

Aug. 9, 1938.

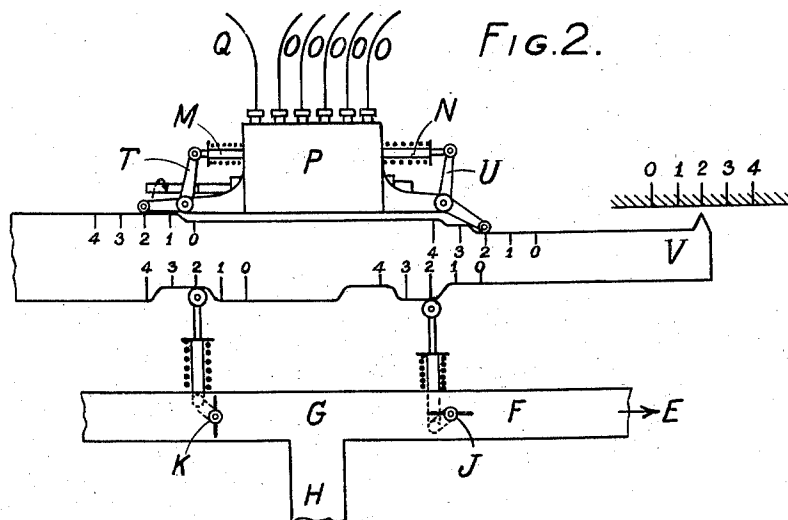
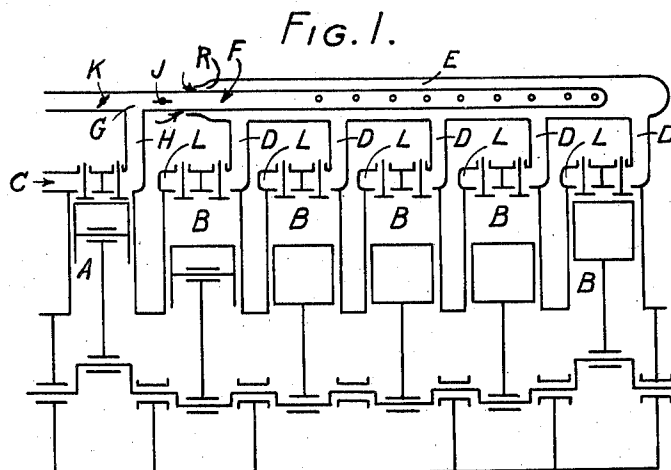
P. L'ORANGE

2,126,483

INTERNAL COMBUSTION ENGINE

Filed Dec. 4, 1935

2 Sheets-Sheet 1



Inventor:

Prosper L'Orange.

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FIG. 3.

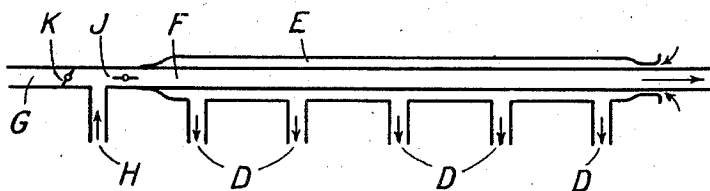
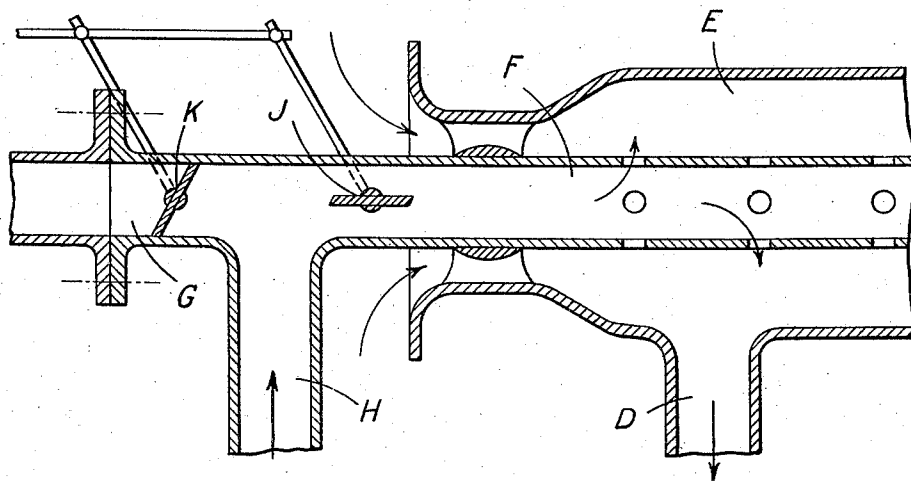


FIG. 4.



Inventor:
P. L'Orange.

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INTERNAL COMBUSTION ENGINE

Prosper L'Orange, Stuttgart-Feuerbach,
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5 Claims. (Cl. 123-27)

Attempts to reduce the weight of Diesel engines are met with difficulties mainly on account of the high pressure produced in the starting of the engine. This pressure is due to the high temperature required for starting and further to the retardation of the ignition which occurs with cold engine and which then brings about a rapid combustion and a consequent rapid rise in the pressure. When the machine is warm the pressure is automatically reduced, and it is also possible to reduce the pressure by throwing a cylinder into communication with an additional clearance space.

In order to allow starting with warm engine it is possible, either to warm the machine itself or to warm the charging air, but this requires heavy electric batteries or other additional, complicated and expensive apparatus.

The problem of weight reduction occurs mostly in connection with multi-cylinder engines for aircraft and the like, and the object of the invention is to achieve such reduction in connection with engines of this type.

For this purpose only one, for instance, of the cylinders is according to the invention designed as a normal, high-compression cylinder, and means are provided for warming, and if need be diluting, the charging air for the other cylinders, during the starting of the engine, by means of the exhaust gases from the high-compression cylinder.

By mixing the charging air of the low-compression cylinders with exhaust gases from the high-compression cylinder, the air will not only be warm but the oxygen content thereof will be diluted. Both actions tend to reduce the maximum pressure in the cylinders at starting, partly because of the dilution of the oxygen content and partly because the warming of the air leads to less retardation of the ignition.

A six cylinder engine, without compressor, as used in aircraft, may be taken as an example. One of the cylinders is adapted for normal high-compression with a ratio of 1:18 and may be provided with a precombustion chamber. The other cylinders have a compression ratio of 1:12 and a volume 30% larger than the first mentioned cylinder. Thus, if the first cylinder has a volume V , the volume of the six cylinders together will be $V + (5 \times 1.3 \times V) = 7.5 V$, i. e., 25% more than the volume of six high-compression cylinders. The operation is then as follows:

1. In starting the engine by hand or electrically, fuel is first fed only to the high compression cylinder.

2. When the engine has started and as soon as the exhaust gases from the high-compression cylinder appear clean, the gases are led by means of the controlling device to a mixing chamber from which the remaining cylinders receive their supply of air, the air being thus mixed with the exhaust gases.

3. After a few strokes of the engine, the low-compression cylinders are fed with fuel, about half the full amount.

4. When the engine has been heated up sufficiently, the exhaust of the high-compression cylinder is diverted, either by hand or by thermally operated means, to the atmosphere, so that the other cylinders will be fed with pure air. At the same time the low-compression cylinders are given their full supply of fuel. The change over may be gradual if desired.

The engine will now work normally with one high-compression and five low-compression cylinders. For idling, for instance during gliding, the control is reversed so that the power will be supplied only by the high-compression cylinder the exhaust from which is again led to the other cylinders in order to keep them warm and ready for restarting with low-compression. This is effected automatically.

Numerically the procedure is as follows:

The exhaust gas from the fully loaded high-compression cylinder has a temperature which is sufficient to raise the temperature of the air and gas mixture received by the other cylinders to about 150° C. This mixture has the volume V of the first cylinder plus the increase obtained by the heating and plus $5 \times 1.3 V$ of the fresh air raised to the same temperature. Thus the mixture is attenuated by the heating by about 30%, and by the admixture of more than 25% exhaust gas by another 25%, i. e., the oxygen content of the heated mixture is about $\frac{2}{3} \times \frac{3}{4} = \frac{1}{2}$ of that of the same volume of a cold air charge.

The compression brings about a further increase in the temperature, so that the mixture will finally have a temperature which is higher than that in the high compression cylinder. Thus the ignition will take place with less retardation, and the maximum pressure will therefore, particularly in view of the low oxygen content, be very low.

The above described engine will be lighter than a normal engine, and it can be started with equal facility. The chamber in which the air is mixed with the exhaust gas adds but little to the weight. Instead of this chamber a heat exchanger may be used for warming the air

which is led through the exchanger in counter-current to the heating gases. In this case the change over to normal running must be delayed until the walls of the heat exchanger have acquired the same temperature as the exhaust gas. The heat exchange may be obtained from the cylinder head or from a chamber formed in the latter.

Fig. 1 of the accompanying drawings represents a diagrammatic view of an engine constructed according to the invention.

Fig. 2 is a diagram of the fuel pump and the controlling device.

Fig. 3 illustrates a form of heat exchanger, and Fig. 4 is a detail sketch of a portion of Fig. 1.

The illustrated engine is provided with a cylinder A, working with high-compression, and with five cylinders B, working with low-compression. For this purpose the clearance space of the cylinder A is restricted as compared with that of the cylinders B. The cylinder A receives atmospheric air at C either direct or from a pre-compressor. The cylinders B receive air at D from a mixing chamber E which communicates at R either with the atmosphere or with a pre-compressor. Into this chamber opens a conduit F which is branched off at G for connection to the exhaust pipe H of the cylinder A as well as to the atmosphere. Throttle valves J and K are provided for leading the exhaust gas either through the conduit F into the chamber E or past the valve K into the atmosphere or into a discharging fan. The fuel pump P (Fig. 2) has a pump element Q which supplies fuel to the cylinder A, and pump elements O which supply fuel to the cylinders B. The pump elements O are controlled by a slidable rod N which is operated by a bell crank U. Another rod M, operated by a bell crank T, controls the pump element Q. The bell cranks, as well as operating members for the throttle valves J and K, bear by spring pressure against a cam rail V which is slidably operated for controlling the engine.

One neutral and four operative positions of the cam rail are indicated in the drawings, and the conditions prevailing in the different positions are as follows:

Position 0: The fuel pump is inoperative; and the valve K is open; and the valve J is closed.

Position 1: The bell crank T gives the pump element Q full feed; the valve K is open; and the valve J is closed; the engine starts.

Position 2: (Illustrated position). The bell crank T gives the pump element Q full feed; the valve K is closed; the valve J is open; and the engine gathers up speed and heat.

Position 3: The bell crank T remains as before; the bell crank U gives half feed to the pump elements O; the valve K is closed; and the valve J is open.

Position 4: The bell crank T remains as before; the bell crank U gives full feed to the pump ele-

ments O; the valve K is open; and the valve J is closed.

For idle running, the cam rail is moved to the position 2. For stopping, the rail is moved to the position 0.

Instead of the illustrated six cylinder engine, a five or seven cylinder, radial engine may be employed and so the invention applies to engines having radially arranged as well as juxtaposed cylinders.

When the engine works with small load, the valves K and J may be maintained in intermediate positions, so that some amount of exhaust gas will be fed to the low-compression cylinder.

I claim:

1. An internal-combustion engine of the compression-ignition and constant pressure cycle type having a plurality of working cylinders arranged in two sections working with different compression, means for feeding fuel separately to the two sections, an air chamber communicating with the atmosphere and with the low compression section for supplying charging air to the cylinders of said section, and means for heating the air in said chamber by the exhaust gases from the high compression section.

2. A structure as claimed in claim 1 wherein the means for heating the air comprises an exhaust pipe arranged to discharge the gases into the air chamber.

3. A structure as claimed in claim 1 wherein the means for heating the air comprises a heat exchanger located within the air chamber.

4. A structure as claimed in claim 1 wherein the high compression section comprises a single cylinder and the low compression section, a plurality of cylinders.

5. An internal-combustion engine of the compression-ignition and constant pressure cycle type having a plurality of working cylinders arranged in two sections adapted to work with different compression, an air chamber supplying charging air to the cylinders of the low compression section, means for heating the air in said chamber by heat transmission from the exhaust gases coming from the high compression section and adapted to lead the air in counter-current to the heating gases, means for supplying fuel to the cylinders, means for regulating the fuel supply separately to each section of the cylinders, valves for controlling the exhaust from the high compression section, and a controlling member for said valve and fuel regulating means operative, on starting the engine, first to connect the high compression section with the fuel supply, then to set the valves for leading exhaust gases from the high compression section to said air chamber, then to connect the low compression section with the fuel supply, and finally to disconnect the air chamber from the exhaust.

PROSPER L'ORANGE.