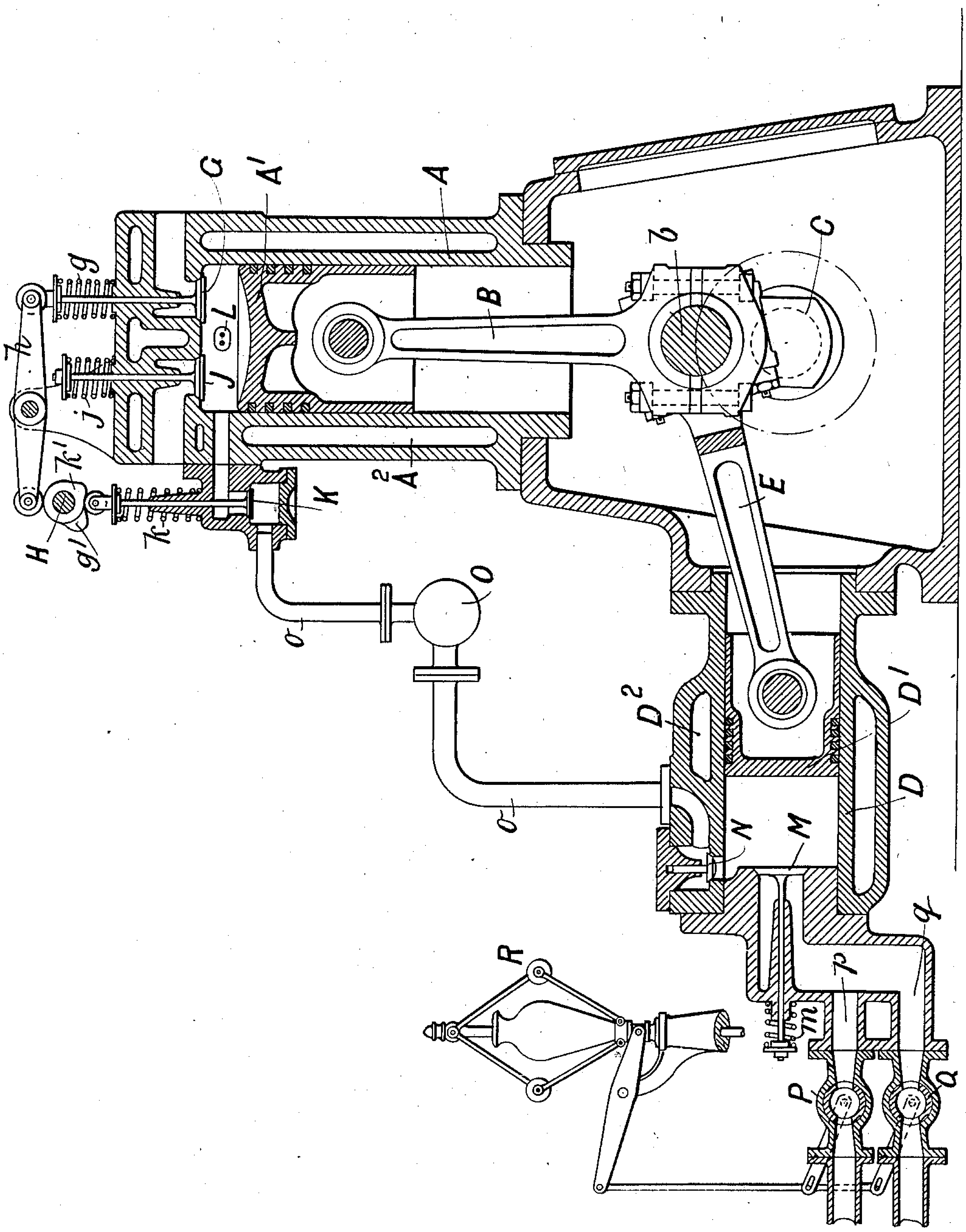
No. 859,746. PATENTED JULY 9, 1907.

E. CROWE.

INTERNAL COMBUSTION ENGINE.

APPLICATION FILED MAR. 23, 1905.



WITNESSES:

W. M. Avery

H. C. Davis

INVENTOR

Edward Crowe

BY Munn & Co

ATTORNEYS

UNITED STATES PATENT OFFICE.

EDWARD CROWE, OF REDCAR, ENGLAND, ASSIGNOR TO DAVY BROTHERS LIMITED, OF SHEFFIELD, ENGLAND.

INTERNAL-COMBUSTION ENGINE.

No. 859,746. Specification of Letters Patent. Patented July 9, 1907.

Application filed March 23, 1905. Serial No. 251,614.

To all whom it may concern:

Be it known that I, EDWARD CROWE, a subject of the King of Great Britain, residing at 25 Teresa Terrace, Coatham, Redcar, Yorkshire, England, engineer, have invented certain new and useful Improvements in an Internal-Combustion Engine, of which the following is a specification.

This invention has for its object to provide an internal combustion engine wherein premature explosion is rendered impossible and wherein the maximum temperature and pressure being developed at the commencement of the working stroke, the highest possible average pressure and the maximum power are obtainable with a given capacity of cylinder.

In internal combustion engines working on the Otto or four-phase cycle, as heretofore constructed, the constituents of the explosive charge have been mixed prior to or during compression, with the result that the power obtainable has been limited in consequence of the necessity for avoiding compressing the mixture so far as to raise its temperature to a point at which premature ignition is liable to occur. This defect has been partially overcome by the provision of additional water-cooled surfaces within the compression space, but such devices besides causing waste of heat, are apt to be rendered of no effect in the event for example of dirt or deposit accumulating on the walls of the compression space.

According to the present invention the air required for effecting complete combustion of the fuel, and the fuel itself (consisting of combustible gas or vapor or a non-explosive mixture of the same with air or inert gas) are compressed separately; the air alone being compressed in the motor cylinder while the fuel is compressed by an independent pump and admitted to the combustion chamber of the motor cylinder only at the moment of ignition. Consequently the formation of an explosive mixture cannot occur before the moment of ignition and hence not only is all risk of spontaneous and premature ignition eliminated, but combustible and inert gases may be used in the motor cylinder in such relative proportions and compressed to such an extent as will enable the development of much greater power than has heretofore been obtainable; the arrangement also serving to secure various other advantages tending to increase the mechanical and thermal efficiency of the engine.

Reference is to be had to the accompanying drawing which shows an elevation of one form of engine constructed according to this invention, in section on the plane wherein lie the axes of the motor and pump cylinders. It is however to be understood that although the form of engine illustrated is convenient, the invention is not limited to such form, and that any other design or arrangement of parts, whereby to carry into practice the principle above referred to, may be adopted.

A is the motor cylinder whereof the piston A^1 is coupled by the connecting rod B to the crank *b* on the shaft C.

D is the pump cylinder whereof the piston D^1 may be coupled by the connecting rod E to the crank *b* (or to a crank co-axial therewith) when, as in the case illustrated, the axes of the two cylinders are at right angles to one another. The cylinders A and D are provided respectively with cooling jackets A^2 and D^2 which extend throughout their effective length.

F is the compression space at the rear end of the motor cylinder, the air and fuel inlets and the exhaust all opening through the walls of this space.

The exhaust valve G of the motor cylinder closes outwardly and is opened against the pressure of the spring *g* by means of a cam g^1 which is mounted on a shaft H revolving at one-half the speed of the crank shaft C. The cam g^1 may actuate the valve G through a lever *h* as shown.

J is the air inlet valve of the motor cylinder which may be arranged to open automatically against the pressure of the spring *j* during the suction stroke of the piston A^1, the pressure generated within the motor cylinder during the working stroke serving (conjointly with spring *j*) to then hold the valve closed.

The fuel inlet valve K of the motor cylinder closes inwardly and is opened, at the end of the compression stroke of the piston A^1, against the pressure of the spring *k* by means of a cam k^1 rotated by (or at the same speed as) the shaft H; the cam being of such form as to allow of the introduction of the fuel proceeding at a rate corresponding to that at which combustion progresses.

A sparking plug is provided in the compression space F as at L.

M is the fuel suction valve at the rear of the pump cylinder D, this valve opening inwardly against the pressure of the spring *m* at each suction stroke of the piston D^1; and N is the pump delivery valve which may open outwardly against spring pressure and which is connected to the fuel inlet valve K of the motor cylinder by a pipe *o* whereon an intermediate reservoir O may be provided. The supply of fuel to the pump cylinder D is regulated by the engine governor R which is made to actuate valves as at P and Q on branch pipes *p* and *q* leading to the valve M; the valve P controlling the admission of gas or combustible vapor and the valve Q that of air when such is used to form a non-explosive mixture before compression.

The action of the engine is as follows:—Assuming the parts to be in position shown, with the motor piston A^1 at the end of its compression stroke, the compression space F will contain a charge of compressed air. At this moment (or slightly earlier) the fuel inlet valve K is opened thus admitting the combustible gas (or mixture of combustible and inert gases) from the reservoir O to the compression space; while at the same time an electric current is passed through the sparking plug L. The combustible gas entering the compression space F being thus ignited, burns in the air compressed in said space, the introduction of the fuel proceeding at a rate corresponding to that at which combustion progresses. The whole contents of the compression space F are thus heated to a temperature corresponding to the amount of combustible gas admitted. Consequently the pressure in space F rises in consequence not only of the introduction of the charge through valve K, but also of such increased temperature of the gases, whether combustible or inert, as is due to the combustion. The motor piston A^1 is thus caused to perform its active stroke, at the conclusion of which the exhaust valve G is opened so that on the return or exhaust stroke of the piston the contents of the motor cylinder A are expelled. At the conclusion of this exhaust stroke the exhaust valve G is closed and, on the piston A^1 performing its next or inhaling stroke, fresh air will be drawn in through the valve J to fill the motor cylinder. On the piston A^1 commencing its next return or compression stroke the air inlet valve J will close, and during the said stroke the air which now fills the cylinder A will be compressed into space F until, on the piston A^1 reaching the end of its compression stroke, the fuel inlet valve K will be again opened as before and the cycle described will be repeated.

As a charge of combustible gas (or of a mixture of combustible gas with air or inert gas) will be compressed in the pump cylinder D at each revolution of the crank shaft C, while the fuel inlet valve K is only opened at every second revolution, it follows that the capacity of the pump cylinder D need only be one-half that of the charge admitted through valve K to the motor cylinder A. That is to say if for example the volume of the charge (wholly or partly combustible) to be admitted through valve K to the motor cylinder be equal to two-thirds the volume of the air compressed within the motor cylinder, the capacity of the pump cylinder D should be equal to one-third that of the motor cylinder A; or in similar circumstances a single pump cylinder having two-thirds the capacity of the motor cylinder would be capable of serving two such motor cylinders.

In any case the governing of the engine is effected by regulating the quantity of combustible gas or vapor admitted through valve P to the pump cylinder D, the quantity of air compressed in the motor cylinder A remaining constant. The arrangement as a whole admits of a very fine adjustment of the fuel consumption being effected, since, however small the quantity of combustible gas or vapor admitted to the cylinder A, this gas or vapor cannot fail to burn, owing to the fact of its being ignited at the moment of entering the space F.

When the engine is running light and the minimum quantity of combustible gas or vapor is being used, the terminal pressure in the working cylinder A will be only slightly higher than atmospheric pressure, so that the engine will work very economically with light loads. As the load increases and a greater quantity of combustible gas or vapor is admitted to the motor cylinder A, the terminal pressure will rise in consequence both of the increased volume of gases in the cylinder and the higher temperature developed. Hence the most economical working conditions will be attained at a point between no load and full load, above which intermediate point the engine will possess a considerable reserve of power which can be exerted on emergency but which, owing to the higher terminal pressure resulting from its development, would be employed under somewhat less economical conditions.

With a view to employing the engine to the greatest advantage by increasing as much as possible the volume of gases within the motor cylinder during the working stroke, it is preferred to mix with the combustible gas or vapor drawn into the pump cylinder D as high a proportion of air or inert gas as the quality of the combustible gas employed renders advisable. Thus for example, when using town's gas or coke oven gas the proportions of the mixture drawn into the pump cylinder D may consist of one volume of combustible gas to (say) two or three volumes of air or inert gas, or thereabouts according to the quality of the combustible gas. Supposing therefore that the proportions required in the final mixture within the motor cylinder A at maximum load are 9 parts of air to one of rich combustible gas, while the mixture within the pump cylinder D is composed of three parts of air or inert gas to one part of said combustible gas, the capacities of the pump and motor cylinders would require to be as 4 and 6 respectively. Under these circumstances, the capacity of the motor cylinder being 6, the total volume of gases doing work within it at maximum load will be 10. If however blast furnace gas or producer gas be employed, the proportions required in the final mixture within the motor cylinder A may be (say) about two volumes of such gas to three of air, and as blast furnace and producer gas are weak and already contain a larger percentage of inert gas (nitrogen for example) further dilution by means of air (admitted to the pump cylinder D) is not advisable. Under these circumstances the relative capacities of the pump and motor cylinders would be as 2 and 3 respectively, or the same as when using town's or coke oven gas.

Claims

1. The combination with an internal combustion engine working on a four-phase cycle and having a motor cylinder and piston adapted to act, alternately, as an air compressor and as a motor, a fuel pumping cylinder and piston for compressing combustible vapor to be consumed in the motor cylinder, a valve-controlled communication between said cylinders adapted to permit the injection of a compressed charge from the fuel-pumping cylinder into the motor cylinder at the conclusion of that stroke of the motor piston, whereby air is compressed in said cylinder, and a device for causing ignition of the combustible vapor on its entry into the motor cylinder; of means for admitting to the fuel-pumping cylinder, along with the combustible vapor, air (or inert gas) in regulable quantity and proportion, and for causing the injection into the motor cylinder, after compression, of a greater quantity of con-

tents of the fuel-pumping cylinder than would be drawn into the motor cylinder by the suction stroke of the piston therein, substantially as and for the purpose set forth.

2. An internal combustion engine of the character described, comprising a motor cylinder and its piston, means for admitting air to the cylinder, a pumping cylinder and its piston, means for operating the pistons, means for controlling the admission of gas and air to the pumping cylinder, a pipe connection between the cylinders, a valve for controlling the communication between the said cylinders, and means for operating said valve, whereby air will be injected with the gas into the motor cylinder at the end of the stroke of its piston which compresses the charge of air.

3. An internal combustion engine of the character described, a motor cylinder, a piston in the cylinder, an exhaust valve for the cylinder, an air inlet valve for the cylinder, a pumping cylinder, a piston in the cylinder, a fuel suction valve for the cylinder, gas and air inlets leading to the fuel valve, valves controlling said gas and air inlets, a pipe connection between the cylinders, a valve controlling the passage of the air and gas from the pumping cylinder to the motor cylinder, means for operating the last named valve, and means for operating the said pistons.

Dated this second day of March 1905.

EDWARD CROWE.

Witnesses:
GEO. SMITH,
JOHN WILLIAM WALTON.