May 19, 1942. R. A. COFFMAN 2,283,184

OSCILLATORY STARTER AND ROTARY BREECH MECHANISM THEREFOR

Filed April 16, 1935 4 Sheets-Sheet 1

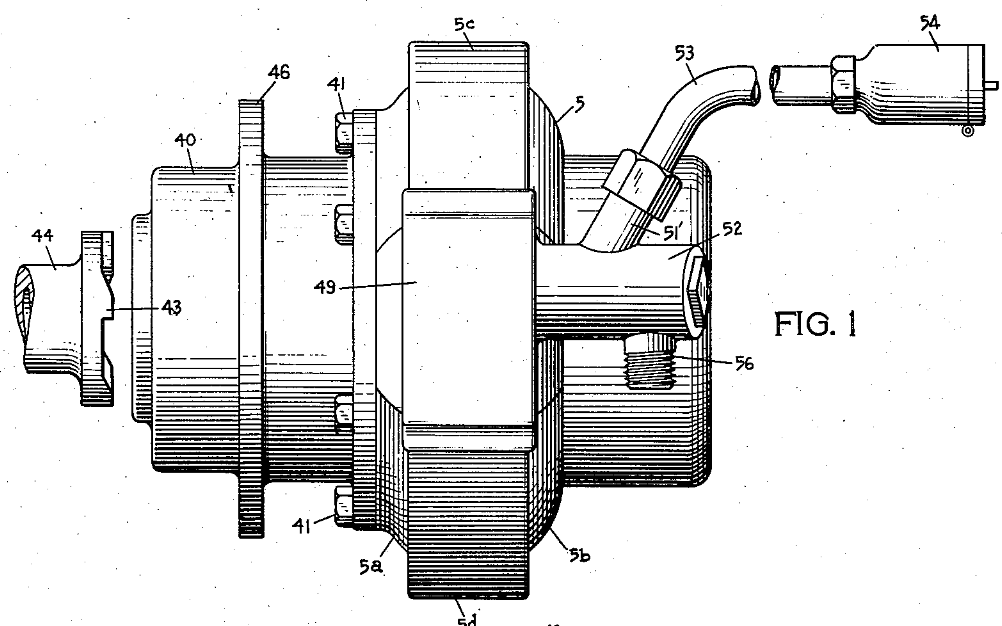

FIG. 1

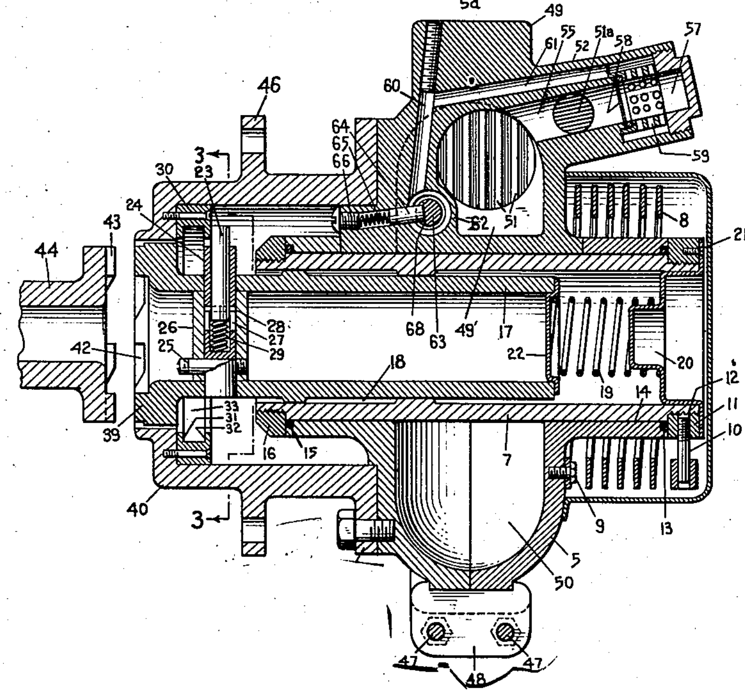

FIG. 2

Inventor

Roscoe A. Coffman

[signature]

Attorney

May 19, 1942. R. A. COFFMAN 2,283,184

OSCILLATORY STARTER AND ROTARY BREECH MECHANISM THEREFOR

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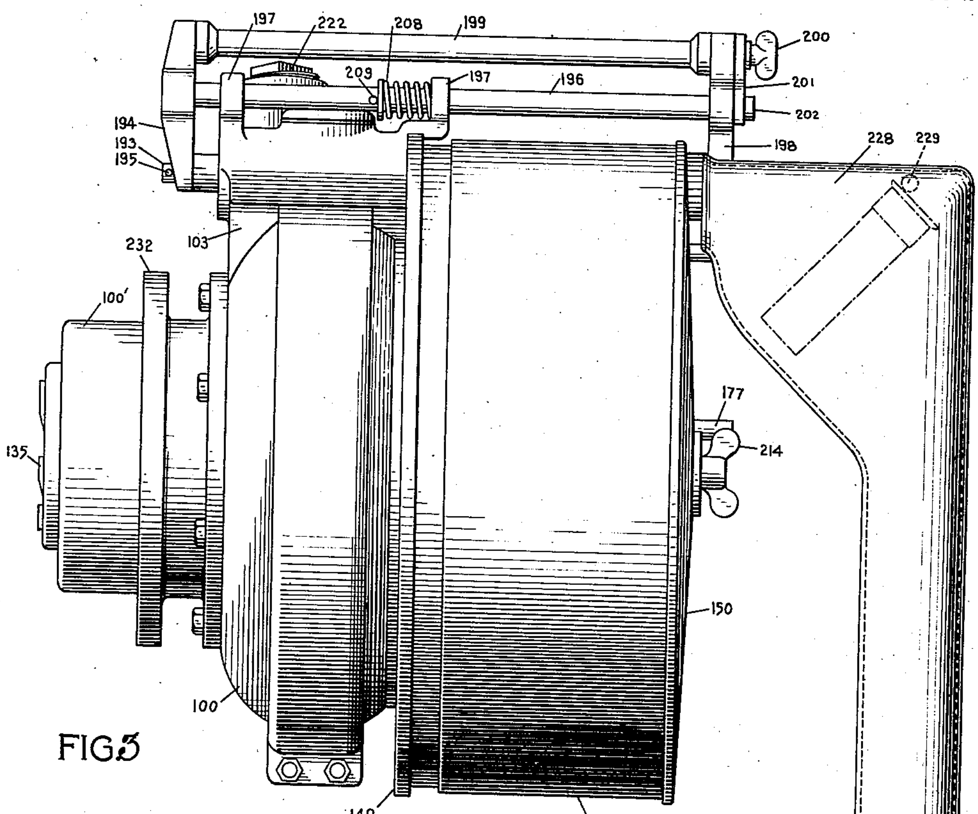

FIG. 3

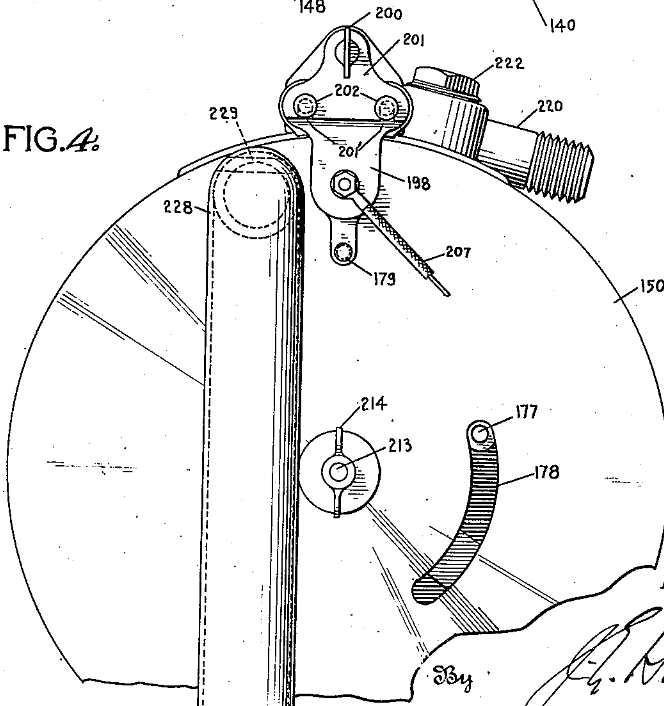

FIG. 4

Inventor

Roscoe A. Coffman

By J. G. Hutchinson Jr.

Attorney

May 19, 1942. R. A. COFFMAN 2,283,184

OSCILLATORY STARTER AND ROTARY BREECH MECHANISM THEREFOR

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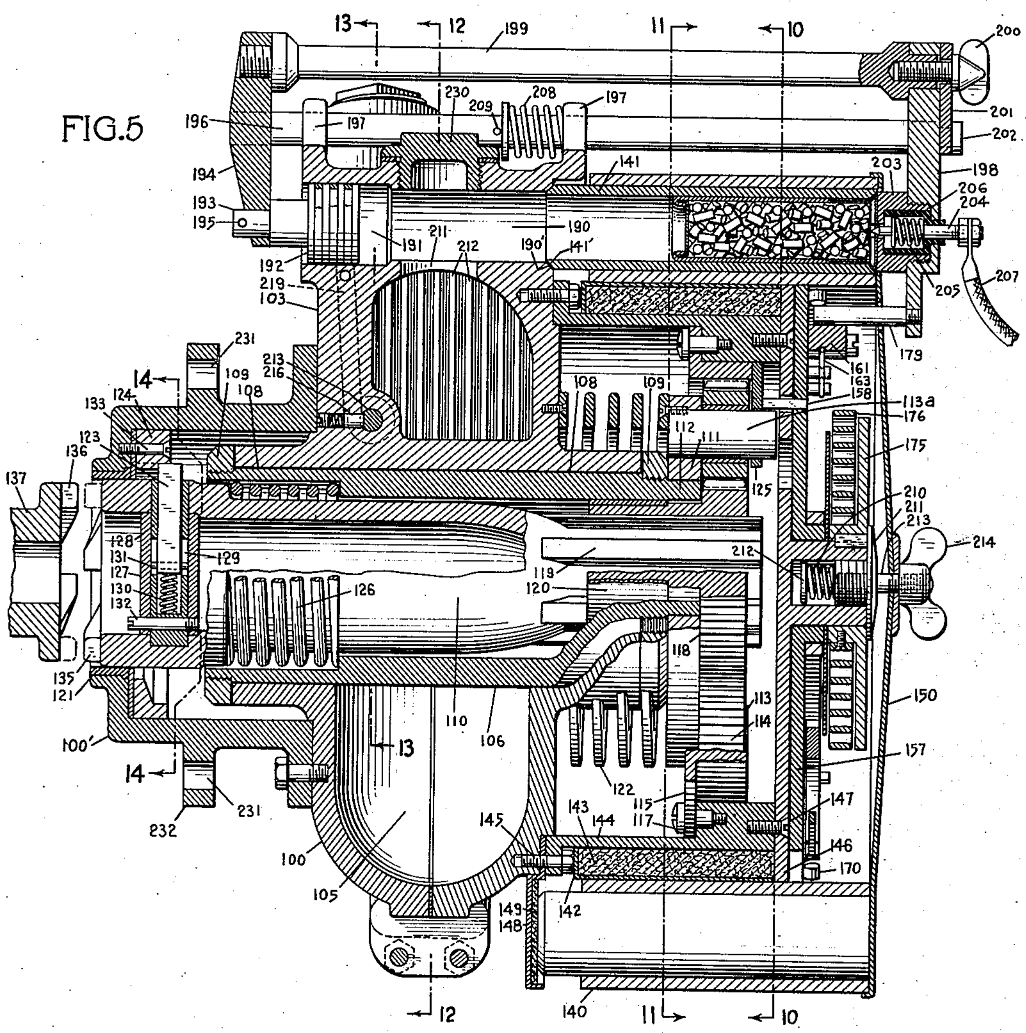
FIG.5



Inventor

Roscoe A. Coffman

By [signature]

Attorney

May 19, 1942. R. A. COFFMAN 2,283,184

OSCILLATORY STARTER AND ROTARY BREECH MECHANISM THEREFOR

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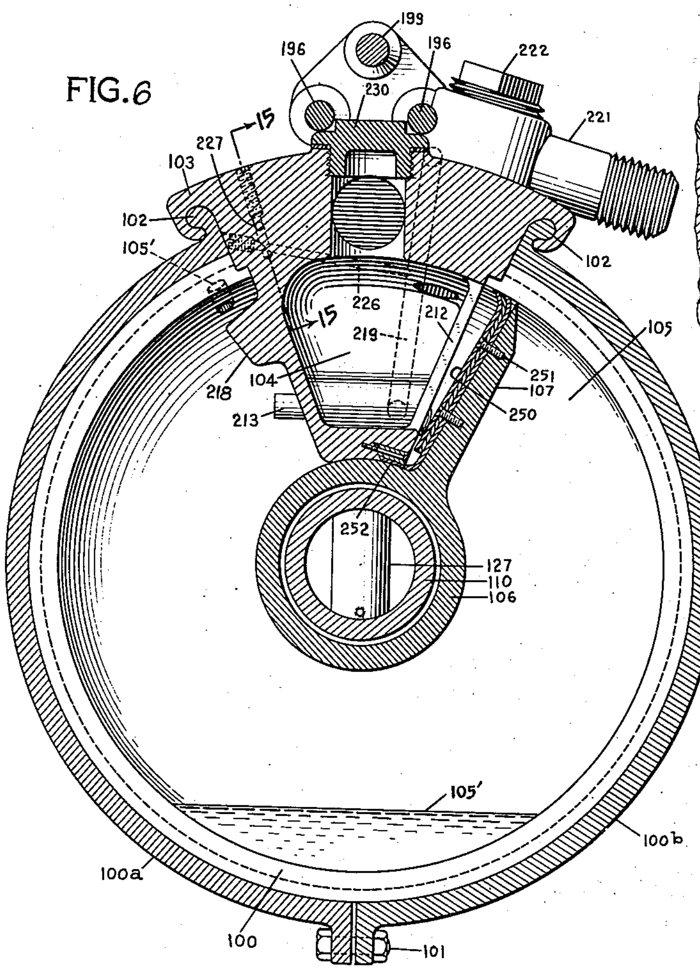
FIG. 6



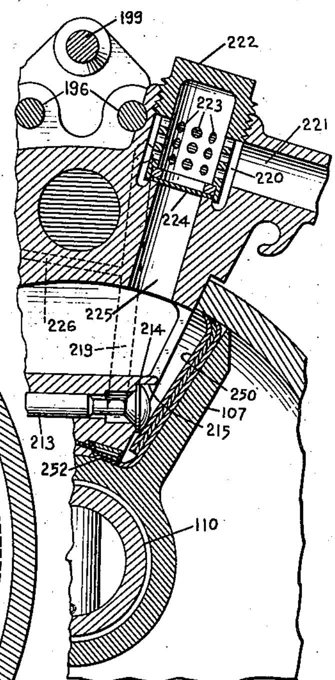


FIG. 7

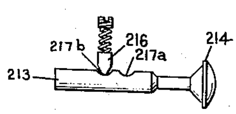


FIG. 8

Inventor

Roscoe A. Coffman

By J. L. Hutchinson Jr.

Attorney

Patented May 19, 1942

2,283,184

UNITED STATES PATENT OFFICE

2,283,184

OSCILLATORY STARTER AND ROTARY BREECH MECHANISM THEREFOR

Roscoe Alexander Coffman, Pittsburgh, Pa.

Application April 16, 1935, Serial No. 16,725

10 Claims. (Cl. 123—18)

This invention relates to fluid pressure motors and more particularly to fluid pressure motors of the oscillating type.

Specifically this invention relates to a fluid pressure actuated oscillatory member adapted to operate within an annular shaped cylinder, providing as its primary object means for successively generating fluid pressure from unit charges and the transmission of the fluid pressure to the cylinder for propulsive purposes operating thereby associated movable mechanisms designed to automatically engage and disengage the jaws of the starter shaft of and thereby start an internal combustion engine. There is further provided at the end of the work stroke operation automatic scavenging means, automatic means for return of the movable parts to their normal position of rest and automatic means for the replacement of the expended unit charge. Further means are provided to automatically and at a predetermined point in the work stroke increase the rotating speed of the driven starter clutch jaw engaging member over the rotating speed of the fluid pressure actuated oscillatory member for purpose of greater efficiency in starting the internal combustion engine.

It is a specific object of this invention to provide an oscillating motor which is adapted to operate under the pressure of propulsive gases generated by a unit charge of combustible material for starting aeroplane engines or the like which will operate under the influence of the combustible unit charge without excessive shock or jar.

It is a further object of this invention to provide a motor of the type designated in which pressure may be gradually accumulated and maintained to operate the motor smoothly and efficiently.

It is a further object of this invention to provide a fluid pressure prime mover and automatically operated means for successively operating the prime mover in conjunction with means for controlling the connection between the shaft of the prime mover and the instrumentalities to be turned thereby.

Broadly, the instant invention combines in a compact unitary structure a rotary breech mechanism carrying a plurality of combustible unit charges and an oscillating starter integrally mounted therewith wherein the mechanisms of the starter are utilized to effect the automatic operation and control of the breeching mechanisms. A particular advantage is thus gained enabling me to mount this entire mechanism in the limited areas available in connection with the mounting of an engine in an aeroplane. A specific object in connection with this close coupling is that it enables me to use a unit charge fuel of two general types dependent upon the desired length of duration of the fluid pressure generation—namely, unit charges of the fast burning type consisting of a multiplicity of fuel pellets affording greater aeration and unit charges of the slower burning type consisting of a single fuel pellet affording a lessor aeration and wherein, if desired, the complete combustion of such unit charge may be effected in the unit charge placement area of the breech.

A specific object of the invention is to provide a burning area for the fuel charge in close coupled relation to the gas expansion chamber wherein the power generated by the expanding gases is utilized for the performance of the desired work operation whereby there is obtained a minimum dissipation of heat units in other than the performance of useful work.

A further object of the invention is to provide a novel assembly and lock means whereby the device is rendered gas leak proof but easily manufactured, assembled and disassembled and a novel method of securing the V block in operable position with respect to the cylinder and the pressures which it necessarily resists.

A still further object is to provide self-contained automatic lubricating means within the cylinder.

It is to be noted that the instant internal combustion engine starting device defined by the foregoing objects is independently operable of any cam or other mechanism attached to or made a part of an internal combustion engine and therefore constitutes a marked differentiation to prior art devices with which I am familiar.

Among the further objects of the invention which will appear from a reading of the following specification are those which contemplate a starting motor which is compact, powerful and of the utmost reliability under all conditions of operation.

Fig. 1 is a top plan view of a motor constructed in accordance with the invention.

Fig. 2 is a central, longitudinal, sectional view through said motor.

Fig. 3 is a side elevation of a preferred embodiment of my invention which includes an automatically operated cartridge magazine.

Fig. 4 is a view looking from the rear of Fig. 3.

Fig. 5 is a central, longitudinal sectional view through Fig. 3.

Fig. 6 is a transverse sectional view on line 12—12 of Fig. 5.

Fig. 7 is a transverse fragmentary sectional view on line 13—13 of Fig. 5.

Fig. 8 is a detail view of the exhaust valve hereinafter to be described.

While the form of the invention having the rotatable cartridge magazine is perhaps the embodiment to be preferred, nevertheless, I shall first describe the form illustrated in Figures 1 and 2 of the drawings because that form is the simplest and an understanding of the same will assist in understanding the more complex embodiment illustrated in the succeeding figures of the drawings.

Referring now more particularly to the drawings, in which the appearance of like reference characters indicate like parts, 5 designates in a general way a casing or cylinder so shaped as to receive an oscillatory piston or impeller. This piston is carried by an oscillatory driving sleeve 7, said sleeve being moved in one direction by the operation of the piston and in the other direction by a stout spring 8, one end of which is connected to the casing 5, at 9, and the other end of which is connected by a stud 10 with a ring-like nut 11. The nut 11 is threaded upon the driving sleeve 7, at 12, and compresses a packing gasket 13 to prevent leakage of gas along the line 14 between the casing 5 and the driving sleeve 7.

In like manner, a packing gasket 15 is compressed by a nut 16 upon the opposite end of the driving sleeve 7, and the driving sleeve 7 is held against endwise movement by these nuts 11 and 16. A driven sleeve 17 is slidably disposed within the driving sleeve 7 and the splined engagement with the driving sleeve 7, as indicated at 18, so that the driven sleeve 17 is caused to partake of the oscillatory movement of the driving sleeve 7, but is rendered capable of endwise movement with respect to the driving sleeve.

A spring 19 is compressed between a cap 20 which may be secured by screws 21 to either the nut 11 or the driving sleeve 7, and a cap 22 which rests against the end of the driven sleeve 17 and tends to thrust said sleeve toward the left in Fig. 2.

When the parts are in a position of rest, the driven sleeve 17 is held against movement toward the left by a cam latch bolt 23. This bolt is slidably mounted in a sleeve 24, said sleeve being held in place by a pin 25 which traverses a tubular member 26 which is carried by the driven sleeve 17. The bolt 23 is capable of a limited radial movement in the sleeve 24, said sleeve being slotted, at 27, for the reception of a pin 28 which is carried by the bolt 23. A spring 29 acts to thrust the bolt 23 outwardly and when the parts are in a position of rest, the bolt bears against the inner face of a cam ring 30 which is U-shaped in cross section and which comprises the outer flange 31 and the inner flange 32 with a channel 33 between said flanges.

Other detailed features of the clutching mechanism as set forth originally in this specification are essential in the successful operation of said clutch, but nevertheless it is deemed unnecessary here to set forth said features in detail as they have no particular bearing upon the invention claimed in this instant application, the clutch features relating to a separate and distinct invention as will be obvious.

However, it may be noted that when the bolt enters the channel 33 upon initial rotary movement of the piston, the driving sleeve 7 and driven sleeve 17, said driven sleeve 17 is permitted to move forwardly or outwardly, Figure 2, under the influence of the spring 19, to project its outer end portion 39 from the casing section 40 which is attached to the casing 5 by means of bolts or other suitable means as shown at 41, and to bring the clutch teeth 42 upon said end of the driven sleeve 17 into engagement with the corresponding clutch teeth 43 of a clutch member 44, which may be mounted axially upon the main drive shaft of an internal combustion engine.

It is apparent that under these circumstances an oscillation of the piston of driving sleeves 7 through its permissible degree of rotation will first be effective to engage the driven sleeve 17 with the clutch member 44 and will thereafter impart a quick starting movement to the clutch member 44.

The perforated lug 46 carried by the casing section 40 is adapted to receive fastening bolts or studs by which the starting motor may be secured in axial alignment with the clutch shaft 44 or to the element to which a limited rotary movement is to be imparted. The casing 5 consists of sections 5*a* and 5*b* which are held in tight engagement with each other by ring sections 5*c* and 5*d*. These ring sections are brought together at the bottom of the casing and are drawn into tight engagement with the sections 5*a* and 5*b* by draw bolts 47 which pass through ears 48 carried by the sections 5*a* and 5*b*.

At one point in the circumference of the cylinder (as will more particularly appear from a description of Fig. 6) the ring sections 5*c* and 5*d* have hook-like engagement with a V-block 49 so that the V-block constitutes in effect a part of the ring sections and is held in firm engagement with the cylinder by the action of the draw bolts 47 as they draw the ring sections down upon the cylinder.

The V-block has a combustion chamber 49′ formed in its interior which is separated from the interior of the cylinder proper, indicated at 50, by a grid or grating consisting of bars 51. The purpose of these bars is to prevent the relatively large particles of combustible fuel employed for propulsion purposes, the nature of which will be more particularly hereinafter described, from entering the cylinder 50.

A neck 51′ formed upon an extension 52 of the V-block 49, is adapted to have a tube or conduit 53 attached to it, and the bore of this neck, indicated at 51*a*, is in communication with a lateral port 55 of the extension 52. An exhaust neck 56 is in communication with the chamber 57 formed in the outer end of the extension 52 and this chamber 57 is normally separated from the port 55 by means of a frangible safety web 58 which is adapted to rupture under excessive pressure and bring the port 55 into communication with the discharge neck 56. However, normally, the chamber 57 and neck extension 56 are cut off from the port 55 by the frangible web 58, and exhaust into the chamber 57 past a grid 59 through an exhaust port 60 and 61: the latter leading from the casing 62 of an exhaust valve 63.

This exhaust valve is so positioned as to be contacted by the motor piston at each of the limits of the stroke of said piston as will more clearly appear from the description of Fig. 6.

A spring detent 64 which is pressed toward the valve by a spring 65 which is held in place by a screw 66 is adapted to snap into one or the other of a plurality of notches as more particularly shown at 217a and 217b of Fig. 8 on the valve stem to hold the valve either in its opened or closed position, as the case may be. When the piston reaches its limit of movement toward the V-block under the influence of the spring 8, it moves the exhaust valve to closed position and when the propulsive gases pass the grid 51 from the chamber 55, said gases may act upon the piston and also may act to hold the exhaust valve in closed position during the time which the piston is traveling all the way around the cylinder or to a position where it strikes against and unseats the exhaust valve 63. During the return movement of the piston under the influence of the spring 8, the exhaust gases are discharged past the exhaust valve and out of ports 60 and 61, past grid 59, through the chamber 57 and out of the exhaust neck 56.

Upon creation of excessive pressures from any reason whatever in chamber 49, the frangible disc 58 will be ruptured and the pressure will be relieved by permitting the gases to pass directly from the inlet port 54 to the chamber 57 and the exhaust outlet 56.

The operation of this form of the invention may be very briefly summarized. A propulsive charge may be discharged from the breech block 54 and from there pass through the tube 53 into the combustion chamber 49′ where the burning charge is completely consumed and in which gas pressure is developed and maintained. The pressure developing within the combustion chamber will move the piston attached to the driving sleeve 7 in a clockwise direction and the driving sleeve 7 will carry the driven sleeve 17 with it in the same direction by virtue of the spline connection between the two. Upon initial clockwise rotation of the driven sleeve 17, the cam latch 23 will be moved sufficiently on its restraining cam ring to permit the driven sleeve 17 to move forward sufficiently to permit its teeth 42 to engage with the teeth 43 of the clutch shaft and the continued rotation of the driving shaft 7 and the driven shaft 17 will impart a rotary starting movement to the shaft 44. As soon as the piston attached to the driving sleeve 7 has reached its limit of oscillation, it contacts the rear projecting end of the valve stem 63 to move the exhaust valve into open position. The spring 8 now acts to move the piston and its associated parts in a counterclockwise direction and during this movement the exhaust gases in the cylinder 50 are expelled through the exhaust port and are forced out of the motor by way of the passages 60, 61, and 56. After the piston has been brought back to its normal position of rest the face of the same will contact the head of the valve stem 63 and move the same to closed position. In the meanwhile, during this counterclockwise movement, the cam latch bolt 23 has cooperated with the cam ring 30 to retract the sleeve 17 and to hold the same out of engagement with the clutch teeth on the shaft 44.

In the form of my invention illustrated in Figures 3 to 8 of the drawings, the oscillating motor is in most respects similar to that of the embodiment just described but nevertheless in order to clearly understand the invention, a brief description of the same will follow. The motor comprises a casing 100 which, as more clearly shown in Fig. 6, is formed of two parts, one part not shown. 100a and 100b comprise a clamp ring in two halves which are bolted together at the bottom by means of bolts 101 which pass through apertures in ears formed at the end of these ring sections. Prior to the insertion of the bolts 101, the ring sections 100a and 100b which are formed with beads 102 at their upper extremities are inserted into grooves in a V-shaped block 103 with their beads 102 in tight contact with the sides of the block. The V-shaped block 103 is provided with a combustion chamber 104 which will be described in more detail hereafter.

The casing 100 is formed with an annular body forming a cylinder 105 about a piston sleeve 106. To the piston sleeve 106 is attached an oscillating piston 107 which is adapted to be driven about the chamber 105 by means of fluid pressure from combustion chamber 104.

The piston sleeve 106 is supported for rotation in bearings 108 formed in the casing at each side of the cylinder 105 and this sleeve is retained in its position and is maintained against endwise movement by retaining rings 109 which are screw-threaded on the piston sleeve 106 and which come into substantial abutment with the ends of the bearing members 108 of the casing 100.

Within the hollow piston sleeve 106 is a driven shaft 100 which is mounted for rotation with the piston sleeve 106 and for relative longitudinal movement with respect thereto.

To the rear end of the piston sleeve 106 is keyed a gear plate 111 by means of keys 112 formed at the rear end of the piston rod and which extend into recesses in the gear plate 111. The gear plate 111 which is adapted to rotate with the piston sleeve 106 carries rotatably mounted therein a plurality of shafts 113, preferably five, upon which shafts are mounted planet gears 114. One of the shafts 113, is made sufficiently long to extend rearwardly beyond the rear surface of its associated gear for a purpose which will hereinafter be disclosed. Each of the planet gears 114 is in contact with teeth on a gear ring 115 which is mounted on the casing of the motor for limited rotary movement.

The planet gears 114 which are mounted on the gear plate 111 are also in contact with a sun gear 118 which is keyed to the driven shaft 110 by means of splines 119 on the rear portion thereof. Therefore, it is evident that the driven shaft 110 and the sun gear 118 move as a unit when rotated, but by virtue of the splines 119 on the driven shaft 110, the driven shaft is permitted to move longitudinally with respect to the sun gear 118 to an extent limited only by the length of the splines and by other mechanism which will hereinafter be described. Between the forwardly extending collar of the sun gear 118 and the piston sleeve 106 is a strip of bearing material such as brass 120 to provide a suitable bearing surface between the rotary internal gear 118 and the piston shaft 106. The driven shaft 110 is mounted in a similar bearing 121 at its forward end which is at the forward end of the motor casing extension 100′.

The piston sleeve 106 is moved against the tension of a strong coil spring 122 by the force of fluid pressure admitted from the combustion chamber 104 in its clockwise direction of movement and the same is returned in a counterclockwise direction by means of the coil spring 122. The driven shaft 110 is retained in a retracted position with its parts within the motor casing by means of a cam latch 123 which is in contact with a cam ring 124.

It is now apparent that when fluid pressure is admitted to the cylinder 105 from the combustion chamber 104, the piston 107 will be moved in a clockwise direction and will thus rotate the piston sleeve 106 by virtue of its integral connection therewith. The coil spring 122 is thus being placed under tension during the clockwise movement of the piston sleeve 106. Since the piston sleeve 106 carries the gear plate 111 with it as it rotates, the natural tendency of the construction of the gears described would be to rotate the sun gear 118 at approximately twice the speed of rotation of the gear sleeve. Inasmuch as the gear ring 115 is free to rotate to a limited extent, such rotation will take place, and the gear ring 115 the planet gears 114 and the sun gear 118 will move as a unit and transmit rotary motion to the driven shaft 110 by virtue of the fact that the sun gear 118 is splined to the driven shaft 110 through the splines 119. Since at this time all of the gears are turning as a unit, the driven shaft 110 rotates at the same speed as the piston sleeve.

As soon as the gear ring 115 has moved sufficiently to bring the end of its respective slots 116 into contact with the screws 117, further rotation of the gear ring is prohibited and as soon as the rotary movement of the gear ring 115 ceases, the planet gears 114 will rotate with respect thereto and will transmit to the sun gear 118 a multiplied speed of movement depending upon the ratio of the gears employed. In the present case, the respective gears are so designed and bear a ratio to each other to impart to the driven shaft 110 two revolutions to each operating stroke of the piston 107. It will be noted that a pawl 125 is carried by the gear ring 115 and this pawl is adapted to contact the extending portion of the gear shaft, and this has been provided for the purpose of preventing the gear ring 115 from rolling ahead of the planet gears 114 and to thus insure the locking together of the entire gear transmission unit during its initial period of operation.

It has heretofore been pointed out that the driven shaft 110 is normally retained in a retracted position against the tension of a coil spring 126 and that the same is held in this retracted position while not in operation by means of a cam latch 123 which is in contact with the cam ring 124 at the forward end of the motor casing.

The motor of this invention is designed to be driven by fluid pressure and more particularly by pressure generated by a burnable unit charge carried in cartridges similar to shot gun cartridges as hereinafter indicated. The present embodiment of the invention likewise has as one of its objects the provision of a cartridge magazine which has a plurality of cartridge chambers and which magazine is ordinarily rotated to bring a shell into firing position after the preceding shell has been discharged. This feature of the invention will now be more particularly described.

140 is an aluminum cartridge magazine ring or housing which carries a plurality of steel cartridge tubes 141 about its periphery at equidistant points. The ring 140 rotates about a bearing member 142 behind which may be placed an insulating material 143 for protecting the loaded shells carried by the magazine from heat generated within the motor. It will be noted that the gear mechanism hereinbefore described is enclosed by an annular ring 144 which is attached to the motor housing at the rear thereof by means of screws 145 and to the rear of the annular member 144 is fixed a back plate 146 by means of screws 147. The bearing 142 for the cartridge magazine 140 is supported by this annular ring 144 and is retained in position by the fixed back plate 146 on one side and by the heads of screws 145 on the other side. Clamped between the motor housing and the annular member 144 is a metal ring 148 which supports on its rear side a compressible material 149, such as asbestos, against which the shell tubes 141 abut, thus sealing the interior of the shell tubes 141 from the possible entrance of sparks or flame. The magazine ring is closed on the rear by means of a removable closure plate 150.

The cartridge magazine is automatic in its operation but its particular details of operation are not set forth herein as they relate to a separate and distinct invention not included in the claimed invention of this instant application.

The magazine closure plate 150, Fig. 4, is apertured to permit the projection of pin 179 which is attached to the firing mechanism normally in engagement with the cartridge holding tube 141.

Should a cartridge for any reason fail to fire, the magazine may be moved to bring a new shell into firing position by grasping the rear extension of the stud 177 and move the same forward 45° to the end of the slot 178 in the closure plate 150. Should the motor be located at a relatively inaccessible position, a suitable lever may be provided to engage the stud 177 for operation.

Centrally and longitudinally of the V-shaped block 103, as most clearly shown in Fig. 5, is provided an inlet port 190 with which the cartridge tubes 141 are adapted to register successively in the position where the cartridges are discharged. The inlet port 190 has a beveled edge 190', which is milled to engage a reversely beveled edge 141' on the forward end of the cartridge tube 141. The inlet port 190 is continued through the V-block 103 at its forward end as indicated at 191. The bore 191 is of a diameter greater than the diameter of either the inlet port 190 or the interior of the shell tube 141 for a purpose which will hereinafter become evident.

Within the bore 191 is a properly packed piston 192, the stem 193 of which extends beyond the V-shaped block 103 and through a fulcrum plate 194. The connection between the stem 193 and the fulcrum plate 194 is fairly loose and is maintained by means of a transverse pin 195 which passes through the stem 193. The fulcrum plate 194 has attached thereto two tension rods 196 which pass rearwardly through guides 197 formed integrally with the V-shaped block 103 to and through a rear breech block carrying plate 198. A compression rod 199 is likewise attached to the fulcrum plate 194, and this rod also passes rearwardly of the motor in substantially its vertical plane, and is attached to the breech block mechanism 198 by means of a thumb nut 200, which passes through a key plate 201 and into the internal screw threads of the compression rod 199. The key plate 201 is slotted inwardly of its lower edge as shown at 201', Fig. 4, for close fitting engagement with channels on the tension rods 196, so that when the key plate with its slots is passed over the channels in the tension rods 196, the heads 202 of the tension rods are locked against the rear surface of the key plate 201.

The breech block carrying plate 198 supports the breech block 203 which is screw threaded into the plate 198, and the breech block is carried in alignment with the inlet port 190 of the motor so that when a shell is brought in alignment between the port and the breech block, the same is in position to discharge the shell. The breech block simply consists of a metal block which is recessed to receive a firing pin 204 which is spring pressed forwardly by means of a coil spring 205. The firing pin is completely insulated from the motor proper by means of an insulated lining 206 which is formed of rubber composition, or any other suitable insulating material. To the rear end of the firing pin 204 is attached an electrical conductor 207 which leads to any suitable source of current for discharging the shell.

To the lower end of the breech block carrying plate 198 is attached the breech block lifting pin 179 which is operated in a longitudinal direction by means of the operating cam 161, as hereinbefore described. Coil springs 208 fixed between one of the guides 197 and a pin 209 extending through the tension bars 196, tend to move the tension bars forward and thus carry the breech block carrying plate 198 and the breech block 203 into contact with the shell within the magazine tube.

Assume now that a new shell has just been moved into firing position and that the magazine ring 140 and the breech block 203 are still held away from the inlet port 190 and the shell, respectively, by means of the magazine lifting arm and the breech block lifting cam 161. After the magazine lifting arm is disengaged from the magazine lifting pins 170, the magazine is urged forwardly so that the cartridge tubes 141 lie in close contact with the asbestos lining 148 in the ring 149, and this operation is induced by the spring 210 which, as shown in Fig. 5, is within the hub of the fixed back plate 146 and bears between a shoulder on nut 211 and a shoulder 212 on the end of the back closure plate holding bolt 213, which in turn has a wing nut 214 screwed to the end thereof to hold the back closure plate 150 in place. Thus, it will be noted that any rearward movement of the magazine ring 140 will be transmitted through the back closure plate 150, and this pressure will tend to pull the bolt 213 rearwardly against the tension of the spring 210, so that when the magazine ring 140 is again released and free to move forward the spring 210 will tend to carry the same into close contact with its associated parts at the front side thereof.

When the breech block lifting pin 179 is free of the breech block lifting cam 161, the springs 208 on the tension bars 196 will carry the breech block into operative position against the shell which is to be discharged. The contact point of the firing pin 204 is first brought to bear against the contact of the shell, and any excessive forward motion imparted to the firing pin 204 is absorbed by the spring 205, thereby preventing damage to the shell.

When current is now supplied to the conductor 207, the same is carried therethrough into the firing pin 204 and into the cartridge, to discharge the same. Upon ignition of the combustible material in the cartridge, the material is expelled from the cartridge tube 141 into the inlet port 190 and through the opening 211, and into the combustion chamber 104. However, if it is desired to substantially vary the length of duration of the fluid pressure generation it has been found advantageous to use a cartridge of the well-known solid or single pellet type which may be consumed in the unit charge placement area represented by shell tube 141 or in the forward chamber 190. Large particles of fuel are retained in the combustion chamber 104 by means of the grating 212 which permit gases to flow into the cylinder 105. Pressure is naturally accumulated in the inlet port 190, in the cartridge tube 141, and in the port 191, and by virtue of the greater area of the piston 192 the same is forced forward to bring tension to bear on the tension rods 196, which in turn transmit the greater pressure through the breech block carrying plate 198 and the breech block 203 to the cartridge tube, thus providing a safety factor against reverse pressure tending to force the cartridge and the breech block rearwardly.

A suitable packing material 250 (Figs. 6 and 7) is fixed to the piston 107 by means of screws 251 so that the same may be replaced if necessary. It will be noted that there is also a packing 252 between the piston sleeve 106 and the bottom of the combustion chamber 104 forming the abutting portion of the motor casing. These packings are provided for the purpose of preventing the leakage of gas past the piston sleeve 106 and piston 107.

As the pressure develops in the combustion chamber 104, the piston 107 is oscillated in a clockwise direction, transmitting power to the various gears and drive shafts as hereinbefore noted. At this point it may be noted that the exhaust valve 213 is held with its head 214 against its seat in the exhaust port 215. The exhaust valve is held in this position during the entire clockwise movement of the motor piston both by value of the gas pressure on its inner surface and by virtue of the engagement between a spring pressed detent 216 with a notch 217*a* in the stem of the exhaust valve. When the piston has completed its stroke and has come into contact with the abutment 218, it contacts the extending end of the valve stem 213 and moves the valve into open or exhaust position, in which position the valve is maintained by engagement with the detent 216, with the notch 217*b* in the step of the valve.

On the return or counter-clockwise movement of the piston 107, the burnt gases are forced from the cylinder 105 past the valve head 214, and into the exhaust duct 219, which it follows into the chamber 220 and from thence to the exhaust passage 221. The chamber 220 is provided with a plug 222 which is screw threaded therein and which is perforated along its depending annulus as at 223 to permit the escape of exhaust gases. These perforations prevent the passage of the gas into the exhaust.

On the inner end of the plug 222 is provided a frangible disc 224 which divides a passage 225 leading to the combustion chamber 104 from the exhaust passage 221. This disc is adapted to break for the purpose of relieving excessive pressure in the combustion chamber 104 by means of venting the same to the exhaust in the event excessive pressures are generated.

From the duct 219 is a branch 226 which leads to a longitudinal duct 227, more particularly shown in Fig. 15 of the drawings, and this is provided for the purpose of leading exhaust gases to the cartridge tube 140 containing the shell which has just been fired. The passage 227 leads through an opening in the ring 149 against which the cartridge tube 141 presses in substantially gas tight relation. After a cartridge has been fired and moved to the left or counterclockwise direction of approximately 18°, whereafter the exhaust of the motor is still taking place, exhaust pressure from the motor being tapped from duct **219** into passage **226** and **227** flows into the cartridge tube **141** with sufficient force to eject the empty shell contained therein through an opening in the rear closure plate **150**, which is of sufficient size to permit the passage of the cartridge. The cartridge is ejected into a tube **228** which is positioned at the rear of the motor and in aligment with the opening in the back closure plate **150**. The tube **228** is provided with a pin **229** extending transversely thereof near the point at which the tube bends at substantially right angles, and this is provided for the purpose of turning the cartridge in the direction the same is to follow through the tube **228** to the exterior of the aeroplane or other vehicle on which the device is used.

The plug **230** on the top of the V-block **103** is provided for the purpose of granting access to the combustion chamber, when necessary, to clean or inspect the same. The whole assembly as described may be conveniently located in alignment with a crank shaft which it is to turn by means of passing bolts through the holes **231**, which are provided in the flange **232** at the forward end of the casing.

The normal bottom of cylinder **105** is utilized as an oil sump **105**, wherein a lubricant is deposited in the normal position of rest and upon movement of piston **107** is wiped, splashed and distributed to the outer bearings of shaft **106** thereby lubricating bearings surfaces **108** between cylinder casing **100** and shaft **106** as well as the inner surfaces of the cylinder itself.

A bleed hole **105***a* as shown in phantom Fig. 12 is provided in the side wall of casing **100** for the purpose of venting the back side of the cylinder space during the operative movement of the piston and permitting suction intake during the return movement of the piston.

While the motor illustrated and described will function with any gas under pressure, it is particularly adapted and intended to be propelled by the gaseous products delivered as a result of the burning of a highly volatile, but non-detonating, type of fuel of the character of that disclosed in my co-pending applications, Serial No. 581,032, and Serial No. 585,594, and to make clear that I deem the use of this method of delivering a propulsive force to the engine to be of great importance. I have indicated in Fig. 1 the tube **53** at the end of which I have located a breech block **54** which may be of the character shown in my co-pending application, Serial No. 536,389, filed May 11, 1931, and which is adapted to receive a unit charge shell such as is disclosed in application Serial No. 581,032. A shell of this character is indicated in Fig. 5 and the same comprises a body of fuel **69** of a nature to burn at such rate as to permit of successful operation of the device.

I find pellets of nitro-cellulose to constitute a satisfactory fuel for this purpose, and I may control the rate of burning as described in my co-pending application Serial No. 581,032, and the pellets may be of varying size and may be fired at varying points to bring about the desired rate of burning. Electrical ignition means, fully described in my aforesaid application, are indicated at **70**, and at **71**, there is indicated a quick flash composition of so sensitive a nature as to be readily ignited by an electric spark or by an electrically heated bridge wire in a common and well known way, and in turn to deliver a flame of such volume and intensity as will assure the ignition of the fuel.

As described in my co-pending application, Serial No. 536,389, now Patent No. 2,005,913, issued June 25, 1935, it is important, in the starting of an internal combustion engine, to deliver the starting impulses to the crank shaft of the engine without excessive shock or jar and to maintain the starting impulses efficiently over the desired period of time.

Further, it is desirable to provide the desired force through the medium of the readily portable unit charge shell herein shown and described, because there are many places where electricity is not available for the use of starting motors, or where compressed air cannot be had except at the cost of other features. The starting of aeroplane engines, for examples, is a field where the difficulties inherent in the use of electrical or compressed air starters have been so great as to bring into existence a class of inertia starters which are manually operated.

I am able to avoid all of these objections and to utilize a simple unit charge shell of approximately the size of a shot gun shell for the starting of the motor, and, since these shells may be electrically fired, I find it possible to control the apparatus from a distant point. Thus, outboard motors located in remote places upon large planes may be started from the cockpit or even from a point wholly outside of the plane.

However, one who seeks to deliver a sufficiently large volume of gas at sufficient pressure to start an engine of this character is confronted with the fact that if the charge develops the pressure as rapidly as is normally attributable to fuel of this character, the resultant forces are imparted to the motor with great shock and jar, while, in case a reduction in the charge is made to avoid shock and jar it results in the delivery of an insufficient quantity of gases and in an almost instantaneous pressure drop after the beginning of the operation which renders the latter part of the stroke of the starting motor wholly insufficient.

Furthermore, all of the formally constructed power generating units which have heretofore been proposed for work of this character have been of a nature to deliver corrosive gases and clogging residue into and upon the operating parts. By locating the breech block and consequently the point of combustion of the shell content at a predetermined point and by utilizing a fuel of the character indicated and by making the combustion chamber of proper capacity, I am able to deliver a gradually increasing pressure of the gases throughout the operation of the piston stroke in a manner that is novel and highly efficient. This is, in part, due to the fact that by properly arranging the rate of burning of the shell content and varying the rate of burning of some of the constituents of the shell with respect to others, some of the pellets constituting the charge will, upon ignition of the shell, be carried into the combustion chamber where they are finally consumed. This burning of the fuel in close proximity to the cylinder maintains the heat and pressure of the gases throughout the piston stroke and yet the pellets cannot enter the cylinder proper because of the presence of properly arranged obstacles.

During the burning of some of the fuel in the combustion chamber, other portions of the fuel are being burned in the breech block and create a reserve and cushioning volume for gases which back up and supplement the action of the gases generated in the combustion chamber. This corresponds to the action described in my co-pending application aforesaid. The net result of all of this is that the force acting upon the piston is a powerful pushing force but not a hammer-like blow and that this pushing force is sustained and maintained substantially throughout the entire stroke of the piston.

The pushing effect secured by the use of a shell of this sort is accentuated by the presence of high pressure steam as a constituent part of the gas. The nitro-cellulose fuel which I employ, delivers not only an amount of oxygen sufficient to support its own combustion, but an additional amount of oxygen. Furthermore, said fuel will form under these conditions of combustion, an amount of hydrogen sufficient to, when united with the excess of oxygen, form water in the form of superheated high pressure steam in such amount as to be a very great benefit and add very materially in the successful operation of the part to be moved. Since this steam is highly expansive, its tendency to continue to expand under the heat maintained by the burning of the charge in the combustion chamber aids in maintaining the pushing action throughout the piston stroke.

I attribute the very great efficiency of this method of delivering the power to the piston of the motor to be in part due to the fact that the fuel used is of a nature to burn slowly enough to permit the chemical reactions to take place as above described to form water. After the fuel has been consumed, the presence of this live steam quenches the flame and renders the exhaust much safer. Further, the presence of this steam may have a great deal to do with maintaining the heat and gas pressure throughout the power stroke.

I am aware of the fact that other motors of the oscillatory type have been devised, but I do not know that any motor of this type has ever been constructed and adapted for use in connection with propulsive charges wherein generation of the charge takes place at least in part substantially within the motor, for the purpose of securing a substantial pushing effect throughout the piston stroke from a readily portable self-contained unit charge of the shell type.

In this specification I have described what I now consider as the preferred embodiments of the invention, but it is to be understood that the invention is not limited to the particular forms shown nor to the particular uses suggested, and it is to be particularly noted that for use with counter-clockwise cranking operations for internal combustion engines that the cooperative relation of my device may likewise be reversed throughout for coacting operation and that furthermore the device may be embodied in other forms and may be applied to other uses, and it is to be understood that in the following claims it is my desire to cover the invention in whatever form it may be embodied.

Having described my invention, what I claim is:

1. A motor of the character described comprising an annular cylinder made in two halves, ring sections embracing said halves for holding them together, a V-block interengaging members between the V-block and ring sections, and means for drawing said ring sections together.

2. In a fluid pressure motor having an annular cylinder and an oscillatory piston movable therein adapted to be moved in one direction only under influence of fluid pressure generated within the motor for providing a single power stroke for engine starting purposes, a V-block traversing the cylinder and serving as an abutment for said piston, a combustion chamber formed within the block and having an outlet from said block in direct alignment with the direction of oscillation of said piston, means for delivering a unit charge of solid fuel to said combustion chamber for burning therein, means for preventing particles of said fuel charge from entering the cylinder but permitting fluid pressure generated by said fluid charge to be delivered through the combustion chamber outlet in direct contact with the working face of said piston for moving the piston within the cylinder for its power stroke, and means for returning the piston to its normal position of rest within the cylinder for a subsequent power stroke.

3. In a fluid pressure motor having an annular cylinder and an oscillatory piston movable therein adapted to be moved in one direction only under influence of fluid pressure generated within the motor for providing a single power stroke for engine starting purposes, a rotatable member mounted axially within the cylinder and to which said piston is fixed, a block traversing the cylinder and serving as an abutment for said piston, a combustion chamber formed within the block and having an outlet from said block in direct alignment with the direction of oscillation of said piston, means for delivering a unit charge of fuel to said combustion chamber for burning therein, means for preventing particles of said fuel fuel charge from entering the cylinder but permitting fluid pressure generated by said fluid charge to be delivered through the combustion chamber outlet in direct contact with the working face of said piston for moving the piston within the cylinder for its power stroke, and a spring device surrounding the rotatable member and so connected with the structure as to be placed under tension during the power stroke of the piston to serve as a means for returning said piston to its normal position of rest within the cylinder for a subsequent power stroke.

4. In a fluid pressure motor having an annular cylinder and an oscillatory piston movable therein adapted to be moved in one direction only under influence of fluid pressure generated within the motor for providing a single power stroke for engine starting purposes, a block traversing the cylinder and serving as an abutment for said piston, a combustion chamber formed within the block and having a fluid pressure delivery outlet from only one face of said block and in direct alignment with the direction of oscillation of said piston, means for delivering a unit charge of fuel to said combustion chamber for burning therein, means for preventing particles of said fuel charge from entering the cylinder but permitting fluid pressure generated by said fluid charge to be delivered through the combustion chamber outlet in direct contact with the working face of said piston for moving the piston within the cylinder for its power stroke, and means for returning the piston to its normal position of rest within the cylinder for a subsequent power stroke.

5. In a fluid pressure motor having an annular cylinder and an oscillatory piston movable therein adapted to be moved in one direction only under influence of fluid pressure generated within the motor for providing a single power stroke for engine starting purposes, a block traversing the cylinder and serving as an abutment for said piston, a combustion chamber formed within the

block, means for delivering a unit charge of fuel to said combustion chamber within which said charge is burned for furnishing fluid pressure to move said piston within the cylinder for its power stroke, an exhaust valve mounted on said block, said exhaust valve being in position to be contacted by and operated by said piston at each of the limits of movement of said piston for opening and closing said valve, and means for returning the piston to its normal position of rest within the cylinder after the exhaust valve has been opened and for a subsequent power stroke.

6. A fluid pressure motor having an annular cylinder and an oscillatory piston movable therein adapted to be moved in one direction only under influence of fluid pressure generated within the motor for providing a single power stroke for engine starting purposes, a block traversing the cylinder and serving as an abutment for said piston, a combustion chamber in close association with said cylinder, means for delivering a unit charge of fuel to said combustion chamber within which said fuel is burned for furnishing fluid pressure to move said piston within the cylinder for its power stroke, an exhaust valve mounted upon said block and in position thereon to be contacted by and operated by said piston at each of the limits of movement of said piston for opening and closing the said valve, and means for returning the piston to its normal position of rest within the cylinder when the exhaust valve has been opened and for a subsequent power stroke of said piston.

7. In a fluid pressure motor having an annular cylinder and an oscillatory piston movable therein adapted to be moved in one direction only under influence of fluid pressure generated within the motor for providing a single power stroke for engine starting purposes, a block traversing the cylinder and serving as an abutment for said piston, a combustion chamber formed within the block, means for delivering a unit charge of fuel to said combustion chamber within which said charge is burned for furnishing fluid pressure to move said piston within the cylinder for its power stroke, an exhaust valve and valve stem slidably mounted on said block and adapted to move across the block so as to be projected from either face of the block within the cylinder whereby said valve and its stem may be contacted by the piston at each of the limits of the travel of the latter for opening and closing said valve, and means for returning the piston to its normal position of rest within the cylinder after the exhaust valve has been opened and for a subsequent power stroke of the piston.

8. A structure as recited in claim 7 in combination with a detent for holding the exhaust valve at each of its limits of movement.

9. In a fluid pressure motor having an annular cylinder and an oscillatory piston movable therein adapted to be moved in one direction only under influence of fluid pressure generated within the motor for providing a single power stroke for engine starting purposes, a V-block traversing the cylinder and serving as an abutment for said piston, a combustion chamber formed within the block, means for delivering a unit charge of solid fuel to said combustion chamber within which it is burned for furnishing fluid pressure to move said piston within the cylinder for its power stroke, an exhaust valve mounted on said V-block and adapted to open toward the working face of said piston, said exhaust valve being in position to be contacted by and operated by said piston at each of the limits of movement of said piston, the fluid pressure moving the piston during its working stroke also serving to retain said exhaust valve upon its seat during such working stroke, and means for returning the piston to its normal position of rest within the cylinder for a subsequent power stroke.

10. In a fluid pressure motor having an annular cylinder and an oscillatory piston movable therein adapted to be moved in one direction only under influence of fluid pressure generated within the motor for providing a single power stroke for engine starting purposes, a block traversing the cylinder and serving as an abutment for said piston, a combustion chamber formed within the block, an exhaust outlet carried by said block, an inlet for a burnable fuel charge carried by said block and in communication with said combustion chamber, means for delivering a unit charge of fuel to said combustion chamber to move said piston within the cylinder for its power stroke, an exhaust valve mounted to move across the block and to be contacted by the piston at each of the limits of the travel of the latter for opening and closing said valve, an exhaust port leading from the exhaust valve to the exhaust outlet, and means for returning the piston to its normal position of rest within the cylinder after the exhaust valve has been opened and for a subsequent power stroke of the piston.

ROSCOE ALEXANDER COFFMAN.