H. H. HEIN.

METHOD OF OPERATING COMBUSTION ENGINES.

APPLICATION FILED FEB. 18, 1913.

1,132,581. Patented Mar. 23, 1915.

Fig. 1.

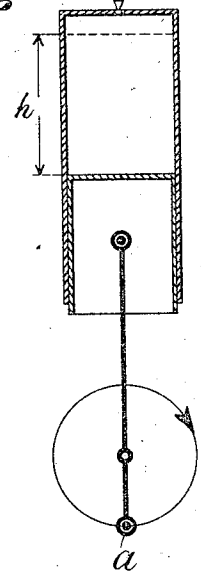


Fig. 2.

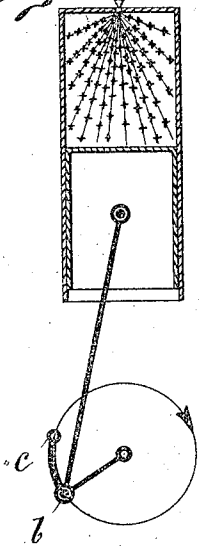


Fig. 3.

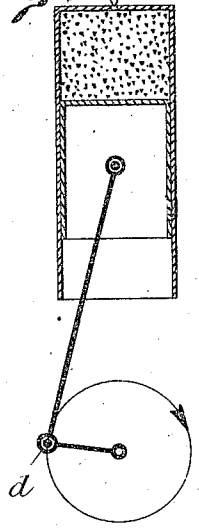


Fig. 4.

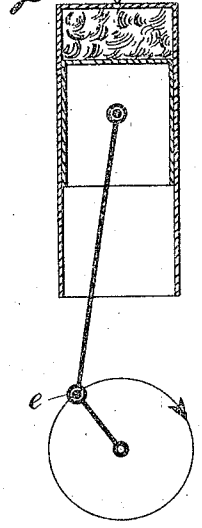


Fig. 5.

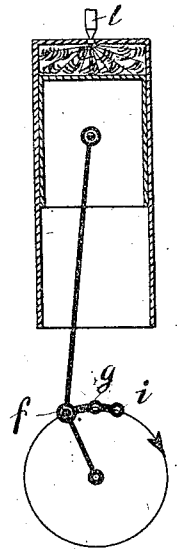


Fig. 7.

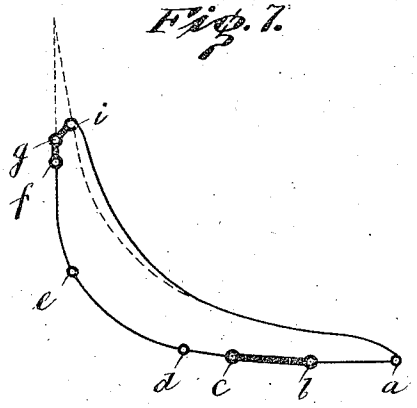
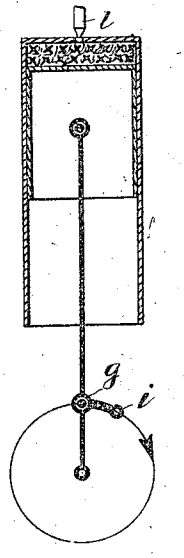


Fig. 6.



Witnesses:
C. S. Ashley
E. W. Akerblom.

Inventor
Hans Heinrich Hein
By his Attorney
Max D. Drawbaugh

UNITED STATES PATENT OFFICE.

HANS HEINRICH HEIN, OF RANDERS, DENMARK, ASSIGNOR TO DEUTSCHE AUTOMOBIL-CONSTRUKTIONS-GES. M. B. H., OF CHARLOTTENBURG, GERMANY, AND I./S. H. HEIN & SONNERS, OF RANDERS, DENMARK.

METHOD OF OPERATING COMBUSTION-ENGINES.

1,132,581. Specification of Letters Patent. Patented Mar. 23, 1915.

Application filed February 18, 1913. Serial No. 749,172.

To all whom it may concern:

Be it known that I, HANS HEINRICH HEIN, a subject of the King of Denmark, residing at Randers, Denmark, have invented certain new and useful Improvements in Methods of Operating Combustion-Engines, of which the following is a specification.

The present invention relates to a method of operating combustion engines, in particular such for liquid fuels, which method affords a considerably more advantageous thermal utilization of the fuel over the methods hitherto known at a very great simplicity of the design of the engine. The acceptance of this method renders the use of many parts dispensable, which were hitherto considered as drawbacks in engines of a similar kind; as for instance the compressor for the injection air of the "Diesel engine", the ignition cap of the "Brons engine", the glowhead with heating lamp and the devices for the dripping cooling water in the "glowhead engine", the carbureter devices for liquid fuels in "carbureter engines" and the like. Notwithstanding the simplicity of the mechanism required for its performance, the novel method allows of the use of easily or not easily volatile fuels, and owing to the high ratio the compression of a good thermal utilization of fuel, whether the engines be constructed on the four-cycle, the two-cycle system or in any other manner.

My invention will be more clear by referring to the accompanying drawing which forms part of this specification and in which the new method is exemplified, Figures 1 to 6 being diagrams showing the several positions of the piston with the piston gear and Fig. 7 being a diagram of the pressures, corresponding positions in the different figures being indicated by corresponding reference characters.

The essential feature of the present invention is as follows: During a stroke of the engine, and preferably during the compression stroke a part of the fuel required for the respective operation is introduced in a mechanically diffused condition, that is without any diffusing air, for instance by means of a diffusing nozzle into the air already contained in the engine cylinder (it being immaterial whether such air has entered into the cylinder with four-cycle engines by the suction stroke or with two-cycle engines as scavenging air); the thus introduced portion of the fuel charge will form with the air in the engine cylinder a purely mechanically produced mixture of fuel and air. It is not necessary that this mixture is inflammable, particularly when a not readily volatile fuel is used. As with the progress of the compression also the heat of the compression will increase, the hitherto only mechanically diffused particles of fuel will be evaporated and form with the air a mixture of fuel vapor and air, which at a given ratio of the mixture will become inflammable at a higher compression. In order to prevent a premature ignition of this mixture when the compression heat rises still further, one or several further portions of the mechanically diffused fuel are introduced during the further compression period into the already existing mixture of fuel and air. This renewed introduction of fuel, the same as the previous one, has first of all the object to absorb the heat of the mixture of fuel and air by its evaporation, and besides to enrich the mixture to the favorable ratio. By suitably arranging the quantity injected, the moment of the injection and the process of the injection the moment of the ignition (in consequence of the compression heat) can be controlled at will in the neighborhood of the upper dead center. Without such renewed introduction of fuel the moment of the ignition could not be accurately determined, and this would cause the engine to knock in running. Besides it would be necessary to employ a lower ratio of the compression in order to avoid premature ignitions, so that a less favorable utilization of the fuel would result. Lastly the ignition of such a mixture of fuel and air would be a sudden one and result in a corresponding pointed diagram. As, now, the subsequently introduced fuel has not as much time at disposal to evaporate as the portion which was first introduced, before the ignition occurs, there will be a combustion going on even after the ignition, and this will result in the diagram being fuller instead of pointed; on the other hand this will insure a more silent running of the engine. The above mentioned continuous introductions may also be replaced by individual,

short injections of a corresponding duration. The individual injections may also pass over into each other by the injections in the intermediate space of time being weaker or smaller. After such thermo-mechanical ignition and expansion the exhaust gases are removed from the engine cylinder and the latter is filled with air before commencement of the next compression period in known manner the same as with the four-cycle, two-cycle or other engines.

With the new method no special apparatus, such as high pressure compressors, etc., are required. The greater portion of the fuel is here introduced at a low pressure, for instance already at the outer dead center of the compression stroke, under circumstances even still earlier. Consequently the fuel has ample time to evaporate and besides only a small amount of heat corresponding to the small quantity of fuel can be absorbed from the mixture, so much the more the compression has to produce only the ignition temperature and not the combustion temperature. The compression may before reaching the ignition temperature of the only diffused mixture and owing to the cooling effect of the additional fuel injection be carried, in favor of a better utilization of the fuel much higher. By the mixture of fuel and air, besides, being obtained by the first fuel injection being made directly into the air in the cylinder at atmospheric pressure approximately, a good economy of the method is insured. Lastly, the new method is remarkable for its simplicity. Besides the more advantageous production of the mixture within the engine cylinder, a suitably gaged remainder of the fuel is introduced before the moment, at which the fuel is ignited by the compression heat. As hereinbefore stated, the second injection has a heat absorbing effect on the mixture and will prevent the self-ignition of the same before the desired moment of ignition. By suitably determining the quantity of fuel and arranging the moment of the injections it is possible to reduce the cooling effect of the subsequent fuel injections and give the same more the character of an introduction of an ignition fuel for inducing the ignition.

Let us follow the different steps of the operation of the engine. According to diagram Fig. 1 the interior of the engine cylinder is filled with air at atmospheric pressure; the stroke of the piston is marked *h*. Fig. 2 shows the commencement of the compression stroke. In the position *b*, for instance, fuel particles which have been diffused at *c* are injected through nozzle *l* into the air in the cylinder. According to Fig. 3 the fuel particles distributed in the air at *c* commence to evaporate with the increasing compression heat and convert the originally mechanical mixture into an ignitible mixture, which is represented in Fig. 4 at *e* after evaporation by the compression heat. For still further increasing the compression, the remainder of the fuel is injected into the mixture of fuel and air according to Fig. 5 from *f* to *i*, whereby heat is absorbed from said mixture. During the further rise of the compression the mixture is further enriched until a suitable ratio of mixture is reached; close to the inner dead center position of the piston according to Figs. 5 and 6 it will then ignite by the compression heat. Fig. 7 represents the process in the cylinder by a diagram. Without changing the operation also fuels of different quality can be introduced at the two subsequent fuel injections instead of one single kind of fuel. In particular an easily volatile fuel may be introduced first and subsequently a less easily volatile fuel. For such introductions preferably several injection nozzles are employed, in particular when the combustion chambers are large. One of the nozzles, especially the one intended for injecting the less easily volatile liquid may be supplied with compressed air or other means for diffusing the fuel. In this case the first part of the fuel is nevertheless injected into the cylinder in a mechanically diffused form without any additional air.

What I claim and desire to secure by Letters Patent is:

1. A method of operating combustion engines with liquid fuel, which is ignited by the compression heat, consisting in first introducing a quantity of fuel without air in a mechanically diffused form into the air contained in the engine cylinder, compressing the same during the compression stroke and thereby causing it to mix with the air and to evaporate and thereupon and before the completion of compression stroke introducing a predetermined additional quantity of mechanically diffused fuel without air into the existing mixture, to enrich the latter and postpone the moment of self ignition.

2. A method of operation combustion engines with liquid fuel, which is ignited by the compression heat, consisting in first introducing a quantity of easily volatile fuel without air in a mechanically diffused form into the air contained in the engine cylinder, then compressing the said fuel, causing it to mix with the said air and to evaporate, and thereupon and before the completion of compression stroke introducing a predetermined additional quantity of less easily volatile fuel into the existing mixture for enriching the latter and postponing the moment of self ignition.

3. A method of operating combustion engines with liquid fuel, which is ignited by the compression heat, consisting in first in-

troducing a quantity of easily volatile fuel required for a charge, without air, in a mechanically diffused form into the air contained in the engine cylinder, compressing the said fuel and causing it to mix with the said air and to evaporate and thereupon and before the completion of compression stroke introducing the predetermined additional quantity of mechanically diffused fuel without air in several stages into the existing mixture for enriching the same and postponing the moment of self ignition.

4. A method of operating combustion engines with liquid fuel, which is ignited by the compression heat, consisting in first introducing a quantity of easily volatile fuel required for a charge without air, in a mechanically diffused form into the air contained in the engine cylinder, compressing the said fuel and causing it to mix with the said air and to evaporate and thereupon and before the completion of compression stroke introducing a predetermined additional quantity of fuel in several stages into the existing mixture for enriching the same and postponing the moment of self ignition, the last portion of the fuel being injected at the commencement of the working stroke.

5. A method of operating combustion engines with liquid fuel, which is ignited by the compression heat, consisting in first introducing a quantity of easily volatile fuel required for a charge, without air, in a mechanically diffused form into the air contained in the engine cylinder, compressing the said fuel and causing it to mix with the said air and to evaporate, and thereupon and before the completion of compression stroke introducing a predetermined additional quantity of less easily volatile fuel of different kind into the existing mixture for enriching the same and postponing the moment of self ignition.

In testimony whereof I affix my signature in presence of two witnesses.

HANS HEINRICH HEIN.

Witnesses:
WOLDEMAR HAUPT,
HENRY HASPER.