**Feb. 18, 1936.** **G. A. WAHLMARK** **2,031,346**

FUEL INJECTION PUMP

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Fig. 2.

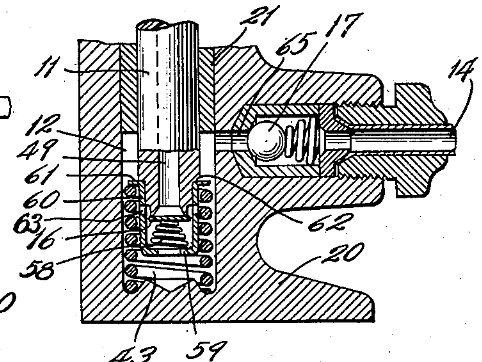

Fig. 1.

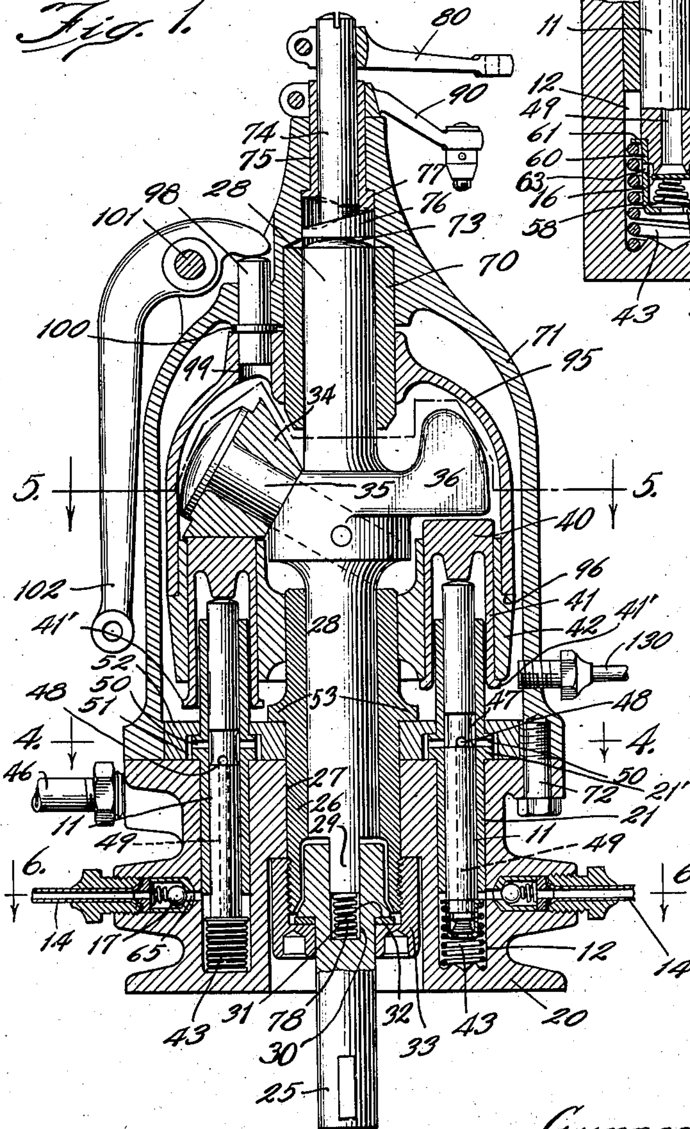

Fig. 3.

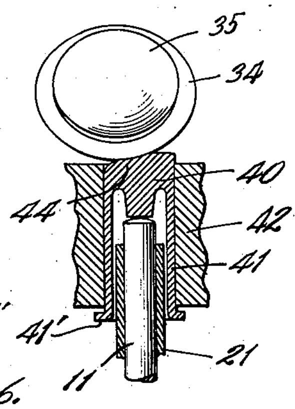

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Fig. 4.

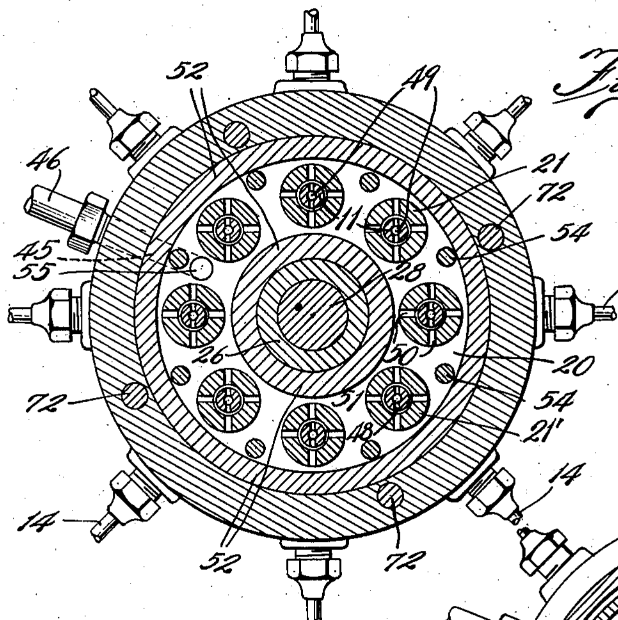



Fig. 5.

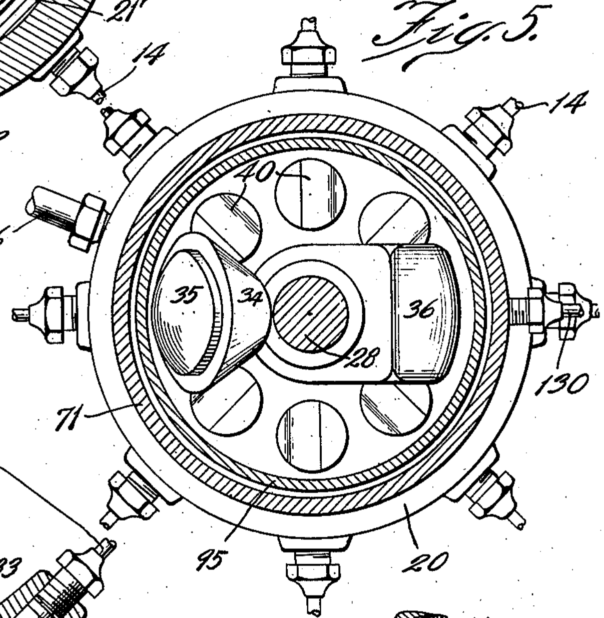



Fig. 6.

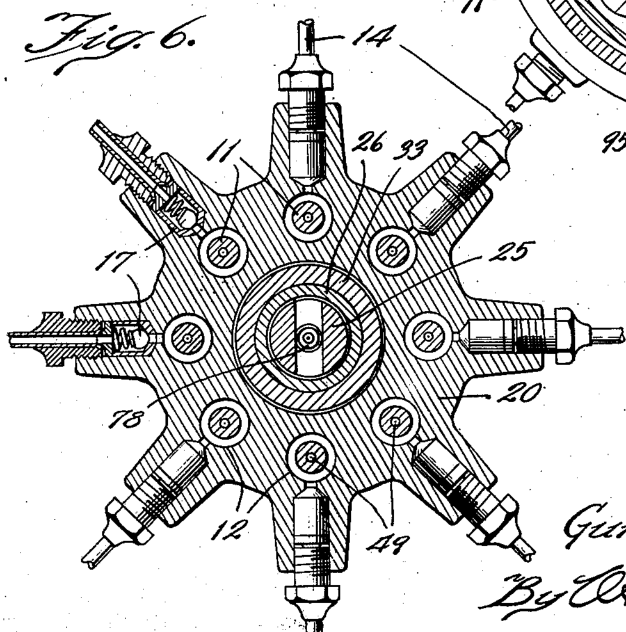
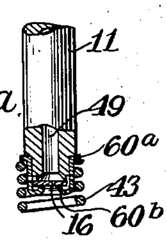



Fig. 2a

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# UNITED STATES PATENT OFFICE

2,031,346

## FUEL INJECTION PUMP

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Application October 17, 1932, Serial No. 638,070

6 Claims. (Cl. 103—38)

More particularly the invention relates to a pump for injecting fuel into the cylinders of an internal combustion engine under pressure, and for controlling the speed and power output of the engine by varying the amount of fuel injected.

By injecting fuel directly into the cylinder of an internal combustion engine, under high pressure, a greatly superior performance is obtained over that which is had when using a carburetor. Maximum power is substantially increased at all speeds. This increase is due partly to the elimination of the pressure drop through the carburetor and partly to the direct effects of the spray itself. Since the supply of fuel to the engine cylinders is under the direct control of the operator (and is not dependent upon the suction of the engine as when using a carburetor) the acceleration and also the operation of the engine under load is greatly improved. Furthermore the idling and starting characteristics of the engine are greatly improved inasmuch as slower idling is possible, and an instantaneous starting at low atmospheric temperature can be readily obtained.

By injecting fuel in measured quantities to the cylinders and accurately metering the quantity of fuel supplied to each cylinder, an even distribution of fuel is obtained together with the resultant economy and improved performance.

It is a general object of the invention to provide a new and improved fuel injection pump for internal combustion engines.

Another object is to provide, for internal combustion engines of the type used in automobiles, a multiple cylinder pump of new and improved construction for metering, timing and injecting quantities of fuel into the cylinders in properly timed relation with the movements of the pistons and the operation of the ignition system, thereby attaining such improved performance.

Another object is to provide an improved fuel injection pump comprising a plurality of vertically disposed cylinders arranged in a circle, a member driven from the engine for reciprocating pistons in said cylinders in properly timed relation, and means operable by the accelerator of an automobile for varying the stroke of the pistons to vary the quantity of fuel injected into the cylinders.

Another object is to provide such a pump embodying means for depressing all of the pistons simultaneously for the purpose of priming the cylinders preparatory to starting and for pumping vapor out of the system.

Another object is to provide such a pump with accelerator operated means for varying the stroke of the pump pistons together with manually operated means for increasing and decreasing the stroke of the pistons beyond the normal stroke obtained by actuating the accelerator of the car.

Other objects and advantages will become readily apparent from the following detailed description taken in connection with the accompanying drawings, in which:

Fig. 1 is a vertical central section through a preferred form of pump.

Fig. 2 is an enlarged fragmentary section through a pump cylinder.

Fig. $2^a$ is a similar view showing a modified form of valve.

Fig. 3 is an enlarged fragmentary section through the upper end of a piston, showing the piston actuator in operative relation to the piston.

Fig. 4 is a horizontal section approximately along the line 4—4 of Fig. 1.

Fig. 5 is a horizontal section approximately along the line 5—5 of Fig. 1.

Fig. 6 is a horizontal section approximately along the line 6—6 of Fig. 1.

While there is illustrated in the drawings and shall herein be described in detail a preferred embodiment of the invention, it is to be understood that I do not thereby intend to limit the invention to the specific form and arrangement shown, but aim to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

Referring more particularly to the drawings, the fuel pump comprises a plurality of pistons **11** and cylinders **12**, eight in number, arranged in a circle, each pump cylinder being adapted to be connected to an engine cylinder by a suitable conduit **14**. The pistons are arranged to be reciprocated in properly timed relation to the engine crank shaft and the stroke of the pistons is arranged to be varied to vary the quantity of fuel injected thereby to vary the speed of the engine. Preferably, the fuel is injected into the engine cylinder through a check valve type of nozzle device. Furthermore, as illustrated most clearly in Fig. 2, a check valve **16** is provided on the lower end of each pump piston so as to admit fuel into the pump cylinders and prevent return flow of the fuel, and ball check valves **17** are inserted in the conduits leading to the injection nozzles so as to provide a relatively small compression chamber in the pump cylinders.

Referring in more detail to the drawings, the pump is illustrated as comprising a base **20** having a plurality of vertically extending bores arranged in a circle so as to provide eight vertically extending cylinders 12 having their lower ends closed. The pistons 11 are positioned in the cylinders and are preferably mounted in sleeve liners 21 which fit into the bores and have their upper ends projecting upwardly from the base.

The pump pistons 11 are arranged to be reciprocated in timed relation to the movements of the engine pistons and as illustrated herein, are arranged to be driven from the crank shaft of the engine by means including a stub shaft 25 rotatably mounted on a vertical axis in the lower portion of the base 20. A sleeve 26 extends through a central bore in the base 27 and has an actuator shaft 28 rotatably mounted therein. The lower end of this actuator shaft is cut away at 29 and is arranged to fit into a slot 30 in the upper end of the stub shaft 25 so as to be driven thereby. The short shaft has a shoulder 31 engaging a bearing disk 32 which is secured to the sleeve 26 by means of a collar 33. The actuator shaft 28 carries a tapered roller 34 rotatably mounted on an inclined radially extending pin 35 so as to be freely rotatable thereon, and is preferably balanced by means of a weight 36. During rotation of the shaft 28 the roller 34 is arranged to actuate the pistons 11.

Preferably the pistons have cap members or portions 40 on the upper ends thereof slidable in bores 41 in a spider 42 which is slidable vertically on the upper end of the sleeve 26. Thus during the rotation of the shaft 28 the pistons are depressed one by one by means of the roller 34. The pistons are returned to their raised positions by means of coiled springs 43 positioned between the pistons and the closed ends of the cylinders 12. The members 40 have annular flanges 41′ at their lower ends arranged to engage the spider 42 to limit the upward movements of the pistons. As illustrated herein, the upper ends of the members 40 (Fig. 3) are grooved at 44 to conform to the curvature of the rollers 34 so as to place the pressure on the center of the pistons and eliminate side thrust. As will be apparent from Fig. 3, the arcuate portion formed on the cap 40 by the groove 44 is on the advance side of a vertical plane extending through the axis of the roller and the left-hand edge of the groove.

Fuel in liquid form is supplied to a port 45 (Fig. 4) in the base 20 by means of a conduit 46 (Figs. 1 and 4), and means is provided to carry fluid from this conduit to the lower ends of the pistons so as to supply fluid to the cylinders when they are raised. In the preferred form of the invention the pistons are provided with annular grooves 47 and have transverse ducts 48 therein communicating with the upper ends of vertical ducts 49 which extend downwardly to the lower ends of the pistons, as shown most clearly in Fig. 2. The lining sleeves 21 are also provided with transverse ducts 50 which communicate with an annular chamber 51 formed between an annularly grooved ring 52 and the top of the base 20. This ring is secured to the base by means including a collar 53 on the sleeve 26 and a plurality of screws 54 (Fig. 4). Fuel is supplied to the chamber 51 from the conduit 46 by means of the horizontal port 45 and a vertical port 55.

As illustrated in the drawings the lining sleeves are provided with annular flanges 21′ which are clamped intermediate the ring 52 and the top of the base so as to seal the lining to the base.

As mentioned hereinbefore, check valves 16 are preferably provided on the lower ends of the pistons 11. The devices are in the form of thin disks or plates without stems, and are arranged to engage the ends of the pistons to close the lower ends of the ducts 49 and are normally held in engagement with the pistons by means of coiled springs 58 (Fig. 2) positioned between the valve and the partly closed end 59 of a tubular bushing 60. As illustrated most clearly in Fig. 2, the springs 43 engage annular flanges 61 on the bushings 60 and maintain them in contact with a shoulder 62 formed on the pistons 11. Thus during upward movement of the pistons the valves 16 are unseated to admit fluid to the cylinder due to the suction created by the receding piston, this fluid passing through apertures 63 in the bushings 60 to fill the cylinder. As pointed out hereinbefore, the ball check valves 17 are preferably provided in outlet ports 65 from the cylinder so as to prevent fluid in the conduits 14 from being drawn back into the cylinders. It will be readily apparent that, with the construction disclosed, any fuel leaking back along the pistons is returned to the annular supply groove 47 or the chamber 51, which are under low pressure, so that there is no opportunity for the fuel to get into the driving mechanism within the casing 71. In the form illustrated in Fig. 2[a] the spring 58 is omitted, the bushing 60[a] being curved upwardly at 60[b] to support the disk valve 16 in its open position. Preferably the valve has a movement approximately equal to its thickness.

In order to vary the quantity of fluid discharged by each piston 11, means is preferably provided for adjusting the shaft 28 axially. In the form illustrated in the drawings (Fig. 1) the upper end of this shaft is rotatably mounted in a bushing 70 supported in a casing or cover 71 which surrounds and encloses the mechanism of the pump above the base 20. This cover is detachably secured to the base by means of screws 72. The upper end of the shaft 28 is rounded at 73, and is engaged by the lower end of a control shaft 74 which is rotatably mounted in a bushing 75, which bushing in turn is rotatably mounted in the upper end of the casing 71. The control shaft 74 has a cam formation or portion of a screw thread 76 formed on the lower end thereof, which cam is arranged to engage a corresponding cam formation 77 on the lower end of the bushing 75 so that when the control shaft 74 is rotated it is moved axially in the bushing 75 so as to move the drive shaft 28 axially. Preferably a coiled spring 78 is positioned between the lower end of the drive shaft and the stub shaft 25 so as to maintain the drive shaft in contact with the end of the control shaft. As illustrated in Fig. 1, the control shaft 74 carries an arm 80 on its upper end and may be connected to the foot pedal accelerator of an automobile.

In order to control the idling speed of the engine and to vary the speed, an arm 90 (Fig. 1) is secured to the sleeve 75 and may be connected by means of a suitable rod to a control handle on the dash. By rotating the sleeve the control shaft 74 is adjusted axially through the action of the cams 76 and 77.

In addition means is preferably provided for injecting fuel into all of the engine cylinders simultaneously for starting purposes. As illustrated herein, this means comprises a tubular member 95 having its lower edge surrounding the upper portion of the spider 42 and resting on a shoulder 96 thereon. The upper end of the member 95 is reduced in size and is slidably mounted on the lower end of the bushing 70. It is readily apparent that depressing the member 95 lowers the spider 42 which, through engagement with the flanges 41' on the cap members 40, depresses the pistons. In the preferred form of the invention means is provided so that this priming action may be accomplished from the dash. For this purpose a pin 98 (Fig. 1) is slidably mounted in the upper portion of the casing 71 and has its lower end positioned in a bore 99 in the member 95. The pin 98 is provided with a collar 100 engaging the upper end of the member 95. Pivotally mounted on the casing 71 on a pin 101 is a curved lever 102 the upper end of which engages the pin 98. The lower end of the lever 102 may be connected by means of a link or rod to a control handle on the dash. Thus by actuating the control lever 102 the operator can prime all engine cylinders simultaneously. This means for reciprocating all of the pistons simultaneously serves also as a means for pumping vapor and entrained air out of the intake lines of the pump.

If desired the priming mechanism can be connected to the starter of the car so that the priming is accomplished simultaneously with the starting.

As illustrated herein an eight cylinder pump is provided for controlling the supply of fuel to an eight cylinder engine, and it is believed readily apparent that, by providing individual piston and cylinder devices for each engine cylinder, accurate control of the amount of fuel injected is obtained. Furthermore by directly varying the strokes of the pistons to vary the amounts of fuel, a simple and efficient accelerating and power varying means is provided. As illustrated herein the strokes of the pistons are varied by adjusting the drive shaft 28 axially and by rounding the upper end of the drive shaft which engages the control shaft there is no tendency for the control shaft to rotate with the drive shaft. Lost motion is effectively eliminated by maintaining the drive shaft in engagement with the thrust bearing formed at its upper end and by providing the coiled springs for urging the pistons upwardly into engagement with the cap members and maintaining the cap members normally with the flanges 41' against the spider 42. By providing a tapered roller freely rotatable on a pin carried in an inclined position on the drive shaft a perfect rolling action between the roller and pistons is obtained, thus eliminating friction and wear and permitting the use of a wide contact between the roller and pistons.

The construction disclosed effectively eliminates any possibility of the fuel getting up into the operating mechanism. As pointed out hereinbefore any leakage past the piston or lining sleeve is caught in the low pressure supply groove 47 and chamber 51. I preferably connect the casing 71 to the oil supply of the engine by means of a conduit 130 (Figs. 1 and 5) and through a suitable pressure reducing valve (not shown) so that the casing is filled with oil and the oil pressure within the casing is slightly greater than the fuel pressure in the chamber 51. Thus the tendency would be for the lubricant to get into the fuel rather than vice versa.

Preferably the valves controlling the inlet of fluid to the cylinders are carried on and are reciprocable with the pistons and are in the form of thin disks as illustrated. Thus the opening and closing of the valves is assisted by the movement of the pistons, the upward movement of the pistons during the suction stroke tending to open the valves to admit fluid, and the downward movement of the pistons tending to close the valves. It is readily apparent that the downward movements of the pistons are extremely sudden and rapid due to the form of contact between the roller 34 and the members 40, so that a quick injection of the fuel into the engine cylinders is obtained.

In the form illustrated in the drawings, the pump is readily adapted for economical manufacture. By providing hardened lining sleeves 21 intermediate the cylinder block and pistons an accurate mounting for the pistons is readily obtained. The sleeve linings need not be a fluid tight fit in the cylinder block, any leakage being prevented by clamping the annular flanges 21' of the linings between the top of the cylinder block and the ring 52.

A simple means is provided for adjusting the drive shaft axially to vary the strokes of the pistons. The provision of the adjustable cam 77 facilitates the varying of the idling speed of the engine.

The mechanism as disclosed is extremely efficient in operation. By connecting the intake conduit 46 to the gasoline tank of an automobile, the pump will effectively suck gasoline into the supply chamber 51 even though the gasoline tank is in the rear of the car and below the level of the pump.

I claim as my invention:

1. A pump comprising, in combination, a cylinder block having a plurality of cylinders, hardened lining sleeves positioned in said cylinders and projecting from the block, hardened cylindrical pistons slidably mounted in said sleeves, a spider positioned above the cylinders, a cap member for each piston slidably mounted on said spider in alinement with the pistons, and having portions arranged to engage the spider to limit the upward movement of the pistons, a drive shaft, means on said drive shaft for actuating the pistons, and means for depressing said spider to actuate the pistons simultaneously.

2. A pump comprising, in combination, a cylinder block having a plurality of vertical cylinders arranged in a circle, flanged lining sleeves in said cylinders projecting upwardly therefrom with the flanges against the top of said block, pistons slidably mounted in said sleeves and extending beyond the upper ends thereof, means for reciprocating the pistons, means for supplying fuel to the lower ends of said cylinders including a grooved ring positioned on said block engaging said flanges to secure said linings in place and forming an annular supply chamber, ports formed in said lining sleeves and pistons connecting said chamber and cylinders, and check valves normally closing the ports in the pistons during the compression strokes of the pistons.

3. A pump comprising, in combination, a cylinder block having a plurality of cylinders arranged in a circle, pistons in said cylinders, a drive shaft extending centrally of said cylinders, means for rotatably supporting said drive shaft, a control shaft positioned axially of said drive shaft and in engagement with the upper end thereof, a sleeve surrounding said control shaft, cam means on said shaft and sleeve operable when said control shaft is rotated to move the control shaft and thereby the drive shaft axially to vary the stroke of the pistons and means for rotating said sleeve independently of the control shaft to vary the stroke of the pistons when the control shaft is in its minimum stroke position.

4. A pump comprising, in combination, a cylinder block having a plurality of parallel cylinders arranged in a circle, pistons in said cylinders,

a drive shaft extending centrally of said cylinders, means for rotatably supporting said drive shaft, means carried on said drive shaft arranged to actuate said pistons in sequence during rotation of the shaft, a member slidably mounted for movement longitudinally of said shaft and having a plurality of bores into which the ends of the pistons project, means for limiting the upward movements of the pistons in said member, and means for depressing said member to actuate all pistons simultaneously.

5. A pump comprising, in combination, a cylinder block having a plurality of parallel cylinders arranged in a circle, pistons in said cylinders, a drive shaft extending centrally of said cylinders, means for rotatably supporting said drive shaft, means carried on said drive shaft arranged to actuate said pistons in sequence during rotation of the shaft, a spider slidably mounted for movement longitudinally of said shaft and having a plurality of vertically extending bores into which the upper ends of the pistons project, tubular bushings in said bores having closed upper ends resting on said pistons and arranged to be engaged by said actuating means, said bushings having annular flanges on their lower ends engaging said spider to limit the upward movements of the bushings and pistons, and means for depressing said spider to actuate all pistons simultaneously.

6. A pump comprising, in combination, a cylinder block, a plurality of parallel cylinders arranged in a circle, pistons in said cylinders, means for reciprocating said pistons comprising a drive shaft extending centrally of said cylinders, and a tapered roller carried on said drive shaft and arranged to engage the ends of the pistons in sequence during rotation of the shaft, means for depressing all of the pistons simultaneously, means for controlling the inlet and outlet of fluid to and from the cylinders, and means for adjusting said drive shaft axially to vary the strokes of the pistons.

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