NOTE.—*The application for a Patent has become void.*
This print shows the Specification as it becomes open to public inspection.

N° 3503 A.D. 1915

(Under International Convention.)

Date claimed under Patents and Designs Act, 1907, being date of first Foreign Application (in France), *4th Mar., 1914*

Date of Application (in the United Kingdom), 4th Mar., 1915

At the expiration of twelve months from the date of the first Foreign Application, the provision of Section 91 (3) (a) of the Patents and Designs Act, 1907, as to inspection of Specification, became operative

Complete Specification not accepted

COMPLETE SPECIFICATION.

Improvements in or relating to Heat Engines.

I, ROBERT ESNAULT-PELTERIE, of 37, rue des Abondances, Boulogne-sur-Seine, Seine, France, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

Two different methods have been hitherto utilised for increasing the efficiency of heat engines.

On the one hand, attempts to follow the theoretical cycles of operation of the engines as closely as possible have been made, while on the other hand, without specially considering the cycles of operation, as intimate a mixture as possible of the combustible and the combustion supporter has been sought. These two conditions are, however, never united in the same motor.

The best combustible mixtures have only been obtained by mixing the constituents before compressing, but owing to the risk of preignition high pressures cannot be resorted to and consequently high efficiency has been lacking.

In motors working with high efficiency, for the purpose of obviating preignitions, it has been necessary to inject the combustible at the end of the compression. But in this case there arises the difficulty of effecting an intimate mixing of the combustible and the air during the very short period available.

The mixing is especially bad when the combustible is injected in the form of a jet into the compression chamber of the motor wherein the charge of compressed air is relatively stationary. For there is then formed around the space occupied by the combustible jet a layer of burnt gas which prevents contact

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between the following combustible particles and the portion of pure air which still remains in the bottom of the cylinder.

To obviate in part this drawback, a portion of the compressed air charge is made use of for further atomising the combustible, but then this portion of compressed air is insufficient of itself to effect complete combustion and the mixture of the two together forms itself into a sort of combustible in opposition to the pure air contained in the compression chamber. This latter combustible is not exempt from the previously mentioned inconvenience, a layer of burnt gas envelopes it and again prevents the combustion being rapid and complete. Moreover, for the mixing of these two masses of gas, the one movable and the other immovable, a sufficiency of time is necessary which is never available at the normal travelling speed.

It is from this that arises, as all practical people know, the impossibility with injection motors of hitherto attaining high speeds of rotation. It is necessary then for the mixture to be sufficiently perfect and be effected in a sufficiently rapid manner, that is to say the whole of the compressed air charge which serves as the atomising air, should as far as possible take an equal part in the atomisation of the combustible, within practicable limits, tending towards the theoretical perfect conception.

The present invention has for its object the attainment of this desideratum by utilising simultaneously in the same motor the efficiency advantage that working at high pressure produces and the advantage that a very homogeneous mixture of the combustible and combustion supporter procure.

If there be employed a motor, in which the compression chamber is connected to the working cylinder end by a relatively restricted passage and the piston approaches this end as near as practicable at the end of its stroke, and in which the combustible is injected across the above mentioned passage at a point sufficiently near the combustion space, then such a motor approaches as nearly as is practicable the conditions indicated in the preceding paragraph. In fact, the largest possible part of the air compressed by the piston is obliged to traverse the passage, and the quantity of air, which at the end of the compression remains between the piston and the orifice of injection is as small as possible with respect to that contained in the compression chamber and in that part of the passage situated between that orifice and the chamber. Nevertheless, practice shows that this arrangement is still insufficient to ensure the formation of a mixture absolutely homogeneous, if certain precautions are not taken.

The principal object of the present invention consists chiefly in the design of the above mentioned passage and of parts associated with it. In co-operation with the passage an improved carburetting process may be followed, the whole arrangement tending to assure the formation of a perfect mixture and permitting a high pressure working without pre-ignition.

The passage connecting the cylinder and the compression chamber is given a flattened section and the combustible liquid is injected across the passage, at the end of the compression period and at one of the extremities of the section, with a force sufficient for the jet to traverse the whole length.

If the said section were circular, there would be on each side of the jet two free spaces so considerable that an important fraction of the air would pass without meeting the combustible; the mixture would not then be homogeneous. With the above indicated arrangement, the combustible assumes the form of a partition which blocks nearly the whole passage and all the portions of the air which traverse it assist in the drawing in of the combustible.

The section of the passage can be of any convenient form, for instance rectangular, trapezoidal, triangular, or oval.

In order to augment further the homogeneity of the mixture produced by the preceding arrangement, baffles are provided in the passage being situated at one or both extremities thereof. These baffles do not act as heaters and so produce an action injurious to the efficiency. If the baffles were to act as a heater then, during the working of the motor, the heater would have a temperature intermediate between that of the exhaust and of the explosion, so that during the compression it would give off heat to the gas and increase the negative work of the compression. On the other hand, during the explosion or combustion, by reason of its temperature being decidedly lower than that of the gas during the explosion or combustion, the heater would absorb heat from the gas and diminish accordingly the positive work of expansion. There would accordingly result a double loss which is avoided in the present system owing to the rapidity with which the gas traverses the above mentioned passage having a flattened section and baffles. For example, if the arrangement of the present invention be applied to a motor of the automatic type with a cylinder of about two litres capacity, the parts would be proportioned so that each portion of the mixture traverses the baffles in a period of from one five thousandth to one one thousandth of a second. If the arrangement is applied to large industrial motors, having large cylinders, this period of time can without inconvenience be one one hundredth or one twentieth of a second.

The difficulty of transmitting heat through gas is well known to all heat engineers and it is easy to calculate that during such short intervals of time the temperature of the gases will not be affected, both during the compression and during the expansion.

It is moreover for the purpose of avoiding all loss of heat at the end of the compression that the compression chamber has only a capacity necessary to contain a single charge of compressed air, so that the charge is without delay carburetted, fired and expanded immediately and the heat due to the compression, also that of the combustion, has not time to be dissipated, causing a loss of equivalent work.

A motor provided with the preceding arrangements should for practical purposes be able to operate while developing a variable power. For that purpose it is necessary that the quantity of combustible should itself be variable. But in order that the combustion may be always good in spite of the diminution of the injected combustible, it is desirable that the quantity of air compressed in the working cylinder should be diminished very nearly proportionally.

To this end, an auxiliary valve provided on the wall of the cylinder is adapted to place the cylinder in communication with the atmosphere or the exhaust duct, the valve being controlled by a cam of suitable form which will permit the closing point of the valve to be varied during the compression stroke. The charge of air compressed by the working cylinder will of course be reduced in proportion as the valve in question is closed later. The controlling cam of this valve may be connected in a suitable way to the cam which controls the injection of the combustible so as to maintain for all degrees of admission the desired composition of the combustible mixture.

This arrangement has also the advantage of preventing the motor stopping when the injected quantity of the combustible is small, for example when running slowly, owing to a diminution of the compression.

The preceding arrangements can also be applied in the case where a combustible gas is used. Owing to the relative greater volume of combustible gas, it is advantageous to effect its admission, not through the small side of the passage, but by several orifices disposed in a line transverse to the axis of the passage or by an opening similarly disposed on the large side of the passage.

With liquid combustibles, it may in certain cases be advantageous to utilise a carburetting device which serves to transform the liquid combustible into a gaseous combustible.

In very fast running motors used in some automobiles and for aviation purposes, the working of the liquid combustible pumps would present a difficulty. If this difficulty is to be avoided it is necessary to effect the injection of the combustible by super-compressed air. But this process necessitates the employment of an orifice for the combustible in the neighbourhood of the valve for the admission of air super-compressed in the cylinder, in order that the atomisation be not effected in advance and that the atomised combustible moreover may only arrive in successive layers of air as has been described. Combustion then takes place gradually, slowly and badly.

To obviate this inconvenience, it is necessary that the combustible should mix with super-compressed air, not at the entry into the cylinder but on the contrary it should be atomised into extreme thinness and preferably in suspension in a mass of gas which can be introduced across the above mentioned passage. In this way, the combustible is atomised in advance and not only at the instant it enters the cylinder. Practice shows in fact that in the second case it is impossible to obtain good atomisation, a homogeneous mixture and a rapid combustion.

Nevertheless, as the gases which serve as the vehicle for the vapour of the combustible should have a pressure which slightly exceeds that of the compression, there is again the objection, if for this purpose air be utilised, of the inconvenience of pre-ignition, at least with the lighter combustibles. It is preferable then, especially with these latter, to make use of for this purpose gas which can be taken from the exhaust.

It follows from this that this portion of the exhaust gases should be reduced to a minimum quantity so as to dilute as little as possible the charge of air contained in the cylinder. This quantity can for example be of the same volume as that which at the end of the exhaust remains in the compression chamber of an ordinary four stroke cycle motor and which can be equal to a fourth or even a third of the cylinder. However, in all cases it should be as near as possible to the limit, where the atomised combustible cannot any longer be conveniently maintained in suspension.

It is this manner of effecting the carburetting of a portion of the exhaust gases which are afterwards compressed for introducing them into the cylinder at the desired moment with the atomised combustible which they contain, which constitutes one of the characteristics of the present invention. The said portion of the exhaust gases can be carburetted in the ordinary manner by a constant level spray nozzle or by mechanical injection.

In the case where gaseous combustible is used, the gas compressor cylinder can comprise a discharge valve analogous to that of the air compressor cylinder so as to allow the quantity of gaseous combustible being varied at will.

The accompanying drawing, given by way of example, will explain the improvements the object of this invention.

Fig. 1 is a view in longitudinal section of a cylinder of a high efficiency motor.

Fig. 2 is a section on X—X of Fig. 1.

Fig. 3 shows a view analogous to that of Fig. 1 but in which the passage connecting the cylinder with the compression chamber comprises a system of baffles constituting a mixing device.

Figs. 4, 5 and 6 are sections on Y—Y, Z—Z, V—V of Fig. 2.

Fig. 7 shows a double mixer.

Fig. 8 shows an exterior view of a conical mixer formed with cross threads.

Figs. 9 and 10 are respectively a longitudinal section and a plan view of a conical mixer.

Fig. 11 shows the application of a mixer to a two stroke cycle motor, and

Fig. 12 is a section on W—W of the mixer.

As is seen from Figs. 1 and 2, the passage *a* which connects the cylinder *b* of the motor and the compression chamber *c* is of a flat section, which in certain cases suffices to produce a good mixture of air and combustible, the latter being injected crosswise of passage *a* by conduit *d*.

But to increase the homogeneity of the mixture of the air and combustible, during their flow through the passage *a*, especially when applied to fast running motors, it is advantageous to place at some convenient point of the passage, a series of baffles of any kind and form. One or other of the mixing devices, single or double, straight or conical, shown in Figs. 3, 7, and 8, 9, 10 can also be used.

The mixer shown in Fig. 3 can be constituted by two pieces *e*, *f* suitably connected at their upper part in a manner to constitute baffles *g*.

The lower part of pieces *e*, *f* can have the form shown in section, Fig. 6. Instead of a single mixer, as represented in Fig. 7, there can be two in passage *a*, one below and the other above the injection conduit *d*. In this case the arrangement shown in Fig. 7 can be employed, in which pieces *e* and *f* are suitably joined at their top and bottom parts to form a double mixer.

In the modification represented in Figs. 8, 9 and 10, the mixer is conical and is constituted by two cross helical screw threads of considerable pitch, in a manner to constitute a series of pyramidal points, serving as baffles for the mixer represented in Fig. 3; the middle part is suitably cut away in a manner to form a cavity *j* and is pierced with a lateral duct *k* communicating by a number of orifices k^1 with the circular cavity *j* so that the jet of combustible arriving at the side of the passage *a* traverses the hole *k*.

In the case where the mixer or system of baffles is of a double nature as shown in Figs. 7 and 9 and a liquid combustible is injected, it is necessary to arrange in passage *a* a free space *j*, above and below the jet, sufficiently large for the liquid combustible, drawn in by the combustion air, to acquire a certain speed before reaching the baffles, and so be prevented from applying itself and being maintained by capillarity on the baffles, which render the starting of the motor difficult.

By way of example, Fig. 11 shows the arrangement of a high efficiency two-stroke cycle motor constructed according to this invention. This motor comprises the working cylinder *b* connected on the one hand in known manner to a scavenging pump *l* and on the other hand to a carburetting cylinder *m* by duct *d* having an automatic or controlled valve d^1. The injection of the gaseous combustible into passage *a* is effected by the orifice *u* shown in section, Fig. 12. In the case where gaseous combustible is used, the suction side of the carburetting cylinder *m* is connected to a gasometer, but if it is desired to utilise a liquid combustible after the manner of a gaseous combustible, this carburetting cylinder would be connected to the exhaust *o* by a nozzle and diffuser like duct *p*, on which would be mounted a constant level or injection nozzle, *q*. A controlled or automatic valve *r* is disposed at the end of duct *p* which opens into the carburetting cylinder. In the motor just described, the ignition is automatic and effected by compression, the advance of the injection corresponding to the advance of the customary injection.

Similarly in the case of a gaseous combustible the regulation of the advance or retardation of the injection is effected by means of valve d^1 which should accordingly be of a controlled type. The said valve can only be automatic in injection motors without variable advance or retardation.

For starting off a sparking plug, not shown, is disposed in at a convenient place in the compression chamber.

On the working cylinder and the carburetting cylinder are arranged controlled discharge valves *s* and *t* which permit of the quantity of air to be compressed and the quantity of gaseous combustible to be injected to be varied in suitable proportions.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. In a heat engine working at a high compression pressure, the arrangement wherein the passage or duct connecting the working cylinder and the charge compression chamber has a restricted and flattened cross section, so

that the combustible jet injected across the passage fills the whole cross section, as and for the purpose described.

2. A heat engine according to Claim 1, in which a single or double baffle member is arranged in the connecting passage or duct to assist in creating a homogeneity of the combustible and air mixture.

3. In a heat engine, according to Claim 2, having a double baffle member, the construction whereby a free space is left between the said member into which the jet of combustible is injected, as and for the purpose described.

4. A heat engine according to Claims 2 and 3, in which the baffle member comprises two pieces connected above and below.

5. A heat engine according to Claims 2 and 3, in which the outer surfaces of the baffle member are constituted by two crossing screw threads of considerable pitch.

6. A heat engine according to Claim 1, in which the combustible is injected through a series of holes disposed along one of the longer sides of the section of the passage.

7. In a heat engine in which ignition is automatically effected by compression of the charge, controlling the time of the commencement of the injection relatively to the constant time of the ignition.

8. In combination with the heat engine claimed in the preceding claims, means for transforming the liquid combustible into a gaseous combustible by atomising it by the aid of a portion of the exhaust gases, and injecting the mixture through a valve into the connecting passage provided with or without a baffle member, substantially as described.

9. In a heat engine according to Claim 8, valvular means for regulating the quantity of air compressed in the working cylinder and of combustible to be injected.

10. A heat engine constructed and operating substantially as described and illustrated with reference to Figs. 1, 2 or 11.

Dated this 4th day of March, 1915.

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Agents for the Applicant.

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[This Drawing is a reproduction of the Original on a reduced scale.]

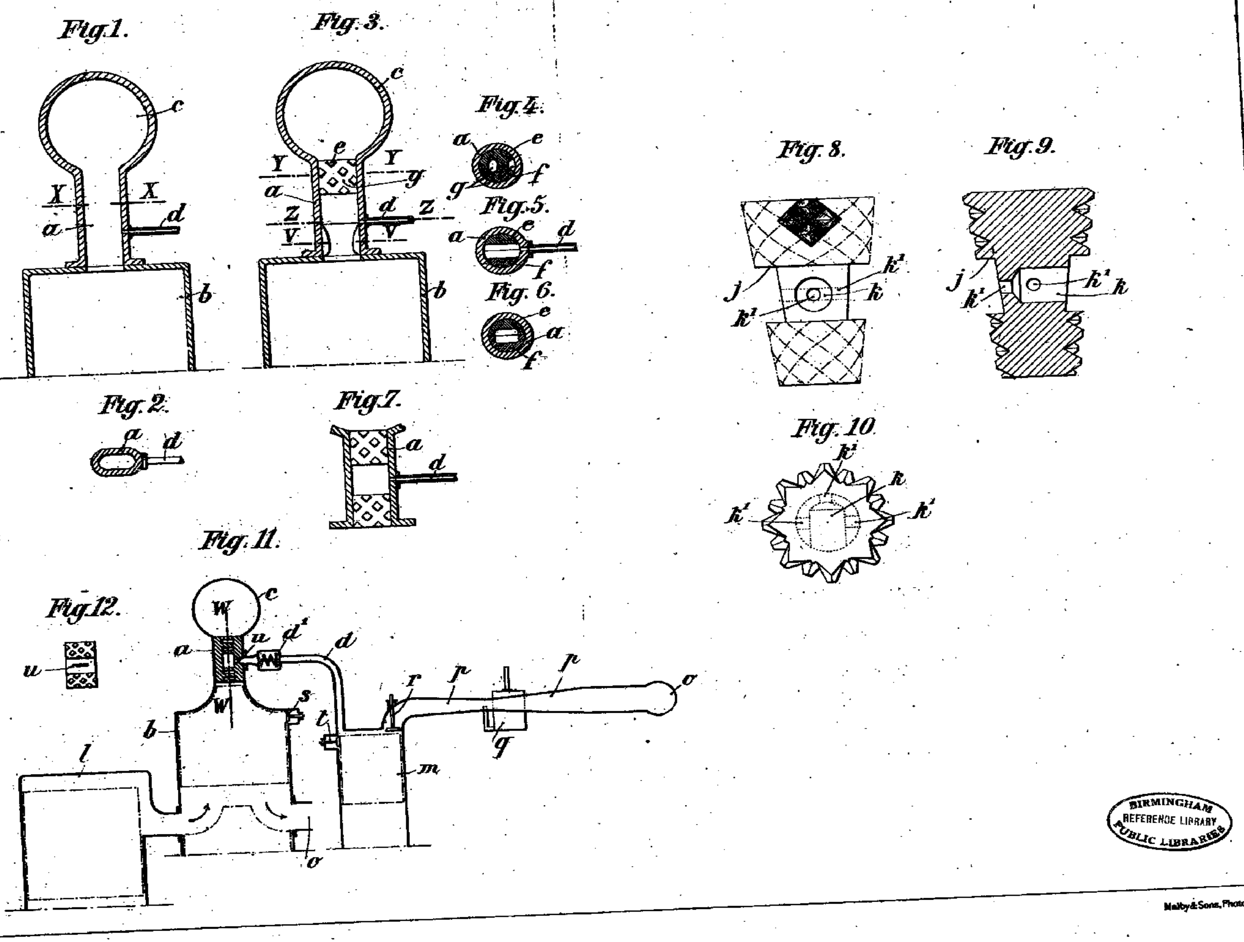

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Fig.1.

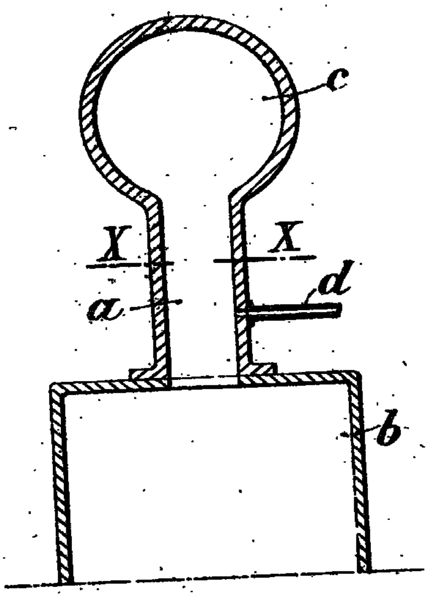

Fig.3.

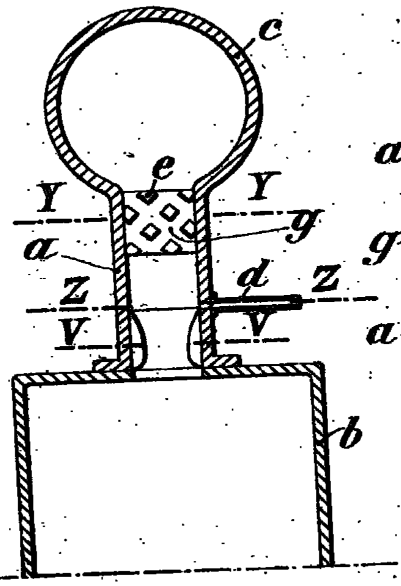

Fig.4.

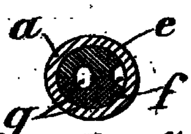

Fig.5.

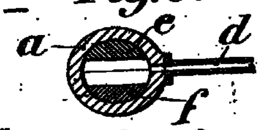

Fig. 6.

Fig.2.

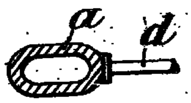

Fig.7.

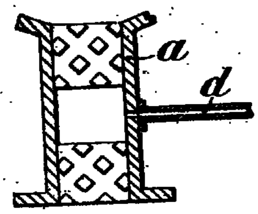

Fig.11.

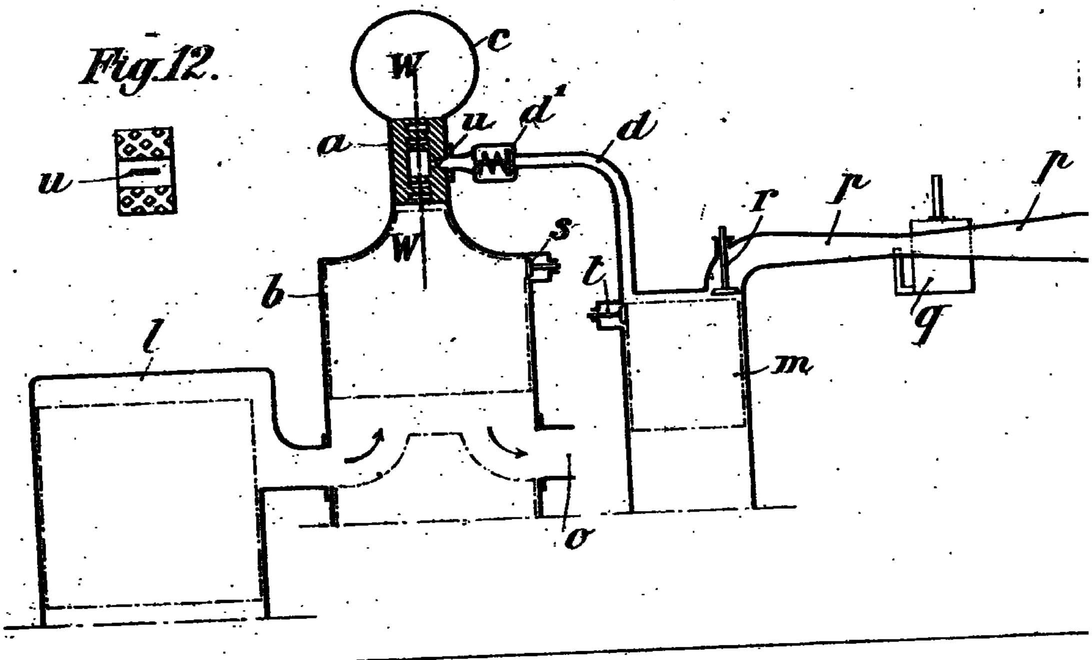

Fig.12.

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Fig. 8.

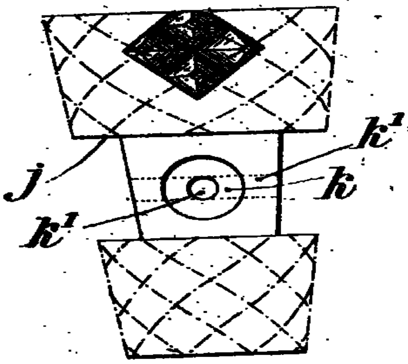


Fig. 9.

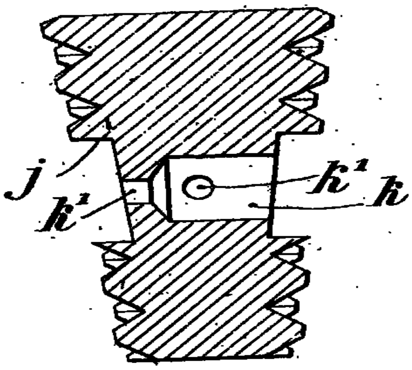
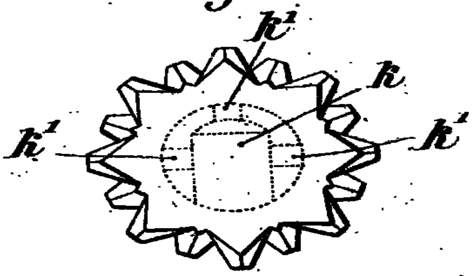
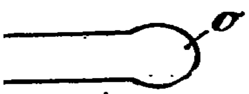


Fig. 10.





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