Nov. 10, 1936. F. A. KING 2,060,221

INTERNAL COMBUSTION ENGINE

Filed July 14, 1932 3 Sheets-Sheet 1

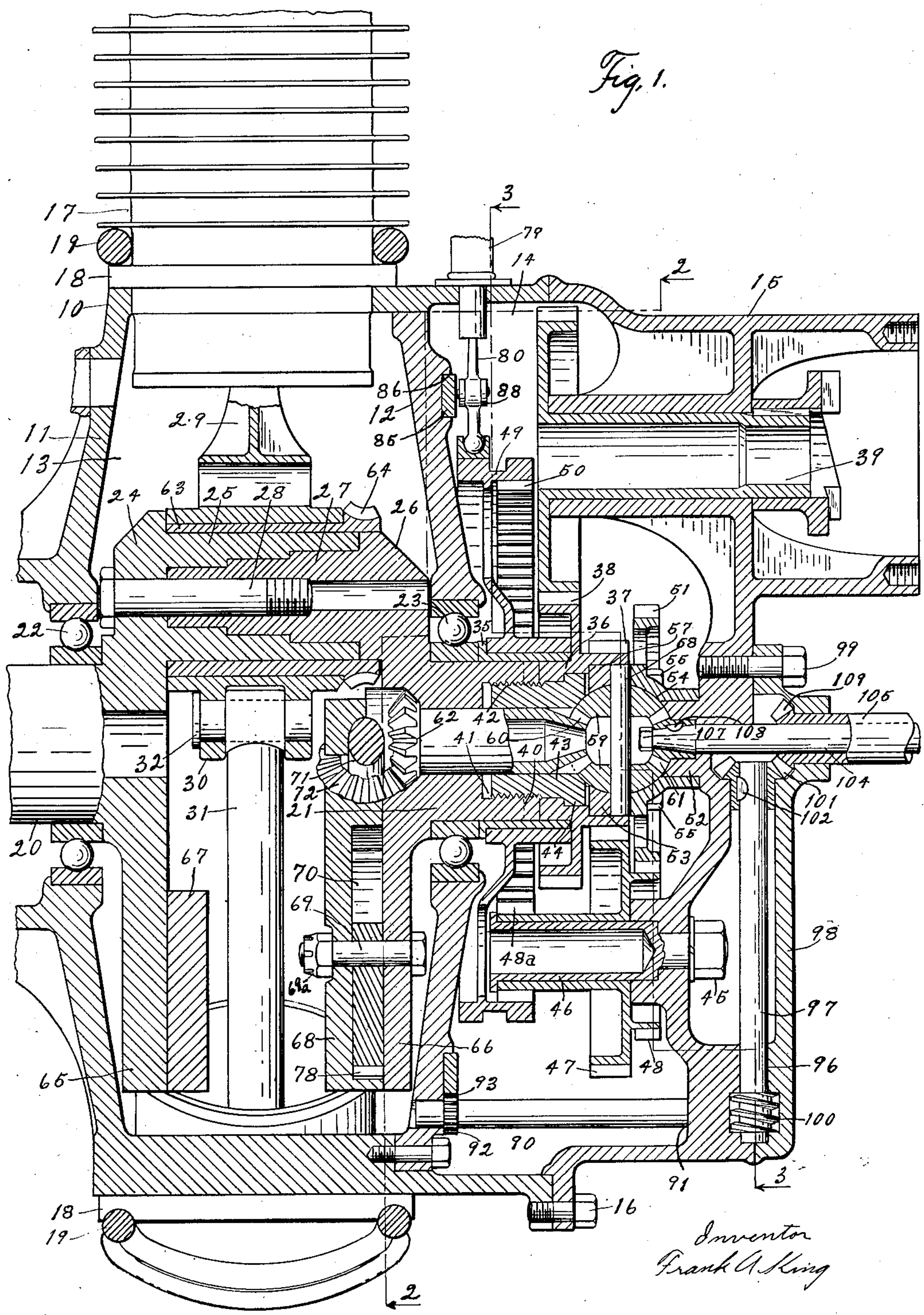

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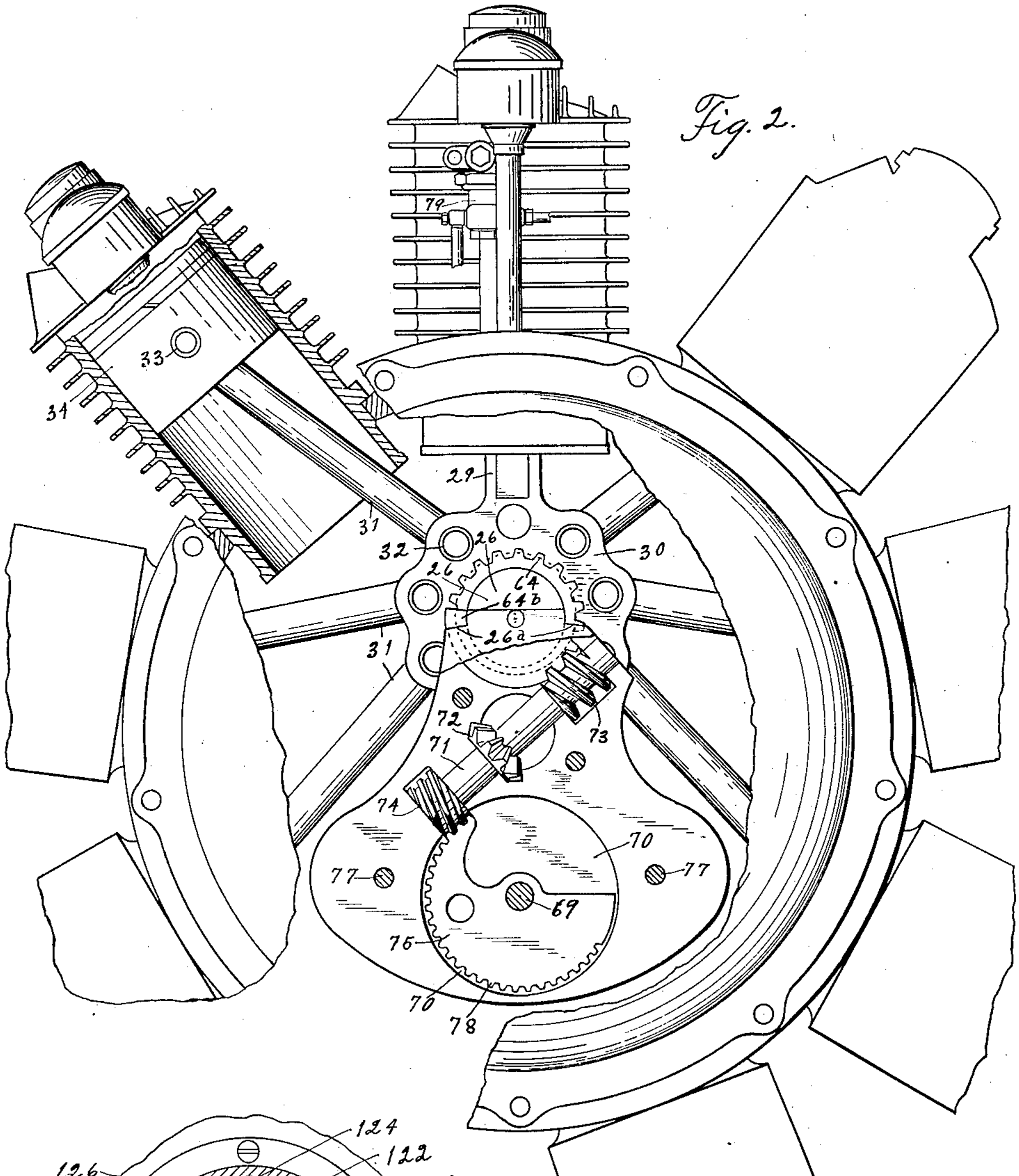
Fig. 2.



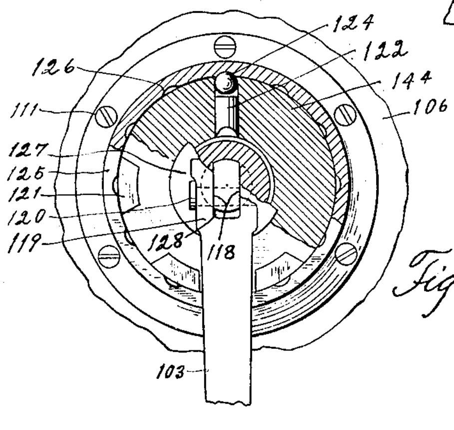


Fig. 6.

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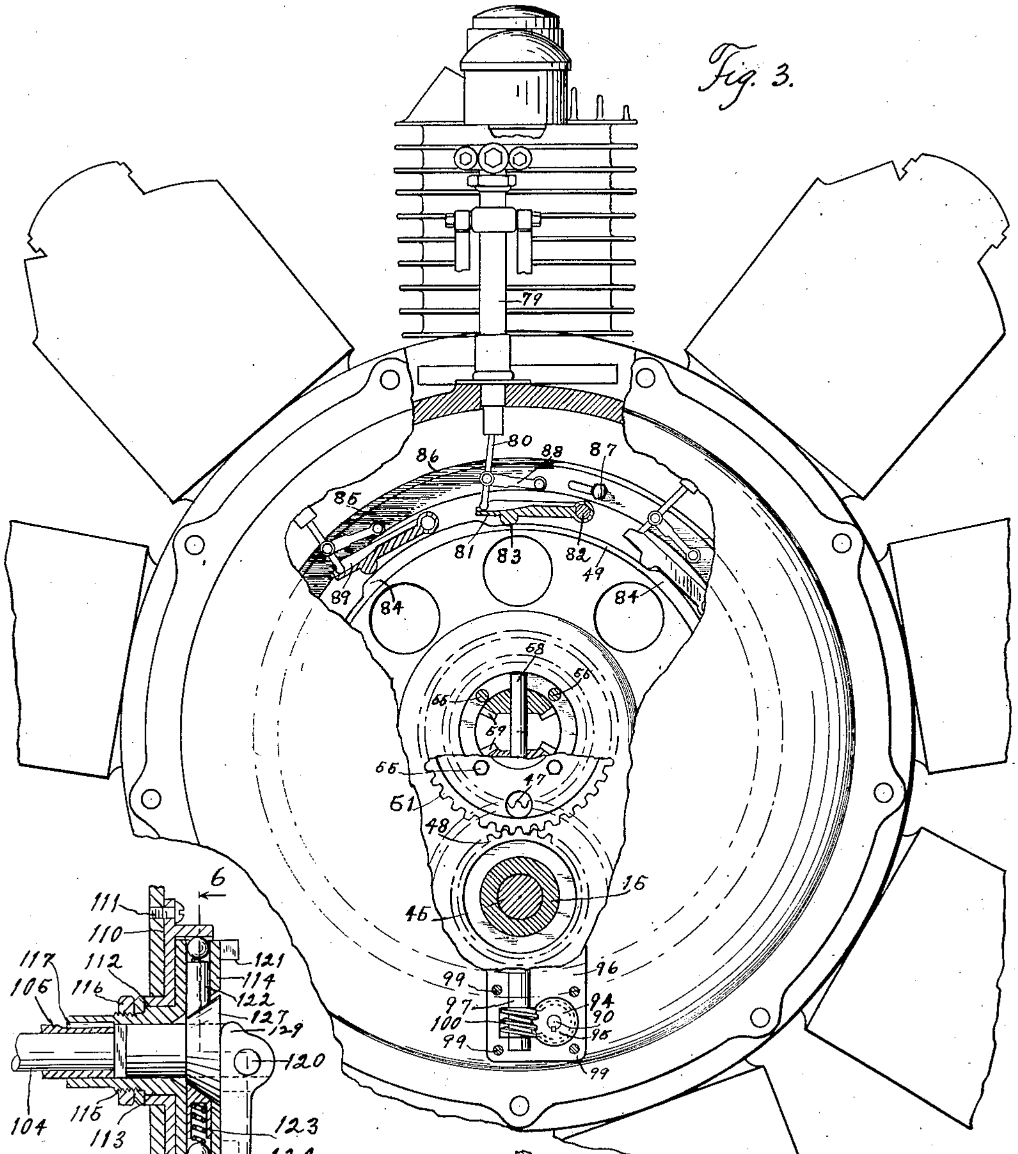
Fig. 3.



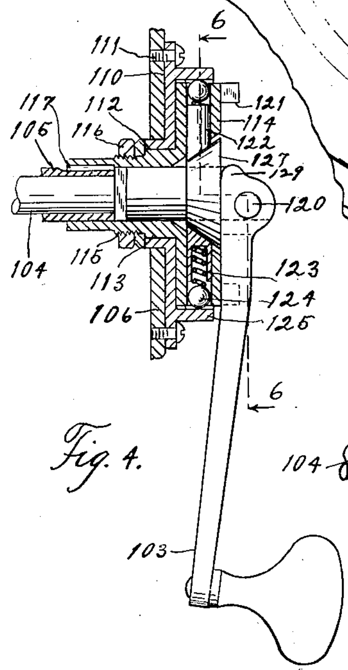


Fig. 4.

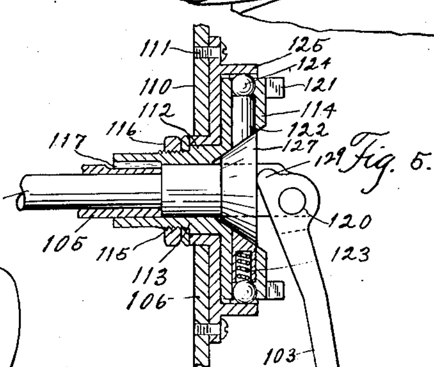


Fig. 5.

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2,060,221

INTERNAL COMBUSTION ENGINE

Frank A. King, Los Angeles, Calif.

Application July 14, 1932, Serial No. 622,487

13 Claims. (Cl. 74—600)

My invention relates broadly to internal combustion engines and more particularly to improvements in compression adjusting devices, wherein an eccentric sleeve is associated with the crank pin.

In my applications for mechanical movements filed July 21, 1931, Serial No. 552,117, now Patent No. 1,920,988, and April 5, 1932, Serial No. 603,373, now Patent No. 1,947,853, I have described and claimed certain means for shifting the radius, or adjusting the throw of a crank pin. My present invention aims to provide improved means for effecting such adjustments, as applied to an internal combustion engine.

In Diesel type engines, heretofore starting trouble has been experienced due to low atmosphere temperature, therefore this invention offers the advantage of being manually controllable to increase the compression ratio and thus raise the temperature of the fuel charge which tends to facilitate starting a cold engine and gives as well a material increase in fuel economy and a more flexible operating engine.

In conventional types of engines fuel economy is sacrificed, especially at reduced throttle opening or speed, due to the fact that compression ratios are reduced in direct proportion to the amount of fuel mixture admitted to the combustion chamber. It is an object of this invention to provide a manually controlled hand crank operated gear train provided with intermediate members connected with a normally rotating gear, and an eccentric crank pin sleeve which normally rotates as a unit with a crank shaft. The hand crank being also provided with selective intermediate members connected with the fuel charge mechanism in such manner as to adjust the compression ratio inversely to the fuel charge admitted to the combustion or compression chamber, so that when operating with a closed throttle, or at reduced speeds, the engine will operate with a high compression ratio, or with the same mean compression ratio as when operating with open throttle or at high speeds, or the compression may be manually adjusted with respect to the fuel charge, while the engine is in operation.

In radial engines of the type referred to, it is, of course, necessary to balance the revolving component weight carried by the crank pin, by an equal weight placed diametrically opposite to the pin. It is therefore obvious that shifting of the crank pin from its normal radius, or on its normal radius will give rise to unbalanced inertia forces.

It is therefore an important object of this invention to provide a novel construction of a shiftable neutralizing or compensating counterweight associated with the usual integral weight on the shaft. Such weight is located diametrically opposite to the crank pin, and is provided with intermediary members connected with the eccentric sleeve, and is adapted to simultaneously counter move with respect to the sleeve and thereby compensate for all changes in harmonic balance, which would otherwise be caused by the shifting of the sleeve and the inertia forces carried thereby.

It is another object of this invention to provide a worm gear self-locking means in connection with the eccentric sleeve and the neutralizing weight whereby the sleeve will be locked against rotation with respect to the crank pin except while adjustments are being made.

These and other objects of my invention which will appear from the following description of certain preferred embodiments are attained by means of the construction illustrated in the accompanying drawings to which reference will now be made and in which:

Fig. 1 is a vertical section through one end of an internal combustion engine constructed in accordance with my invention;

Fig. 2 is a rear elevation of the engine, but on a reduced scale, and shows the rear case broken away and the crank shaft and counterbalance mechanism in cross section on lines **2—2**, of Fig. 1;

Fig. 3 is a view similar to that of Fig. 2, taken on lines **3—3**, of Fig. 1;

Fig. 4 is a longitudinal cross sectional view of the controlling crank adjusting means as applied to its respective controls;

Fig. 5 is a view similar to that shown in Fig. 4, and shows the controller crank in a different position; and

Fig. 6 is a rear elevation showing parts in cross section taken on lines **6—6**, of Fig. 4.

Referring now to the drawings by characters of reference, numeral **10** designates the crank case of an internal combustion engine, which is preferably in the form of a multi-cylinder radial Diesel type engine, but, as above stated, it is to be understood that this invention is equally applicable to the conventional radial type of engine.

The annular barrel-like crank case **10** is provided with special partitions **11** and **12**, between which is formed compartments **13**. On one side of compartments **13** is another compartment **14** which is formed in part by the crank case cover

15 which is secured to the crank case by screws 16, and is for the reception of mechanism for operating the cylinder valves and for other accessory mechanism.

Cylinders 17 extend radially from the crank case and are formed with shoulders 18 which bear against the crank case and are secured thereto by a pair of annular compression bands 19 or other suitable means.

The crank shaft is hollow and of the single throw type and consists of two sections 20 and 21 which are supported by the usual type bearings 22 and 23. The forward section 20 has an arm 24 and a crank pin 25 formed integral therewith, the other section of the shaft includes the arm 26 and is provided with shoulders 26*a* and a forwardly projecting portion 27 which telescopes into the pin 25 and is carried completely through it, the two sections being secured together by a bolt 28.

The usual type of master rod 29 is provided with a hub 30 which is mounted upon the crank pin and a plurality of connecting rods 31 are pivotally secured in a circular relation around the hub 30, by the pins 32. The connecting rods and the master rod extend into the pistons and are secured thereto by the pins 33, and impart to the pistons 34 a reciprocating motion. It will be understood that arm 26 must be detached from the crank pin in order to assemble the master rod on the pin, such mechanism being well known to those skilled in the art.

A sleeve 35 is placed partly over the shaft which abuts against the bearing 23. The sleeve projects past the shaft thus forming a collar wherein is placed the hub 36 of a drive gear 37, such drive gear being provided with an integral gear 38, and a starting mechanism 39 is operatively connected thereto.

The hub of the drive gear 37 abuts against the end of the shaft and the two ends are notched or serrated as indicated by dotted lines 40, and are adapted to cooperate to operatively connect the same in direct driving relation. The end of the shaft is provided with a longitudinal bore 41 that is internally threaded as at 42, and an externally threaded hollow plug 43 is placed through the hub 36 and screwed into the internally threaded end of the shaft, and carries a flange 44 that engages a corresponding internal shoulder in the hub 36.

A nut 45 secures a stub shaft 46 to the casing and upon it is journalled a compound gear 47 and 48 which has formed integral therewith gear 48*a*. This latter gear drives a cam drum 49 by means of an internal gear 50 and operates the cylinder valves not shown. The cam drum is journaled upon the sleeve 35 and is secured thereon by the web of gear 38, and in this instance is driven by the train of gears 37, 47, 48*a* and internal gear 50, at one-eighth crank shaft speed, and in the opposite direction to the crank shaft rotation.

With a crank shaft and engine of this character I propose to associate compression ratio adjusting mechanism whereby the compression may be manually adjusted at the will of the operator while the engine is running. To this end I provide gear 51 which is mounted upon the boss 52 of the casing, and carries with it a split section 53. Gear 51 and section 53 have a centrally located opening 54 whose surface is spherically curved and the two parts are secured together by screws or studs 55, thus the section forms a hub on gear 51 which enters the bore 57 of gear 38, and is also supported thereby.

In order to make adjustable connections with a normally rotating assembly or gear, I provide the compound gear 48 which is in mesh with gear 51 and in this instance the speed of gear 51 is half that of the crank shaft, and the two turn in the same direction. A pinion shaft 58 is carried between the gear 51 and its respective section 53, and this shaft carries preferably two bevel differential or planet gears 59, which are located in the curved opening of the gear 51 and its section 53. Shaft 58 is carried in a radial plane transverse to the axis of gear 51. Pinions 59 are in mesh with the operable gears 60 and 61, the latter remains stationary except when adjustments are being made, while the former normally rotates as a unit within the hollow portion of the crank shaft, and the plug 43.

The gear 60 is formed integral with a hollow shaft and this is provided at its opposite end with another bevel gear 62, which may also be formed integral therewith, thus forming a dual gear. The hollow shaft is carried loosely within the hollow portion of the plug 43 and the shaft 21.

In compression ratio changing devices of this character it is necessary to increase or decrease the relative piston stroke to change the clearance volume, and that is accomplished by placing an eccentric sleeve 63 on the crank pin. This sleeve is mounted on the crank pin, and within the hub of the master rod between arms 24 and 26 when the shaft is in assembled relation.

I provide this sleeve with a section of worm gear teeth 64 and a lug 64*b*, which are preferably formed integral therewith.

Numerals 65 and 66 designate counterweights, each of which are provided with sections 67 and 68, such sections being secured to their respective weights by bolt 69, nut 69*a* and rivets 77. These weights are formed integral with the crank shaft members, and the component weight thereof including the sections is of a normal weight value equal to the centrifugal force produced by the weight of the crank pin and its respective parts and members carried thereby, while in rotation. It is therefore obvious that any changes in the crank pin throw relative to the shaft will cause a discrepancy in the correct harmonic balance of the engine. To overcome such discrepancy, I provide the novel construction of a counterweight which is in a machined recess 70 that is adapted to receive a rotatable shaft 71, which is rotatably mounted between the weight 66 and its section 68. Shaft 71 is provided with a bevel gear 72 which is in mesh with gear 62, and a worm gear 73 which is in mesh with worm gear teeth 64 on the eccentric sleeve. Shaft 71 is also provided with another worm gear 74. The worm gears are preferably formed integral but may be secured to the shaft by any suitable means.

I provide a shiftable neutralizing or auxiliary counterweight 75 which is in the form of a semicircular gear, and is revolvably mounted on a bolt 69 being located in the recess 70 of section 68, and is secured therebetween by nut 69*a*, or other suitable means. The teeth 78 on the neutralizing weight are in mesh with worm gear 74, the pitch of this worm is equal to worm 73 and therefore the neutralizing weight is adapted to move a corresponding angle and in a counter direction with respect to the sleeve, the shoulders 26*a* and lug 64*b* serve as a stop for the sleeve. The counterweight is so shaped and proportioned that it will neutralize or compensate for all discrepancy in balance produced by inertia forces while adjustments are being made. It is obvious, however, that this mechanism may be extended to the opposite counterweight by the provision of similar intermediary gear means, but as this is merely duplication or carrying forward of the same idea, it has not been shown.

For convenience of illustration in this instance the fuel injection device or fuel charge mechanism 79 consists of the conventional type, which is associated with each of the cylinders and is actuated by a rod 80, which is connected with the rocker lever 81, the rocker lever being pivotally mounted upon pins 82 secured to the casing. The inner side of each of the rocker levers is provided with an abutment 83, which engages the cam drum 49. As the lobe 84 of the cam drum raises the rocker lever, the rod 80 will be moved in a direction to cause an injection of fuel into the cylinders.

In order to vary the stroke of the rod 80 which varies the fuel charge the rods are arranged to be adjusted angularly in their relation with the rocker levers so that the length of a movement of such rods can be varied.

An adjustable ring 85 is shiftably mounted within the flange 86 on the partition wall and is secured thereto by screws 87 which are screwed into the wall. A link 88 is pivotally attached to each of the rods and to the ring member, so that upon rotation of the ring member, link 88 will move the rods 80 longitudinally of the rock levers in their engaging relation with the curved faces 89. Curved faces 89 are formed so that shifting of the rods relative thereto will cause a change in both the timing and the stroke of the rods which are adapted to regulate the fuel charge through the injection device.

For the purpose of moving the ring 85 in a direction to increase or decrease the fuel charge, I provide a shaft 90 located in compartment 14 parallel to the axis of the engine, and one end of which is journaled in the partition wall 12 adjacent to the ring, while the opposite end is journaled in the case as at 91. The end adjacent to the ring is provided with an integral spur gear 92, which is in mesh with a section of spur gear teeth 93 on the ring 85. The other end of shaft 90 is provided with a worm gear 94 which is secured thereto by a key 95.

The outer side of the casing is machined as at 96 to receive shaft 97, which is located at right angles to shaft 90, and is rotatably secured thereto by a bearing cap 98 and screws 99. Shaft 97 is provided with an integral worm 100 that is in mesh with worm gear 94, the opposite end of shaft 97 being provided with a bevel gear 101, which is secured to it by key 102.

In order to uniformly and simultaneously adjust the compression ratio changing mechanism inversely to the fuel charge device or either one with respect to the other, I provide the novel adjusting means comprising a hand controlled crank 103, more clearly shown in Figs. 4, 5 and 6.

Numeral 104 designates a compression ratio controller shaft, while 105 is a fuel charge or throttle regulating shaft, which in this instance is tubular and the controller shaft is carried therein. Both shafts extend to the instrument board 106 of an airplane, or other suitable support.

The forward end of the controller shaft is tapered and threaded to receive a nut 107 which secures the bevel gear 61 thereon by key 108. The tubular shaft is provided with an integral gear 109 which is in mesh with gear 101.

I provide a flanged supporting member 110 which is attached to support 106, by screws 111, and it is bored as at 112 to receive the hollow shank portion 113 of a similar shaped adjusting element 114, the shank extends through the bore and it is threaded as at 115 to receive a nut 116 which retains the element in place for rotation by the crank. The shank extends over the tubular shaft and is keyed thereto by key 117.

The end of the controller shaft is provided with a lug having parallel surfaces 118, and which is adapted to receive the bifurcated end 119 of the controller crank, which is pivotally secured thereon by pin 120. The element 114 is provided with a series of arcuate lugs 121 on its outer surface and a diametrical bore transverse to its axis, wherein are placed pins 122. The inner ends of pins 122 are beveled, while the outer ends are bored to receive springs 123, which are compressed by balls 124.

The member 110 is provided with an annular rim 125, the internal periphery of this rim being provided with a plurality of grooves or notches, 126, across which the balls are adapted to travel in their circular path. I provide a cone 127 which is provided with an elongated aperture 128 therethrough which corresponds to the parallel surfaces 118 on the controller shaft, and it is placed thereon and is adapted to be actuated by the shifting of the controller crank as shown in Figs. 4 and 5. A slight clearance is left between the pins 122 and the balls, to allow the balls to be moved from their respective grooves, while adjustments of element 114 are being made. Grooves 126 serve as a frictional detent means to retain the crank in position when adjustments are not being made. The crank is in engagement with the arcuate lugs 121 as shown in Fig. 4. Thus it is obvious that the controller shaft, and the tubular or fuel charge shaft may be adjusted together as a unit.

The crank is provided with a lip portion 129 on the bifurcated end thereof which is adapted to move the cone forwardly when the crank is tilted rearwardly about pin 120 as shown in Fig. 5. Thus the cone will force the pins outwardly against the balls and retain the balls in their respective grooves, and thereby restrain element 114 from being moved while the crank is employed to turn shaft 104, to the desired position for adjusting the fuel charge mechanism.

The operation of my invention is as follows: Gear 47 is integral with gear 48 and is therefore driven by the crank shaft. The function of gear 51 which is in mesh with gear 48 is to maintain the pinion shaft 58, in the desired position as a result thereof the pinion shaft rotates as a unit with gear 51 at half crank shaft speed in the direction shown in the drawings. It is to be understood that changes may be made in the ratios shown without departing from the spirit and scope of the invention.

The bevel gears 59 rotate idly on the pinion shaft between the bevel gears 60 and 61, until an adjustment is to be made. When an adjustment of the eccentric sleeve 63 is to be made, the controller crank is moved, as before stated, the motion is transmitted through the controller shaft to the train of gears described, as follows: gear 61, gears 59, gear 60, integral gear 62, gear 72, worm gear 73 and the section of gear teeth 64 on the sleeve, whereby the worm gear will produce adjustment of the eccentric sleeve.

When adjustments are not being made, the gears 59 are being rotated idly between a relatively stationary gear 61 and gear 60, which, though loose within the shaft, is rotating at the same speed as the shaft. Due to the pitch of the threads of the worm gear 73, and the teeth 64 of the sleeve the latter is positively held against accidental movement.

As stated, the compression ratio adjusting mechanism may be adjusted simultaneously with the fuel charge mechanism, or the former may be adjusted with respect to the latter, the gear ratios and direction of rotation being adapted to normally adjust one control inversely to the other, and includes the tubular shaft 105, gear 101, shaft 96, worm gear 100, shaft 90, integral gear 92 and the section of gear teeth 93 on the ring 86 in the Diesel type engine. If my invention is applied to the conventional type engine, it is only necessary to connect some intermediary member of the fuel control mechanism to the carburetor thereof (which is not shown).

Although but one form of the invention has been illustrated, and but a single application thereof has been described in detail, it will be apparent to those skilled in the art to which the invention pertains, that various modifications and changes may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

Having described the invention what is claimed as new is:

1. In a variable crank throw explosion engine, a crank, a crank pin associated with said crank, an eccentric sleeve mounted for adjustment on the crank pin circumferentially thereof, an adjustable counterweight carried by said crank, and means carried by the crank including a worm for collectively adjusting said sleeve and counterweight relative to each other.

2. In a variable crank throw explosion engine, a crank, a crank pin associated with said crank, an eccentric sleeve turnable circumferentially on the crank pin, an adjustable counterweight carried by said crank, and means for rotating said sleeve and coincidently adjusting said counterweight relative to said sleeve and adapted to normally retain said sleeve and counterweight in their adjusted positions.

3. In a variable crank throw explosion engine, a crank, a crank pin associated with said crank, an eccentric sleeve mounted for turnable movement circumferentially of said crank pin, a counterweight carried by said crank and pivoted diametrically opposite said crank pin, a rotatable shaft carried by said crank, gear connections between said rotatable shaft and said sleeve and counterweight for effecting rotation thereof on turning said shaft, and means for manually revolving said shaft.

4. In a variable crank throw explosion engine, a crank, a crank pin associated with said crank, an eccentric sleeve turnable circumferentially on the crank pin, worm teeth on said sleeve, a turnable counterweight carried by said crank, worm teeth on said counterweight, a rotatable shaft carried by said crank, worms on said shaft engaging the teeth on said sleeve and said counterweight, and means for manually rotating said shaft.

5. In a variable crank throw explosion engine, a crank, a crank pin associated with said crank, an eccentric sleeve mounted on said pin for turnable movement circumferentially thereof; worm teeth on said sleeve, a worm revolubly carried on said crank shaft meshing with said teeth, and means extending through said crank shaft for rotating said worm to adjust said sleeve; said worm serving to lock said sleeve in its various adjusted positions relative to the crank pin.

6. In a variable crank throw explosion engine, a hollow shaft having a crank, an eccentric associated with said crank, means on the crank to support said eccentric for relative adjustment, worm gear teeth on said eccentric, a worm carried by said crank meshing with the teeth on said eccentric, a controller shaft coaxial with the hollow shaft, and a differential gear train extending through said hollow shaft intermediate the worm and controller shaft having cooperative gear engagement with the worm and hollow shaft.

7. In a variable crank throw explosion engine, a crank, a crank pin associated with said crank, an eccentric sleeve adjustably mounted on the crank pin, worm gear teeth on said sleeve, a revoluble shaft carried by said crank, a worm carried by said shaft meshing with the teeth on said sleeve, a controller shaft, a differential gear train intermediate the revoluble shaft and the controller shaft, said gear train including a gear shaft, a gear on said shaft engaging said worm carrying shaft, and means for rotating the gear shaft, the controller shaft adapted to rotatably adjust the sleeve with respect to the crank through said gear train.

8. In a variable crank throw explosion engine, a crank, a crank pin associated with said crank, an eccentric mounted for rotatable adjustment on the crank pin, worm gear teeth on the eccentric, a shaft carried by the crank, a worm on the shaft engaged with the teeth on said eccentric, a gear on the shaft and a dual gear in mesh therewith, a controller shaft, a differential gear mechanism drivably connected intermediate said dual gear and controller shaft and adapted to adjust the eccentric relative to said pin.

9. In a variable crank throw explosion engine, a crank, a crank pin associated with said crank, an eccentric mounted for rotatable adjustment on the crank pin, worm gear teeth on the eccentric, means for controlling the limit of the eccentric adjustment, a shaft carried by the crank and a worm integral therewith in mesh with the teeth on said eccentric, a gear on the shaft and a dual gear in mesh therewith, a controller shaft, a differential gear mechanism drivably connected intermediate said dual gear and the controller shaft, and adapted to adjust the eccentric with respect to said limit.

10. In a variable crank throw explosion engine, a hollow crank shaft, a crank on said crank shaft, a crank pin associated with said crank, a geared eccentric sleeve mounted for adjustment on the crank pin of said crank shaft, gearing located in the hollow shaft, a worm gear in engagement with the geared sleeve and with said gearing a gear carrier adjacent the end of the shaft and provided with a stub shaft, the latter interposed across the shaft axis, gears adjacent the shaft and the carrier and adapted to rotate said carrier, a normally stationary bevel gear mounted with the carrier, and a gear rotatably mounted on the stub shaft meshing with the normally stationary gear and connected with said gearing.

11. In a variable crank throw explosion engine, a hollow crank shaft, a crank on said crank shaft, a crank pin associated with said crank, an eccentric sleeve rotatably mounted upon the crank pin and gear teeth integral therewith, a bevel gear, a worm connected to said bevel gear and in mesh with said gear teeth, a dual bevel gear loosely mounted in the hollow of the shaft meshing with said first mentioned bevel gear, a gear carrier

adjacent the end of the shaft, bevel gears in said carrier, a train of gears associated with the shaft and the carrier and adapted to rotate the latter a normally stationary gear coaxial with the shaft and of a diameter less than the shaft; the bevel gears in said carrier being operatively connected to the loosely mounted dual gear and the normally stationary gear.

12. In a variable crank throw explosion engine, a hollow crank shaft, a crank on said crank shaft, a crank pin associated with said crank, an eccentric sleeve rotatably mounted on the crank pin, a gear carrier adjacent the end of the shaft, a stub shaft in said carrier, the latter being interposed across the shaft axis, a gear connected to the shaft and adapted to rotate the carrier, a normally stationary gear coaxial with the shaft and of a diameter less than the shaft, a planet gear rotatably carried by the stub shaft and in mesh with the normally stationary gear, driving connections between said planet gear and said eccentric sleeve for turning the latter on said pin, and controlling means connected to the normally stationary gear.

13. In a variable crank throw explosion engine, a crank shaft, a crank pin associated with said crank shaft, an eccentric sleeve rotatably carried by said crank pin, differential gear mechanism arranged internally of the crank shaft, driving connections between said differential gear mechanism and said eccentric sleeve for turning the latter on said pin and means for actuating said differential gear mechanism.

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