly, so that it would apparently include petrol engines. The construction is as follows:

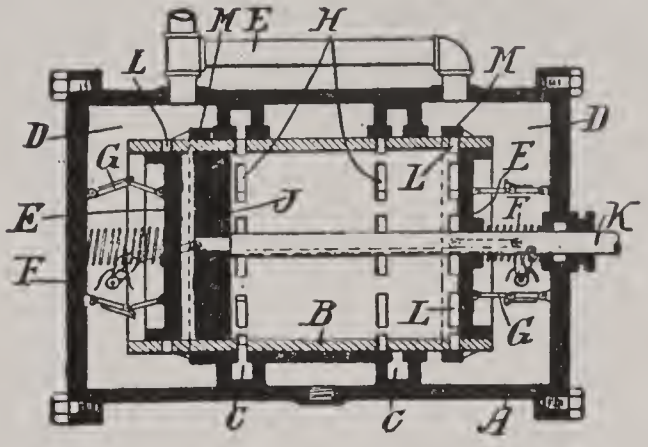

Fig. 1.—Longitudinal Section.

In a casing A is arranged a sliding sleeve or cylinder B, the sleeve being guided by hollow rings C. These rings divide the casing into end Chambers D, to each of which live steam is admitted by the pipe E. The sliding cylinder B is provided with yielding cover plates E, which are backed up by springs F, but can be held rigidly in position by means of mechanically operated toggle links G. The hollow rings C form exhaust passages and communicate with the interior

of the cylinder B by means of ports H. The working piston J slides to and fro in the sliding cylinder B together with the piston rod K. At each end of the sliding cylinder are formed inlet ports L, which can be covered by movable rings or valve sleeves M. As the piston moves back, say, to the left, the cushioning of the steam in the end of the cylinder forces the valve cover E to the left, compressing the spring F and closing the toggle links as shown. The valve moves further than the position illustrated, so as to uncover the inlet ports L. Fresh steam is admitted from the

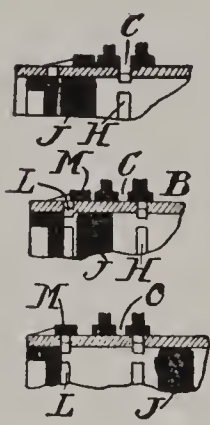

Fig. 2.—Exhausting on right side of piston J.

Fig. 3.—Admission of steam through ports L, exhaust H being closed.

Fig. 4.—Inlets ports L closed by ring M, expansion taking place.

valve chests D through these ports (see Fig. 3) and forces the piston J outwards, the cylinder B also moving outwards together with the valve cover E, which moves under the action of the spring F. After a little movement of the parts in this direction the ports L approach the ring M, which, by a suitable mechanism, is then moving in the opposite direction. The result is that the ring M covers the ports L and cuts off the admission of steam (Fig. 4). The piston continues to travel outwards under the influence of the steam in the cylinder, the exhaust ports H not being in communication with the exhaust chamber C because the cylinder B is moved too far over to the right, as shown in Fig. 4. On the return stroke the cylinder is moved back into the exhaust position shown in Fig.

2, in which the exhaust ports H coincide with the exhaust chambers C.

The same operation is effected on both sides of the piston, the engine being a double-acting one.

The inventor states in his specifications: "I believe myself to be the first to provide a combination of a main working piston reciprocating in a cylinder and two or more co-axial and co-operating valves, at least one of which surrounds the piston and may constitute the cylinder barrel, these valves being preferably both non-seating valves sliding axially on each other. I also believe myself to be the first to provide a sleeve valve telescoped with the cylinder casing and with a cylinder head or other cylindrical member internal to the sleeve valve, the sleeve valve having a movement relative to the working piston and controlling communication with the cylinder space."

It is difficult to state the bearing of this American specification on the Knight British patents without thorough investigation, but it is possible that it will have the effect of narrowing the claims. The Knight engine is at present controlled in this country by two patents, No. 14,720 of 1905 and No. 12,355 of 1908. The first of these is claimed to be a master patent, but it is extremely doubtful whether its scope can be considered to be of any great importance. Certainly the United States specification referred to shows that it has been proposed, prior to the first Knight patent, to use sliding cylindrical valves for admission and exhaust purposes, and to arrange these valves to move in opposite directions to effect quick cut-off, as is the case with the valves L and M referred to above. The second Knight patent does not seem to be of very material importance in view of the fact that

illustrated descriptions of the Knight engine were published before the patent was applied for. The result has been that the second patent is limited to such few details as were not published in the previous descriptions.

This American patent will probably be of some importance in America, as it would seem that the Knight construction may infringe some of the claims, the more important of which read as follows:

"No. 36. The combination of a casing, a reciprocating piston and two cylindrical valves surrounding the piston and operating one upon the other.

"No. 39. The combination of an axially movable cylinder valve, a piston reciprocating therein, a sleeve valve movable on the outside of the cylinder valve."

SLIDE VALVE ENGINE PATENTS*.

Mr. C. Y. Knight on the Alleged American Anticipation.

Last week we gave some particulars of an alleged anticipation of the Knight engine in the United States, as the Packard Motor Company had acquired the Reeve steam engine patent and held that the Knight patent was an infringement of it. It should be clearly understood that this claim has not been legally substantiated. It is merely a claim made by the Packard Company, who appear to have unearthed this Reeve patent with the idea of using it as a means for obtaining a better bargain with the owners of the Knight patents, as the Packard Company are desir-

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*Reprint of article from Autocar, London, England, March 12, 1910.

ous of obtaining a license to make slide valve engines under the Knight patents in the United States. Mr. Knight himself deals with the question so fully that it is hardly necessary for us to make any comment, though we do not think it is out of place to point out that the alleged anticipation of the Knight-Daimler engine is a mere paper invention which would never work as an internal combustion engine. In fact, we question whether it could be made to function as a steam engine, though it might possibly be run at slow speeds. Another very significant feature of the attempt to put forward the Reeve patent as an anticipation of the Knight is found in the fact that in his original patent Reeve's idea of one of its principal advantages was that it enabled eccentrics to be eliminated for operating the valves. This shows very plainly what was in the mind of the inventor Reeve, although in the reissue it is stated that the wonderful advantage of the elimination of the eccentrics has been omitted.

A word of explanation is necessary in regard to "reissues." In America, if a patentee finds that his patent is invalid or his specification contains mistakes, he cannot amend as is the case in his country, but must apply to the Patent Office for his original patent to cease and for a new patent to issue in its place. Further, if an inventor should find that he has omitted to claim a feature in the original specification to which he is entitled, he can insert such a claim in his reissued patent.

In the present case it appears that a claim has been inserted in the reissued patent which was not in the original, such claim being alleged to cover the Knight engine. Mr. Knight maintains that the reissue is invalid, and that the claim or claims inserted

cannot be substantiated, which really are matters which do not affect either the Knight patents here nor the use of the Knight engines in England, though, of course, these matters are of importance in America.

There are many other points upon which we might dwell, but the situation will be found to be reviewed so thoroughly by Mr. Knight himself that there is no need for us to explain it further.

All that we need do is to repeat that an abridgement of the original Knight patent was published in The Autocar of October 31, 1908, while the later patent which covers a number of improvements contained in the present Daimler engine was published in our columns on June 12, 1909, as follows:

"An internal combustion engine working on the four-stroke cycle, comprising a cylinder and two internal sleeves with cylinder and sleeves being provided with ports arranged at the combustion end of the engine, the ports being opened and closed when required by positively moving the sleeves, the whole of the required port motion being obtained without the use of port, traversed by the piston."

It will be noticed that the above claim is very broad, covering as it does all internal combustion engines of sleeve type which omit the lower port which is traversed by the piston. Broad as this claim is, however, it only relates to an improvement, as embodied in a special or particular model, as the essential features of the engine are covered by Knight's earlier patent of 1905, which broadly covers all four-cycle engines employing sleeves for valving purposes, regardless of the number of sleeves, or whether they are internal or external to the cylinder.

In conclusion, we should say that the documentary evidence, patents, etc., referred to by Mr. Knight

have been submitted to us for our inspection, and that Messrs. Knight and Kilbourne, the owners of the Knight patent, have challenged the Packard Co. to take legal steps to substantiate their claims.

Mr. Knight's communication on the subject is as follows:

"In last week's issue The Autocar gave space to an editorial article on page 321 under the heading 'Slide Valve Engine Patents: An Alleged American Anticipation of the Knight Engine,' publishing in this article certain hastily-drawn conclusions based upon drawings from a United States patent issued to S. A. Reeve in 1908, reissued in 1909, and now the property of the Packard Motor Car Co., of Detroit, Mich., U. S. A., the leading builders of high-class cars of America.

The Alleged Anticipation.

"So far as the patent in question is concerned, I need only call the attention of the reader to the fact that the claims which The Autocar printed in connection therewith, and which purport to cover the Knight engine, were conceived and placed on record five years after the Knight American application was filed, and four years after the British patent was granted! What is more, these claims are acknowledged by their authors to have been based upon the the perfected Knight motor as produced by the Daimler Co., purchased by the Packard Motor Car Co. in 1908, for testing purposes in connection with their negotiations for an American license, and that the claims were expressly drawn to cover such motor.

The Early Negotiations.

"When the acquisition of the Knight motor by the Daimler Co. was made known in England eighteen months ago, negotiations were entered into between ourselves and four leading American firms for the American rights. Three out of these four sent their chief engineers across to Coventry to investigate personally the claims made for the motor, and all these reported favorably to their companies. The Packard Co. was one of these four, and their chief engineer, in the person of Mr. Russell Huff, twice in the interests of his company visited the writer at the Daimler Works—once in 1908 and once in 1909. In the fall of 1908 arrangements were made with the Daimler Co. by which each of the four concerns were permitted to purchase a 38 h. p. motor for testing purposes, and Mr. Huff in particular was given the freedom of the works by the Daimler Co. at my request, and all information of a technical character desired was furnished him even to the analysis of the iron from which the sleeves of the Knight motor are made. This was all given in confidence as a matter of course, with the understanding that the Packard Co. were interested in becoming one of the four American licensees, and there was no indication that they were acting other than in good faith."

Later Developments.

"In October last, however, Mr. Kilbourne and our American solicitor, Mr. Lonas, were summoned to Detroit by the manager of the Packard Co. for the stated purpose of taking up the negotiations, that company having had almost a year of time in which to test the 38 h. p. Daimler-built engine. When they ar-

rived at the Packard Works they were met by Messrs. Tibbetts and Watson, patent attorneys for the Packard Co., who informed them that they had brought up a United States patent for a steam engine, which patent was applied for in 1901, and granted in 1908, and had had this steam engine patent reissued to cover the use in America of the double sleeve as employed by the Knight motor. They did not claim that this was a patent under which an engine similar to the Knight could be built, or that their patent was practicable for any sort of internal-combustion engine, but that by re-drafting the steam engine claims they had so worded them that they could make trouble for Knight and Kilbourne in America.

Subsequent Investigations.

"Subsequent investigation upon our part revealed the fact that as soon as the Packard Company opened negotiations in 1908 for an American license, one of its patent experts was sent to Washington to search the patent records for some sort of information which would afford the company grounds upon which to get Knight and Kilbourne within its power and enable it to control the introduction of the Knight engine in America. In his search this agent, Tibbetts, came across a patent, No. 880,824, applied for by Sidney A. Reeve, September 20, 1901, covering a valve mechanism 'for engines and compressors,' in which the ordinary steam piston worked in an open end cylinder, which Reeve, in his original patent described as a 'barrel valve,' which had ports at each end, the said ports being opened and closed through the movement of the valve by the friction of the piston. The valve enclosed at either end of a piston valve, described

by Reeve as 'discharge valves,' which moved automatically, and on the outside of the sleeve were two annular valves for cut-off purposes, used as governors, being in shape narrow rings. The device had never been built even experimentally as a steam engine, and two of its claimed leading and novel features upon which the original patent was issued were the claim (1) that it was as a valve mechanism 'worked without the use of eccentrics or other positive means,' and (2) that the piston valves were so actuated as to make it impossible, because of their movability, for the engine to be damaged through water which might condense in the pipes and flow to the cylinder.

The Reissued Reeve Patent.

"The Packard attorneys agreed with Reeve to purchase rights under this patent, provided a re-issue could be had which would at least in words cover the Knight engine. By having before them the Knight engine sent over by the Daimler Co. and carefully studying its construction and operation, these attorneys, Watson and Tibbetts, proceeded to re-write the Reeve patent. That part which Reeve in his original described as a 'discharge valve,' Watson and Tibbetts, in order to establish a semblance to the Knight motor, described as a 'head'; the narrow rings which Reeve had called 'annular' or 'ring valves,' Watson and Tibbetts stretched through language into 'sleeves.' All claims to the novelty of a valve gear 'working independent of eccentrics or other positive means' were left out, because that would have revealed the original and real intention of Reeve, who had not the slightest idea of inventing a petrol motor. Some forty-seven new claims were drawn, all based upon the effort to

transform a 'ring' into a 'sleeve,' and a 'movable valve' into a 'fixed head.'

How the Reissue Passed the Patent Examiners.

"Inasmuch as there was no suggestion of any intent to cover its use as an internal-combustion engine, the application for the reissue never came under the observation of the patent examiners in the division of internal-combustion engines. When Knight and Kilbourne asked what they (the Packard Co.) proposed in the premises, they answered that they would demand a half interest in the American royalties for the Knight motor. This was rejected at once. Then, after some weeks of reflection and the perusal of several opinions from patent experts regarding the validity and scope of the Reeve patent, their attorney, Watson, submitted the following proposition to Knight and Kilbourne, January 11, 1910:

"We submit the following proposition:

'1. The Packard Company to assign to Knight and Kilbourne all of its rights under the Reeve reissue patent, and to receive as a consideration 5 per cent. of the gross royalties derived from licenses under the Knight and Reeve patents, plus an amount equal to 75 per cent. of all royalties which the Packard Company shall have to pay for its licenses under the Knight and Reeve patents, the minimum royalty payable to the Packard Company under this arrangement to be $10,000 per annum for the first five years, or an amount equal to the minimum royalty provided in the license which the Packard Company shall take under the Knight and Reeve patents.

Or—

'2. The Packard Company to assign all of its right under the Reeve patent to Knight and Kilbourne, and to receive 20 per cent. of the gross royalties received by Knight and Kilbourne from licenses under the Knight and Reeve patents or any of them; the

minimum royalty payable to the Packard Company under this arrangement to be $10,000 per annum for five years, or an amount equal to the minimum royalty which the Packard Company shall be required to pay Kilbourne and Knight by the license under the Knight and Reeve patents.'

These propositions were promptly rejected by Knight and Kilbourne through their attorney, Mr. F. E. Lonas, and negotiations with the Packard Co. broken off.

Scope of the Reeve Patent.

"Had Knight and Kilbourne considered for one moment that what was offered them was what it purported to be—a bona fide basic patent covering their construction or even strengthening their claims in America—they would certainly have been very unwise to have rejected the Packard proposition, which also carried with it the understanding that they were to pioneer the introduction of the Knight motor in the United States, insuring the ready placing of the remaining available licenses.

"The proposition was rejected, because we were assured first, by Mr. Dugald Clerk, after a careful search and review of the situation, that our rights were in no wise affected by the said Reeve patent as reissued, and his opinion was unqualifiedly corroborated later by our own and several other American solicitors after several weeks of exhaustive search in connection with the case.

A Rule or Ruin Policy.

"When their propositions were rejected the Packard Co. resorted to the rule or ruin policy of publishing the statement that the Reeve steam engine patent,

which they had bought up and reissued, controlled the side valve situation in America.

"'What is this Reeve patent, and what is a reissue?' the reader naturally inquires.

"The Reeve patent purports to cover a type of slide valve steam engine quite common in the Patent Office. His original claims must have been very narrow, because there are many other steam constructions anticipating him by years which employ every single feature which he claims to be novel to his construction in the reissued patent!

"A 'reissue' in America is a process under the American law, by which an inventor, after his patent has issued, can amend it to cover errors or to make more clear his original intentions.

"The courts have uniformly held that this right did not extend to a right to so redraft the patent as to cover the intervening right of some other inventor, nor could it be employed for speculative purposes. In the case of the Reeve reissue the Knight engine had been on the market, fully advertised, and in the hands of the public from three to four years before it ever occurred to Reeve, who had never built even a model of his own invention, that his steam engine patent applied for in 1901, and issued in 1908, might be so worded by amendment as to cover on paper and possibly absorb the fruits of years of labor and a fortune in money expended by another to produce something which had proven practical and a great success which he never had dreamed of, and to which his construction was wholly and admittedly unsuited and impossible.

The Limitations of a Reissue.

"No person can go into the Patent Office with a drawing prima facie impractical and either directly or in an amendment secure valid claims to cover something different. This is what the Packard Co. in America have attempted in their manipulation of the Reeve patent. First, prima facie the Reeve construction is impractical for an internal combustion engine, if not, in fact, a steam engine, and in his original claims he never suggested, nor was his patent drawn in a manner to show he ever expected, it could be used for internal combustion purposes. And when the Packard Co.'s attorneys reconstructed this patent through ingeniously worded claims and veiled designs eight years after it was filed, the most they expected to accomplish was to take advantage of its specifications to secure allowances which would bring some features of the Knight engine into conflict, so that through threats of prolonged litigation they might secure control at terms dictated by themselves of the Knight interests in the United States. If these reissued patents were basic and legitimately secured, and an internal-combustion engine could be built under them why negotiate with Knight and Kilbourne at all? Why offer to permit the Knight patents to absorb from 80 to 95 per cent. of the American royalties, aside from these accruing from the payments of the Packard Co.?

"The English reader is not particularly interested in the details of the methods employed by Packard agents in securing the reissue of the Reeve patent, or how it was accomplished without coming under the observation of the examiners in the department of internal-combustion engines, nor is it particularly per-

tinent here to go into the mystifying ramifications of patent law and technical verbiage bearing upon the relations of these patents to each other. More than a dozen patent drawings similar to the Reeve have been public property for ten to thirty years. During the past five years something like twenty patents have been granted in various leading countries to Knight and Kilbourne covering the Knight combination for internal-combustion engines, and in no single instance has one of these patents been cited in conflict. It is customary in the United States to keep patents unissued in the office as long as practicable in order to have all necessary time for perfecting the construction and strengthening the claims where possible. The famous Selden patent covering the entire motor car in America was thus held for ten years; the Reeve patent itself was filed in 1901 and not issued until 1908.

The Knight Patent.

"Broad claims completely protecting the Knight motor as now built have been allowed by the United States Patent Office for nearly five years; the Reeve patent has been published two years; also the Knight motor and its principles have been widely advertised and made known as broadly as possible in mechanical circles. Yet there has been no suggestion from the United States patent authorities, familiar with the claims of both constructions that the Knight petrol engine structure infringed the Reeve steam engine. During this time experts for at least ten important motor concerns have searched the patent records of the various countries for anticipations of the Knight patents without success. Knight and Kilbourne have

spent thousands of pounds to acquaint themselves with the true state of the art, throughout the world, and, basing their confidence upon the reports of the best patent experts in the various countries, have notified the Packard Co. of America that not only will they make it extremely easy for the owners of the Reeve patent to get the matter before the proper court, but have in the public prints of America challenged them to bring suit, suggesting in such challenge that their failure to promptly do so would be accepted by Knight and Kilbourne, and doubtless by the public, as evidence of their lack of courage to present such a flimsy case to a court of competent jurisdiction

"In conclusion, it may be stated that inasmuch as Reeve does not claim to cover even in his reissue the elements necessary for the construction of an internal combustion engine, but only certain features, which, even if valid in America, are of no importance abroad, because no such rights are claimed by anybody outside of the United States, anything done or said in this connection has no bearing whatever upon this side."

Supplementary to
Pamphlet

The Knight Engine

and

The Packard Motor Car Company

PACKARD MOTOR CAR COMPANY.

DETROIT, MICH., U. S. A., MAY 10, 1910.

MR. F. E. LONAS,
Care Knight & Kilbourne,
CHICAGO, ILLINOIS.

MY DEAR SIR:

I am advised that your people have published and sent out a pamphlet entitled "The Knight Engine and the Packard Company." Will you kindly send me some copies?

I regret that you feel so annoyed at the Packard Company about the Reeve Patent situation as indicated by your article in a recent issue of the "Motor Age."

We have been asked from time to time by various parties about the Knight motor, and stories have been so industriously circulated that we were going to use the Knight motor as soon as we could get to making them, and the facts being to the contrary, I was asked by our Vice-President, Mr. S. D. Waldon, if he should say anything in regard to the situation. I advised him that I saw no reason why he should not make a statement of the facts.

This was done to the representative of "Motor Age," among others, and an article was written up around the brief facts.

Your people took exception to the matter, but there were so many misstatements and falsehoods in circulation with regard to the situation that a simple statement of the facts seemed the proper thing to make. Whenever I see you I can certainly make clear to you that there was and is no animosity on our part, and no intent on the part of the Packard Motor Car

Company to do an injustice to anybody, as we see it. I rather feel that the injustice possibly is on the other side.

We certainly are not to blame that Mr. Reeve made this invention in 1901. This Company does not believe in doing injustice to anybody, nor does it believe in having injustice done to it. This attitude, I am sure, you will yourself fully approve of. We feel that it is always at all times proper to tell the exact facts and state the pure unadulterated truth.

Again, please permit me to express to you my regret for having taken any step which has annoyed you so much as this seems to have done, but it could not well be avoided.

The attack upon this Company in "Motor Age" is, of course, unwarranted and greatly at variance with the facts and the exact history of the negotiations, which is, of course, always unfortunate.

We wish we could see the value of the Knight inventions through the same rose-colored glasses as yourselves. We hope we may be able to in the future, but our most diligent experimental efforts, at great expense, so far have been unavailing.

We are always glad to co-operate with an inventor in aiding the development of his ideas and we took hold of your matters with free and unbiased minds, and spent our time and money and have not been able to set our stamp of approval on the Knight ideas, regardless of patents or rates of royalties.

Now through the development of the Reeve Patent on double sliding sleeve valves, and also the obvious weakness of the Knight motor situation as to its patentable features being so extremely limited through the rejection by the United States Patent

Office of the double sliding sleeve valve features, due to the illustration and description of it in "Motor Age," October 26, 1905, more than two years before Mr. Knight filed his application for patent thereon, the patent situation in the United States is different from that which we supposed it was when we first took up the matter a year or more ago, and bought from you your English-Daimler motor for study.

It is clear that so far as the patent situation goes, the Reeve Patent and the Knight pending Patent applications are both necessary to any sort of patent control of the so-called Knight motor.

It must also be clear to you that our inability to find in the Knight-Daimler motor the "wonder of the age" in motors as you view it, had led us to be unable to meet your views. We are acting according to the light we have.

Our motor car manufacturers have had some bitter and expensive experience with American legal processes in patent litigation, and we are naturally wary of how we load up on expensive royalties without getting any protection in return, and especially in these times of increasing competition.

The suggested royalty basis which you proposed for a 30 H. P. size of motor was approximately $100 per motor. That would be an added cost of making of our motor of say 20 per cent. and in motors of approximately similar sizes manufactured by parts makers for cheaper cars would be an increase in motor cost of say 50 per cent, both of which would be prohibitive and absurd, even if the motor was the "wonder of this wonderful age."

No manufacturer of motor cars could in his right mind add to his burden of costs any such amount for

something which would not in our judgment do the work required by the user of a motor vehicle any better or in any more satisfactory manner than the work is now being done by the present world's standard form of poppet valve motor.

The user would have to be asked to pay an added price to get mechanical features which would have no observable superiority and would incidentally have many objectionable features, both from a shop point of view as well as the user's viewpoint, which have been already eliminated from our Packard motor and others, as for example:

One of the tests has been to run the motor without water until it sticks or without sufficient lubrication until the same result occurs. These forms of neglect and carelessness of operation often occur, and in the Packard type of motor as soon as it has cooled off, water and oil can be replenished and the car is again ready for the road, whereas, in the English-Daimler Knight type of motor the sticking of the pistons and sleeves reduces the engine to a state of wreckage necessitating towing it to a repair shop and extensive and expensive replacement of broken parts.

I only mention this as one of the several serious points of trouble. Difficulty of proper lubrication might be mentioned as equally important, but it is not necessary to argue the many details.

Please kindly send me some of the pamphlets which I have heard you are sending out so that I may know what is going on.

Yours very truly,

(Signed) HENRY B. JOY,
President.

CHICAGO, MAY 16, 1910.

HENRY B. JOY, ESQ.,
Pres. Packard Motor Car Company,
DETROIT, MICH.

DEAR SIR:

In reply to your favor of the 10th instant, I note your expression of regret at having, as you state it, "annoyed me," but I beg to assure you that the indignation which I naturally felt at the action of the Packard Motor Car Company, after failing in its efforts to sell Knight & Kilbourne the worthless Reeve patent, into which it had unsuccessfully attempted to incorporate claims covering the Knight invention by the use of confidential information give it by them, in attempting to intimidate those negotiating for licenses to manufacture Knight engines in the United States by the publication of February 10th, in Motor Age, was quickly followed by amusement at the amateurish and ineffective manner in which that attempt was made, and its evident inability to make any reply to my answer of February 17th, in the same publication.

If your company had confined itself to a statement that it did not intend to adopt the Knight engine there would have been no occasion for my reply, but when the statement was made that it controlled basic patents covering slide valve or double sleeve valve motors; that the Knight motor was an infringement, and that any patents Knight might obtain would necessarily be subordinate to the Reeve patent, I thought it necessary to give the public the truth regarding the entire matter.

Your effort to convey the impression that the publication of February 10th was intended only to stop gossip as to your adoption of the Knight engine

I cannot permit to go unchallenged. What you were very obviously trying to do was to intimidate others who might desire to adopt the Knight engine which you had unsuccessfully attempted to secure by palming off on Knight & Kilbourne a worthless patent for a steam engine, which your attorneys admitted had never been built and which they further admitted could probably not be used at all in constructing a successful combustion engine. Your intention to try to intimidate those desiring to adopt the Knight engine is further evidenced by your recent letters to some of those with whom we have been negotiating, containing veiled threats of suits for infringement. I do not believe this will scare anybody in view of the fact that you have not had the courage to sue Knight & Kilbourne for infringement, as you were challenged to do by my letter of February 17th, published in the Motor Age. I quite appreciate the reasons for your discretion in keeping out of a fight where you know you will lose, but do you not think that that sort of tactics has reached a point where it will no longer serve a useful purpose?

In reply to your statement that the Packard Motor Car Company does not intend to do an injustice to anybody, and that you do not see that you have done an injustice to anybody, I must say that you are either woefully ignorant of the facts, or your moral eyesight is very defective. I should prefer to believe that the former is true, and that you have not been given all the facts by those acting for you.

I note your statement, "This company does not believe in doing injustice to anybody, nor does it believe in having injustice done to it. * * * We feel that it is always at all times proper to tell the

exact facts and state the pure unadulterated truth." You are right in assuming that I fully approve of such sentiments. I regret to say, however, that candor compels me to inform you that in its dealings with Knight & Kilbourne your company has not followed the code of ethics laid down by you. Ethics, like all other rules, are only useful when observed, and no amount of profession can atone for failure to practice them.

You say, "The attack upon this company in Motor Age is, of course, unwarranted and greatly at variance with the facts and the exact history of the negotiations, which is, of course, always unfortunate." I am greatly surprised that you should make such a statement. How you can designate as an "attack" the action of one who is himself attacked, as we were in this instance, and defends himself by a statement of the truth, I cannot understand. Wherein this so-called "attack" was unwarranted and at variance with the facts, I challenge you to point out. If you can show anything in my statement which is either unwarranted or at variance with the facts or exact history of the negotiation, I shall be only too glad to correct it and make all amends in my power.

It is my invariable practice in all transactions to adhere strictly to the facts, and my training has been such as to make me very careful in collecting and preserving evidence of the facts as they transpire in all important negotiations. That practice was followed in this instance, and I am, therefore, very certain that upon careful investigation you will find that I have confined myself strictly to the facts and the truth. My statement is largely based upon documentary evidence and data concerning which there can be no

question. I do not, however, profess to be infallible, and if you can point out any statement of mine that is incorrect, I shall be only too glad to correct it.

You state, "We certainly are not to blame that Mr. Reeve made his invention in 1901." We are not blaming you for any invention that Reeve made in 1901, but for the attempted appropriation of the Knight invention which Reeve only discovered in 1909, when it was disclosed to him by your attorneys, Messrs. Watson & Tibbetts. Both of these gentlemen explicitly admitted to Mr. Kilbourne, Mr. Hopkins and I that the Reeve patent was discovered by Mr. Tibbetts in his search in the United States Patent Office at Washington, and that they then hunted up Mr. Reeve, told him if he would apply for and secure a reissue of his patent with claims which they would prepare, they would purchase from him the United States right for internal combustion engine; that an agreement to that effect was made with Reeve. The reissue was applied for within two months after the return of your Chief Engineer from a visit to England, where he obtained a large amount of confidential information as to the construction and merits of the Knight engine from Mr. Knight and the Daimler Motor Company, and within one month after the receipt of a Knight engine shipped you by the Daimler Motor Company.

Messrs. Watson & Tibbetts further admitted that the claims which they prepared, and which were subsequently incorporated in the Reeve reissue, were prepared by them with the express object of covering the Knight engine, and they expressed themselves the belief that they did cover it. When Mr. Hopkins told them that a mere statement of such an admission by

them to a court would be sufficient to enlist the sympathy of the court on behalf of the inventor of the Knight engine, and result in their defeat, they admitted it and said that while the Reeve reissue was not strong in their hands it would be strong in the hands of Knight & Kilbourne, and a very effective weapon against others. They further indicated the weakness of the position of your company by reducing the amount asked for the Reeve patent from fifty per cent of the gross United States royalties of the combined Knight and Reeve patents to ten per cent, but we were subsequently informed by them that you, on behalf of the Packard Motor Car Company, demanded in addition a free license to manufacture Knight engines. It is needless to say that had they or you had any confidence in the validity of the Reeve reissue and its control of sleeve valve engines in the United States, you would not have been trying to sell it to us for ten per cent or fifty per cent, under such circumstances you would probably consider you were very generous if you offered us ten per cent of the combined royalty.

Since we terminated the negotiations by refusing your proposal to sell us the Reeve patent, Brown & Hopkins have made a complete investigation of the entire matter, and we now know what we did not at first know, that the Reeve reissue is absolutely worthless. It would not even have made a respectable scarecrow.

I note the implied invitation in your letter to reopen negotiations for the purchase of the Reeve patent, but in view of the fact that we are not in the waste paper business, I do not know any use we could make of it.

I shall not attempt to make any decisions for the United States Patent Office, as your patent counsel seem disposed to do, in advance of action on the pending applications for patents covering the Knight inventions, but I may tell you that this phase of the matter is not giving me nearly so much uneasiness as it appears to be giving you.

On the question of royalties, I must also put you right. You say our proposed royalty basis is approximately one hundred dollars per motor for a thirty horse power motor. There is an error of only forty dollars in the statement, the actual figure being sixty dollars. If, as you state, one hundred dollars would add twenty per cent to the cost of your motor, its present cost is five hundred dollars. The cost of our thirty-eight horse power motor, including royalty, would not be more than five hundred and thirty dollars, and with the superior methods of manufacture and larger output in American factories, it would probably cost considerably less. When with this fact is taken into consideration the further fact that our motor of a given size gives about twenty-five per cent more power than a poppet valve motor it will be apparent that the additional cost of paying a royalty to us is entirely wiped out. But this is not all. Our royalty proposal for the United States, on the basis of the production of the Packard Motor Car Company for the coming year, as given to me by Mr. Tibbetts, for your large cars, would figure less than forty-five dollars each, which would result in a saving over your present cost, leaving out of consideration the increased horse power that the Knight engine is capable of continuously developing.

This brings me to a consideration of the only remaining and probably most interesting point in your letter, the merit of the Knight engine as compared with the Packard engine. At the outset I must confess to a considerable degree of surprise at the statements made by you with reference to the merits of the Knight engine. First, because it is at variance with statements made to me by your Vice-President, Mr. Waldon, your Chief Engineer, Mr. Huff, and the statements of Mr. Huff to Mr. Knight and others. Second, because it is entirely inconsistent with the attitude of your company in trying so hard to secure a license from Knight and Kilbourne with the Reeve patent as partial payment. Under these circumstances I am constrained to believe that the views for the first time expressed in your letter of the 10th, as to the merits of the Knight engine, may be a case of "sour grapes."

An additional reason for my surprise is that I know you are aware that the four leading automobile manufacturers of Germany, France, England and Belgium, viz., Daimler Motoren Gesselschaft of Unter-Turkheim, Germany, manufacturers of the celebrated "Mercedes" cars; Panhard & Levassor of Paris; Daimler Motor Co. of England, and the Minerva Company of Antwerp, Belgium, have, after an exhaustive investigation and tests, adopted the Knight motor, and that two of them are now using it exclusively in their cars and that the others are getting ready to do so as fast as they can. You are also doubtless aware of the fact that so great has been the success of this engine that premiums are being paid by purchasers for the privilege of getting cars equipped with it, a thing unknown in the European motor

industry for several years, and that the Daimler Motor Company within the past sixty days has increased its prices for all models because of the tremendous demands for cars with Knight engines, and its inability to take care of the business offered. It must either be that these veteran leaders of the automobile world are crazy and the discriminating buyers are the same, or else they, like myself, have not yet learned of the great merit of the Packard engine.

You make certain statements concerning the Knight engine which has been in your hands, which we, of course, have no means of verifying, but which I am frank to tell you we cannot accept on your ex parte statement. You have also made statements regarding objectionable features which you say are possessed by the Knight motor, but which have been eliminated from the Packard motor.

This raises squarely the issue as to the comparative merits of the Knight and Packard engines, concerning which I should not expect you to accept my views, nor can I accept yours without a practical demonstration.

As you express yourself as being hopeful that you may be able in the future to see the value of the Knight engine through the same "rose-colored glasses" as ourselves, a comparative test may enable one of us to get our glasses properly focused, and incidentally also give the motor industry generally, both manufacturers and buyers, some valuable light on this interesting subject.

The Challenge.

I, therefore, propose on behalf of Knight & Kilbourne that a test under the most rigid supervision of

some disinterested and well-known club or society of engineers be carried out along the lines of the test to which two Daimler-Knight engines were subjected under the auspices of the Royal Automobile Club of Great Britain and Ireland in March, 1909, which resulted in the Daimler Motor Company being **awarded the Dewar Trophy for the most meritorious performance of that year in the automobile world.**

I suggest that this test take place as soon as possible at some suitable place in the United States to be agreed upon when it will be convenient for Mr. Knight, who is now abroad, to be present.

Your large motor, if I am correctly informed, is 5 x5½", being 40 H. P., according to the A. L. A. M. rating. We have a motor of nearly this size, 4⅞ x 5⅛", being 38.4 H. P. according to the A. L. A. M. rating. I propose that we submit three of our motors of this size to a comparative test with three of your 40 H. P. motors in accordance with the following conditions:

Conditions of Challenge.

1. That the six engines shall be tested on the bench for a period of 132 hours continuous running.

2. That the horse power given off shall at no time during the test fall below the A. L. A. M. rating multiplied by 1.3, the piston speed to be 1,000′ per minute. If a higher piston speed is used, the minimum horse power to be given off by the engine shall be increased proportionately.

3. That the water temperature of the inlet shall be kept at 125° Fahrenheit during the test.

4. That upon completion of the bench test, the engines, without any of their vital parts being dis-

turbed, shall be installed in standard touring cars and run for a distance of two thousand miles each on the Indianapolis track, this distance to be completed in not more than fifty hours running time. That the touring cars in which the engines are installed for this track test shall be as nearly as possible alike in weight, size of wheel, gear ratio, etc., so as to provide similar conditions for all the engines.

5. That upon completion of the track test, the engines shall be again placed upon the bench and run for five hours under the same conditions as the previous bench test referred to in paragraphs one, two and three.

6. That the six engines from the commencement to the finish of the test shall be under the direct observation both day and night at all times of unbiased observers appointed by some club or engineering society to be mutually agreed upon, or failing such agreement by a joint committee of five members; two to be appointed by Knight & Kilbourne and two by the Packard Motor Car Company, and the fifth by the four thus chosen. That representatives of both Knight & Kilbourne and the Packard Motor Car Company be permitted to be present at all times to give direction and assistance in carrying out the test of their respective engines, and that they also be permitted in each of the cars during the track tests.

7. That during the bench test readings be taken of each of the engines not less than once every half hour of the horse power at the entered speed, which I suggest be twelve hundred revolutions per minute. This will give a piston speed of 1,100′ per minute for your engine, and 1,025′ per minute for the Knight engine.

On this basis, your engine would have to develop at all times not less than 57.2 H. P. and the Knight engine 51.17 H. P.

8. An accurate record shall be kept of the fuel consumption per horse power on the bench and also of the cars on the track and the same grade of gasoline shall be used by all of the engines.

9. An accurate record shall be kept of the consumption per horse power of lubricating oil by each of the engines, and also by each of the cars during the track test.

10. An accurate record shall be kept and readings made at the same time as the horse power readings are taken of the temperature of the circulating water at the intake and exhaust for each of the engines under test.

11. A record of repairs or adjustments, if any, the following, however, while they shall be recorded and included in the certificates to be issued by the Judges, will not debar the engines from continuing the test.

Defects of —

Gasolene supply.
Water circulation.
Ignition system.
Exhaust piping.
Brake system.

The time for all necessary repairs and their nature and any replacements shall be noted and the engines shall be called upon to make good such time as is thus lost under the general conditions governing the test.

12. At the conclusion of the test of each engine it shall be completely dismantled and the Judges shall make a careful examination of all of the parts for the purpose of ascertaining their condition and amount of wear shown. If any of the engines are so far destroyed as to be unable to complete the test, an accurate record shall be made of such fact, and the cause or causes thereof, so far as possible, with the list of the parts broken or damaged, and the extent of such break or damage.

13. The record of the track tests shall disclose the number of miles traveled, the average speed per hour, total weight carried, number of gallons of gasoline used, distance per mile in gallons, number of ton miles per gallon, number of stops and reasons for same, together with their duration and a general statement of the running qualities of the engines so far as quietness, freedom from vibration, etc., are concerned.

14. At the conclusion of the final five hours bench test, one Knight and one Packard engine shall be run for periods of ten minutes each pulling the maximum load they will pull at speed, rising by 100 revolutions per minute each from 400 to 1,800 revolutions per minute to give the comparative power of the two motors at a wide range of speeds. The final test to be made without any adjustments or disturbance of the engine or any of its accessories. This will demonstrate whether the two engines are ordinary or special engines, and whether flexibility and other important features have been sacrificed for the purpose of securing power at a fixed speed.

15. The entire test shall be open to the representatives of the daily and technical press, to whom

the fullest information shall at all times be given by the Judges as to the progress of the tests.

16. As considerable expense will be involved in such a test for the payment of Judges and observers and other incidental expenses, I suggest that each contestant deposit $5,000 with the Judges to be used in defraying such expenses with an agreement that if any balance is left of the amount so deposited it shall be turned over to the contestant who shall be awarded a certificate by the Judges for the best all around performance in the test.

I have suggested three engines, thinking you may prefer to have that number in case of any unforeseen accident to which any engine is liable, but if you prefer a less number we shall be pleased to meet your wishes in that regard.

With reference to running without water and oil, I regard this as a wholly unfair test to any engine, because it is not a condition to which any engine, in the hands of a user of ordinary prudence and common sense, is ever likely to be subjected. However, if you wish to carry out such a test, we are willing to meet you, and in that event I suggest upon completion of the final bench test, one of the Packard engines and one of the Knight engines be again installed in touring cars, the water removed from the radiators and engines, the lubricating oil drained from the bases and the two cars run on the track on direct speed at 20 miles per hour until one of them stops, after which a careful examination shall be made of the condition of both engines.

If there are any conditions which I have named which do not seem fair to you, I shall be pleased to have an expression of your views as to a modification

and will be ready to meet you on any reasonable basis for such a test.

As you have expressed the opinion that your engine is free from many objectionable features which you assert the Knight engine has, I take it for granted you will be glad to enter upon such a contest as I have suggested for the purpose of verifying your opinion and claim.

Trusting I may have the pleasure of receiving a prompt acceptance of this challenge from the Packard Motor Car Company, and suggesting a time and place for meeting to arrange details, I am,

Very truly yours,

(Signed) F. E. LONAS.

DRIVING NOTES.

The following useful hints and tips will no doubt be found useful to those who are owners or drivers and will show those who can already drive how to obtain best results from his car. Owing to the concave depression in the detachable heads of this motor water will remain in them after the rest has been drained out of the motor and radiator as this space is below the outlet pipe. Consequently if the car is to be left standing in winter time where it will freeze up this water must be removed. Almost any oil or grease gum may be used for this purpose. Unless a strong anti-freezing solution is used this is a very important point to observe. Otherwise the freezing of the water in these heads would crack them and necessitate expensive repairs.

Starting the Engine.

If the gauge shows that there is no pressure in the gasoline tank, close the tap on the pressure pump and work the latter till the gauge registers 2 lbs. pressure. Turn on the petrol tap, flood the carburetter slightly, switch on the accumulator ignition, give the starting handle two or three turns, and the engine should start. The throttle lever should only be advanced about one inch from the "closed" position and the ignition lever should be similarly placed. When the engine has started, the magneto ignition should be switched on instead of the accumulator. If it is desired to start on the magneto, the ignition lever on the wheel should be fully advanced.

Starting the Car.

The car can always be started on second speed, except when on a steep hill. The engine should not be raced excessively at starting; it will be found that the clutch may be let right in when the engine is running comparatively slowly. As soon as the car is under way, top gear should be engaged, and, after this, it will be found that the full variation in speed, whether on the level or up hill, can be obtained simply by opening or closing the throttle.

Running the Car.

The best rule to follow with regard to the control levers is to keep the throttle closed as much as possible for the speed desired, to supply as much extra air as the engine will take, and to advance the ignition lever. For very slow running it is best to cut off the extra air supply altogether. For very fast running, full air, and full ignition advance must be used. When

climbing hills at fast speed, it will usually be found best to pull the throttle lever back three or four notches, and also slightly to retard the ignition lever if the engine begins to labor.

Gear Changing.

When changing up from second speed to third, or from third to top, the throttle lever should be retarded, the clutch pedal depressed about half way, and the change speed lever moved quickly over to the correct position.

When changing down, the throttle lever should be left half-way advanced, the clutch slightly depressed, and the gear lever moved into neutral position. The clutch should then be let in for a moment, and immediately afterwards depressed, the gear lever being slipped into position simultaneously with the last clutch movement.

Another method of changing down is to leave the throttle lever half advanced, to press gently on the clutch pedal till the clutch is only just free and then to pull the change speed lever right back into the lower gear. For a quiet change with this method, it is essential that the clutch pedal should not be pressed forward more than about a quarter of an inch.

Only when engaging a gear with the car at rest should the clutch pedal be pushed right forward.

Brakes.

The foot brakes should be used normally, the hand brake being reserved for emergencies and long descents. The engine should always be used as a brake by fully closing the throttle. The clutch should

not be disengaged until the car is being brought to a standstill.

Hints to Drivers.

(1.) The maxim for the careful driver is "Don't take any risks." If this is acted upon, there will not be much chance of accidents.

(2.) Keep a careful look out at all cross roads and when entering a main road. It is at these places that most of the serious accidents occur.

(3.) Remember that the silence of the car makes the speed seem much less than it actually is. This fact should be carefully kept in mind and allowances made accordingly.

(4.) Drive slowly round corners if you wish your tires to last long, and for the same reason avoid sudden application of the brakes, except in case of emergency.

(5.) Always show consideration for other road users, whether pedestrians, cyclists, or horse drivers. This consideration consists in (a) not trying to pass too closely, and (b) slowing down for a few moments when passing on a dusty or muddy day.

(6.) Drive slowly on greasy surfaces and avoid sudden acceleration or application of the brakes. Use the engine as a brake, and avoid use of the clutch as much as possible.

(7.) If a short patch of unrolled stone is encountered, the best way to proceed is to approach it with just sufficient speed to enable the car to roll over the patch with the clutch disengaged. This is better for the tires than driving the car slowly over the patch. Above all, the car should not be stopped when on the stones, for the effort of starting might perhaps damage the rear tires.

Washing the Car.

If the well-finished appearance of the car is to be maintained, careful washing is essential. It is advisable to wash the car frequently, particularly when the car is new, and the washing must invariably take place at the end of the day's run, before the mud has dried on the varnish. Cold water must be used and nothing else, for the addition of petrol, paraffin, or anything of this nature will cause the varnish to become dull quickly. The water should be sprayed on with a hose, but the pressure must be reduced considerably, otherwise the particles of mud will scratch the surface. When all the mud and dust has been washed off, the body may be wiped down with a wet sponge and afterwards dried with a clean chamois leather.

Excess of water should not be used on the steering arms or pivots, or else the lubricating oil may be washed out.

If the leather upholstery is dirty, it may be washed with soap and water, and afterwards polished, if necessary, with leather reviver.

The cushions should always be taken out of the car and dried after a run on a wet day.

A French-polished surface should not be washed with soap and water; a drop of linseed oil will quickly restore its brilliancy.

Hints on the Treatment of Bodies.

(1.) Never bang a door to shut it; a properly fitted door shuts easily with a gentle slam. Continued banging will loose the hinges and so set up a rattle, while the paint is apt to chip and fall.

(2.) If a door rattles, the hinges should have the attention of a coachbuilder. The adjustment is simple and effective, whereas the common method of nailing a piece of leather along the door post will make matters much worse in the end.

(3.) The car should not be left in the sun on a hot day unless this is unavoidable. The heat may cause the varnish to blister.

(4.) The car must never be pushed along by placing the hands against the panels, or by pulling on the door handles or similar fitments. The correct method is to push the back of the frame or, easier still, to turn the wheels by pulling on the tires.

To Lower a Landaulette Hood.

(1.) Drop the inside curtain and fix it along the back pillar with the window.

(2.) Undo the two fasteners on top of the hood.

(3.) Raise the folding part of the roof straight up.

(4.) Fold the near-side joint just enough to pass the center, and do the same on the other side. Do not attempt to fold the hood down first.

(5.) From the back of the car pull the hood gently down.

(6.) When the hood is folded, the back light should not hang on the back panel but must be folded inside, resting on the back squab.

Hints on the Care of Tires.

(1.) See that the tires are inflated up to the correct pressure, and verify this by using a pressure gauge occasionally. The table given below shows the correct pressure for the various sizes.

(2.) The wing nuts and valve nut must be tightened up occasionally to prevent water getting inside the tire.

(3.) The small dust cap must always be fitted over the valve to ensure an airtight joint, and the rubber disc inside it must never be omitted.

(4.) If the air slowly leaks out of a tube and no puncture is apparent, the hexagon nut which secures the valve to the tube may require tightening.

(5.) The wheels should not be washed if the tires are deflated, otherwise water and grit will penetrate to the inside of the tire.

(6.) Tires which appear to be in good condition should be taken off and examined at least every 5,000 miles. If the rims are rusted inside, they must be cleaned and painted. The cover must be well chalked before it is replaced.

(7.) Great care must be taken to prevent oil coming in contact with the tires, for nothing is more injurious to the rubber.

(8.) All covers carried on the car should be well protected by means of a waterproof wrapper and all tubes should be carried in a rubber bag containing a handful of chalk.

Proper Inflation for Cord Tires.

All	3½″	Cord	Tires.	49	lbs.
"	4″	"	"	56	"
"	4½″	"	"	63	"
"	5″	"	"	70	"
"	5½″	"	"	77	"

Proper Inflation for Fabric Tires.

All	3″	Fabric	Tires.	55	lbs.
"	3½″	"	"	60	"
"	4″	"	"	70	"
"	4½″	"	"	80	"
"	5″	"	"	90	"
"	5½″	"	"	100	"
"	6″	"	"	110	"

TROUBLES AND THEIR LOCATION.

As was stated at the commencement of this book, troubles with the engine or other parts of the car are not matters of frequent occurrence; on the contrary, a whole season may pass without recourse ever having to be made to the directions given below.

When, however, any unusual symptom is apparent, either by some noise or by a falling off in the power of the engine, the circumstances should be noted, and, by reference to the following table, the reason can be at once determined.

All possible causes of the given trouble are stated, but a small amount of general experience should enable the operator to choose the one appropriate to his case.

Trouble. Engine Will Not Start—

CAUSE. (1.) Carburation.

(2.) Ignition.

REMEDY. (1.) Flood carburettor to make sure that the gasoline is flowing properly. If mixture "weak" (probable in cold weather or when first starting), inject a little gasoline in the cocks on

the inlet pipes. If mixture "rich" (possible in hot weather or when the engine is hot after a run), open cocks on inlet pipes if necessary.

(2.) Examine the sparking plugs for water or oil on the points. Examine accumulator and switch; see if wiring terminals disconnected or loose; see if trembler blade stuck. Try if the engine will start on the magneto, having first advanced the ignition lever.

Trouble. Engine Starts but Will Not Continue to Run—

CAUSE. (1.) Accumulator run down.

(2.) Gasoline not flowing freely to carburettor.

REMEDY. (1.) Try the other accumulator or switch on to magneto.

(2.) See if tap turned on fully; see if gauge shows correct pressure at tank; see if dirt in float chamber or pipes.

Trouble. Engine Will Not Run Fast—

CAUSE. (1.) Accumulator weak.

(2.) Ignition retarded.

(3.) Magneto requires adjustment.

(4.) Silencer choked.

REMEDY. (1.) Recharge the accumulator.

(2.) See if ignition lever works the distributor correctly.

(3.) Adjust contact breaker.

(4.) Remove silencer and clean the tubes.

Trouble. Engine Stops Suddenly—

CAUSE. Ignition failure.

REMEDY. Examine the wiring from magneto or accumulator to the switch and to the frame.

Trouble. Engine Will Not Stop When Switched Off—

CAUSE. (1.) If firing is regular, switch defective or wire disconnected.

(2.) If firing is irregular, pre-ignition.

REMEDY. (1.) To stop the engine, shut the throttle or turn off the gasoline; then examine switch and wiring.

(2.) Clean plugs; if necessary, clean burnt oil from cylinders by removing the heads.

Trouble. Engine Misfires Regularly in One Cylinder—

CAUSE. Plug defective wire loose or short circuited; asbestos washer on inlet pipe broken (unlikely).

REMEDY. Change plug; examine wiring; fit new washer.

Trouble. Engine Misfires Irregularly—

CAUSE. (1.) Ignition.

(2.) Carburettor.

REMEDY. (1.) Examine contact breaker, distributor, wiring, switch, plugs, accumulator.

(2.) See if there is any dirt or water in the float or jet chamber; see that the gasoline is flowing properly.

Trouble. Engine Fires in Silencer—

CAUSE. Unfired charges passing through the engine.

REMEDY. Examine as in last section; particularly see if the plug points are too far apart.

Trouble. Engine "Popps" or Fires Back Into Carburettor—

CAUSE. (1.) Mixture too weak.
(2.) Ignition occurring at wrong time.

REMEDY. (1.) Lease extra air shut; examine pressure and fuel supply; see if there is any dirt or water in the carburettor; see if the inlet pipe joints are loose.
(2.) Look for short circuits in distributor.

Trouble. Engine Does Not "Pull" Well—

CAUSE. (1.) Ignition or carburettor faulty.
(2.) Engine short of oil.
(3.) Silencer may be choked with burnt oil.
(4.) Brakes may be dragging—indicated by the drums becoming hot.
(5.) If in winter, the engine may be too cold.

REMEDY. (1.) As before.
(2.) See if pump working properly, and if there is sufficient oil in base.
(3.) Clean out the burnt oil.
(4.) Adjúst the brakes.

(5.) Remove fan belt; replace this when the warm weather comes.

Trouble. **Engine Overheats (indicated by water boiling in radiator)—**

CAUSE.
(1.) Ignition too much retarded.
(2.) Want of water.
(3.) Circulation defective.
(4.) Fan not working.
(5.) Pump not working.
(6.) Engine short of oil.

REMEDY.
(1.) Drive with ignition lever fully advanced.
(2.) Refill the radiator after the engine has cooled down somewhat.
(3.) Clean pipes out with soda.
(4.) Adjust fan belt.
(5.) See if pump-driving cotter is in place.
(6.) Put oil in base chamber; pour a little through the taps on the inlet pipe.

Trouble. **Engine Makes Unusual Hissing Noise—**

CAUSE. Leakage of gas from cylinder or pipes.

REMEDY. See if sparking plug broken; if inlet or exhaust pipes loose; or their washers blown out; see if taps on inlet pipe open.

Trouble. **Engine Makes Knocking Noise—**

CAUSE.
(1.) Pre-ignition.
(2.) Loose bearings.

REMEDY.
(1.) Retard spark. If knock still continues change the plugs one at a

time. If necessary, clean burnt oil out of cylinders.

(2.) This should not occur till after a long period of running.

Trouble. Engine Runs Well But Will Not Drive Car—

CAUSE. Clutch slipping.

REMEDY. See if clutch pedal is fouling the foot-board; increase tension on spring; pour a little gasoline on leather; as a last resource apply Fuller's earth or resin to the leather.

Trouble. Unusual Noise in Transmission Gear—

CAUSE. (1.) If a humming noise, the gear box or rear axle is probably short of grease or oil, or one of the bearings requires lubrication.

(2.) If a tapping or knocking noise, some part loose.

(2.) Locate the source of the trouble by noting its frequency relative to the rate of revolution of the rear wheel, or to that of the propellor shaft (the rate of the latter being approximately three or four times that of the rear wheels). When the source is located, jack up the wheels and examine the parts for undue play or looseness. If the trouble is in the propellor shaft, examine the universal joints and the gear box brake.

TO LOCATE A MISFIRING CYLINDER.

If the engine is misfiring regularly in one or more cylinders, the source of trouble may be located by cautiously touching the separate exhaust pipes in turn. Those pipes which lead from the defective cylinders should be cooler than the others. Another method is to short-circuit the plugs of each cylinder in turn, while the engine is running. To do this, a wooden-handled screwdriver should be held so that the metal blade is in contact with the cylinder head and with the terminal of the plug. If the cylinder which is being tested is firing correctly, this short-circuiting of the plug will reduce the speed of the engine. When the misfiring cylinder is reached, no reduction in the engine speed will be noted.

UNUSUAL NOISES.

On account of the multitude of moving parts on a car, slight squeaks or noises are sometimes set up. Owing to the exceptional silence of running of Knight engined cars, these slight noises are specially noticeable, and hence a few words on their location may be useful. If the squeak is regular in occurrence, it must be caused by some revolving part. By running the engine with the car at rest, it can be determined whether the trouble is in this part or not. If not in the engine, the squeak is probably in the clutch mechanism or in one of the universal joints, or perhaps the brakes are rubbing slightly on their drums. A few minutes with the oil can will put these matters right. If the squeak is intermittent, the springs and spring shackles should be examined and lubricated. When the squeak is specially noticeable on rough roads it is almost certain to be caused by one of these parts.

USEFUL TABLES

MILLIMETRES AND INCHES.

Mm.	Inches.	Mm.	Inches.	Mm.	Inches.	Mm.	Inches.
1	0·0394	26	1·0236	51	2·0079	76	2·9922
2	0·0787	27	1·0630	52	2·0473	77	3·0315
3	0·1181	28	1·1024	53	2·0866	78	3·0709
4	0·1575	29	1·1417	54	2·1260	79	3 1103
5	0·1968	30	1·1811	55	2·1654	80	3·1496
6	0·2362	31	1·2205	56	2·2047	81	3·1890
7	0·2756	32	1·2598	57	2·2441	82	3·2284
8	0·3150	33	1·2992	58	2·2835	83	3·2677
9	0·3543	34	1·3386	59	2·3228	84	3·3071
10	0·3937	35	1·3780	60	2·3622	85	3·3465
11	0·4331	36	1·4173	61	2·4016	86	3·3859
12	0·4724	37	1·4567	62	2·4410	87	3·4252
13	0·5118	38	1·4961	63	2·4803	88	3·4646
14	0·5512	39	1·5354	64	2·5197	89	3·5040
15	0·5906	40	1 5748	65	2·5591	90	3·5433
16	0·6299	41	1·6142	66	2 5984	91	3·5827
17	0·6693	42	1·6536	67	2·6378	92	3·6221
18	0·7087	43	1·6929	68	2·6772	93	3·6614
19	0·7480	44	1·7323	69	2·7166	94	3·7008
20	0·7874	45	1·7717	70	2·7559	95	3·7402
21	0·8268	46	1·8110	71	2·7953	96	3·7796
22	0·8661	47	1·8504	72	2·8347	97	3·8189
23	0·9055	48	1·8898	73	2·8740	98	3·8583
24	0·9449	49	1·9291	74	2·9134	99	3·8977
25	0·9843	50	1·9685	75	2·9528	100	3·9370

INCHES AND MILLIMETRES.

Inches.	0	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$
0	0.0	1.6	3.2	4.8	6.4	7.9	9.5	11.1
1	25.4	27.0	28.6	30.2	31.7	33.3	34.9	36.5
2	50.8	52.4	54.0	55.6	57.1	58.7	60.3	61.9
3	76.2	77.8	79.4	81.0	82.5	84.1	85.7	87.3
4	101.6	103.2	104.8	106.4	108.0	109.5	111.1	112.7
5	127.0	128.6	130.2	131.8	133.4	134.9	136.5	138.1
6	152.4	154.0	155.6	157.2	158.8	160.3	161.9	163.5

Inches.	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$
0	12.7	14.3	15.9	17.5	19.1	20.6	22.2	23.8
1	38.1	39.7	41.3	42.9	44.4	46.0	47.6	49.2
2	63.5	65.1	66.7	68.3	69.8	71.4	73.0	74.6
3	88.9	90.5	92.1	93.7	95.2	96.8	98.4	100.0
4	114.3	115.9	117.5	119.1	120.7	122.2	123.8	125.4
5	139.7	141.3	142.9	144.5	146.1	147.6	149.2	150.8
6	165.1	166.7	168.3	169.9	171.5	173.0	174.6	176.2

MILES AND KILOMETRES.

Kilo.	Miles.	Kilo.	Miles.	Kilo.	Miles.	Kilo.	Miles.
1	$\frac{5}{8}$	20	$12\frac{3}{8}$	38	$23\frac{5}{8}$	56	$34\frac{3}{4}$
2	$1\frac{1}{4}$	21	13	39	$24\frac{1}{4}$	57	$35\frac{3}{5}$
3	$1\frac{7}{8}$	22	$13\frac{5}{8}$	40	$24\frac{7}{8}$	58	36
4	$2\frac{1}{2}$	23	$14\frac{1}{4}$	41	$25\frac{1}{2}$	59	$36\frac{5}{8}$
5	$3\frac{1}{8}$	24	$14\frac{7}{8}$	42	$26\frac{1}{8}$	60	$37\frac{1}{4}$
6	$3\frac{3}{4}$	25	$15\frac{1}{5}$	43	$26\frac{3}{4}$	70	$43\frac{1}{2}$
7	$4\frac{3}{8}$	26	$16\frac{1}{8}$	44	$27\frac{3}{8}$	80	$49\frac{3}{4}$
8	5	27	$16\frac{3}{4}$	45	28	90	$55\frac{7}{8}$
9	$5\frac{5}{8}$	28	$17\frac{3}{8}$	46	$28\frac{5}{8}$	100	$62\frac{1}{8}$
10	$6\frac{1}{4}$	29	18	47	$29\frac{1}{4}$	200	$124\frac{1}{4}$
11	$6\frac{7}{8}$	30	$18\frac{5}{8}$	48	$29\frac{7}{8}$	300	$186\frac{3}{8}$
12	$7\frac{1}{2}$	31	$19\frac{1}{4}$	49	$30\frac{1}{2}$	400	$248\frac{1}{2}$
13	$8\frac{1}{8}$	32	$19\frac{7}{8}$	50	$31\frac{1}{8}$	500	$310\frac{3}{4}$
14	$8\frac{3}{4}$	33	$20\frac{1}{2}$	51	$31\frac{3}{4}$	600	$372\frac{7}{8}$
15	$9\frac{3}{8}$	34	$21\frac{1}{8}$	52	$32\frac{1}{4}$	700	435
16	10	35	$21\frac{3}{4}$	53	$32\frac{7}{8}$	800	$497\frac{1}{8}$
17	$10\frac{5}{8}$	36.	$22\frac{3}{8}$	54	$33\frac{1}{2}$	900	$559\frac{1}{4}$
18	$11\frac{1}{4}$	37	23	55	$34\frac{1}{8}$	1000	$621\frac{3}{8}$
19	$11\frac{3}{4}$						

CONVERSION OF METRIC INTO ENGLISH MEASURE.

1 millimetre is approximately $\frac{1}{25}$ inch and is exactly ·03937 inch.
1 centimetre is approximately $\frac{13}{32}$ inch and is exactly ·3937 inch.
1 metre is approximately $39\frac{1}{4}$ inches and is exactly 1·0936 yards.
1 kilometre is approximately $\frac{5}{8}$ mile and is exactly ·6213 mile.
1 kilogramme is approximately $2\frac{1}{4}$ lbs. and is exactly 2·21 lbs.
1 litre is approximately $1\frac{3}{4}$ pints and is exactly 1·76 pints.

To convert metres to yards, multiply by 70 and divide by 64.
To convert kilometres to miles, multiply by 5 and divide by (approx.).

To convert litres to pints, multiply by 88 and divide by 50.
To convert grams to ounces, multiply by 567 and divide by 20.

To find the cubical contents of a motor cylinder, square the diameter (or bore) multiply by 0·7854 and multiply the result by the stroke.

SPEED TABLE.

Time of One Mile.	Miles per Hour.	Time of One Mile.	Miles per Hour.	Time of One Mile.	Miles per Hour.
Min. Sec.		Min. Sec.		Min. Sec.	
0 40	90	1 22	43·9	2 12	27·3
0 41	87·18	1 23	43·3	2 15	26·7
0 42	85·6	1 24	42·8	2 18	26·1
0 43	83·8	1 25	42·4	2 21	25·5
0 44	81·8	1 26	41·9	2 24	25
0 45	80	1 27	41·4	2 27	24·5
0 46	78·2	1 28	40·9	2 30	24
0 47	76·6	1 29	40·4	2 33	23·6
0 48	75	1 30	40	2 36	23·1
0 49	73·4	1 31	39·6	2 39	22·6
0 50	72	1 32	39·1	2 42	22·2
0 51	70·6	1 33	38·7	2 45	21·8
0 52	69·2	1 34	38·3	2 48	21·4
0 53	68	1 35	37·9	2 51	21·1
0 54	66·8	1 36	37·5	2 54	20·7
0 55	65·4	1 37	37·1	2 57	20·3
0 56	64·2	1 38	36·7	3 0	20
0 57	63·2	1 39	36·4	3 6	19·4
0 58	62	1 40	36	3 12	18·8
0 59	61	1 41	35·7	3 18	18·2
1 0	60	1 42	35·3	3 24	17·7
1 1	59	1 43	34·9	3 30	17·1
1 2	58	1 44	34·6	3 36	16·7
1 3	57·1	1 45	34·3	3 42	16·2
1 4	56·3	1 46	34	3 48	15·7
1 5	55·4	1 47	33·7	3 54	15·4
1 6	54·5	1 48	33·4	4 0	15
1 7	53·7	1 49	33	4 6	14·6
1 8	53	1 50	32·7	4 12	14·3
1 9	52·2	1 51	32·4	4 18	13·9
1 10	51·4	1 52	32·1	4 24	13·6
1 11	50·7	1 53	31·8	4 30	13·3
1 12	50	1 54	31·6	4 36	13
1 13	49·4	1 55	31·3	4 42	12 8
1 14	48·6	1 56	31	4 48	12·5
1 15	48	1 57	30·8	4 54	12·2
1 16	47·4	1 58	30·5	5 0	12
1 17	46·7	1 59	30·2	5 12	11·5
1 18	46·2	2 0	30	5 24	11·1
1 19	45·6	2 3	29·2	5 36	10·7
1 20	45	2 6	28·6	5 48	10·3
1 21	44·4	2 9	27·9	6 0	10

PERSONAL MEMORANDA.

Name .....

Address .....

.....

Nearest Rly. Stn.....

Telegraphic Address .....

Telephone Number .....

MOTOR MEMORANDA.

Date of Purchase.....

Car No..... .....

Registration Number .....

Motor Driver's License Number.....


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