K. E. SCHREBER.
PROCESS OF WORKING EXPLOSIVE ENGINES.
APPLICATION FILED NOV. 27, 1903.

898,512. Patented Sept. 15, 1908.

Fig. 1.

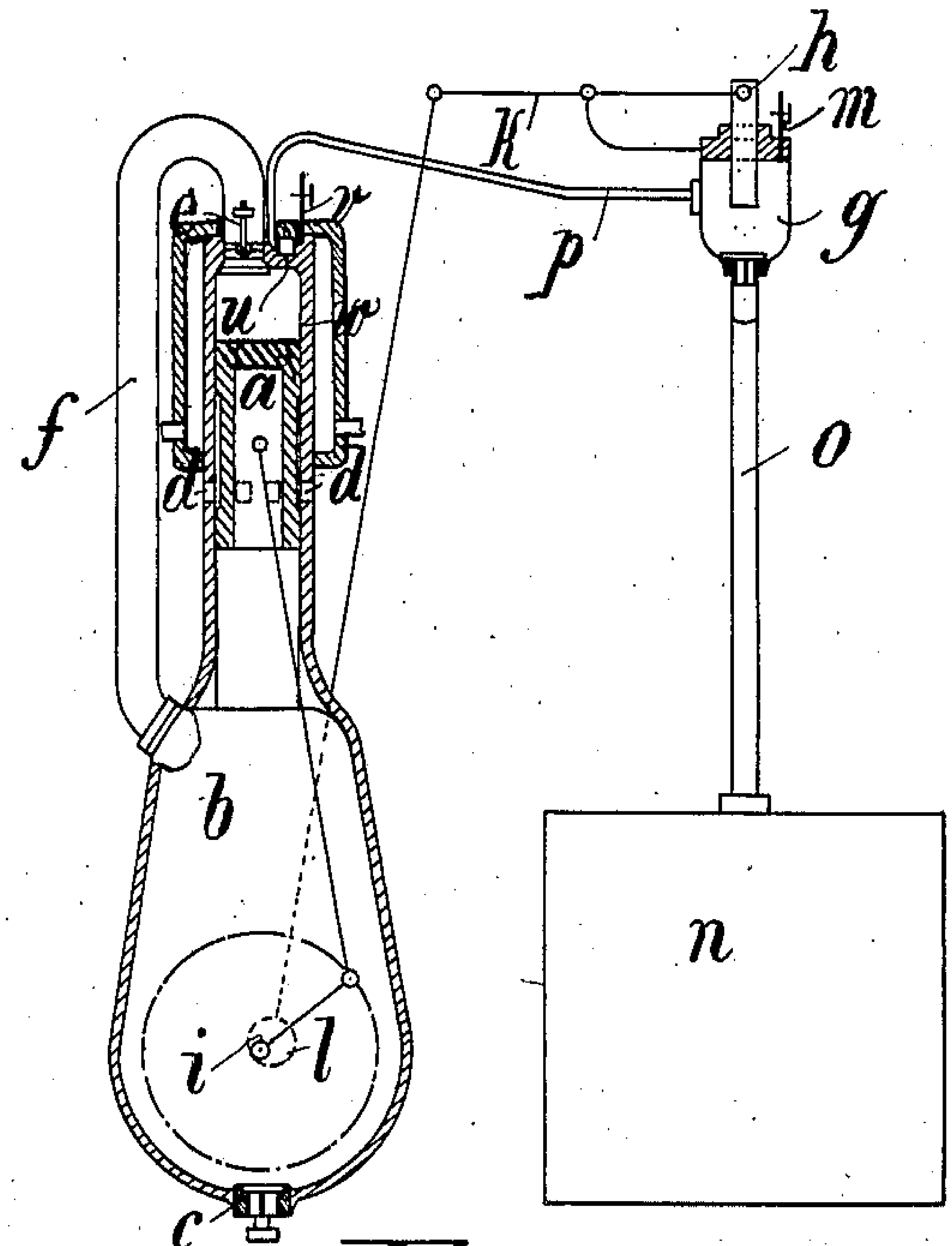
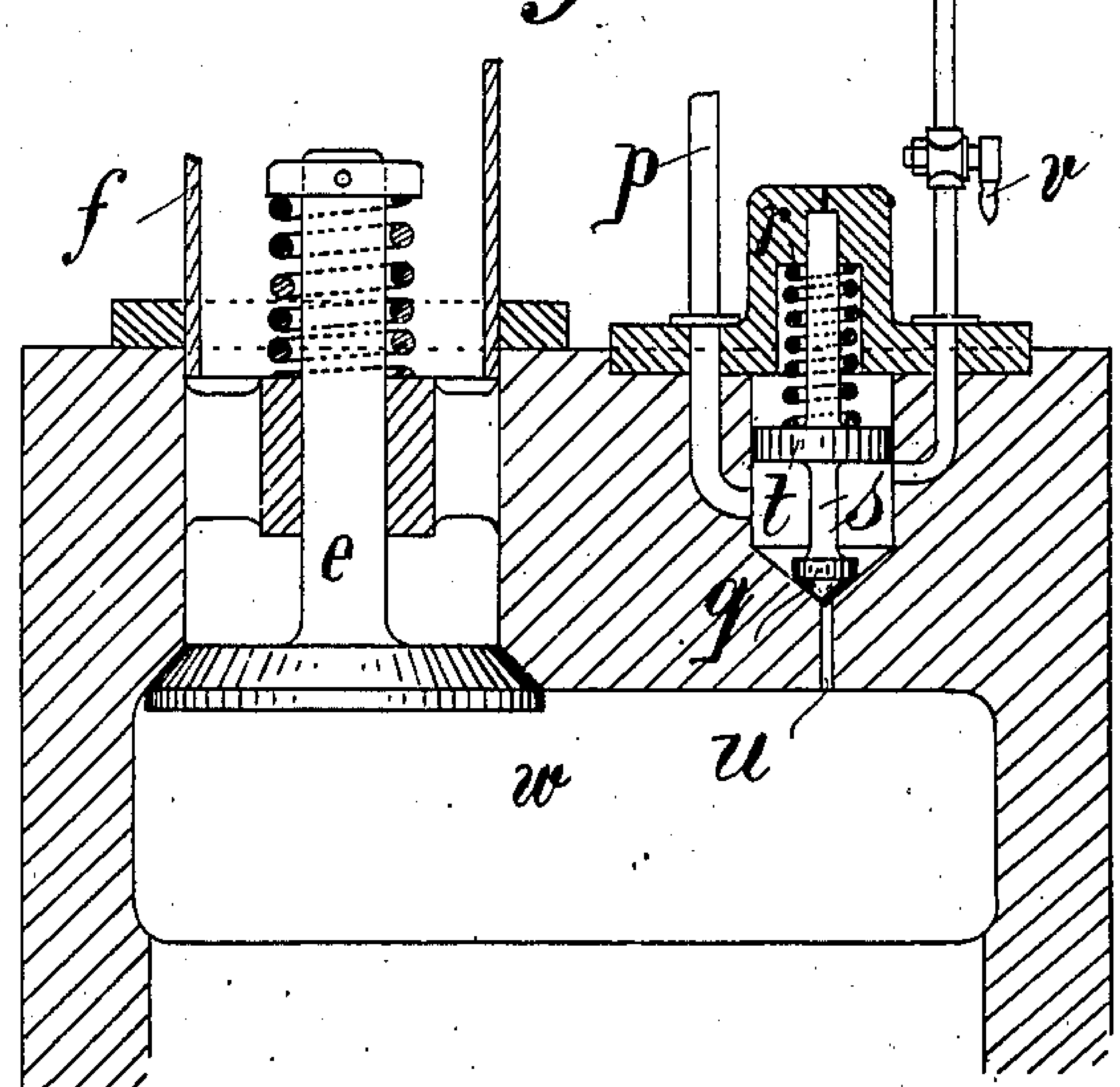


Fig. 2.



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PROCESS OF WORKING EXPLOSIVE-ENGINES.

No. 898,512. Specification of Letters Patent. Patented Sept. 15, 1908.

Application filed November 27, 1903. Serial No. 182,785.

To all whom it may concern:

Be it known that I, KARL EDMUND SCHREBER, a citizen of the Empire of Germany, residing at Greifswald, Germany, in the Province of Pomerania and Kingdom of Prussia, have invented certain new and useful Improvements in Processes of Working Explosive-Engines, of which the following is a specification.

My invention relates to a process or method of operating explosive engines, and the object thereof is to provide a method of cooling the medium under compression by the piston, in order to maintain this medium below the ignition point of the explosive mixture, which method will give a higher efficiency of work than other known methods of which I am aware.

The general object sought by my invention has been, to a certain degree, attained by engineers, but so far as I am aware, the methods heretofore followed have involved the mixing of the cooling agent with the explosive mixture before or at the time the same is introduced into the cylinder or to inject the cooling agent alone into the cylinder, in both cases no special reference being paid to the degree of heat of the medium under compression at the time of the introduction of said agent, or to the degree of increase of temperature of said medium under the continued compression of the same.

In contradistinction to these known methods, my method comprehends the gradual introduction of the cooling agents directly into the cylinder, said introduction commencing only after the medium under compression has attained a predetermined temperature.

By the present invention the internal cooling is effected with the employment of the least possible quantity of cooling medium, so that the compression can be carried past the limit hitherto attainable. For this object a liquid requiring a suitable amount of heat for evaporation is injected or sprayed into the interior of the working cylinder in such a way that the injection begins after the inflammable mixture, or rather the air not yet mixed with inflammable material, has been heated up to the evaporating temperature of the injected liquid corresponding to the existing pressure. From this point onwards the injection must take place so gradually that the heat produced by the compressing work done during a known part of the increase in pressure shall just suffice to evaporate the cooling liquid injected during the same time. Care must also be taken to effect a sufficient distribution of the injected liquid through the whole interior of the cylinder. In large engines it may be necessary to divide up the inlet passage into several parts in order to effect this object, and in this way the greatest possible amount of the mixture, or rather air, to be compressed may be cooled by the liquid.

The liquid employed for the internal cooling must possess a suitable heat of evaporation; water must also be taken primarily into consideration. But if liquid inflammable material or fuel is employed in the explosion engine the heat of evaporation of this material may under certain circumstances be sufficient. If that is not the case, the heat of evaporation may be raised up to the proper value by the admixture of water with the liquid fuel, supposing such mixture to be possible. If such mixture is not possible and at the same time the evaporating heat of the liquid fuel is insufficient to produce the cooling, then water must also be injected in addition to the fuel. Whether or not the two liquids can be injected simultaneously, or one after another, and in the latter case in what order they may be injected, depends upon the nature of the fuel or inflammable liquid; but in any case the order of succession can always be so arranged that the heat existing in the gas within the cylinder owing to the work done in compression will suffice to evaporate the inflammable liquid so that separate evaporating apparatus will be rendered unnecessary.

In order to better explain how this invention may be applied in practice it will be described with reference to a spirit motor working upon this principle. This motor is illustrated in the accompanying drawings in which:—

Figure 1 illustrates the whole arrangement of the motor, and Fig. 2 shows a part of the cylinder head in section.

In spirit motors, as also in all motors upon this principle and working with liquid inflammable material, pure atmospheric air is drawn in during the indrawing stroke, and on this account these motors can be readily constructed as two-stroke cycle motors. In the form of spirit motor shown the back of the piston *a* will serve for the drawing in of air, the crank casing *b* being made air tight. During the compression stroke of the piston air will be drawn into the crank casing through a self acting valve *c*, and will be slightly compressed in this casing during the expansion stroke. Supposing that the piston is approaching the end of an expansion stroke, it will uncover and open the exhaust slots *d* formed in the cylinder casing, and the gases of combustion will escape into the exhaust ways. As soon as the pressure in the cylinder *w* has fallen sufficiently the self-acting air inlet valve *e* arranged in the cylinder head opens, and the air under slight pressure streams from the crank casing through the pipe *f* into the cylinder *w* from which it expels before it the remainder of the gases of combustion. The guiding part of the main piston must of course be of such a length that it always keeps the exhaust slots *d* closed to the side of the crank casing. When the piston again advances in the direction of compression it closes the exhaust slots and then the compression of the air contained in the cylinder commences. As soon as the temperature of this air is sufficiently raised by the work of compression the injection of the spirit is begun, more or less of the amount of spirit required for the cooling being supplied by water according to the excess of air with which the explosive mixture is to be made. The injection can be so adjusted by suitable regulating devices that the temperature in the cylinder obeys a suitable predetermined law. For example, if the temperature is to remain constant during the injection, the injected mixture must obey the law:—

$$v.\ n.^{A} = \text{const.}$$

Where v is the volume existing at the moment in front of the piston, n is the number of molecules contained in this volume, and A is a constant depending upon the heat of evaporation of the injected liquid and the predetermined temperature. It will be advantageous to allow the temperature to rise slowly so that it always remains somewhat higher than the boiling temperature of the injected liquid corresponding to the existing pressure. If the speed of the injection is so measured that in normal working the necessary amount of the inflammable liquid is already injected somewhat before the end of the stroke, it is possible for the working of the motor to be regulated by adjustment of the feed in exactly the same way as in steam engines. The compression following after the termination of the injection cannot then raise the temperature up to the self-ignition point.

The injection of the spirit through the pipe *p* is effected by means of a pump *g*, the plunger *h* of which is operated from the valve-gear shaft *i* by means of a lever arrangement *k* for example, in which the size of the eccentric *l* must be fixed according to the predetermined law for the temperature in the cylinder. It will be evident also that the movement of the lever *k* might be produced by its end being operated by a cam turning on a shaft. By the stroke of the plunger *h* in one direction the spirit is discharged into the working cylinder, while in the return stroke more spirit is sucked up from the storage tank *n* through the pipe *o*. The pump must always be filled with spirit, without any air bubbles, in order that the law and the quantity of the spirit to be injected may not be disturbed owing to the compressibility of said air bubbles. For this purpose a small air outlet cock *m* is placed on the pump, which cock will be opened during the filling of the pump, but will be closed during the feeding of the liquid by said pump.

By placing the pressure valve of the spirit feeding system in the head of the cylinder, the pump can be guarded from the high pressure produced by the explosion. One method of producing this arrangement is as follows. The passage *u* leading into the cylinder, and by which the spirit will be injected, has a conical enlargement in which a conical valve head *q* Fig. 2 fits in order to close the passage *u*, the valve being pressed upon its seat by a spring *r*. The spring must be strong enough to resist the pressure upon the tube area during the explosion. A small piston *t* is mounted upon the narrow stem *s* of the valve and works fluid tightly in the same chamber as the valve head. The excess of the pressure surface of the piston *t* over that of the valve head is so adjusted that the liquid forced by the pump is enabled by its pressure acting on the said piston to overcome the force of the spring and to lift the valve from its seat. The space between the piston *t* and the opening leading to the cylinder must always be filled with spirit. An air outlet cock *v* must also be provided for use in the first filling as was the case in the pressure pump *g*. If the passage *u* leading into the cylinder is closed sufficiently tightly by its valve head, the space remains filled with spirit which can not burn because no oxygen can obtain access to it; in large motors several openings of this kind would have to be provided leading into the cylinder. The cylinder *w*, and especially the cylinder head at the place where the spirit inlet valve is arranged, must be well cooled in order that the spirit may always be well below its boiling point. For motors working with liquid fuel which will not mix with water two such pumps and injection valves must be provided, one for the liquid fuel and the other for the water.

When the liquid fuel or inflammable matter is very completely utilized it is easily possible, especially in large motors, to provide for a prolonged expansion by arranging in a suitable manner for the air inlet valve to be operated from the valve-gear shaft in such a way that said valve is first closed after the piston has made a part of its compression stroke. The remaining part of the stroke then only serves for producing the compression, while for the expansion the whole stroke is employed up to the opening of the exhaust slots. Apart from this regulation of the inlet valve no alteration need be made in the arrangement.

If it is desired to employ liquid fuels which are difficult to vaporize, such for instance as petroleum residues or crude oils, it will be well in order to make sure of the vaporization to warm to a certain extent the indrawn air, by taking the exhaust gases around or in suitable passages through the crank casing, or by preventing the complete expulsion of the burned gases from the cylinder by the incoming air. As soon as the heavy oil is vaporized the temperature can be again considerably reduced by the injection of water, as although the whole pressure is required for the evaporization, a very much lower partial pressure would be necessary to produce the condensation temperature after the mixture of the vaporized fuel with the air. For the ignition any suitable known method of ignition may be employed.

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. The method of cooling the explosive charge of an internal combustion engine to increase the capabilities of compression thereof, which consists in injecting a cooling liquid directly into the working cylinder of an engine at a point during the compression of the charge when the temperature of the latter has been raised by the heat incident to said compression to a temperature equal to the boiling point of the cooling liquid and continuing the injection of said cooling liquid during the further compression of the charge.

2. The method of cooling the explosive charge of an internal combustion engine to increase the capabilities of compression thereof, which consists in injecting a cooling liquid directly into the working cylinder of an engine at a point during the compression of the charge when the temperature of the latter has been raised by the heat incident to said compression to a temperature equal to the boiling point of the cooling liquid, and then gradually injecting such cooling liquid, during the further compression of the charge so that the heat produced by the compression during a part of the increase in pressure shall suffice to evaporate the cooling liquid injected during the same time, said evaporation serving to reduce the temperature of the charge.

In testimony whereof I have signed my name to this specification in presence of two witnesses.

KARL EDMUND SCHREBER.

Witnesses:
JOHANNES HEYN,
JULIUS UTCOHT.