Nov. 7, 1933. H. C. EDWARDS 1,933,620

INTERNAL COMBUSTION ENGINE

Filed Jan. 5, 1932 2 Sheets-Sheet 1

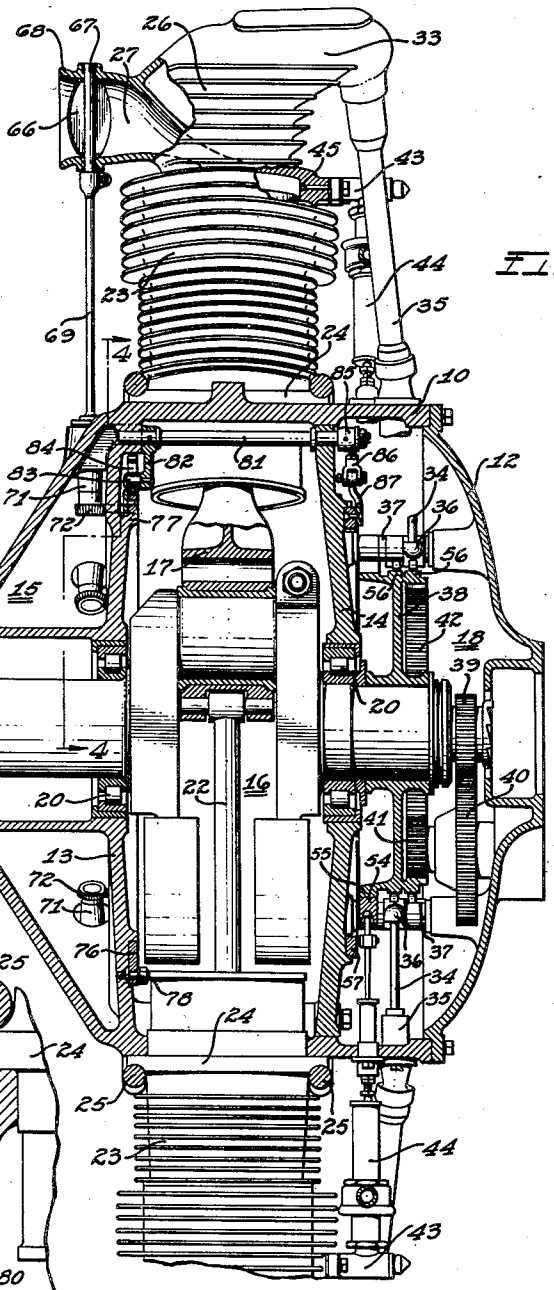

FIG. 1

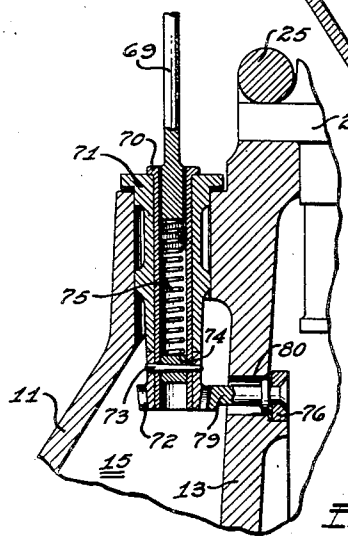

FIG. 2

Inventor
HERBERT C. EDWARDS.

By Milton Sitton

Attorney

Nov. 7, 1933. H. C. EDWARDS 1,933,620

INTERNAL COMBUSTION ENGINE

Filed Jan. 5, 1932 2 Sheets-Sheet 2

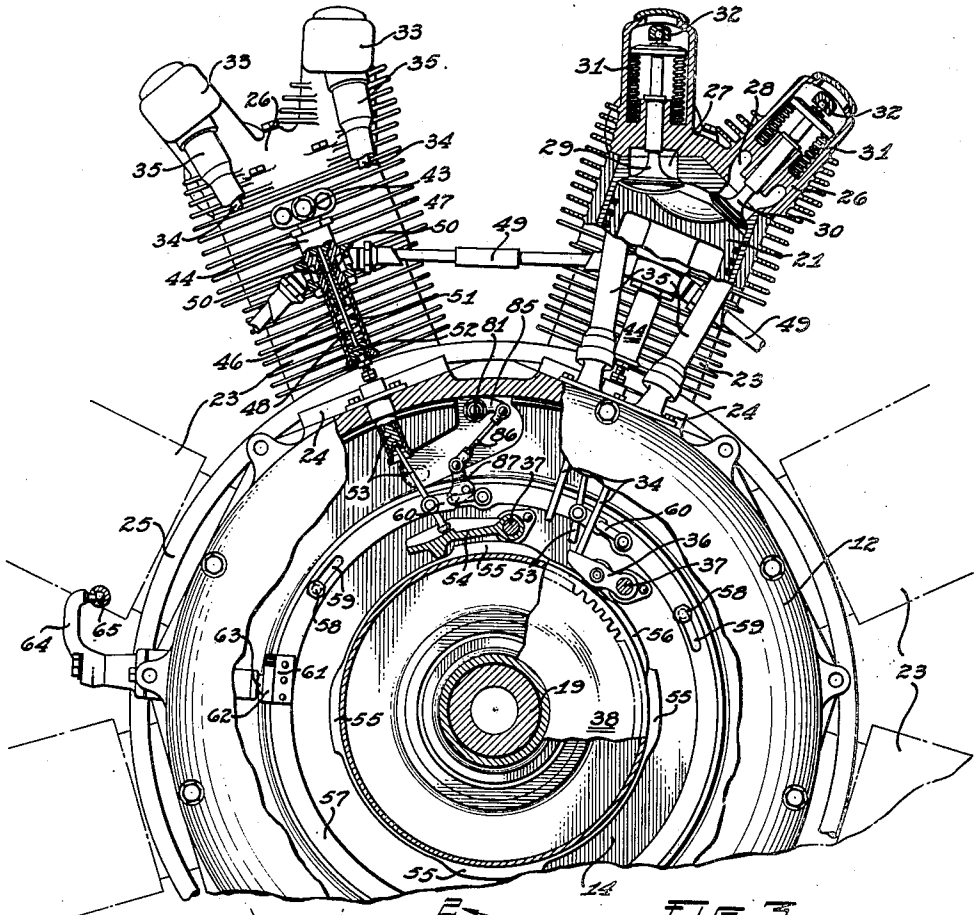

FIG. 3

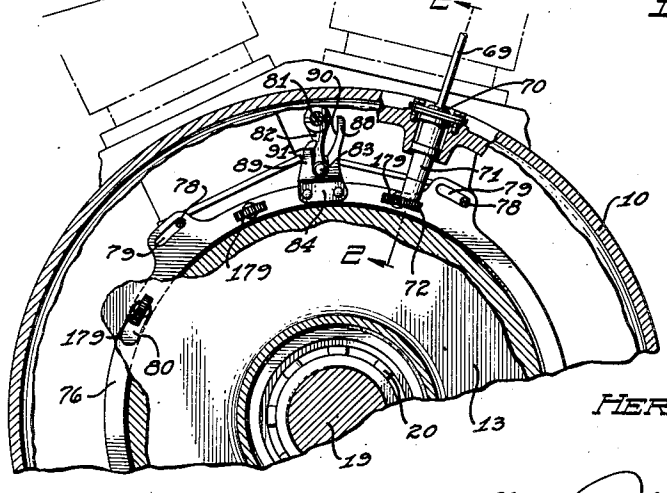

FIG. 4

Inventor
HERBERT C. EDWARDS.

By Miller & Sittler

Attorney

Patented Nov. 7, 1933 1,933,620

UNITED STATES PATENT OFFICE

1,933,620

INTERNAL COMBUSTION ENGINE

Herbert C. Edwards, Detroit, Mich., assignor to Packard Motor Car Company, Detroit, Mich., a corporation of Michigan

Application January 5, 1932. Serial No. 584,846

10 Claims. (Cl. 123—139)

This invention relates to internal combustion engines and more particularly to engine control mechanism.

In engines having air and fuel introduced separately into the combustion chambers and ignited by heat of compression, difficulty has been experienced, particularly when the engine is employed as a power plant of an aeroplane, in regulating the charges so that the engine will idle at a desired low speed without stalling. In other words, during idling the fuel oil regulation with a normal air charge must be of such a quantity that it prevents stalling and consequently the power development is more than is desirable for landing and maneuvering aeroplanes.

An object of my invention is to provide a new and novel form of mechanism for regulating the air charges in a definite relation with the fuel oil charge regulation of an engine whereby low power development will result without stalling.

Another object of the invention is to provide an engine of the character above specified with mechanism which will stabilize the idling operation.

A further object of the invention is to provide an engine, of the type in which air and fuel oil are introduced separately into and mixed in the cylinders, with means which accelerates the air circulation in the cylinders as the supply is reduced.

Still another object of the invention is to provide a new and novel manner of regulating engine valve mechanism for controlling the air charges entering the cylinders.

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 a vertical sectional view of an engine showing my control mechanism associated therewith;

Fig. 2 is a fragmentary sectional view taken on line 2—2 of Fig. 4 and illustrating a part of the control mechanism in its relation with the crank case;

Fig. 3 is an end elevational view of the engine partly broken away and partly in section, illustrating the fuel regulating mechanism and the interior of one of the cylinders;

Fig. 4 is a sectional view taken substantially on line 4—4 of Fig. 1.

Referring now to the drawings by the characters of reference, 10 represents a barrel type of crank case having an integral front wall 11, a removable rear wall 12, and interior partitions 13 and 14. The partitions are arranged in parallel relation, the partition 13 being formed as an integral part of the crank case casting and partition 14 being removably secured. This relation of partitions in the crank case forms a front chamber 15, a chamber 16 in which the master rod 17 is located and a rear chamber 18 in which is housed mechanism for controlling the charge forming mechanism. A crank shaft 19 extends axially through the crank case and partitions and is carried by suitable bearings, as indicated at 20. The master rod is mounted on the crank pin and pistons 21 are secured to the connecting rods 22 associated with the master rod in the usual manner.

Cylinders 23 extend radially from the crank case and are provided with flanges 24 which bear against flat faces on the crank case and are secured by a pair of tension band means 25. The cylinders are formed with an integral dome, to each of which is secured a head 26. Extending through each of the associated heads and domes is a pair of passages or ports 27 and 28, the passage 27 being the air inlet and the passage 28 being the exhaust outlet. Each passage 27 is controlled at its interior end by means of a poppet valve 29 while each passage 28 is controlled at its interior end by a poppet valve 30. Such valves are normally closed by a plurality of coiled springs, as indicated at 31, and are opened by rock levers, as indicated at 32, pivotally mounted in housings 33 forming a part of the cylinder heads. Push rod mechanisms 34 are associated with valve operating rock levers and extend through housings 35 into the chamber 18 where they engage rock levers 36 which are mounted on shafts 37 and arranged circularly in the chamber. A cam 38 is mounted on the rear end of the crank shaft 19 to engage the rock levers 36 and is driven from the shaft through reduction gearing 39, 40, 41 and 42, the gear 42 being formed interiorly of the cam. This reduction gearing is preferably of an 8 to 1 ratio so that the cam will be driven at ⅛ crank shaft speed and in an opposite direction relative thereto.

The engine illustrated is of the nine cylinder radial type operating on the four stroke cycle. The cam 38 is arranged to open the valves 29 through the intermediate mechanism during the air intake stroke while the valves 30 are opened during the exhaust stroke. Air is drawn into the cylinders, is compressed therein and fuel oil is injected into the compressed air charges near the end of the compression stroke of the pistons,

whereupon the fuel oil mixes with the compressed air and ignition takes place due to the heat of compression.

In order to supply the charges of fuel oil, I provide injection devices associated preferably one with each cylinder. Each device is similar and consists of the nozzle portion indicated generally at 43 and a pump device indicated generally at 44. The nozzle outlet end is indicated at 45, in Fig. 1, and, in Fig. 3, I have illustrated the details of a pump mechanism which can be employed. This pump mechanism is formed with an exterior housing 46 within which is arranged a barrel 47, the pump plunger 48 being reciprocated in the barrel. The barrel communicates with the interior of the nozzle and is connected with the fuel supply manifold 49 by means of ports 50 which extend through the barrel and through the pump casing. Within the pump casing is a coil spring 51 which engages a guide member 52 with which the pump plunger is connected and normally moves the pump plunger in a direction such that it uncovers the ports 50. When the ports are uncovered, fuel in the manifold 49, which is preferably under low pressure, will fill the barrel with oil, movement of pump plunger toward the nozzle forcing oil out of the barrel through the ports 50 until such ports are covered by the plunger, whereupon a high pressure is formed behind the oil trapped in the nozzle and a portion thereof is displaced through the nozzle end 45 into the cylinder. Regulation of the pump plunger stroke, with respect to its movement after closing the ports 50 will regulate the quantity of fuel injected into the cylinder.

Articulated push rod mechanism 53 extends through the crank case and the outer end is adjustably associated with the pump plunger guide 52 while the inner end rests upon the curved face formed on the rock lever 54 which is mounted on the shaft 37, there being one of such mechanisms associated with each pump. It will be noted that the cam 38 is provided with three parallel sets of lobes for operating the three rock levers mounted on each of the shafts 37, there being four lobes 55 for actuating the fuel rock levers and four lobes, as indicated at 56, in two sets for actuating the inlet and exhaust rock levers 36.

Adjustment of the inner part of the articulated push rods 53 along the curved faces on the rock levers 54 will regulate both the quantity in the fuel charges and the time of delivery thereof as the arcuate movement of the rock levers 54 along the curved face with which the push rods engage is different. In order to regulate the position of the push rods on the curved portion of the rock levers 54, I provide an endless control ring 57 which is held against the partition 14 by means of bolts 58 extending through arcuate slots 59. Links 60 connect the inner end of the articulated push rods with this ring 57 and the ring is given a rotational movement in either direction through means of a rack 61 fixed thereto and a pinion 62 which is fixed upon the shaft 63 extending through the crank case and controlled by an arm 64 fixed thereto. A suitable mechanism, as indicated at 65, is associated with the arm 64 so that the shaft can be rotated from a remote point. Rotation of the ring member 57 will vary both the quantity of the fuel charges and the time of their injection. As shown in Fig. 3, the fuel push rods are arranged in a position on the curved faces of the rock levers such that the arcuate movement imparted to the rock levers 54 by the cam 38 will not be sufficient to cause the pump plungers 48 to close the ports 50 and consequently no fuel charges will be delivered when the mechanism is so regulated. Movement of the push rods in an anti-clockwise direction on the curved faces, as viewed in Fig. 3, will increase the fuel charge quantities and will advance the timing thereof so that through the medium of the ring member 57 fuel control can readily be had.

A second valve mechanism is associated with each of the air inlet passages 27 in order to regulate the quantity of air entering the cylinders when the poppet valves 29 are open. Arranged preferably adjacent the inlet end of the passage at 27 is a butterfly valve 66 which is fixed to a shaft 67 extending transversely through the neck 68 formed as a part of the cylinder head. In order to control such butterfly valves, I provide rods 69 each having one end clamped to a shaft 67 and the other end splined to a hollow extension 70 which projects through a bearing 71 extending through the crank case wall. The inner end of such rod extensions 70 have a bevel gear 72 secured thereto by means of a key or tapered pin 73, such key also extending through a bearing 74 in the hollow rod extensions. A coiled spring 75 extends between each rod 69 and bearing 74 and exerts axial pressure against the associated rod so that the ends of the rods will be held against the necks 68 and reduce vibration as well as noise.

A ring member 76 is arranged in the chamber 16 and surrounds a shoulder 77 projecting laterally from the partition 13, there being bolts 78 extending through arcuate recesses 79 in the ring to hold the ring against the partition and, at the same time, allow limited rotation thereof in either direction. The ring is provided with rack members 179 which project through arcuate slots 80 in the partition 13 and mesh with the gears 72 keyed to the rod extensions 70. Rotational movement of the ring member 76 will move the racks therewith and will rotate the gears 72 and the associated rods 69 which, in turn, will rotate the butterfly valves 66 because of their connection with the shafts 67. Thus through regulating the position of the ring member 76, the position of the butterfly valves in the inlet passages 27 can be simultaneously and uniformly regulated so that the desired quantity of air will pass into the cylinders when the valves 29 are mechanically held open through the mechanism previously described.

Suitable mechanism can be provided for controlling the position of the ring member 76, however, I prefer to utilize the fuel regulating mechanism for this purpose so that a single manipulation by the operator will regulate both ring members, and also, so that the butterfly valves will be regulated in a definite relation with the fuel oil regulation. To this end, I provide the rod 81 which traverses the chamber 16 and is supported by the partitions 13 and 14. Fixed to this rod is a lever 82 having a roller carrying arm 83 engaging a slotted bracket 84 which extends from and is fixed to the ring member 76. Fixed to the rod 81 in the chamber 18 is another arm 85 which is connected by an adjustable link 86 to a bracket 87 fixed to the ring member 57. Rotational movement of the ring member 57 will transmit rotation to the shaft 81 through means of the bracket 87, the link 86 and the arm 85, and the rotation of the shaft 81 will be imparted to the ring member 76 through means of the arm 82 engaging with the bracket 84. Thus the two ring members 57 and 76 will be rotated

upon manipulation of the control extension 65 by the operator, in a manner hereinafter described.

In starting the engine, it is desirable that the fuel injection devices be regulated so that they are set to deliver a maximum fuel charge in order to form a readily ignitable charge during turning over of the crank shaft, but just as soon as the engine starts to operate under its own power the throttle is shifted back from a position adjacent the end of the rock levers 54 to a position nearer the shafts 37 so that smaller fuel charges suitable for idling of the engine will be injected. The butterfly control mechanism is preferably of such a character that the valves will be substantially closed under 300 engine R. P. M. and will be gradually moved from a closed to a wide open position between 300 and 1400 R. P. M., and beyond 1400 R. P. M., the butterfly valves will be wide open. This arrangement of opening the butterfly valves is preferable because the engine illustrated provides the power plant of an aeroplane in which 1400 R. P. M. is requisite to sustain flight, it will be understood, however, that the opening and closing of the butterfly valves with respect to the fuel injection and the R. P. M. of the engine can be arranged as desired.

The air inlet passages 27 are of Venturi form and are arranged to enter the cylinders in a tangential relation such that air drawn in during the suction strokes of the pistons will rotate within the cylinders.

When the butterfly valves are partially closed, the speed of the air flowing through the passages 27 will be swifter than when the valves are open, and thus the air rotation within the cylinder will be faster and a better mixture with fuel oil injected therein will thus be had. By reducing the air supply when the engine is idling, a better mixture will result, and stability during idling operation will be had because of increased air rotation. When the butterfly valves are closed or partially closed and the engine has been cut down to an idling speed, such as it is when an aeroplane is getting ready to land or is gliding, a vacuum is created in the cylinders during the suction stroke which must be overcome by piston work and thus the propeller, (not shown), mounted in a conventional manner at the front end of the crank shaft 19, will be rotated at a slower speed than would occur if the butterfly valves were not throttling the air inlet passages. Thus the butterfly valves can be utilized to act as a brake upon the engine and, at the same time, to improve the character of the fuel mixture such that there is less likelihood of the engine stalling during idling operation.

The bracket 84 is formed with two arms 88 and 89 between which there is formed a slot into which the extension 83 of the arm 82 extends. The base portion of the slot, formed by the adjacent surfaces of the arms, is substantially straight while the outer end portion of the slot, formed by the similarly curved inner faces 90 and 91, is arcuate. Looking at Fig. 4, which is a front view of the butterfly valve operating mechanism, the ring member 76 is at one extreme position of its adjustment and in such position the fuel adjustment ring 57 is at one extreme position of its adjustment wherein the pump push rod mechanisms are related with the rock levers 54 such that the stroke imparted by the cam 38 will not be sufficient to cause the pump plungers to close the ports 50 and consequently the engine will not operate. With the rings in such position, the arm extension 83 will lie at the base of the groove in the bracket 84. Movement of the ring 57 away from the cutoff position shown in Fig. 3 will increase the stroke of the push rods and thereby increase the stroke of the plungers so that the fuel charges are increased in quantity. Similar movement will be transmitted to the ring member 76, causing it to move in a clockwise direction, as viewed in Fig. 4, through engagement of the arm extension 83 with the inner face of the arm 90. So long as the arm extension bears against the straight portion of the inner face of the arm 90, the ring 76 will respond to the rotation of the shaft 81 and rotation of the ring 57, but when the arm extension 83 reaches the arcuate portion of the inner face of the arm 90, the ring 76 will not be moved as the arm face will be more than the radius of the arcuate movement of the arm 82. It will be thus seen that the entire adjustment of the ring 76, while increasing the fuel quantity, takes place during the time that the arm extension 83 engages the straight portion of the inner face of the arm 88. When the fuel volume is decreased through movement of the ring member 57 in a clockwise direction, as viewed in Fig. 3, the arm extension 83 will engage the inner face of the arm 89 of the bracket 84 and will move the ring member 76 in an anticlockwise direction, as viewed in Fig. 4, however, there will be no movement of the ring member 76 until the arm extension reaches the straight portion of the inner face of the arm 89. In other words, the curved inner face 91 of the arm 89 merely serves as a guide. When the control mechanism for the fuel is in the position shown in Fig. 3, the butterfly valves are adjusted to a position slightly past the transverse relation in the passages 27 so that the first portion of the movement of the ring 57 to increase the fuel slightly, will move the butterfly valves to a position transversely of the passage and such movement will be continued with a continuation of the movement of the ring 57 until the butterfly valves are wide open. The groove in the bracket 84 is of such a character that the valve will be wide open at approximately 1400 R. P. M. and will extend transversely of the passages at approximately 300 R. P. M. and thus there is a gradual opening or closing of the butterfly valves between 300 and 1400 R. P. M. which, with the engine illustrated, may be termed the idling range. The butterfly valves are of slightly less diameter than the passages in which they are arranged so that there will be a small amount of air drawn into the cylinders even when the valves extend transversely of the passage. Rotation of the ring 76 will move the racks 179 therewith and will thereby transmit rotation to the gears 72 which are keyed to the shaft extensions, and as the shaft extensions are splined to the rods 69 and as the rods 69 are fixed to the shafts 67, the butterfly valves will in this manner be rotated.

The links 86 are adjustable so that the distance between the brackets 87 and the arms 85 can be regulated. Such regulation of the links will change the relation of the connecting mechanism between the two ring members so that the movement imparted to the ring member 76 relative to the movement of the ring member 57 can thus be varied. In this way, the timing of the closing movement of the butterfly valves relative to the fuel adjustment can be regulated as desired within a limited range.

Although the invention has been described in connection with a specific embodiment, the prin-

ciples involved are susceptible of numerous other applications which will readily occur to persons skilled in the art. The invention is therefore to be limited only as indicated by the scope of the appended claims.

What I claim is:

1. In a fuel injection engine, having a crank case and radial cylinders provided with air inlet passages, means for controlling the flow of air through the passages comprising valves, rods fixed to the valves, gear means in the crank case associated to rotate the rods, a movable ring member mounted in the crank case, racks on the ring member arranged to mesh with the gear means, and ring actuating means extending exteriorly of the crank case.

2. In a fuel injection engine, having a crank case and radially extending cylinders with air inlet passages leading therein, said crank case having an arcuately slotted partition therein, means for controlling the flow of air through the passages comprising valves, rods fixed to the valves, gear means in the crank case on one side of the partition, said gear means being associated with the rods, a ring mounted in the crank case on the side of the partition opposite from the gear means, rack means associated with the gear means, said rack means projecting through the arcuate slots in the partition and being fixed to the ring member, and ring member regulating means extending exteriorly of the crank case.

3. In an engine, having a cylinder with an air intake conduit, a shaft extending into the conduit, a butterfly valve in the conduit fixed to the shaft, a rod secured to the end of the shaft exteriorly of the conduit, a hollow extension splined to the rod, resilient means in the hollow extension exerting pressure axially against the rod, and means for rotating the rod extension.

4. In an engine, having a cylinder with an air intake conduit, a shaft extending through the conduit, a butterfly valve in the conduit fixed to the shaft, a rod secured to the end of the shaft exteriorly of the conduit, a hollow extension splined to the rod, a coil spring in the hollow extension exerting pressure axially against the rod, and means for rotating the rod extension.

5. In an engine, having a crank case and radially extending cylinders with air intake conduits, mechanism for controlling the flow of air through said conduits comprising a pair of ring members, means connecting the ring members, valves in the air intake conduits, shafts fixed to the valves for rotating the same, shaft rotating mechanism including racks and gears associated with one of the ring members, and means associated to rotate the other ring member.

6. In an engine, having a crank case and radially extending cylinders with air intake conduits, mechanism for controlling the flow of air through said conduits comprising a pair of ring members, means for rotating one of the ring members, valves in the air inlet conduits, actuating mechanism intermediate the other ring member and said valves, and adjustable means for connecting said ring members, said connection being effective to operate the valve associated ring member during only a part of the range of movement of the other ring member.

7. In an engine, having a crank case and radially extending cylinders with air intake conduits, mechanism for controlling the flow of air through said conduits comprising valves in the conduits, a pair of ring members, actuating connections between one of the ring members and the valves, means associated with the other ring member for imparting rotational movement thereto, and connecting means between the ring members including an adjustable link, the adjustment of said link regulating the angular movement of said ring member for actuating the air valves with respect to the angular movement of the fuel control ring member.

8. In an engine, having a crank case and radially extending cylinders with air intake conduits, mechanism for controlling the flow of air through said conduits comprising valves in the conduits, a pair of ring members within the crank case, actuating means connecting one of the ring members with the valves, means associated with the other ring member for imparting rotational movement thereto, a rotatable cross shaft mounted in the crank case, and link means connecting the shaft with the two ring members, said link means associated with one of said ring members having a lost motion connection.

9. In an engine, having a crank case and radially extending cylinders with air intake conduits, mechanism for controlling the flow of air through said conduits comprising valves in the conduits, a pair of spaced ring members in the crank case, actuating mechanisms connecting one of the ring members with the valves, means associated with the other ring member for imparting rotational movement thereto, a rotatable shaft mounted within the crank case, and a pair of link means connecting the shaft with the ring members, one of said link means including a slotted bracket fixed to a ring member and an arm extending through the slot.

10. In an engine, having a crank case and radially extending cylinders with air intake conduits, mechanism for controlling the flow of air through said conduits comprising valves in the conduits, a pair of ring members within the crank case, valve rotating mechanism associated to be actuated by one of said ring members, means associated with the other ring member for imparting rotational movement thereto, a shaft mounted in the crank case, arms fixed to the shaft, and an adjustable link between one of the arms and a ring member, and a slotted bracket fixed to the other ring member and co-acting with an arm on the shaft, the slot in said bracket having the end portion thereof curved at a greater radius than the length of the associated arm, whereby rotation of the shaft will be imparted to the bracket carrying ring member by the arm during only a part of its actuation.

HERBERT C. EDWARDS.

CERTIFICATE OF CORRECTION.

Patent No. 1,933,620. November 7, 1933.

HERBERT C. EDWARDS.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, line 25, after "barrel" insert the words and the nozzle and the connection therebetween; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 19th day of December, A. D. 1933.

Richard Spencer

(Seal) Acting Commissioner of Patents.