

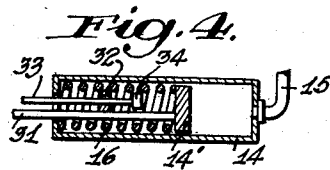
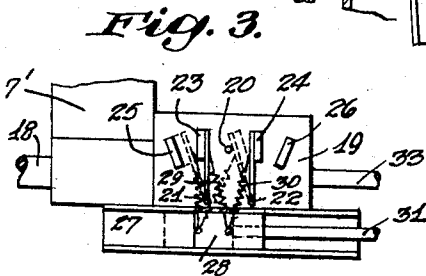
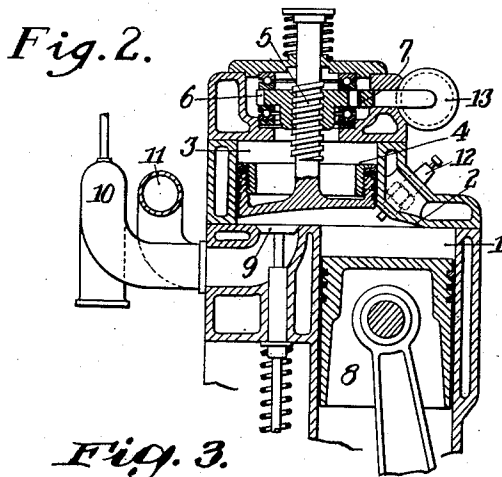
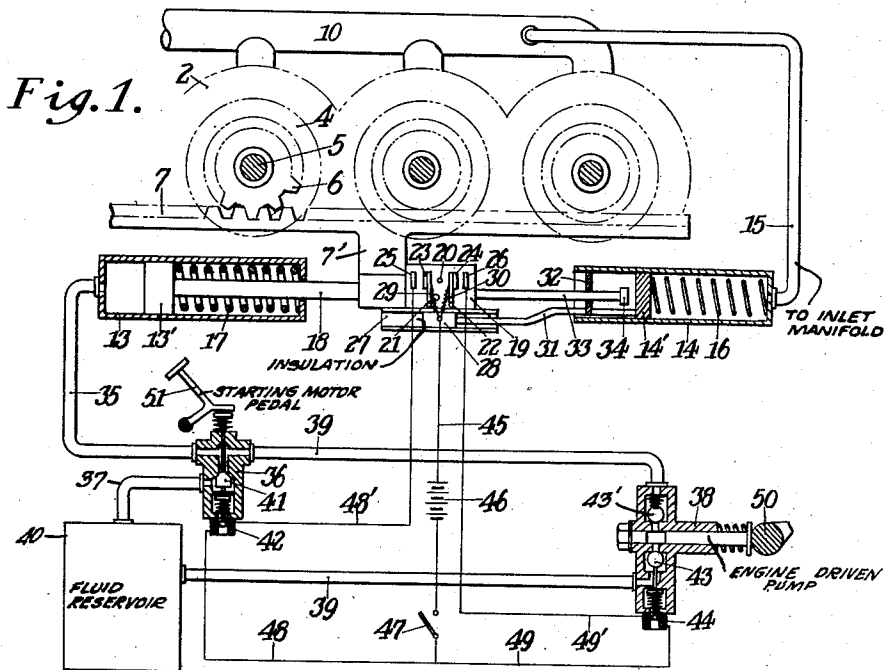
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VARIABLE COMPRESSION RATIO INTERNAL COMBUSTION ENGINE

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VARIABLE COMPRESSION RATIO INTERNAL COMBUSTION ENGINE

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2 Claims. (Cl. 123—48)

This invention relates to a variable compression ratio internal combustion engine having a movable member incorporated in the wall of the combustion engine.

The object of the invention is to provide such a regulating device in which the operation of the compression ratio regulating mechanism is controlled by an electrical control means responsive to and actuated by variation of the engine speed and load thereby automatically and quickly regulating the compression ratio and attaining high thermal efficiency of the engine under varying loads.

In internal combustion engines, it is desirable for the purpose of obtaining higher thermal efficiency to vary the compression ratio according to the degree of suction which varies according to the load and the engine speed, so that the engine operates under the maximum compression ratio permissible for each condition, and such variation is especially desirable and advantageous when operating on lighter load.

This invention is designed to attain such adjustment, and according to this invention the means for varying the compression ratio comprises a movable member or a piston incorporated in the wall of the combustion chamber and means for displacing said movable member or piston, means being provided for electrically controlling the compression ratio varying means.

In the practice of the invention, the compression ratio varying device may be directly controlled electrically, or it may be controlled through the action of another source by opening and closing an electric circuit or circuits. The opening and closing of the controlling electric circuit may be automatically controlled by utilizing the variation of the vacuum in the intake manifold or variation of the explosion gas pressure, which vary according to the engine load, engine speed, etc.

The invention will now be fully described with reference to the accompanying drawing, in which:—

Fig. 1 is a diagrammatic view of an automatic controlling device utilizing the vacuum prevailing in the intake manifold, and

Fig. 2 is a longitudinal section of a mechanism for varying the compression ratio by displacing the position of a movable member forming a portion of the wall of the combustion chamber.

Fig. 3 shows upon a larger scale the arrangement of an electric switch used in the invention,

and

Fig. 4 shows a modified form of the gas servo-motor.

In the embodiment shown, the controlling electric circuit is governed by utilizing the variation of the vacuum in the intake manifold, whereby the inlet or outlet passage of liquid is controlled so that the liquid pressure is varied to effect automatic control of the mechanism for displacing a movable member provided in a portion of the wall of the compression chamber. For the sake of convenience, the compression ratio adjusting mechanism will first be described.

Referring to the drawing, particularly Fig. 2, forming the upper wall of the combustion chamber 1 there is a cylinder head 2 which is provided with a cavity 3. Inserted in said cavity 3 there is a piston-like movable member 4 which has a rod 5 extending upwardly. A gear 6 with its bore internally threaded is engaged by said threaded rod 5. Engaging with said gear 6 is a toothed rack 7. By moving said rack 7 the threaded rod 5 carrying the movable member 4 is raised or lowered, so that the effective volume of the combustion chamber 1 is varied accordingly. 8 is a working piston; 9 is an intake valve; 10 is a suction pipe or intake manifold; 11 is a discharge pipe or exhaust manifold; and 12 designates an ignition plug.

A liquid servo-motor 13 and a gas servo-motor 14 are arranged in a tandem relation. The gas servo-motor 14 is connected through a pipe 15 to the intake manifold 10, and the piston 14' is urged by a weak spring 16. The liquid servo-motor 13 is provided with a servo-motor piston 13' which is urged toward the liquid side by a spring 17. To the piston rod 18 is connected the above-mentioned toothed rack 7 by vertical arm 7', and thereto is also secured an electric switch 19. This switch comprises two movable contacts 23 and 24 having moving points 21 and 22 respectively and arranged symmetrically with respect to a stop 20, said contacts 23 and 24 being adapted to be moved into contact with fixed contacts 25 and 26 respectively, and slide 28 which is slidable along a guide block 27 (which is suitably secured to the cylinder head) and is electrically connected with said movable contacts 23 and 24, the latter being pulled by springs 29 and 30. The slide 28 forms an extension of a piston rod 31 of the piston 14' of the gas servo-motor 14. A stop 32 is arranged at a predetermined distance from the piston 14'. A rod 33 secured to the switch 19 extends through the stop 32 into the servo-motor cylinder 14, and at its free end it is provided with a head 34. The liquid servo-motor

13 is connected through a pipe 35 to a discharge valve chest 36 which in turn is connected to a liquid reservoir 40 through a discharge pipe 37 at one side and through a supply pipe 39 at the other. In said supply pipe 39 is inserted a liquid supply pump 38. A discharge valve 41 is normally held in closed position by a spring, and is opened by energization of a solenoid 42. Similarly, a supply valve 43 is normally closed by a spring and is opened by energization of a solenoid 44. 43' is a check valve provided in the delivery of the liquid supply pump 38. 45 is a common conductor. 46 is a source of electric current. 47 is a hand operated switch. 48 and 48' are conductors forming the discharge valve controlling circuit. 49 and 49' are conductors forming the supply valve controlling circuit. 50 is a cam for operating the liquid supply pump 38, and is fixed on a shaft driven from the crank shaft of the engine. Preferably, the discharge valve 41 is so arranged as to be actuated also by depression of a starter pedal 51 when the invention is applied to motor vehicles.

As the load decreases or the engine speed is raised, the negative pressure or the vacuum in the intake manifold becomes higher, so that the piston 14' of the gas servo-motor 14 is moved towards the right (in Fig. 1) against the action of the spring 16, whereby the slide 28 is also moved towards the right (Fig. 1). As a result of rightward movement of the lower point of connection of the springs 29 and 30, the movable contact 24 comes into contact with the fixed contact 26, thereby closing the circuit comprising the conductors 45, 49, solenoid 44 and the conductor 49'. By energization of the solenoid 44, the supply valve 43 is opened. At this time, the discharge valve 41 is held in closed position by the spring. The liquid in the reservoir 40 is forced into the servo-motor cylinder 13 through the pipes 39 and 35, and acts upon the piston 13', forcing it to the right and consequently the rod 18 and the toothed rack 7. Actuated by said rack 7 through the gear 6 and the threaded rod 5, the piston-like member 4 is lowered, whereby the compression ratio is increased. When the pressure in the gas-servo-motor 14 becomes balanced with the vacuum in the intake manifold, the movement of the piston 14' ceases. However, the supply valve circuit remains closed, so that the piston 13 does not stop its movement and the compression ratio changing movement is continued, moving the switch 19 towards the right. When the switch 19 is centralized with respect to the slide 28, the movable contacts 23 and 24 return to the normal open position, opening the supply valve circuit, whereby the supply valve 43 returns to the normal closed position under the action of the spring. Thus, the supply of liquid is shut off, and the action of the liquid servo-motor 13 is stopped, thereby maintaining the desired compression ratio.

As the load increases or the engine speed is lowered, the above mentioned parts partake of the reverse movements. Namely, the movable contact 23 comes into contact with the fixed contact 25, closing the circuit comprising the conductors 45, 48, solenoid 42 and the conductor 48'. The energized solenoid 42 opens the discharge valve 41. Whereupon, the piston 13' acted upon by the spring 17 forces the liquid in the servo-motor cylinder 13 back to the reservoir

40. The toothed rack 7 moves in the reverse direction, and the compression ratio is decreased thereby.

In any event, when increasing or decreasing the compression ratio, the distance of the differential movement of the slide 28 and the electrical switch 19 is limited by the co-operation of the stop 32 and the head 34 of the rod 33, so that the movable contacts 23 and 24 are prevented from moving too far preventing correct action of the device or causing breakage of the device.

When it is desired to utilize the exhaust gas pressure in the gas servo-motor 14, the compression spring 16 is provided at the left side of the piston 14' as illustrated in Figure 4. By such modification, the same result may be attained as mentioned above.

In the preferred form of the embodiment of this invention described with reference to the accompanying drawing, it will be understood that the electric power required for the operation of the device is but a small amount of that required for energizing the solenoids for opening the valve which govern the supply and discharge of the liquid, and that the compression ratio varying mechanism is actuated by liquid pressure, and the controlling circuit is opened at suitable times, so that the mechanism is stopped in the position for maintaining the desired compression ratio. By such device, the operation of regulating the compression ratio is automatically and quickly effected with accuracy.

What I claim is:—

1. In a variable compression ratio internal combustion engine, means forming a combustion chamber having a movable wall member, a compression ratio varying mechanism adapted for moving said movable wall member comprising a liquid servo-motor having a servo-motor piston and servo-motor cylinder, said servo-motor cylinder being connected to a source of liquid pressure, a pipe connecting said liquid servo-motor and the liquid source, a controlling valve in said pipe, a gas servo-motor connected to the intake manifold of the engine, a gas servo-motor piston therefor having a piston rod extension, an electric switch, means carried by said piston rod extension for actuating said switch, a solenoid for actuating said controlling valve, and an electric circuit including said solenoid and said electric switch.

2. In a variable compression ratio internal combustion engine, means forming a combustion chamber having an auxiliary piston member, a compression ratio varying mechanism adapted for moving said auxiliary piston member comprising a liquid servo-motor having a servo-motor piston and a servo-motor cylinder, said servo-motor cylinder being connected to a source of liquid pressure, a pipe connecting said liquid servo-motor and the liquid source, a controlling valve in said pipe, a gas servo-motor connected to the exhaust pipe of the engine, a gas servo-motor piston therefor having a piston rod extension, an electric switch, means carried by said piston rod extension for actuating said switch, a solenoid for actuating said controlling valve, and an electric circuit including said solenoid and said electric switch.

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