Jan. 28, 1936. Y. HIRONAKA 2,029,169

INTERNAL COMBUSTION ENGINE

Filed June 13, 1932

FIG. 1.

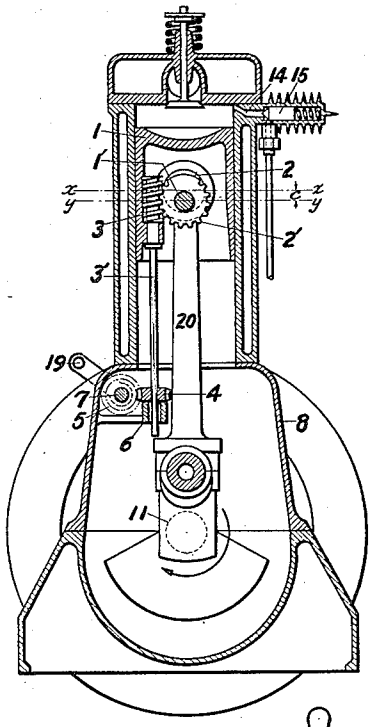


FIG. 2.

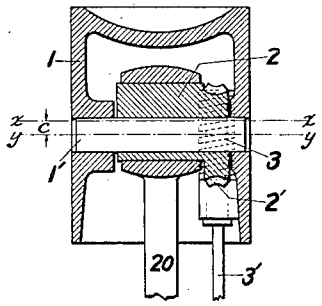


FIG. 4.

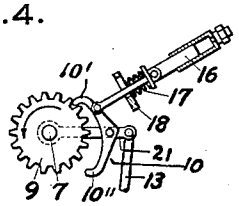


FIG. 3.

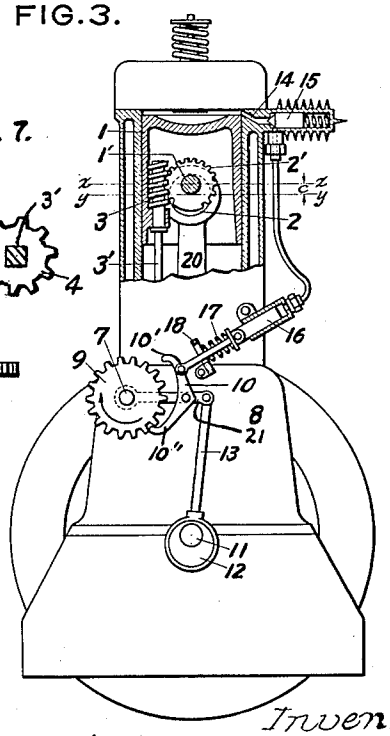


FIG. 7.

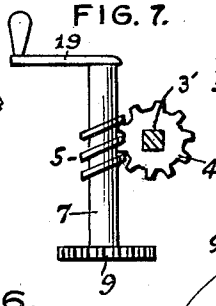


FIG. 5.

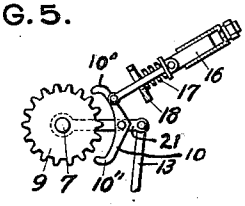
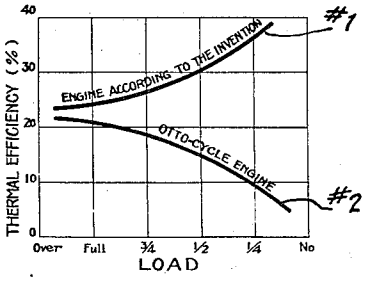


FIG. 6.



Inventor

Yasusaburo Hironaka

by Connolly Bros

Atty

Patented Jan. 28, 1936 2,029,169

UNITED STATES PATENT OFFICE

2,029,169

INTERNAL COMBUSTION ENGINE

Yasusaburo Hironaka, Tsuwano-cho, Kano-Ashi-gun, Shimane-ken, Japan

Application June 13, 1932, Serial No. 617,006

4 Claims. (Cl. 123—48)

This invention relates to improvements in internal combustion engines, and has for an object to provide a means whereby, by altering or regulating the spacial volume of the explosion-chamber of the engine in accordance with the load, the compression ratio can be controlled to a certain degree. Another object of the invention is to enhance, under any conditions of load, the thermal efficiency of the engine by regulating the pressure of compression in such a manner that it may become most adapted for the state or nature of the combustible mixture, throughout the varying circumstances of the load.

The invention is hereinafter described with reference to the accompanying drawing, in which:—

Fig. 1 is a sectional elevational view of an internal combustion engine embodying the present invention;

Fig. 2 is an enlarged view of the piston of the engine, shown in side elevational section;

Fig. 3 is a front elevational, partly sectional, view of the engine, showing particularly the automatic regulating device when it assumes a position for increased compression ratio;

Fig. 4 is a view showing a particular part of the automatic regulating device when it occupies a position for reduced compression ratio;

Fig. 5 is a view showing the particular part of the automatic regulating device when it assumes a position for maintaining the compression ratio constant; and

Fig. 6 is a diagram showing in comparison thermal efficiencies. Curve #1 represents that of an engine according to the present invention while curve #2 indicates that of the ordinary Otto-cycle motor.

Fig. 7 is a detail view of the manual operating means.

Similar numerals denote similar parts throughout the several figures.

Referring to the drawing, the piston 1 has a piston-pin 1' around which is fitted an eccentric hub 2 to which is rotatably attached the piston end of the connecting rod 20 of the piston, the axial line x—x of the eccentric hub being displaced from the axial line y—y of the piston-pin by an eccentricity, say, C. The eccentric hub 2 is formed at one end with a worm-gear 2' which is concentric with the piston-pin 1 and engaged with a worm 3 the lower end of which is connected with a bar 3' which is square in section. Adjacent to the lower end of the square bar 3' there is mounted thereon a worm-gear 4 which is slidable along on the former by means of its square opening which is formed to coincide with the sectional dimensions of the square bar 3', the said worm-gear 4 being engaged with another worm-gear 5 supported by a bracket 6. The arrangement of the square bar is such that when the piston 1 is set in motion the former is actuated by the latter so as not only to rotate but to slide along through the opening through the worm-gear 4. A shaft 7 on which is mounted the worm-gear 5 projects outwards from the casing 8 of the engine, this shaft being so disposed that it may be either rotated by an automatic device or by hand.

The device for automatically rotating the shaft 7 is illustrated in Figs. 3 to 5 inclusive, which consists of an arrangement of parts as described below. To the portion of the shaft 7 projecting outside the casing of the engine, there is attached a gear-wheel 9 which is adapted to be engaged by a pawl device 10 having two fingers 10' and 10'' respectively, the said pawl device being so arranged that it may urge the said gear-wheel to revolve in either direction. The pawl device 10 is pivotally mounted on a lever 21 which is connected to a rod 13 projecting from an eccentric cam 12 fitted on the crank-shaft 11. A passage 14 is provided and communicates with the combustion-chamber of the engine, so that the explosion pressure in the combustion-chamber may be conducted to a plunger 16 through a non-return valve 15. The plunger 16 is furnished with a spring 17 which is supported by an abutment 18 and adapted to oppose the pressure of the said plunger, while one end of the plunger is pivotally connected with the pawl device 10.

If a hand-manipulated system is preferred, the shaft 7 may be rotated simply by a hand-lever 19 attached to the said shaft, as shown in Figs. 1 and 7.

The automatic device for rotating the shaft 7, referred to, is operated as follows:—

It is understood that the engine is equipped with a suitable governor to control the supply of explosive mixture, which need not be shown or described.

When the load on the engine is diminished the governor is actuated and accordingly causes a decrease in the admission of the fuel mixture charge or allows a leaner mixture to be admitted, the maximum explosion pressure of the engine is lowered and this results in a reduction in the pressure acting on the plunger 16, thereby making the latter unable to balance the pressure of the spring 17 any longer. Thereupon the pawl device 10 assumes a position as shown in Fig. 3, permit-

ting the lower finger or paw 10'' to become engaged with the gear-wheel 9, so that the said lower finger or paw 10'' urges, under the influence of the reciprocal motion of the rod 13 actuated from the eccentric 12 on the crank-shaft 11, the said gear-wheel to revolve in the direction indicated by an arrow in the drawing. The motion of the gear-wheel 9 is transmitted to the eccentric hub 2 through the worm gearings 5—4 and 3—2', thereby causing a gradual rise in the compression ratio of the engine. Therefore, the output of the engine is enhanced, resulting in an increase in the speed of rotation. Now the governor is actuated so that it follows that the leaner the composition of the admitted mixture grows the greater the maximum explosion pressure of the engine becomes. If the maximum explosion pressure rises to a pre-determined value, or also if a premature ignition takes place, allowing the pressure acting on the plunger 16 to overcome the compression of the spring 17, the pawl device 10 will assume the position as illustrated in Fig. 5, thereby bringing the operation of the compression regulating device to a stop. The engine will then commence to work at a constant degree of compression (namely, a value of compression ratio in proximity to the highest possible amount of such value obtainable under the circumstances, subject to load, etc.).

On the other hand, as the load of the engine becomes greater, the governor is actuated, permitting thereby a richer mixture to be admitted and accordingly increasing the fluid pressure acting on the plunger 16, the balance of forces set up between the latter and the spring 17 thereby being destroyed, and forcing the pawl device 10 to assume a position different from that referred to hereinbefore, while the upper paw or finger 10' of the pawl device comes into action as shown in Fig. 4. Therefore, the compression regulating device is actuated to move in the direction contrary to that referred to above. Now, as the maximum explosion pressure is lowered by degrees, a correspondingly gradual decrease in the fluid pressure acting on the plunger 16 takes place, the said pressure therefore balances the compression of the spring 17, and allows thereby the compression regulating device to resume the position, as illustrated in Fig. 5.

To provide positive operation throughout the stages of operation hereinbefore described, it is necessary that the pressure of the burned gases prevailing in the space between the non-return valve 15 and the plunger 16, be sufficiently high to allow for losses by contraction of the said gases due to cooling, leakage around the plunger and so forth.

Where the hand-manipulated device is used, the compression ratio may be regulated by rotating the hand crank 19 and altered to such a value as desired, provided that the same may not exceed the limit of twice the radius of eccentricity.

It is understood that the thermal efficiency of an internal combustion engine is determined largely by the pressure attained during the compression stroke of the engine. With regard to the known Otto-cycle engine, it has however been necessary that the degree of the compression ratio be based on overload condition, or, in other words, limited within such a safe range of values as will not cause a premature ignition or detonation, even though the engine is worked at an overheated temperature and with the full admission of a rich mixture, and, for that reason, it has been the practice that the engine of that type be operated at a relatively low compression ratio when compared with the Diesel engine. In actual cases, it has been difficult to make engines of the Otto-cycle type attain a compression ratio higher than 6–1. The fact is obvious that the Otto-cycle engine does not attain its maximum permissible pressure even at a full load.

It is further pointed out, from the theoretical point of view, that, in order to produce as much work as possible from the admitted charge, the Otto-cycle engine should have a higher compression ratio at reduced loads than at a full load, inasmuch as the governor comes into operation so as to diminish the amount of the fuel mixture charge admitted or make the composition of the same leaner. It is to be noted that lean mixtures do not at all cause ill effects such as detonation, premature ignition and so forth, even if the engine is operated at a compression ratio from 10 to 1 to 13 to 1. Experiments have shown that thermal efficiencies developed in such cases are considerably higher than those obtained by subjecting rich mixtures to low pressure or the efficiencies obtained at full load. It is admitted that the compression ratio of an engine at reduced loads is considerably lower than that necessary for the maximum compression pressure because of the constant fixed volume of the combustion chamber (that is, the minimum volume of the combustion chamber which is permissible at an overload). Accordingly, it would be expected that the engine of the Otto-cycle type should have thermal efficiencies higher at reduced loads than at full loads. However, actually the converse is the case, and such thermal efficiencies become lower at reduced loads, as diagrammatically illustrated in Fig. 6. This fact seems to be one of the outstanding drawbacks of the Otto-cycle engine.

According to this invention, however, means is provided so that the compression ratio may be regulated either automatically or by hand in such a manner that the engine can be operated at all times at a compression ratio which is in proximity to the highest possible ratio obtainable under the circumstances, subject to conditions of load, richness of the fuel mixture, temperature of the engine, and so forth. As a result, the thermal efficiency is enhanced throughout the varying ranges of the load, especially when the engine is operated at reduced loads, as indicated in Fig. 6.

It has been found that fuels of inferior qualities such as heavy-oils are not adapted for use in engines of the Otto-cycle type, because of the fact that they cannot be gasified with ease either at atmospheric or at slightly raised temperatures. According to this invention, it is possible to make use of fuels of this nature, and such fuels, which are admitted in the form of mixtures while retaining a spray-like state, are subjected to high pressures and thereby thoroughly gasified at relatively high temperatures so as to finally effect a self-explosion. In this respect, it is to be noted that the usual ignition device is entirely dispensed with in the invention.

One of the cases where the invention can be advantageously carried into effect is engines for use in motor vehicles. Motor vehicle engines of the ordinary type are operated under frequent variations in output as well as crankshaft speed. It is well known that they are operated on an average at loads from ¼ to ½ the full output of the engines, and consequently they are oper-

ated at reduced efficiencies. The present invention appropriately overcomes such disadvantages and brings about considerable increases in the thermal efficiency as well as the economy in the consumption of fuel, by ensuring an efficient degree of the compression ratio in accordance with the changes in the loads and speeds of crankshaft rotation.

I claim:

1. In an internal combustion engine, having a frame, a piston, a piston rod, a piston pin carrying an eccentric hub connecting the piston and piston rod, the combination of means for rotating said hub in opposite directions to vary the stroke of the piston and compensate for variations of pressure in the engine, said means comprising a transverse shaft mounted on the engine frame, a ratchet wheel mounted on said shaft, a pawl device engageable with said ratchet wheel and constructed and adapted to turn said ratchet wheel in alternately opposite directions, means operable through the rotation of said ratchet wheel to rotate the said eccentric hub to different positions and means controlled by variations of pressure in the engine for actuating said pawl device.

2. In an internal combustion engine having a frame, a cylinder, a piston, a piston pin, a connecting rod, the combination of an eccentric sleeve rotatively mounted on the piston pin and carrying one end of the connecting rod, a worm gear concentric with the piston pin, a worm with which said worm gear engages, a vertical shaft carried on the engine frame and by which said worm is supported and which is vertically movable and axially rotatable, a transverse shaft mounted on the engine frame, a worm carried by said transverse shaft, a worm gear having a central opening through which said vertical shaft extends and is movable lengthwise, said last named worm gear being in rotatable engagement with said vertical shaft and means controlled by variations of pressure in the engine for rotating said transverse shaft alternately in opposite directions and thereby altering the throw of the piston to compensate for said variations.

2. An internal combustion engine, comprising a frame, a cylinder, a piston reciprocable therein, a piston rod, a piston pin and a crank shaft, the piston pin being provided with an eccentric sleeve embraced by the piston rod and the said sleeve being provided at one end with a worm gear concentric with the piston pin, a worm with which said worm gear is engaged, a squared rod on which said worm is mounted and which is rotatably carried by the piston and movable lengthwise therewith, a second worm gear mounted on the engine frame and having a central square opening through which said squared rod is slidable, a transverse shaft mounted on the engine frame, a worm fixed on said shaft and engaging with said second worm gear, a gear wheel carried by the last named shaft outside the engine frame, means responsive to variation in pressure in the engine for rotating said last named shaft in alternately opposite directions and thereby altering the throw of the piston to compensate for variations in said pressure.

4. In an internal combustion engine, including a cylinder and piston, means for varying the throw of the piston under variations of pressure in the cylinder, including a shaft, a ratchet wheel mounted thereon, a pawl device for turning said shaft in alternately opposite directions and means for actuating said pawl device and turning said ratchet wheel in a direction dependent on the variation of pressure in the cylinder.

YASUSABURO HIRONAKA.