Feb. 24, 1931. L. M. WOOLSON 1,794,047

INTERNAL COMBUSTION ENGINE

Filed Nov. 20, 1929 3 Sheets-Sheet 1

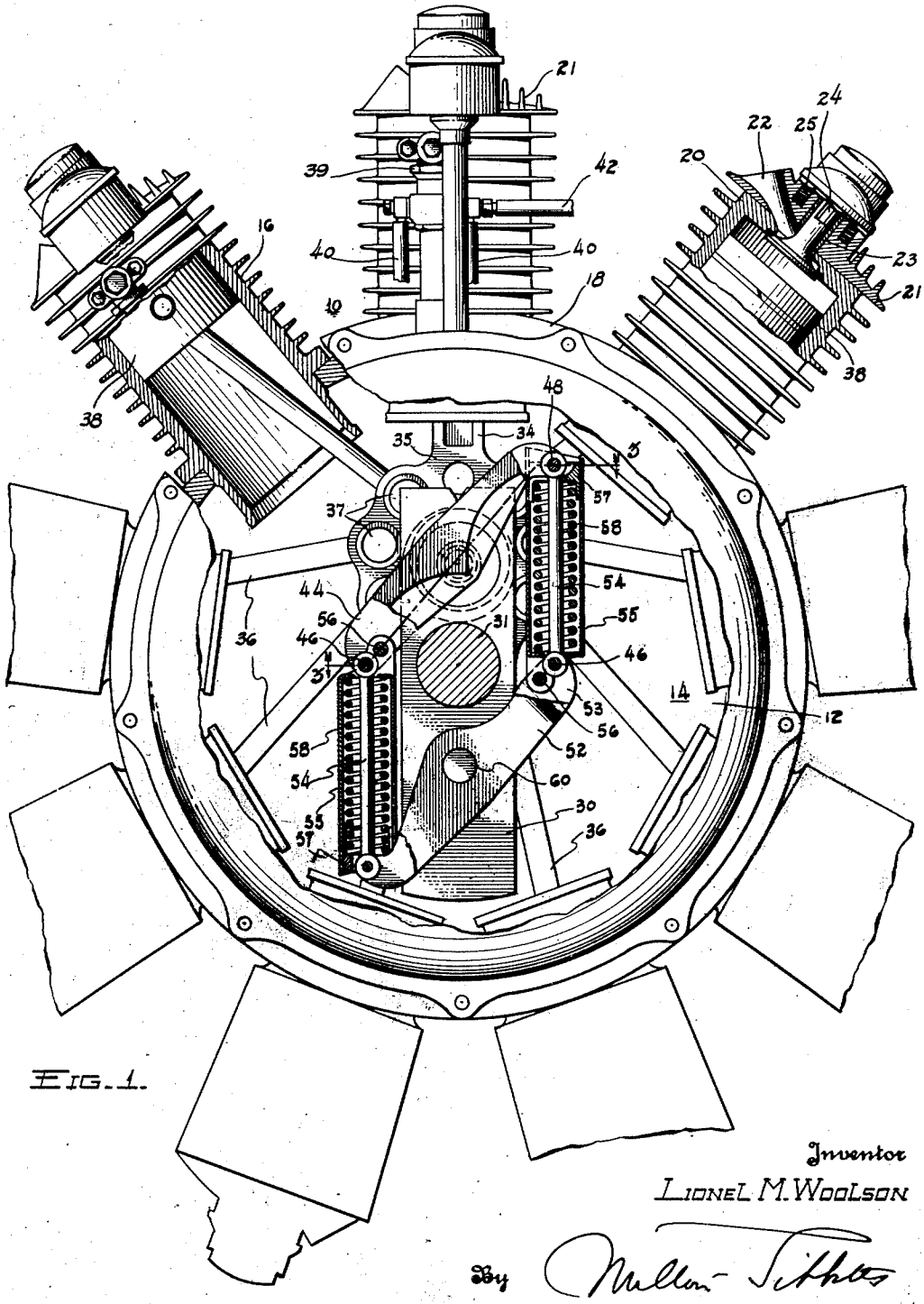


FIG. 1.

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INTERNAL COMBUSTION ENGINE

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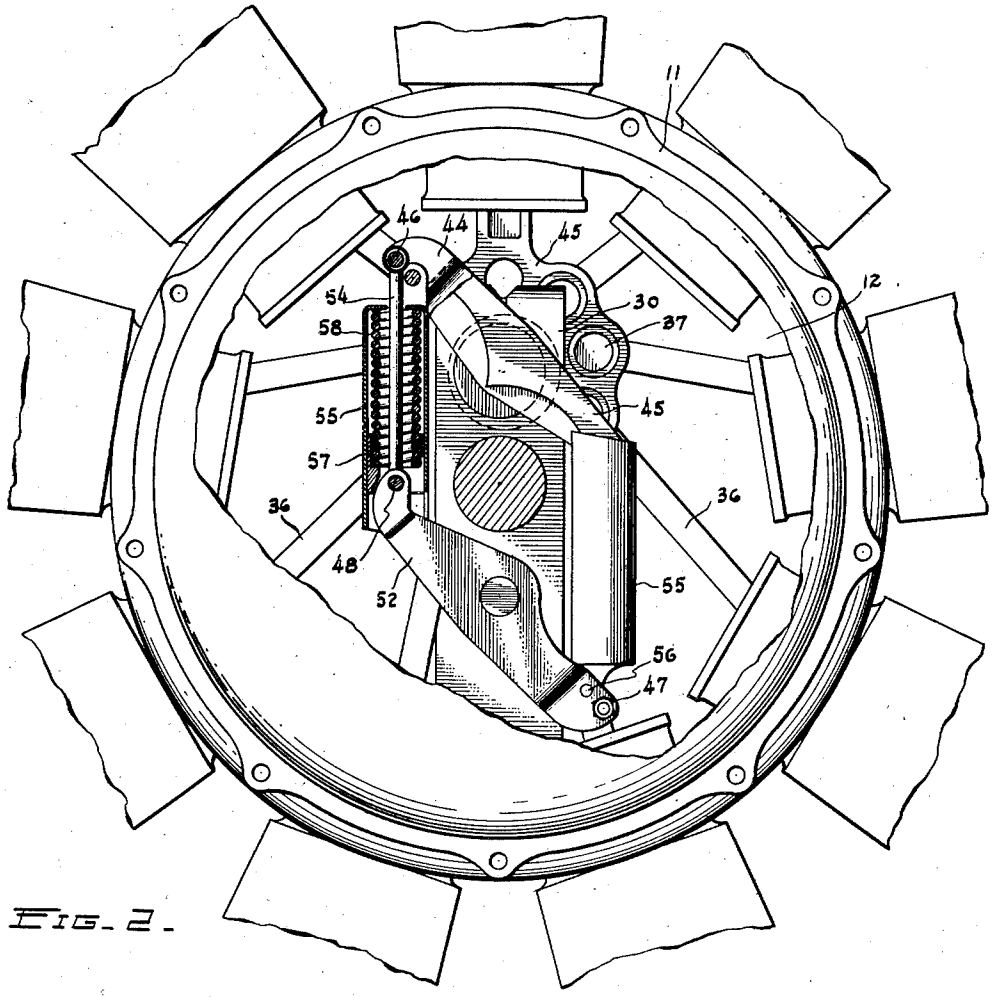


FIG. 2.

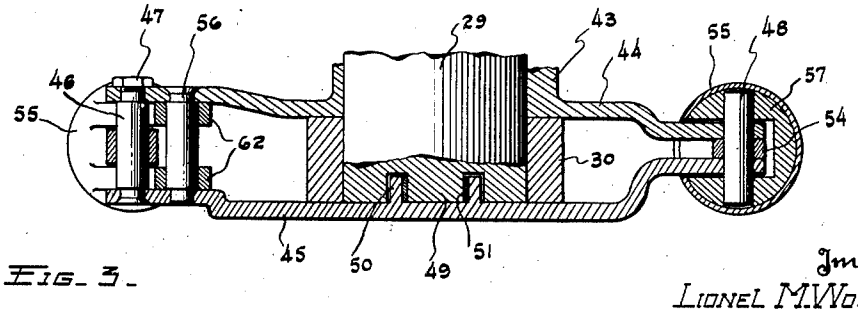


FIG. 3.

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INTERNAL COMBUSTION ENGINE

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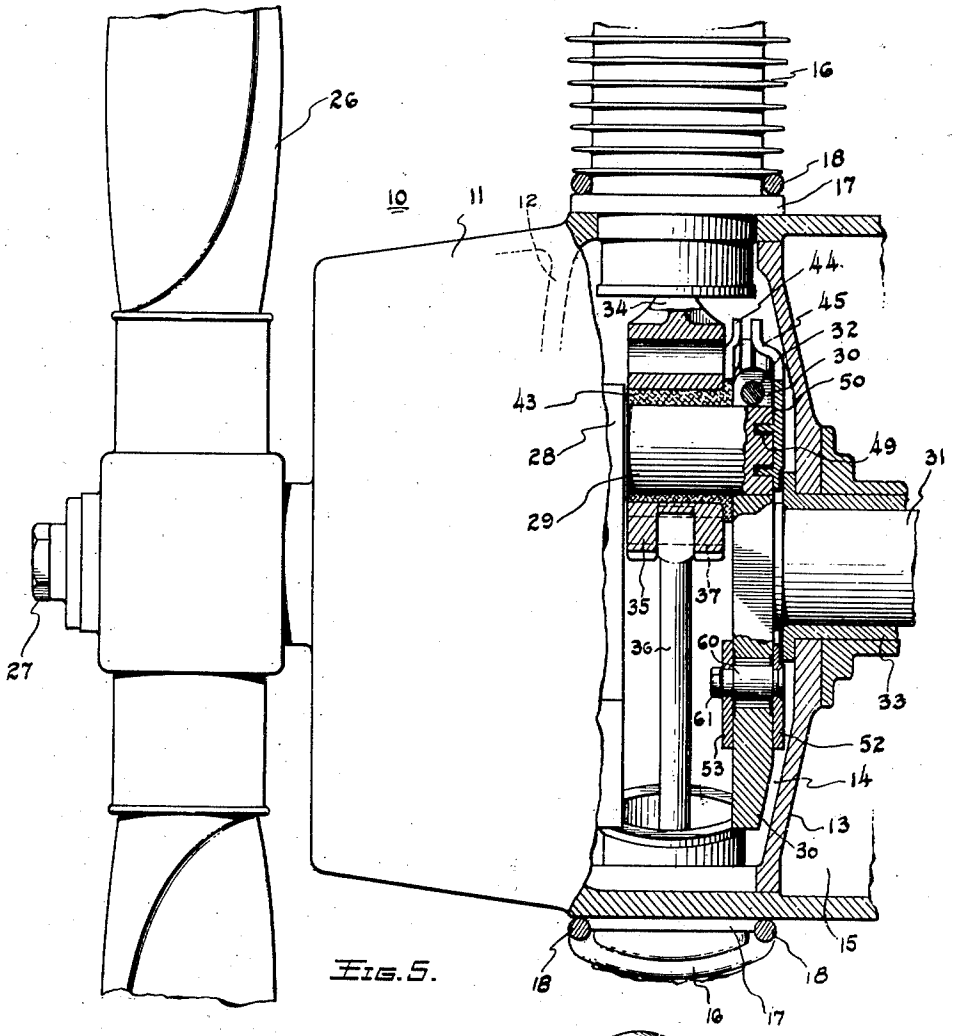


FIG. 5.

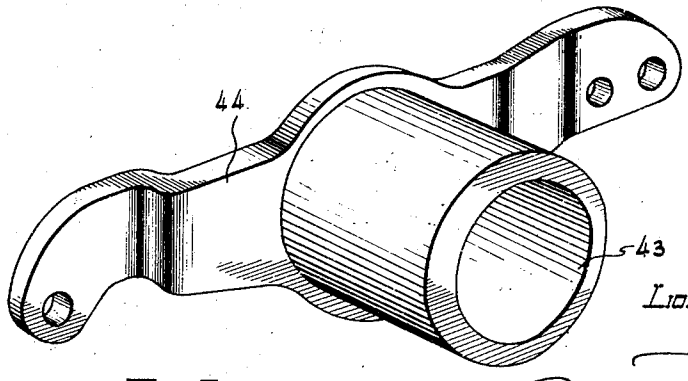


FIG. 6.

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UNITED STATES PATENT OFFICE

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INTERNAL-COMBUSTION ENGINE

Application filed November 20, 1929. Serial No. 408,583.

This invention relates to internal combustion engines, and more particularly to compression ratio regulating mechanism.

An object of my invention is to automatically regulate the compression ratio in an engine inversely to the speed so that when starting or running at low speeds, the engine will operate with a high compression ratio, and when the engine is running at a high speed, it will operate with a lower compression ratio.

Another object of my invention is to provide an internal combustion engine with automatic mechanism for varying the quantity of air drawn into the cylinders in accordance with the speed of the engine.

A further object of the invention is to provide a compression ratio regulating mechanism for an internal combustion engine which is controlled automatically by the speed of the crank shaft rotation and associated compactly with the crank shaft.

These and other objects of the invention will appear from the following description taken in connection with the drawings which form a part of this specification and in which:

Fig. 1 is an end view of an engine, the crank case being broken away and parts being in section to show my invention in associated relation with the engine;

Fig. 2 is a similar view with the compression ratio mechanism in a different position from that in which it is shown in Fig. 1;

Fig. 3 is a sectional view taken on line 3—3 of Fig. 1 illustrating the compression ratio mechanism;

Fig. 4 is a fragmentary side elevational view having the engine casing broken away to show the compression ratio mechanism within the crank case; and

Fig. 5 is a prospective view of the eccentric bearing and the associated arm by means of which its position upon the crank shaft is fixed and changed.

Referring now to the drawings by characters of reference, 10 designates generally the power plant of an airplane which is preferably in the form of a radial Diesel type of engine. The annular barrel-like crank case 11 is provided with spaced partitions 12 and 13 between which is formed a compartment 14, and on one side of such compartment is formed another compartment 15 for the reception of mechanism operated by the crank shaft for actuating the cylinder valves and the fuel injection devices. Cylinders 16 are arranged to extend radially from the crank shaft and are formed with shoulders 17 which bear against the crank case and are secured thereto by a pair of annular compression bands 18, such compression bands absorbing all of the explosion loads from the cylinders and transmitting the same annularly to the crank case. The cylinders are each provided with an integral head 20 upon which an auxiliary head 21 is secured, such heads being formed with a single Venturi passage 22 extending therethrough at an angle to the axis of the cylinder and tangential with the inner wall of the cylinder. Such passages serve for both the air inlet and the exhaust and communicate with the interior of the cylinders and with atmosphere. A valve 23 is associated with the inner end of each of such passages, each valve being opened by a lever 24 actuated by mechanism which extends from the compartment 15 and closed by coil springs 25.

The crank shaft extends axially of the crank case and projects through the forward end thereof, a propeller 26 being mounted upon the projecting end of such shaft and secured thereon by a fastening means 27. The shaft preferably consists of two sections, the forward section having an arm 28 and a crank pin 29 formed integrally while the other section of the shaft includes the arm 30 and an integral shaft portion 31. The upper end of the arm 30 is bifurcated and is clamped around an end of the crank pin and secured thereto by the bolt 32, so that the two shaft sections can be detached when the bolt 32 is loosened. The crank shaft is carried by the crank case and is supported by suitable bearings, one of which is shown at 33. A master rod 34 is provided with a hub 35 which is mounted upon the crank pin 29, and a plurality of connecting rods 36 are pivotally secured in a circular relation around the hub 35 by the pins 37. The connecting rods and the master rod extend into the cylinders and

are connected to the pistons 38. It will be understood that assembly of the master rod hub on the crank pin is accomplished through endwise movement when the sections of the shaft are separated, a master rod being maintained upon the crank pin between the two arms 28 and 30 when the shaft is assembled.

The engine illustrated is, as before stated, of the radial Diesel type and operates upon a four-stroke cycle. The valve operating mechanism is arranged to hold the valves open during the exhaust and the air intake strokes, such valves being closed during the compression and explosion cycles.

The fuel oil charges are introduced separately into the cylinders, the air portion of the charges being drawn directly from atmosphere through the passages 22 on the suction strokes of the pistons 38, while the fuel portion of the fuel mixture is introduced into the cylinders during the compression of the air charges and prior to top center position of the pistons. Any suitable form of fuel injection mechanism can be employed to introduce the fuel oil into the cylinders, but I prefer that a separate injection device be associated directly with each cylinder and such devices are indicated generally at 39, each of such devices consisting of a nozzle portion which extends through the associated cylinder and a pump portion which is driven by mechanism operated from the crank shaft within the compartment 15. It will be understood that the fuel is injected under high pressure and in an atomized condition by the injection devices so that it will be projected partially across the interior of the cylinders and will be mixed with the compressed air charges which are rotating within the cylinder due to the manner in which the passages 22 are positioned and formed. A suitable manifold, as indicated at 40, extends intermediate the cylinders and is connected with each of the fuel injection devices and to propel oil through the manifold under low pressure, and an overflow conduit 42 is associated with the uppermost portion of the manifold for conducting excess fuel back to the source of supply. For a better understanding of the particular type of engine so far described, reference may be had to my co-pending application, Serial No. 358,899, filed April 29, 1929.

In order that the compression ratio of the engine can be regulated I provide a bearing sleeve 43 for the hub of the master rod, such bearing sleeve having an eccentric bore through which the crank pin 29 extends. It will be understood that the arm 30 must be detached from the crank pin in order to assemble the bearing sleeve 43 and the master rod upon the crank pin 29. The position of the bearing sleeve upon the crank pin can be adjusted and fixed by mechanism which I will now describe so that the compression ratio is automatically regulated inversely to and by the speed of the crank shaft.

Formed integral with the sleeve 43 is an arm 44 to which another arm 45 is secured in parallel relation by the bolt 46 and nut 47 and the pin 48, the crank arm so extending intermediate and spacing such arms. The end of the crank pin 29 is formed with a circular recess to form the bearing 49 upon which the circular flange 50 formed on the arm 45 telescopes, a bushing 51 being interposed between the bearing and the flange. The arms 44 and 45 are secured together as an integral structure or mass, the center of gravity of which is off-set from the axis of the crank pin. Parallel with and counterbalancing such off-set mass is another structure which includes a pair of spaced parallel arms 52 and 53 which are secured together in a manner similar to the arms 44 and 45 by the bolt 46 and nut 47 at one end and by the pin 48 at the other end. A pair of rods 54 are pivotally mounted upon the pins 46 and 48 at each end of the arm structures and maintain them in parallel relation. The arms 52 and 53 are pivotally carried by the crank arm 30, a pin 60 being riveted to the arm 52 and passing through the crank arm and arm 53 in which relation it is retained by the nut 61 from axial displacement. The arms 52 and 53 are pivoted to the crank arm with the center of gravity off-set so that they will balance the arms 44 and 45.

Cylindrical housings 55 telescope the major portion of the rods 54 and are secured one to each of the sets of arms by a pin 56 which is riveted to one of the arms and extends through the other. The housings are inverted relatively and the unsecured end of each telescopes the end of the rods through which the pin 48 extends, thus maintaining such pins in assembled relation, the housings being slotted at such end to allow the arms to project therethrough. The pins 48 extend through a piston 57 in each housing and thus the pistons will reciprocate upon rocking movement of the sets of arms relative to the crank shaft. Coil springs 58 are arranged within the housings and are interposed between the pistons and the opposite end of the associated housing. The housings are provided at one end with off-set parallel extensions 62 through which the pin 56, riveted to the arm 45, extends, and such pins are attached a similar distance from the pins 46 and in a direction toward the middle of the arm structures.

The compression ratio regulating device above described is arranged so that it is actuated by centrifugal force upon rotation of the crank shaft, and the device rotates with the crank shaft in a rotary adjustable relation so that the stroke of the pistons and the compression within the cylinders is regulated by the engine speed in a manner such

that high compression ratio is caused when the engine is running at the lower speeds and low compression ratio results when the engine is running at the higher speeds. Upon a variance in the compression ratio, which is inverse to the speed, the quantity of air which is drawn into the cylinders for the air charge will likewise vary because the evacuation of the cylinders varies with the variance of the piston operation in the cylinder. As a result, the compression is regulated inversely to the engine speed by this automatic compression ratio controlling device and the air charge varies directly with the speed.

The springs 58 are arranged within the housings 48 and cause the speed of the engine to reach approximately 1400 R. P. M. before centrifugal force moves the parallel off-set pairs of arms from the normal position, as shown in Fig. 1. This rate of speed at which the device starts to be actuated is preferred because it is required to sustain flight of the associated airplane, the device can be regulated to permit centrifugal force to actuate the sets of arms at any speed of the crank shaft which may be desired. As shown in Fig. 1, the sleeve 43 is in a relation with the crank pin such that high compression ratio results. The crankshaft rotates in a clockwise direction as viewed in Figs. 1 and 2, and upon its attaining a speed more than 1400 R. P. M. centrifugal force will cause the off-set arm structures to move in parallel relation in the same direction as that of the crank shaft as illustrated in Fig. 2. It will be seen that the eccentric bearing is shifted relative to the crank pin so that the master rod is moved by the crank shaft in an area which will lower the compression ratio. The range of movement of the compression ratio mechanism and associated bearing is between the positions shown in Figs. 1 and 2. When the speed of the engine is reduced, centrifugal force does not have as great an effect upon the off-set arms and the springs will return the arms toward the position shown in Fig. 1, and thereby will rotate the eccentric bearing upon the crank pin in an anti-clockwise direction which will raise the compression ratio.

It will be seen that with the device above described, the compression ratio is highest at slow speed and lowest at high speed, and that the compression ratio is automatically controlled inversely to the speed of the engine. With a Diesel type of engine, starting is difficult because of the cold condition of the cylinders, and with this device the engine will be operated with a high compression ratio when starting so that in this manner the rise of temperature within the cylinders is accelerated and will aid in the starting of the engine. The device also functions when the engine is operating at slow speeds to produce a high compression ratio and will thus increase the temperature within the cylinders which is an advantage with Diesel type of engines used as the power plant of an airplane, because when gliding the fuel is reduced to an extent such that the engine will run at a slow speed and therefore a high temperature is insured within the cylinders under these circumstances which assists the combustion of fuel. This arrangement for Diesel airplane engines is especially advantageous when the air for the fuel charges is drawn directly into the cylinders from the exterior because under many conditions the atmosphere is cold and tends to chill the cylinders so that combustion is retarded. Under such circumstances when combustion once ceases such cold air often chills the cylinder which has ceased firing to such an extent that it is very difficult to again start combustion and if too many cylinders cease firing the engine will stop running entirely.

The compression ratio regulating device is useful to assist in the control of the temperature within the cylinders and to regulate the quantity of air drawn into the cylinders for the fuel charge. The device is light in weight and is compactly associated with the crank shaft in a manner such that no extra space within the engine is required for its reception.

While I have herein described in some detail a specific embodiment of my invention, which I deem to be new and advantageous and may specifically claim, I do not desire it to be understood that my invention is limited to the exact details of the construction, as it will be apparent that changes may be made therein without departing from the spirit or scope of my invention.

What I claim is:

1. In a radial internal combustion engine, a crank shaft, a connecting rod structure including a master rod, an adjustable eccentric bearing intermediate the crank shaft and the master rod hub, connected pairs of balanced off-set arms connected to the bearing, said arms being actuated by centrifugal force to determine the position of the bearing relative to the crank shaft, and means opposing the effect of centrifugal force upon the arms.

2. In a radial internal combustion engine, a crank shaft, a connecting rod structure including a master rod, an eccentric bearing intermediate the crank shaft and master rod hub, balanced off-set means connected with the bearing, said means being responsive to centrifugal force to actuate the bearing and produce decreased compression ratio with increased speed, and means opposing the effect of centrifugal force to actuate the arms.

3. In a radial internal combustion engine, a crank shaft, a connecting rod structure including a master rod, an eccentric bearing intermediate the crank shaft and master rod hub, a connected parallel arm

structure pivoted to the crank shaft and fixed to the bearing, said arms being rotated upon the crank shaft by centrifugal force, and resilient means opposing the effect of centrifugal force tending to rotate the arm structure.

4. In a radial internal combustion engine, a crank shaft, a connecting rod structure including a master rod, an eccentric bearing intermediate the crank shaft and master rod hub, a connected parallel arm structure connected to the bearing, said structure being actuated by centrifugal force to change the bearing position upon the shaft and varying the compression inversely with the crank shaft speed, and spring means normally maintaining the bearing in high compression ratio effecting position.

5. In a radial internal combustion engine, the combination with the crank shaft and the master rod, of a compression ratio controlling device comprising an eccentric bearing sleeve intermediate the master rod hub and the crank shaft, a connected parallel arm structure fixed to the bearing sleeve, and spring members associated with the arm structure, said device regulating the compression ratio inversely to the speed of the crank shaft.

6. In a radial internal combustion engine, a crank shaft, a connecting rod structure including a master rod, an eccentric bearing sleeve between the crank shaft and the master rod hub, an arm structure fixed to the bearing sleeve with the center of gravity off-set from the crank shaft axis, a second arm structure pivotally connected to the other arm structure and arranged to balance the same, and means opposing the effect of centrifugal force upon the arm structures.

7. In a radial internal combustion engine, the combination with a crank shaft and a connecting rod structure including a master rod, of a compression ratio regulating device comprising an eccentric bearing sleeve loosely mounted intermediate the shaft and the master rod hub, balanced arm structures connected in parallel relation and to the bearing sleeve, parallel housings intermediate the arm structures, and coil springs in said housings.

8. In a radial internal combustion engine, the combination with a crank shaft and a connecting rod structure including a master rod, of a compression ratio regulating device comprising an eccentric bearing sleeve loosely mounted intermediate the crank shaft and the master rod hub, a pair of balanced arm structures, one of the structures being fixed to the bearing sleeve, rods connecting the arm structures in parallel relation, and means opposing the effect of centrifugal force to change the relation of the arm structures relative to the crank shaft.

9. In a radial internal combustion engine, the combination with a crank shaft and a connecting rod structure including a master rod, of a compression ratio regulating device comprising an eccentric bearing sleeve loosely mounted intermediate the crank shaft and the master rod hub, a pair of balanced off-set arm structures, one of the structures being fixed to the bearing sleeve, parallel rods pivotally connecting the arm structures, housings substantially telescoping the rods and pivoted at one end to one of the arm structures, and means in the housings opposing the effect of centrifugal force tending to vary the position of said arm structures relative to the crank shaft.

10. In a radial internal combustion engine, the combination with a crank shaft and a connecting rod structure including a master rod, of a compression ratio regulating device comprising an eccentric bearing sleeve intermediate the crank shaft and the master rod hub, spaced parallel arm structures being fixed to the bearing sleeve, rods pivotally connecting the arm structures, housings telescoping the rods, said housings being pivoted to an arm structure in off-set relation to the associated rod, and means in the housings opposing movement of the arm structures relative to the crank shaft resulting from crank shaft speed.

11. In a radial internal combustion engine, the combination with a crank shaft and a connecting rod structure including a master rod, of a compression ratio regulating device comprising an eccentric bearing sleeve intermediate the crank shaft and the master rod hub spaced parallel arm structures carried by the crank shaft, one of the arm structures being fixed to the eccentric bearing sleeve, rods pivotally connecting the arm structures in parallel relation, housings telescoping the rods and pivoted at one end to an arm structure, a plunger in each housing connected to the associated rod, and coil springs intermediate the plungers and an end of the housings.

12. In a radial internal combustion engine, the combination with a crank shaft and a connecting rod structure including a master rod, of a compression ratio regulating device comprising an eccentric bearing sleeve intermediate the shaft and the hub of the master rod, an arm formed integral with the eccentric bearing, means balancing said arm, and means opposing the effect of centrifugal force tending to move the arms relative to the crank shaft.

In testimony whereof I affix my signature.

LIONEL M. WOOLSON.