P. L'ORANGE.

METHOD OF OPERATING EXPLOSIVE ENGINES.

APPLICATION FILED JAN. 27, 1909.

959,951.

Patented May 31, 1910.

2 SHEETS—SHEET 1.

Fig. 1.

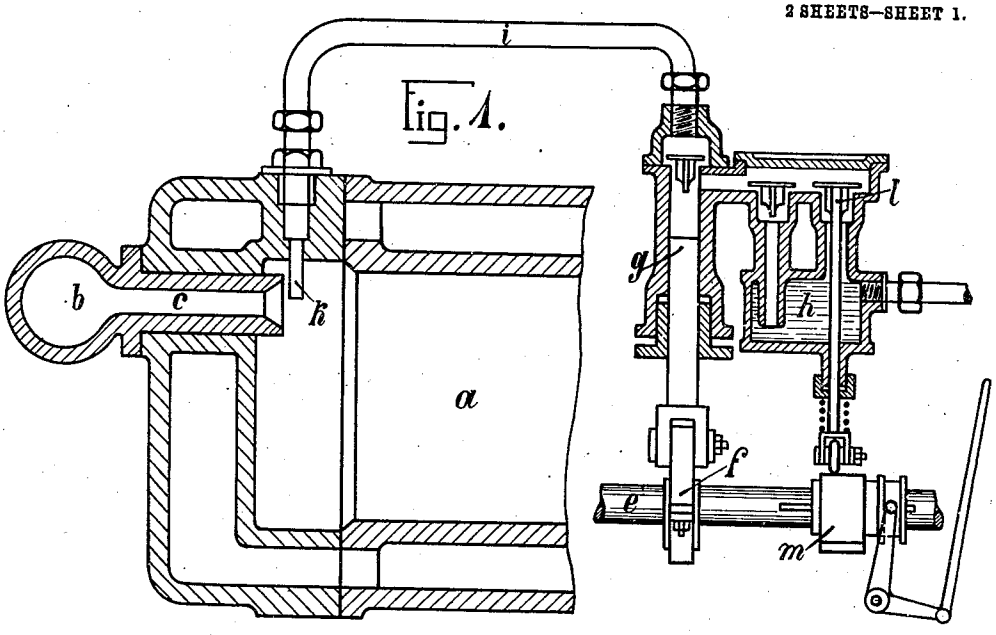


Fig. 2.

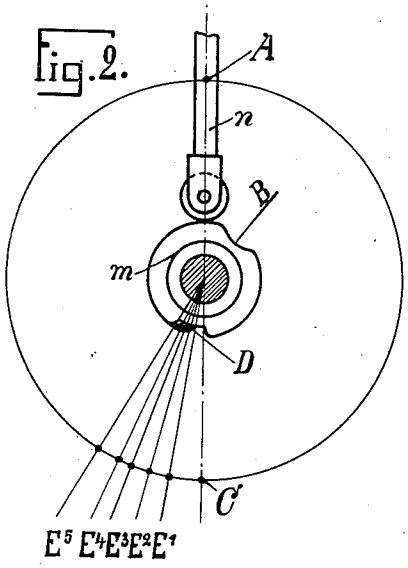
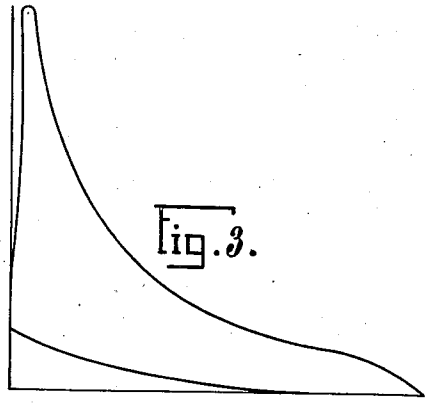


Fig. 3.



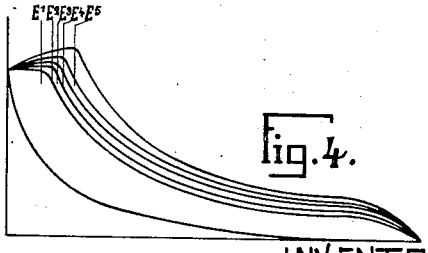


Fig. 4.

WITNESSES

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2 SHEETS—SHEET 2.

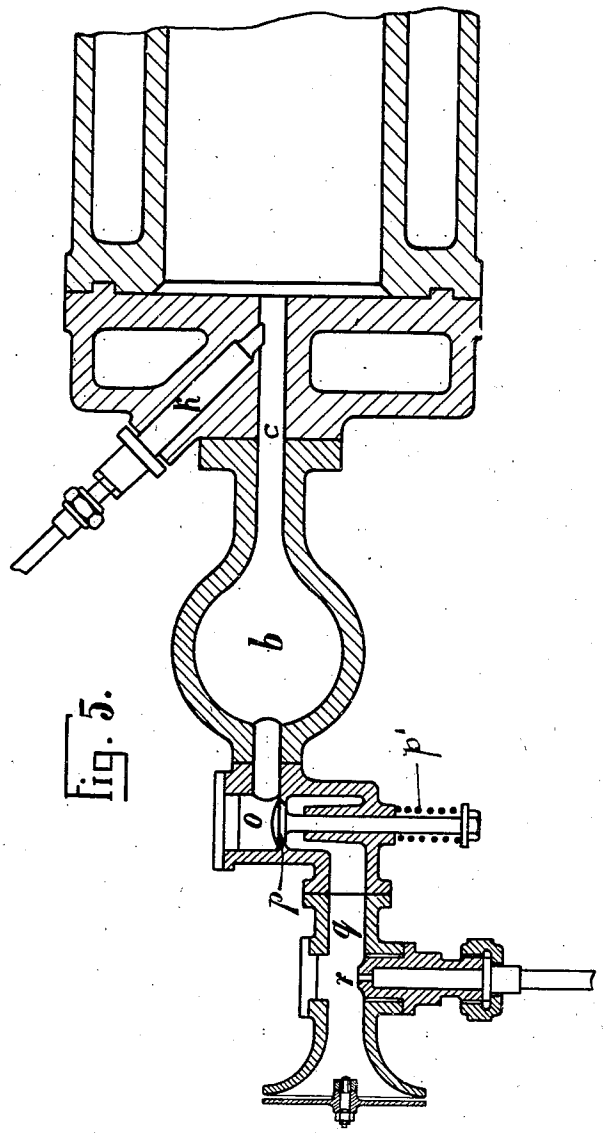

Fig. 5.

WITNESSES

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UNITED STATES PATENT OFFICE.

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METHOD OF OPERATING EXPLOSIVE-ENGINES.

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To all whom it may concern:

Be it known that I, PROSPER L'ORANGE, engineer, a subject of the German Emperor, and resident of Mannheim, Stamitzstrasse 2, Germany, have invented certain new and useful Improvements in Methods of Operating Explosive-Engines; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to an improved method of operating explosive engines of that class, in which the cylinder is in constant communication with a hot retort or combustion chamber into which the charge of the cylinder is forced during the compression stroke, to be ignited therein. In engines of this character, in front of the discharge of the canal connecting the retort and the cylinder a cup has been provided against which the liquid fuel was thrown before the compression or during the first part of the same. The air forced into the retort during the compression stroke carries along a part of the fuel, so that a mixture of fuel and air is produced within the retort, which is ignited by a special igniter or by self-ignition, when the piston is at its dead point. The glowing jet of gas passing from the retort into the cylinder carries along the fuel left on the cup and throws the same into the air within the cylinder, where it is subjected to an explosive combustion. Engines of this character are objectionable in this respect, that the whole amount of the fuel is at the same moment thrown from the cup into the cylinder, so that it is not sufficiently atomized when it comes in contact with the air. Therefore its combustion is incomplete, and the engine is covered with the residues of the combustion after a short time of operation.

The object of my improvements is to avoid this disadvantage. For this purpose the portion of the liquid fuel which is first brought into the retort is brought into the same before or during the compression stroke, and it is ignited when the piston is near its dead point, while the feeding of the second portion of the fuel into the cylinder begins immediately before or after the ignition and extends over any desired part of the working stroke. The second portion of the fuel, or the working fuel, is fed through one or more apertures and at such a place that it is blown in a state of fine distribution into the jet of glowing gas shooting out from the retort, in a manner which has heretofore been used in Diesel motors. It is essential, however, that the jet of gas shooting out from the retort lasts as long as the working fuel is fed through its nozzle, so that the latter is perfectly atomized. This may be effected, for example, by using a retort of proper size and by providing a correspondingly narrow passage between the retort and the cylinder. Various means may be provided for feeding the fuel required for the explosion within the retort. For example a pump may be provided which forces the fuel into the retort during the suction stroke, the compression stroke, or the exhaust stroke, or a branch pipe may be connected to the pressure tube of the pump for the working fuel, so that a single pump is required in the engine, or a certain amount of an explosive mixture of air and fuel may be drawn into the retort through a small suction valve during the suction stroke. A simple method consists in forcing the fuel through the working nozzle during the compression stroke, so that it is carried along into the retort by the air pressed into the same. The working fuel, or the whole charge, is preferably fed into the cylinder immediately in front of the canal connecting the retort and the cylinder, or within the same. But the working fuel may also be fed into the said canal at a point near the cylinder. In all the cases, however, the jet of the working fuel must strike the jet of the burning fuel escaping from the retort substantially in a transverse direction and at such a point, that the speed of the jet of the burning gas is sufficient to cause a complete atomization of the working fuel.

For the purpose of explaining the invention, I have shown an example of an engine adapted to carry the new method into effect, in the accompanying drawing, in which the same letters of reference have been used in all the views to indicate corresponding parts.

In said drawing Figure 1, is a vertical longitudinal section of the rear part of a combustion engine and of parts coöperating therewith, Fig. 2, is a detail cross-section of the cam shaft and showing the parts on an enlarged scale, Fig. 3, is a diagram illustrating the operation of the engine, Fig. 4, is a similar diagram corresponding to different loads of the engine, and Fig. 5 is a vertical

longitudinal section of a modified arrangement in which a certain amount of an explosive mixture of air and fuel is drawn into the retort during the suction stroke through a suitable suction valve.

With the working cylinder *a* a retort or combustion chamber *b* communicates through a canal *c*. The cylinder may be provided with cooling means, or with heating means, or means of this character may be dispensed with, according to circumstances. By a pump *g* the liquid fuel is drawn in by suction from a reservoir *h*, and it is fed into the cylinder through a tube *i* and a nozzle *k* having its discharge end in front of the canal *c*. The pump *g* is actuated by an eccentric *f* keyed to a cam shaft *e*. It is provided with a valve *l* which, when actuated by a cam *m* permits a portion of the fuel drawn in by the pump to flow back into the reservoir *h*. Fig. 2 shows the cam *m* on an enlarged scale. It also shows the circle of the machine crank the outer dead point of the working piston being indicated at A and the inner dead point of the same at C.

For the purpose of simplicity, it may be supposed in the present example, that the engine is an engine working in tempo two. Shortly after the compression is completed, the notch B of the cam *m* engages an antifriction roller mounted on a stem *n* connected with the valve *l*. Thereby the said valve, which before was open, is closed, and the pump forces fuel into the cylinder through the nozzle *k*. By the rearward stroke of the piston the air is compressed within the cylinder, and forced into the retort *b*, and it carries along the small amount of fuel fed into the cylinder. Now the valve *l* is again opened, so that the admission of the fuel is interrupted, until the piston arrives nearly at its dead point. Now the mixture of gas and fuel is ignited within the retort, either by the hot walls of the latter or by a glow pipe, an electrical igniter, or the like. On account of the considerable increase of the pressure caused by the explosion within the retort a hot jet of gas shoots out at great speed through the narrow passage *c* into the cylinder. At the same moment the feeding operation of the pump is again started, because the notch D of the cam *m* closes the valve *l*. In case of full load, fuel is fed until the crank of the engine arrives at the point E^5, and the capacity of the retort *b*, the amount of fuel fed into the same, and the cross-section of the canal *c* are such, that a jet of gas shoots out at high speed from the canal *c*, until the crank arrives at the point indicated at E^5. If the load of the engine is decreased, the governor of the engine moves the cam *m* to the left, so that other portions of the notch D engage the roller of the valve stem *n* and cause the same to open the valve and to shut the admission of fuel at an earlier moment. The various points of the notch of the cam causing the opening of the valve *l* at an earlier or later moment according to the load of the engine are indicated at E^1, E^2, E^3, etc. Instead of interrupting the feed of the pump at B and starting the same at D, the feeding operation of the pump may be continuous. Also in this case the direction of the jet of the fuel is automatically deflected in the opposite direction by the ignition, because before the ignition of the fuel the pressure within the cylinder is greater than that within the retort, and after the same the pressure within the retort is greater than that within the cylinder, so that the fuel which is continuously fed is first forced in one direction into the retort and afterward in the opposite direction, longitudinally of the cylinder, under the action of the stream of gas shooting out of the retort.

In the diagram shown in Fig. 4 the effect of the varying length of the feeding periods is illustrated by the different lengths of the horizontal part of the line representing the combustion period. The points at which the combustion is stopped according to the load of the engine are indicated by the same letters as in Fig. 2. The notch B, however, for feeding the fuel into the retort has the same dimension for all the charges. In the preferred construction the said notch is of such a length that the amount of fuel fed into the retort is sufficient for operating the engine when there is no load on the latter, so that in this case no fuel is fed into the cylinder after the ignition has taken place.

When using fuel of high gasification temperature, such for example as crude naphtha, the compression within the working cylinder must be comparatively high (from 15 to 20 atmospheres), in order to assure a complete combustion. In such cases, premature ignition of the mixture forced into the retort would be unavoidable, if the compression within the retort were the same as that within the working cylinder. To avoid this, the cross-section of the canal *c* is made so small, that only a small proportion of the pressure set up within the cylinder is transmitted to the retort. Therefore, the compression within the retort is considerably smaller than that within the cylinder, whereby a premature ignition is avoided. The effect of this construction is illustrated in the diagram shown in Fig. 3. As compared to the diagram illustrated in Fig. 4, which corresponds to the case of equal compression within the retort and within the cylinder, the compression is small in the case illustrated by the diagram of Fig. 3, and the explosion is similar to that of engines of ordinary construction. By reason of the

small cross-section of the canal *c* the balancing of the pressure between the retort and the cylinder and the discharge of the gas from the retort into the cylinder takes place during such a part of the stroke of the piston as corresponds to the period of admission of fuel in case of maximum load of the engine.

In Fig. 5, wherein there is illustrated an arrangement by which an explosive mixture of air and fuel is drawn into the retort through a suction valve during the suction stroke, *p* indicates a valve that operates in a housing or casing at the rear end of the retort *b*, said valve coacting with a suitable seat in order to control communication between the retort *b* and a fuel admission duct *q*. This valve may be controlled by a spring *p'*, or it may be automatically operated in any suitable way. Communicating with the admission channel *q* is a fuel duct *r* which is in communication with the atmosphere so that the fuel passing through the channel or duct *q* will be mixed with air in suitable proportions. On the suction stroke the valve *p* will be opened in order to admit the mixture of fuel and air into the retort *b* and on the compression stroke the mixture in the retort will be ignited, as previously indicated, causing a stream of highly heated gas to shoot out into the cylinder through the canal or duct *c*. At this time, a charge of fuel is introduced into the canal *c* through the duct *k*, the amount of this second or working charge corresponding to the load on the engine, and the working charge will be ignited and atomized by the gas jet in the manner hereinbefore indicated, though in this case, the working fuel is introduced directly into the canal *c* instead of directly into the cylinder.

What I claim is—

1. The method of operating combustion engines, having a heated retort or combustion chamber constantly communicating with the working cylinder, which consists in feeding an explosive mixture of fuel and air into the said combustion chamber, causing the said mixture to explode within the combustion chamber solely by contact with the hot walls of the latter, and forcing fuel into the working cylinder near the discharge of the combustion chamber into the cylinder while the hot gas from the combustion chamber shoots out into the cylinder.

2. The method of operating combustion engines having a retort or combustion chamber constantly communicating with the working cylinder, which consists in forcing a small amount of fuel into the working cylinder before the explosion stroke of the same, causing the ignition of the mixture of air and fuel pushed by compression from the cylinder into the combustion chamber, and forcing fuel into the working cylinder near the discharge of the combustion chamber into the cylinder while the hot gas from the combustion chamber shoots out into the cylinder.

3. The method of operating combustion engines having a retort or combustion chamber constantly communicating with the working cylinder, which consists in forcing an amount of fuel into the combustion chamber which is sufficient to drive the engine when there is no load, causing the said mixture to explode within the combustion chamber and forcing fuel into the working cylinder near the discharge of the combustion chamber into the cylinder while the hot gas from the combustion chamber shoots out into the cylinder.

4. The method of operating combustion engines having a retort or combustion chamber communicating with the working cylinder, which consists in feeding into said combustion chamber a relatively fixed amount of explosive mixture, causing such mixture to explode within the combustion chamber, and forcing fuel into the jet issuing from the combustion chamber into the cylinder, in correspondence with the load on the engine.

In testimony whereof I have affixed my signature, in presence of two witnesses.

PROSPER L'ORANGE.

Witnesses:
H. ELKAN,
TERESA CATTURANI.