Aug. 30, 1932. L. M. WOOLSON 1,874,682

INTERNAL COMBUSTION ENGINE

Filed July 21, 1930

FIG. 1

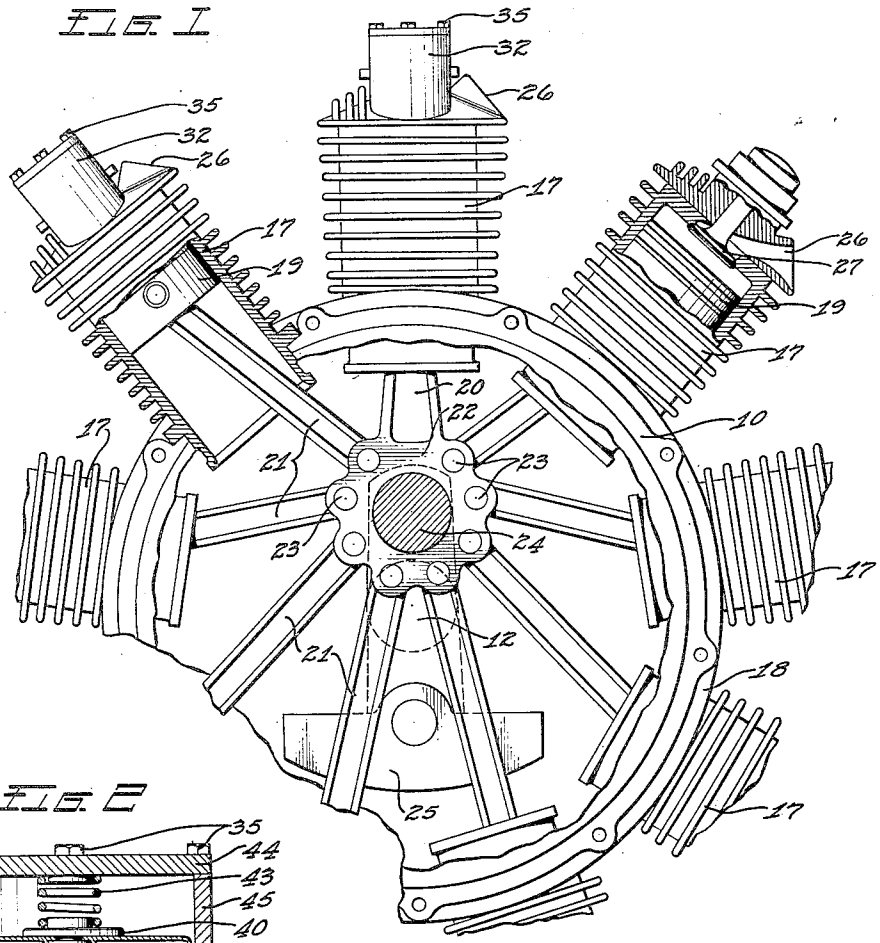
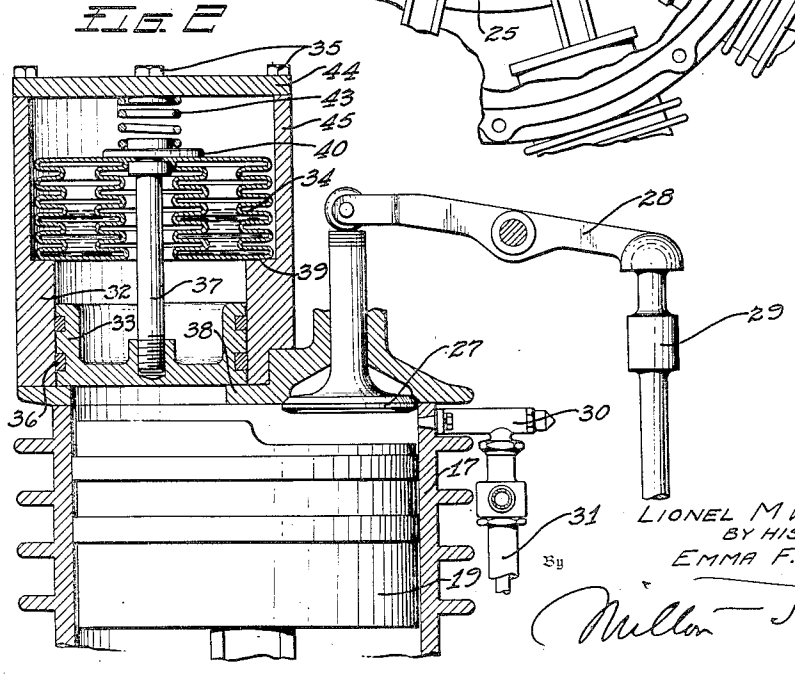


FIG. 2



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INTERNAL COMBUSTION ENGINE

Application filed July 21, 1930. Serial No. 469,328.

This invention relates to internal combustion engines, and more particularly to engines of the compression ignition type.

In engines of this class, commonly known as Diesel engines, air is drawn into the cylinder and then compressed to the point where its temperature rises sufficiently to automatically ignite the fuel, which is forced into the cylinder while the air is thus compressed. However, when such engines are cold, or have been idling, or have been running upon low fuel supply, it sometimes happens, as they have been heretofore constructed, that the air when compressed will not reach a temperature which at all times will insure ignition. It is desirable therefore to have the air compression sufficiently high to insure ignition under all conditions, but this leads to unnecessarily high pressures when the engine is working under full fuel charges.

The object of this invention, therefore, is to secure the high compression necessary for reliable ignition when the engine is starting or when idling, and yet avoid or overcome the unnecessarily high pressures produced when the engine is working with full fuel charges.

Stated in another way, the object of the invention is to vary the air compression ratio and the high load combustion pressure inversely with the temperature of the engine or of the cylinders thereof.

Another object of the invention is to vary the air compression ratio, and the high load combustion pressure, inversely with the temperature when the temperature has reached a definite and fixed value.

In engines of the Diesel type, the amount of heat developed during operation, generally speaking, is proportional to the fuel burned. When the engine is running idly or on reduced load, the fuel required to keep the engine running is small compared to that required when the engine is working under normal or heavy load. The temperature of the engine, and particularly of the cylinder and cooperating parts, therefore varies with the fuel burned; so that, in a broad sense, the temperature of these parts varies with the load, being lowest when the engine is starting or idling and highest when it is running under maximum load.

While the air compression, when the engine is starting or is idling must be sufficient to effect ignition, when the engine is running under normal or heavy load, the heat developed raises the general temperature of the engine, and this helps to raise the temperature of the air; so that, after the engine has heated up, it is not essential that the air compression shall be as high as when the engine is starting or idling.

The inventor proposes to make use of the variations in the thermal condition of the engine, and particularly of the cylinders thereof, to lower the air compression ratio, as well as the high fuel combustion pressure, when the engine has acquired a definite and rather fixed temperature. To this end, the head of each cylinder is provided with a thermostat of the type which becomes active or effective upon a definite fixed rise in temperature. As here shown, this thermostat consists of a capsule or bellows, preferably of the form known in the art as a "sylphon" in which a substance is sealed which has a definite vaporizing point, and therefore expands the chamber or sylphon by the pressure produced by the vaporization of the material. The power thus made available is used to operate a compensating piston arranged directly in the combustion chamber or in some auxiliary chamber communicating therewith, so as to vary the size of the combustion chamber in accordance with the temperature of the engine. By this means, when the temperature of the engine, or the cylinders thereof, attains a rather definite degree, depending upon the vaporizing point of the material in the expansible element, the compensating piston is moved out to thereby enlarge the clearance volume of the cylinder, thereby lowering both the air compression ratio and the high fuel combustion pressure.

Inasmuch as the air compression ratio of engines of this character is quite high, amounting to approximately 16 to 1 of the original volume of air, the space occupied by the air when thus compressed is quite

small compared to the space initially occupied by the same; and since it is only necessary that the combined clearance volume of the cylinder and that produced by the movement of the compensating piston shall be from twenty to thirty per cent greater than the clearance volume of the working cylinder alone, it will at once be understood that the movement of the compensating piston need not be very great in order to provide the additional space required.

The broad idea of varying the air compression inversely with the engine temperature has been disclosed, and mechanism for effecting this result duly claimed, in this inventor's earlier application, Serial No. 374,368, filed June 28, 1929. In that case the compression ratio is varied by automatically varying the stroke of the pistons in their respective cylinders, while the invention which forms the foundation of the present application is based upon the use of a thermal responsive element in connection with each cylinder, or of some chamber supplemental to the cylinder, so that upon operation of the thermostat the clearance volume or combustion space will be varied. By the use of a thermostat which becomes effective upon a fixed rise in temperature, the clearance volume is enlarged only after this temperature shall have been reached.

Fig. 1 is an end elevation of a multiple cylinder engine with the improvement embodied therein; and

Fig. 2 is a vertical section taken through one of the cylinders, showing in detail one of the thermostatic devices attached thereto.

Referring to the drawing, the character 10 indicates the crank case of an internal combustion engine, which, as here shown, is a multiple cylinder engine, intended more particularly for aeroplane use, although of course this invention is not limited to that particular type of engine. Within the crank case is a shaft 12 rotatable in suitable bearings, not illustrated herein, and which may be of any preferred form, as for example, such as those illustrated and described in this inventor's earlier application, Serial No. 374,368, above referred to.

Arranged around this crank case 10 are cylinders 17 of any desired number, nine being shown in the engine here illustrated, and these cylinders are connected to the casing in any convenient way as by compression hoops 18. Within each cylinder is a piston 19 of usual construction. Pivotally connected to one of these pistons is a pitman 20, and to the others are similarly connected pitmen 21. The pitman 20 is what is usually termed a master pitman, and has a hub 22 secured rigidly thereto or made integral therewith, and to this hub all of the other pitmen are pivotally connected, as by pins 23. The hub 22 is mounted directly upon the wrist pin 24 of the crank shaft 12, and serves to rotate the shaft in the usual way. One or more weights 25 of any preferred form serve to counterbalance the wrist pin, the pistons and other movable parts. This arrangement of cylinders and pistons cooperating with a single crank shaft is old and well known, and forms no part of the present invention.

The engine here illustrated is of the four cycle compression ignition type. Each cylinder is provided with a single air channel 26 and a single valve 27. Air is drawn into the cylinders through the air channels, and the products of combustion escape therethrough; the valves 27 thus serve both as inlet and outlet valves, and the channels 26 serve both to admit air and to discharge the products of combustion. Each valve 27 is operated in any suitable way, as by a rocker bar 28 and actuating rod 29, working in timed relation with the other elements of the engine, as is usual in engines of this character.

Cooperating with each cylinder is a fuel supply mechanism comprising a nozzle 30 and a pump 31. These nozzles and pumps may be of any suitable construction, and therefore are here illustrated only diagrammatically. The pumps must of course be connected to work in timed relation with the other parts of the engine; and it may be said that it is highly desirable that each pump shall be as close as possible to its cooperating nozzle, so that fuel may be injected directly in desired variable quantities from the pump through the nozzle into the cylinder.

Considering the operation as starting with the valve 27 open, movement of the piston down the cylinder draws air into the chamber. The valve is then closed, and on the up stroke the air is compressed to the point where its temperature will ignite the fuel; the fuel is injected before the maximum compression, as is usual in engines of this character. The resulting combustion raises the pressure in the cylinder still higher and gives the piston its working stroke; just before the piston reaches the end of its down stroke, the valve 27 is opened and the products of combustion allowed to escape; the cylinder is substantially cleared of the products of combustion upon the up stroke of the piston. As the piston again moves down, it draws fresh air into the cylinder, and the cycle of operation is repeated.

The upper parts of the several cylinders constitute the combustion chambers of the engine. Cooperating with these combustion chambers are thermostats and cooperating devices for enlarging this clearance volume as the temperature of the engine rises; that is, as the temperature of the engine and particularly the cylinders rises, these combustion chambers are automatically enlarged, and this enlargement is brought about by the thermal changes in the engine itself. But

this enlargement of the clearance volume or the combustion space takes place only after the temperature of the cylinders shall have reached a predetermined point; so that there will be no movement of the compensating pistons until this temperature is reached.

Broadly speaking, the means for enlarging the combustion chamber consists of an auxiliary chamber which communicates with the main cylinders; a movable wall or piston, which is withdrawn more or less as the predetermined temperature is reached; and a thermostat which becomes effective to move the piston at the proper time.

Thus, referring to the accompanying drawing, and particularly to Fig. 2 thereof, 32 represents the compensating cylinder, 33 the piston therein, and 34 the thermostat for operating the piston. A piston rod 37 is fixed to the piston. The piston normally rests upon a seat 38 around the opening in the top of the cylinder 17; and the thermostat rests upon a seat 39 formed in the cylinder 32.

The thermostat 34 contains a substance which will vaporize or boil when its cylinder working under full load attains the temperature determined upon, but which will not boil under the temperature produced by the engine when starting or idling or working upon minimum load.

The form of this thermostat is of the so-called "sylphon" type, wherein the walls are made of flexible material deeply corrugated so that it may elongate considerably under the pressure produced within the chamber. Any suitable material which will boil at the desired temperature may be used, as for instance water or alcohol. But this material is illustrative only, and any other suitable substance may be used having a boiling point of approximately 200° Fahrenheit.

The expansible element of the thermostat as here illustrated is made annular in form but any other form may be employed. With the annular form, the piston rod 37 extends through the thermostat. The piston rod 37 carries at its upper end a disk 40, which rests upon the top of the thermostat 34.

Cooperating with the thermostat and auxiliary piston is a spring 43 having one end resting upon the disk 40 and the other bearing against the top 44 of the casing 45 which surrounds the thermostat and forms an extension of the cylinder 32. This spring should be of substantial resistance, so that it may hold the piston against movement due to the pressure produced when the engine is idling or working under low pressure. At such times, the thermostat is not operative, and the piston must be prevented from rising.

Moreover, the spring 43 must be of sufficient strength to prevent a rise of the auxiliary piston under the pressure produced by the combustion of full fuel charges. But it must be so designed that it will yield under the pressure produced by the thermostat or under the pressure of the thermostat taken in connection with the combustion pressure. Therefore, as the temperature rises, the bellows or sylphon will expand under the pressure produced therein, and the thermostat alone, or the thermostat and the cylinder pressure combined, will lift the piston 33, thereby enlarging the combustion space or clearance volume of the cylinder. When the cylinder cools, due to a lessening of the fuel charges, the liquid in the thermostat will condense and the thermostat will contract; and the atmospheric pressure on the outside of the thermostat, together with the force of the spring will then cause the chamber to collapse, thereby permitting the spring to force the piston 33 to its seat, and thus restrict the combustion space to that of the working cylinder alone.

To give some idea of the size of the compensating cylinder relative to the working cylinder, it may be said that it need only be sufficient to increase the clearance volume or combustion space of the working cylinder by twenty or thirty per cent. Thus, in a cylinder of say four and a half inches in diameter, and a normal compression ratio of 16 to 1, it will be sufficient if this compression ratio can be reduced to 12 to 1, or approximately those figures. That is, the compensating cylinder and piston need only be sufficient to provide added space which amounts to twenty to thirty per cent more than the normal compression volume of the cylinder. Thus, with a working cylinder of the size mentioned, and the compression ratio of 16 to 1, a compensating cylinder two inches in diameter, and a movement of the compensating piston of half an inch will be sufficient. These figures are merely illustrative, and may be regarded as varying with the needs of each particular case.

It will be understood that various forms of the invention other than those described above may be used without departing from the spirit or scope of the invention.

What is claimed is:

1. In an internal combustion engine, the combination of a combustion chamber, a piston therein, and means for varying the capacity of the chamber, said means being responsive to changes in the temperature of the chamber.

2. In an internal combustion engine, the combination of a combustion chamber, a piston therein, and thermo-responsive means operable during a predetermined temperature range in the combustion chamber for varying the capacity of the chamber in accordance with the temperature thereof.

3. In an internal combustion engine, the combination of a combustion chamber, a piston therein, a thermo-responsive device operable during a predetermined temperature

range therein, and means operated by the thermo-responsive device for varying the capacity of the chamber in accordance with the temperature thereof.

4. In an internal combustion engine, the combination of a combustion chamber, a piston therein, a thermostat responsive to temperature developed by the engine and operable during a predetermined temperature range, and a compensating piston in the combustion chamber controlled by the thermostat for varying the capacity of the chamber.

5. In an internal combustion engine, the combination of a combustion chamber, a piston therein, a compensating piston therein, and a thermostat operable during a predetermined temperature range in the chamber for operating the compensating piston to vary the capacity of the chamber in accordance with the temperature.

6. In an internal combustion engine, the combination of a combustion chamber, a piston therein, a compensating cylinder, a compensating piston therein, an expansible chamber containing a substance volatile upon predetermined rise in the temperature thereof for expanding the chamber and thus withdrawing the compensating piston to enlarge the chamber when the temperature thereof exceeds a predetermined amount.

7. In an internal combustion engine, the combination of a cylinder, a piston therein, a compensating piston therein, a thermostat operable during a predetermined temperature range in the chamber for operating the compensating piston, and a spring for restraining the piston.

8. In a compression ignition engine, the combination of a cylinder, a piston therein, a compensating piston therein, and a thermostat responsive during predetermined variations in the temperature of the cylinder for operating the compensating piston to vary the clearance volume of the cylinder directly with the temperature thereof and inversely with the air compression.

9. In a compression ignition engine, the combination of a cylinder, a piston therein, a compensating piston therein, a thermostat responsive during predetermined changes in temperature of the cylinder for operating the compensating piston to enlarge the clearance volume of the cylinder upon a predetermined rise in temperature thus decreasing the air compression ratio, and contracting the clearance volume upon a fall of the temperature to a predetermined point thus increasing the air compression ratio.

10. In a compression ignition engine, the combination of a plurality of cylinders, a piston in each cylinder, a thermostat cooperating with each cylinder and operable during a predetermined range of temperature thereof, means cooperating with each cylinder and operated by the thermostat thereof for varying the clearance volume of the cylinder whereby each cylinder governs its own operation according to the requirements thereof.

11. In an internal combustion engine, a plurality of cylinders, a piston for each cylinder, a compensating piston for each cylinder, a thermostat for each cylinder operable during a predetermined temperature range thereof for governing the compensating piston, whereby the capacity of each cylinder and thereby the compression ratio is determined by the conditions of its own cylinder.

12. In a compression ignition engine, the combination of a plurality of cylinders, a piston for each cylinder, a compensating cylinder cooperating with each cylinder, a compensating piston in each compensating cylinder, a sylphon containing a substance vaporizable at a predetermined temperature for actuating the compensating piston of its own cylinder, whereby the compression ratio is varied in accordance with the requirements of each cylinder.

13. The method of operating a compression ignition engine which consists in supplying air at a predetermined ratio of compression, supplying fuel according to the power required, and varying the clearance volume of the engine in accordance with engine temperature.

14. The method of operating a compression ignition engine which consists in compressing the air to the maximum ratio when the engine temperature is below a predetermined degree, supplying fuel to the engine, and thermostatically varying the capacity of the combustion chamber and thereby the air compression ratio in accordance with the engine temperature when the engine temperature is above the predetermined degree.

In testimony whereof, I have hereunto subscribed my name this 17th day of July, 1930.

EMMA F. WOOLSON,
Executrix of the Estate of Lionel M. Woolson, Deceased.