April 26, 1932. W. LUXMORE 1,855,805

INTERNAL COMBUSTION ENGINE

Filed March 26, 1928 8 Sheets-Sheet 1

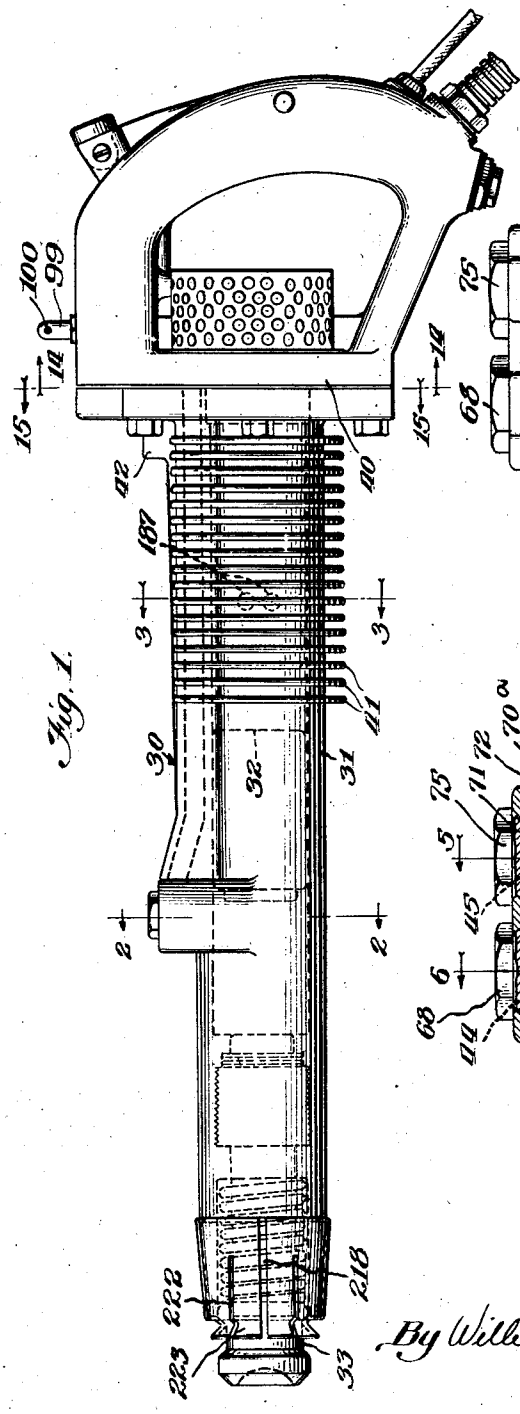


Fig. 1.

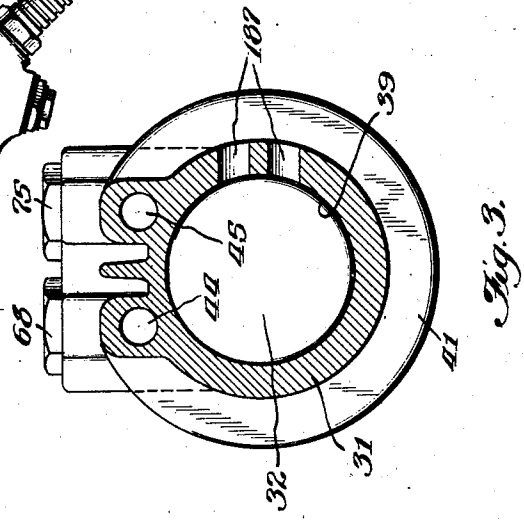


Fig. 3.

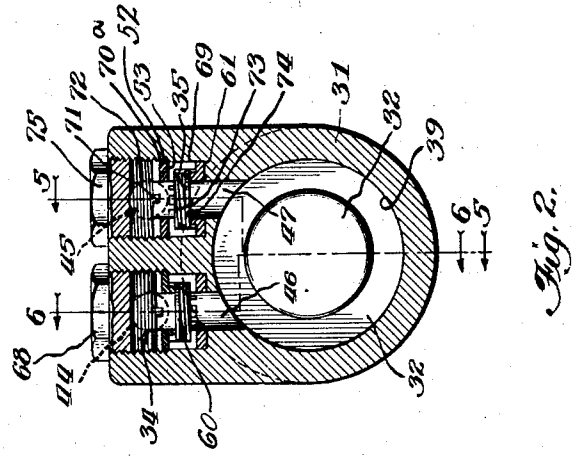


Fig. 2.

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INTERNAL COMBUSTION ENGINE

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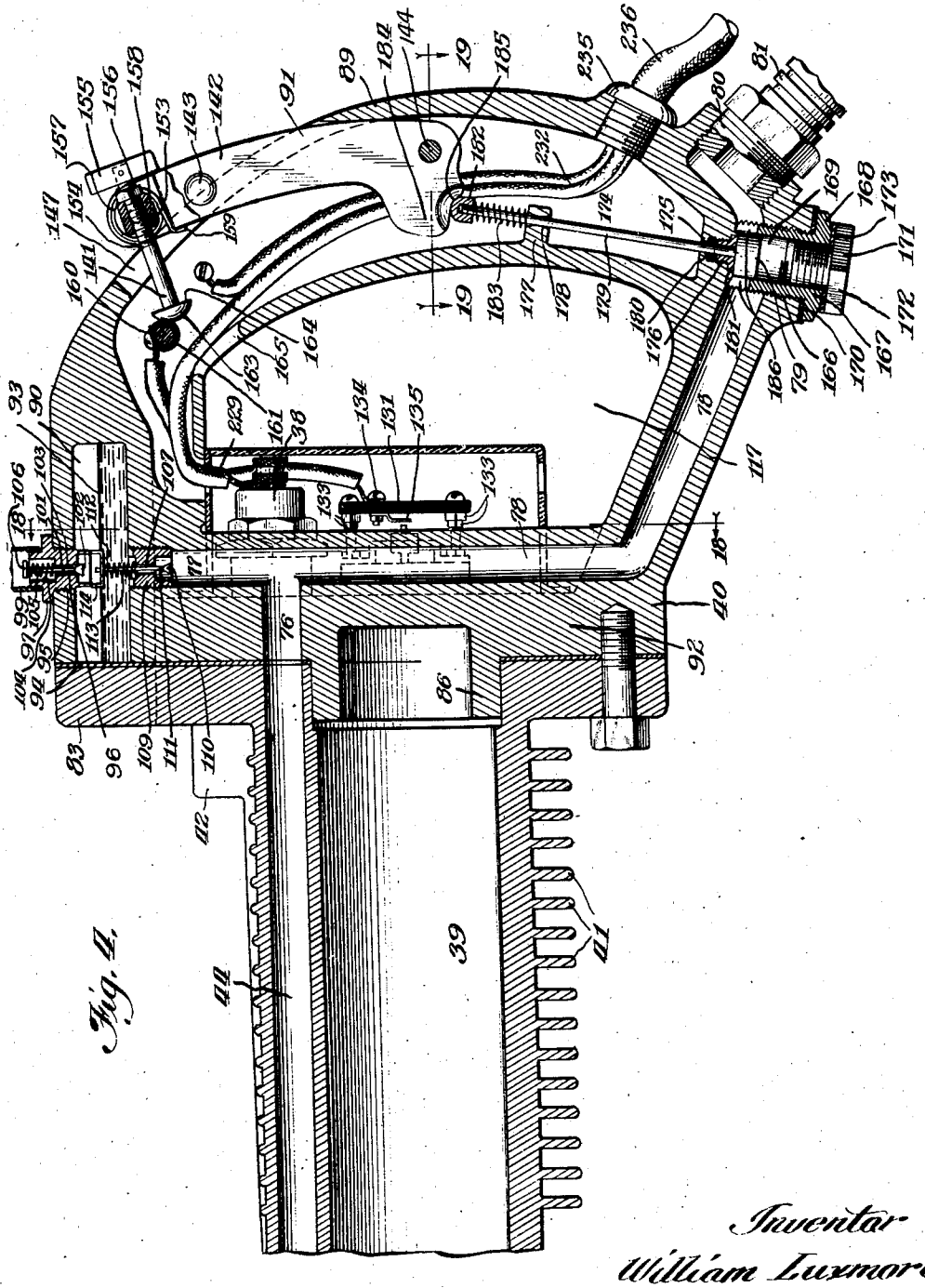


Fig. 4.

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INTERNAL COMBUSTION ENGINE

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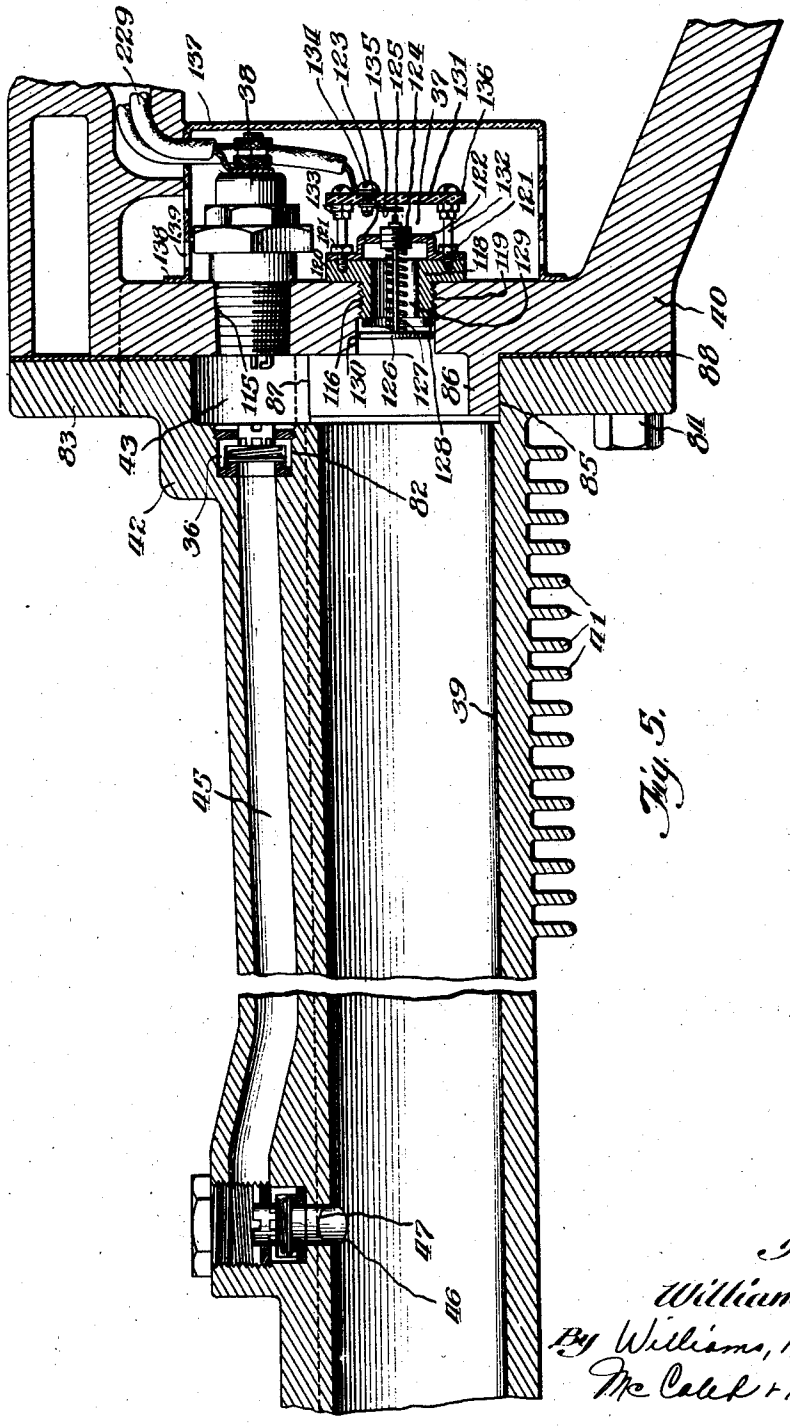


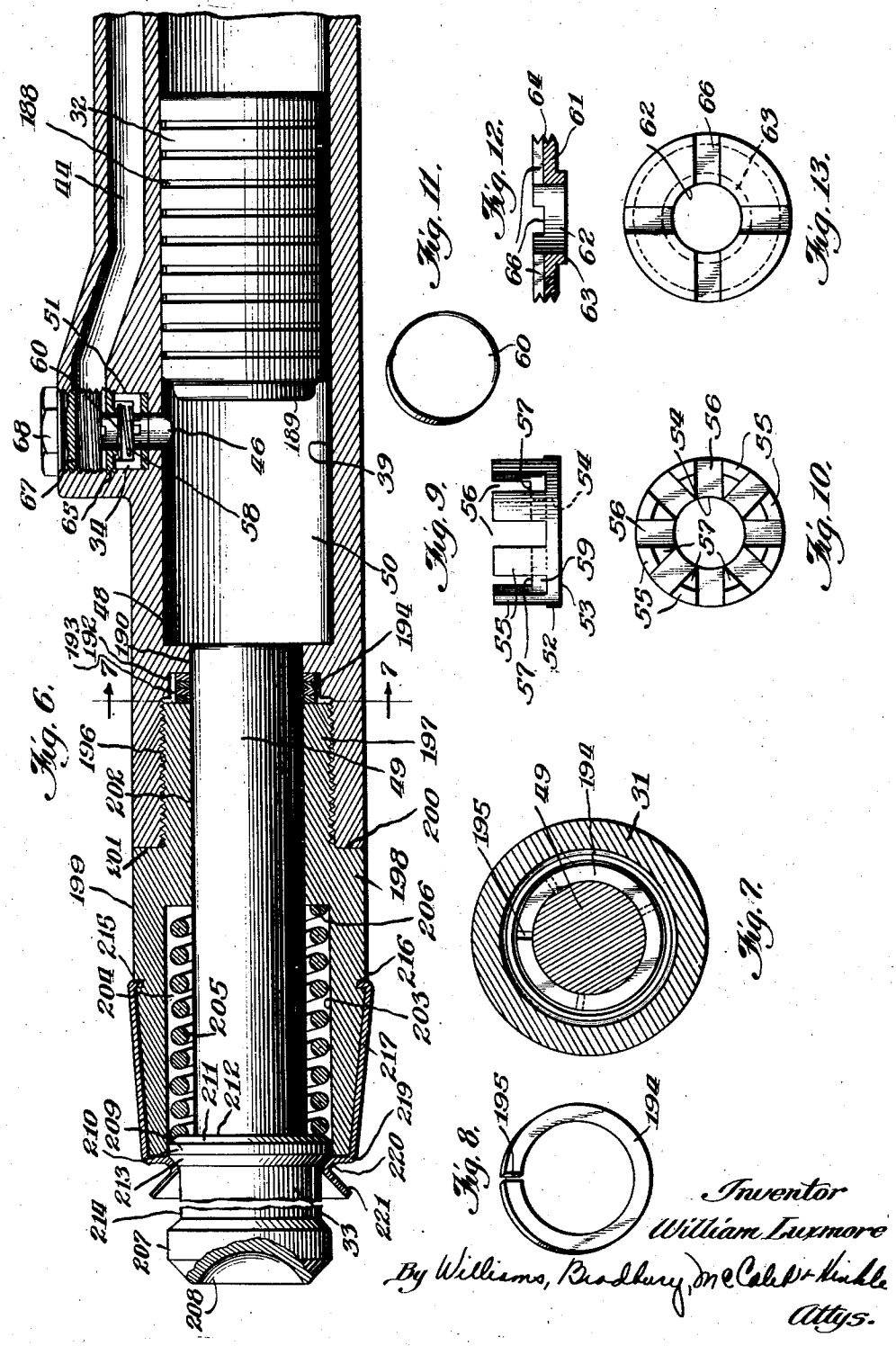
Fig. 5.

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INTERNAL COMBUSTION ENGINE

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INTERNAL COMBUSTION ENGINE

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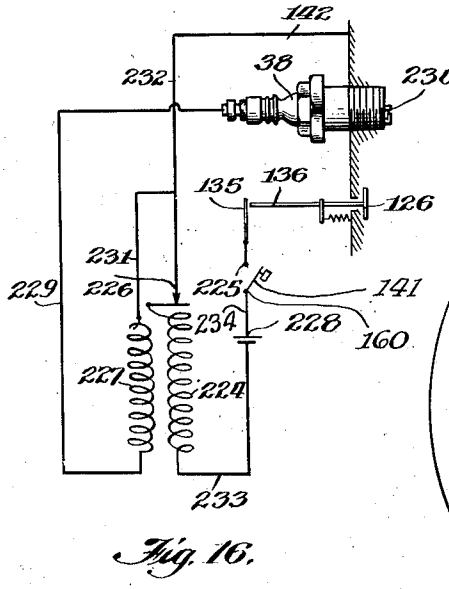


Fig. 16.

Fig. 14.

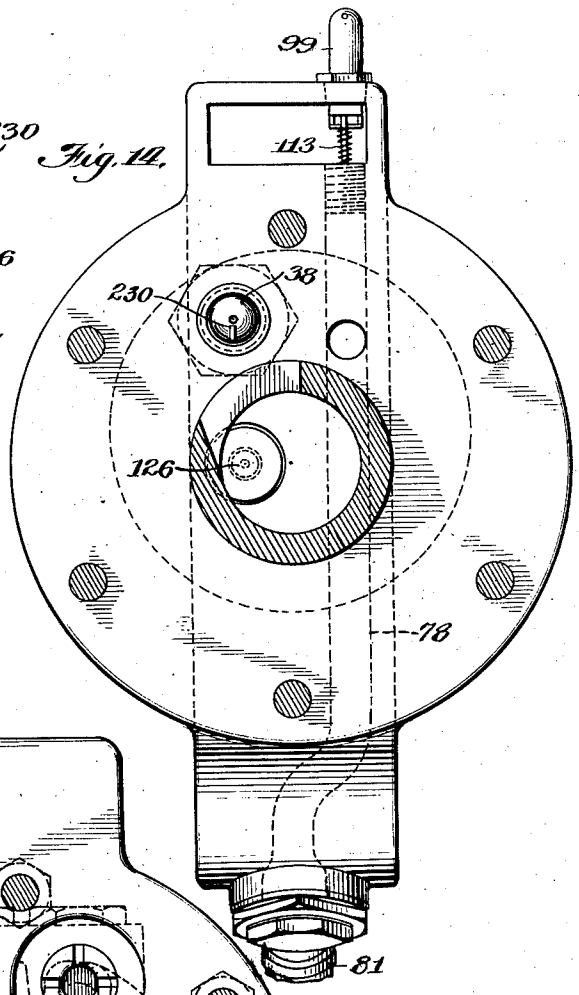
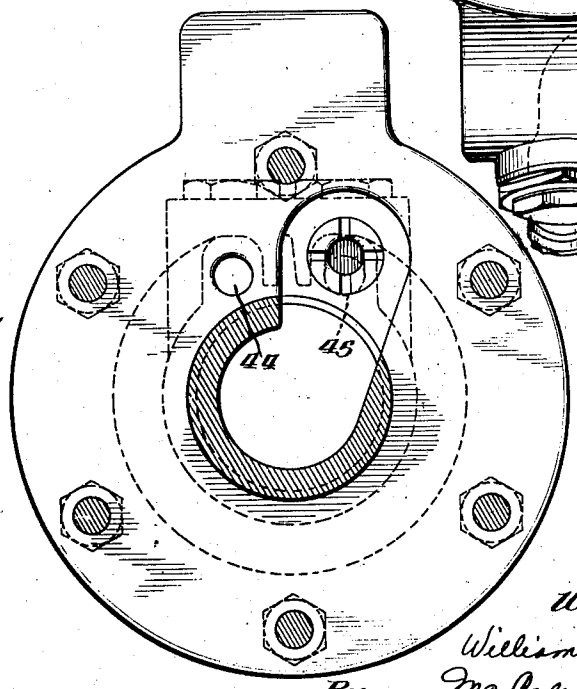


Fig. 15.



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INTERNAL COMBUSTION ENGINE

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Fig. 17

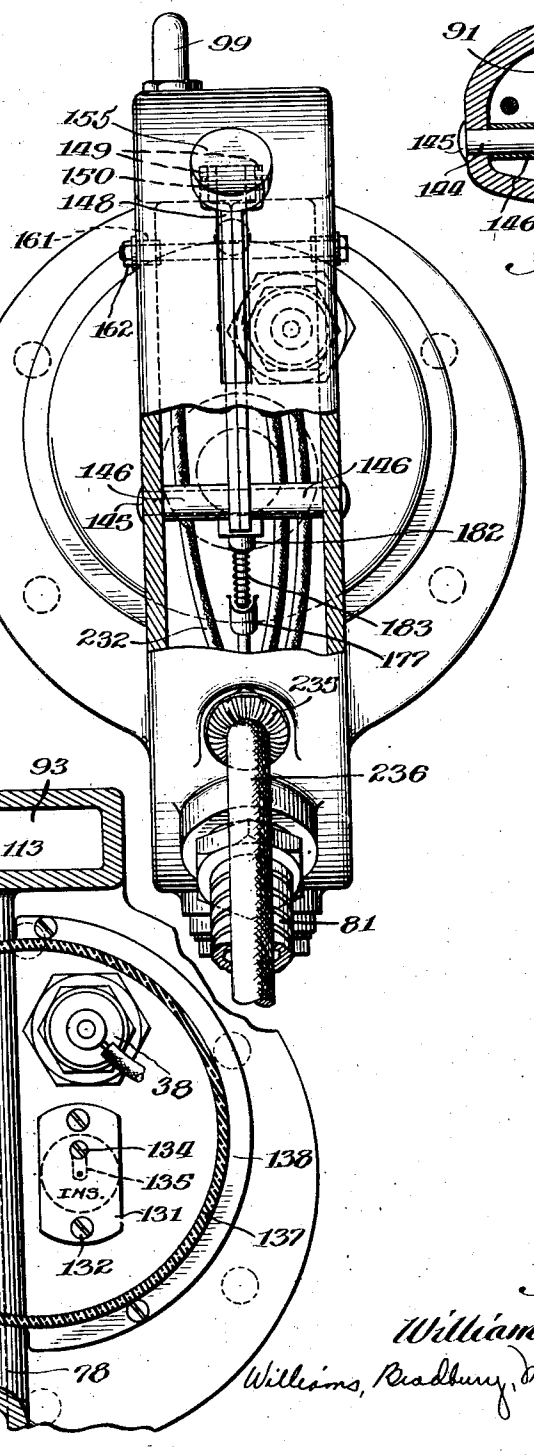


Fig. 18.

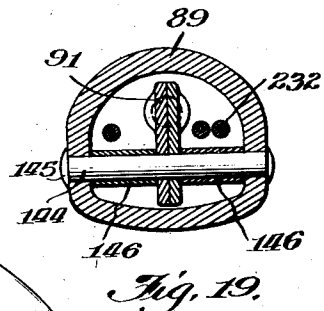


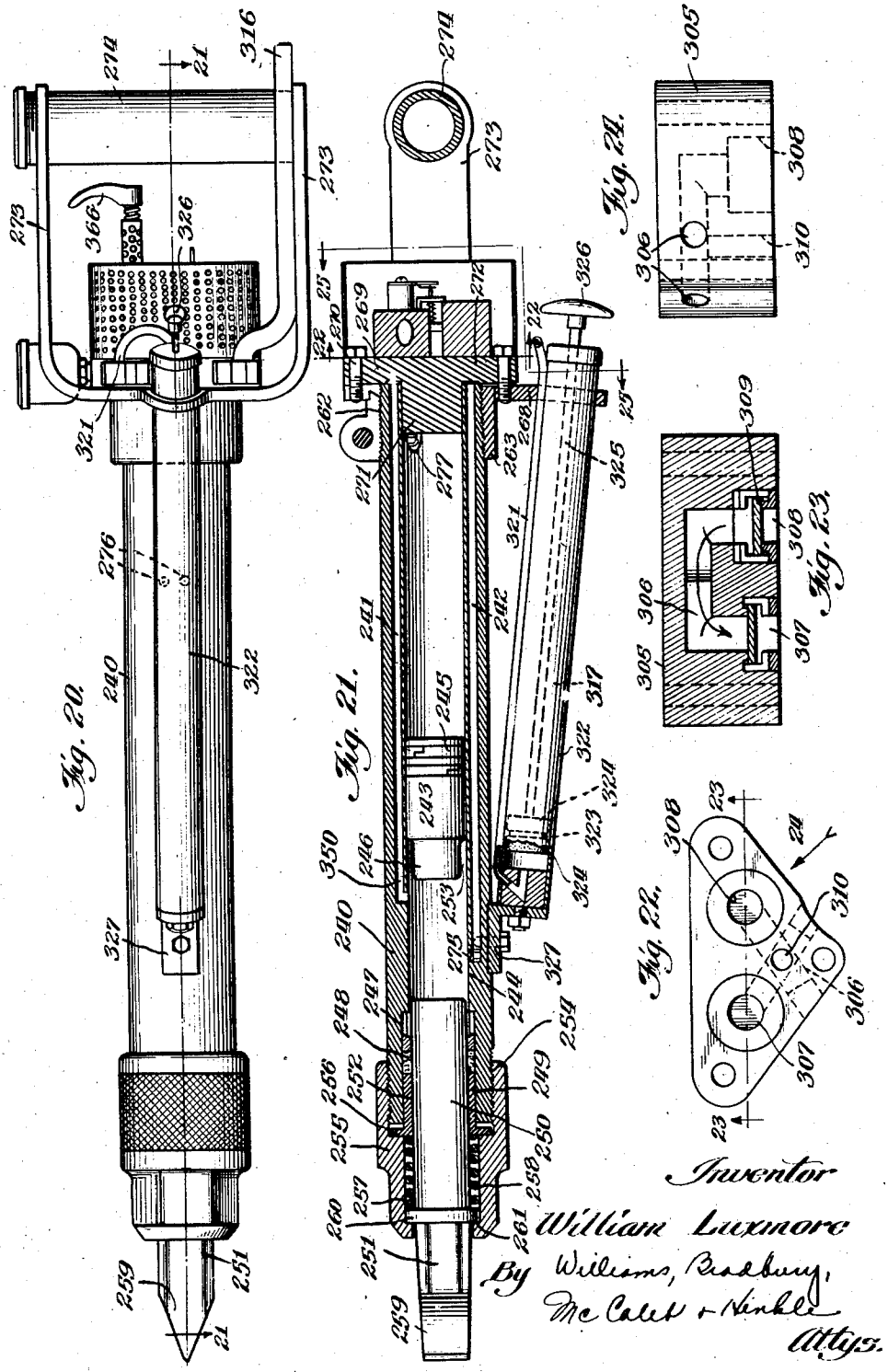
Fig. 19.

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INTERNAL COMBUSTION ENGINE

Filed March 26, 1928 8 Sheets-Sheet 7



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INTERNAL COMBUSTION ENGINE

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Fig. 25.

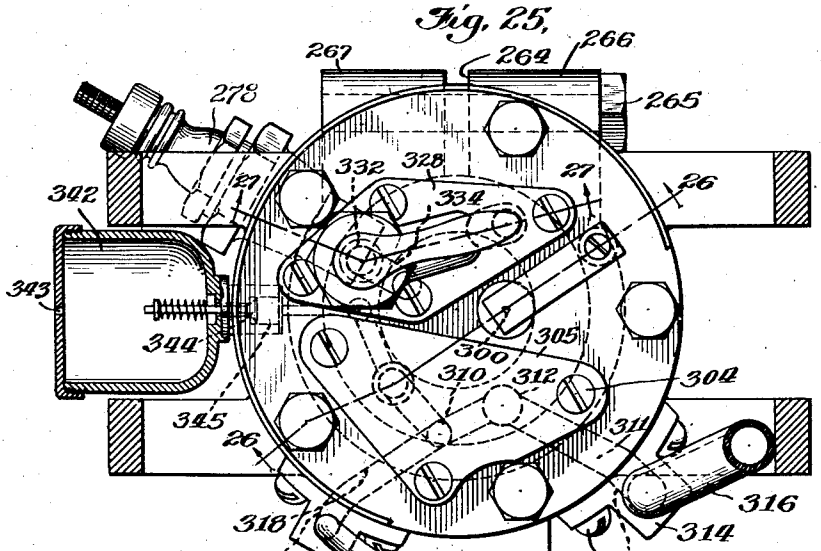


Fig. 26.

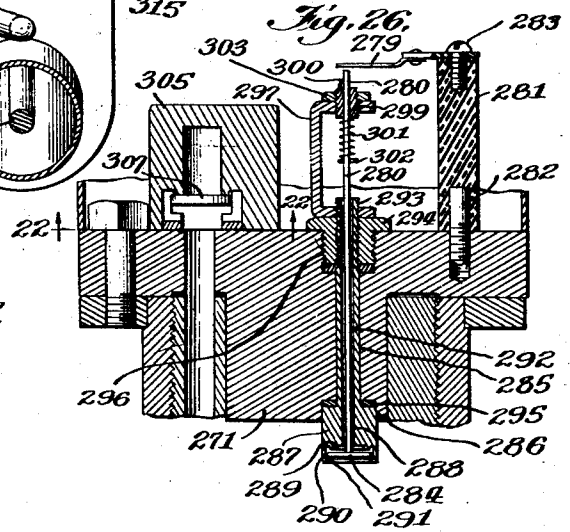
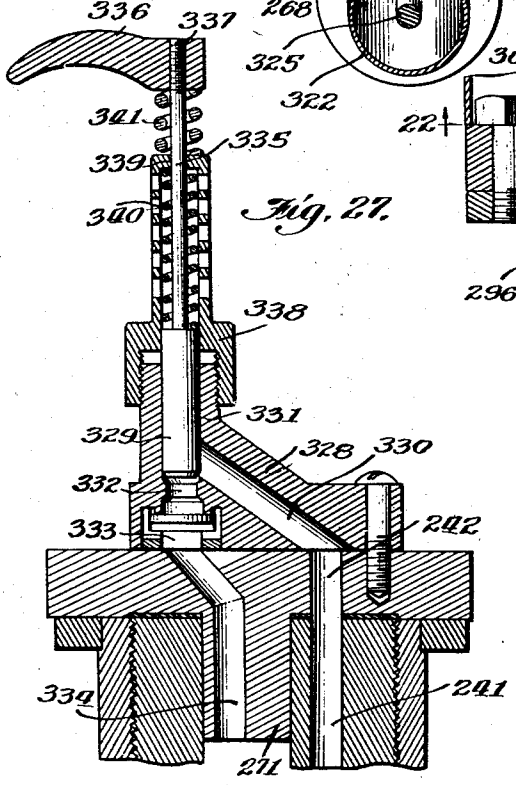


Fig. 27.



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UNITED STATES PATENT OFFICE

WILLIAM LUXMORE, OF CHICAGO, ILLINOIS

INTERNAL-COMBUSTION ENGINE

Application filed March 26, 1928. Serial No. 264,843.

The present invention relates to internal combustion engines and is more particularly concerned with engines adapted to actuate power hammers or the like.

The power hammers now generally used for riveting by structural iron and steel workers or for pavement work, are usually actuated by compressed air.

To operate one or more of such air hammers, it is necessary to provide auxiliary equipment consisting of a compressor, a prime mover, a tank and a plurality of high pressure hose connections. Such auxiliary equipment is generally of sufficient capacity to operate all of the hammers on a particular job, and in fact a whole truck load of auxiliary equipment is necessary to keep one or more hammers in operation.

If but one or two hammers are required on the job, it is nevertheless necessary to transport the whole truck of equipment and to operate the large compressor at an extremely low efficiency. Also the initial cost and the maintenance of such auxiliary equipment is expensive and this of course greatly increases the cost and maintenance per hammer.

The high pressure hose connections are also expensive to maintain and a source of constant trouble.

One of the objects of the present invention is the elimination of the foregoing difficulties and others by the provision of a power hammer actuated by an independent internal combustion device which requires a minimum of auxiliary equipment.

Another object of the invention is the provision of a novel and simple reciprocating internal combustion engine which may be used for many different purposes.

Another object of the invention is the provision of an internal combustion power hammer which is light, compact, easy to manufacture and assemble, economical of fuel and which may therefore be used at a high efficiency wherever power hammers are now employed.

Another object of the invention is the provision of an internal combustion power hammer having a minimum of moving parts, including a cylinder and a piston which is adapted to be reciprocated by the expansive action of gases and which does not require any of the mechanism usually employed to actuate valves and to return the piston to compression, such as fly wheels, crank shafts, cams, connecting rods, springs, etc.

Another object of the invention is the provision of a novel internal combustion engine in which all of the moving parts such as pistons, valves and ignition devices are controlled by the condition of gases within the cylinder, thereby eliminating all other connecting mechanism and greatly reducing the number of moving parts.

Another object of the invention is the provision of an improved commercial form of the internal combustion power hammer shown in my prior application, Serial No. 326,609, filed September 26, 1919, of which this application is a continuation in part.

Another object of the invention is the provision of a novel tool holding mechanism for power hammers, which enables quick substitution of other tools in the hammer by simply pulling out the tool in use and shoving in another tool.

Another object of the invention is the provision of a novel hammer mechanism whereby the force of the blow may be determined by the relative position of the tool in the power hammer which is in turn controlled by the force exerted on the handle of the power hammer by the operator.

Another object of the invention is the provision of novel valve and ignition devices for internal combustion engines, and novel control mechanism for internal combustion power hammers.

Other objects and advantages of my invention will be apparent from the following description and accompanying drawings, in which similar characters of reference indicate similar parts throughout the several views.

Referring to the eight sheets of drawings accompanying this specification, Fig. 1 is a side elevational view of my internal combustion power hammer;

Fig. 2 is an elevational cross-sectional view

taken on the line 2—2 of Fig. 1, looking in the direction of the arrows;

Fig. 3 is a similar cross-sectional view taken on the line 3—3 of Fig. 1, looking in the direction of the arrows;

Fig. 4 is an enlarged detail cross-sectional view of the handle and of the power hammer, taken on the line 4—4 of Fig. 18, looking in the direction of the arrows;

Fig. 5 is a similar view omitting portions of the handle and taken on the line 5—5 of Fig. 2;

Fig. 6 is an enlarged detail view of the opposite end of the power hammer, taken on the line 6—6 of Fig. 2;

Fig. 7 is an elevational cross-sectional view taken on the line 7—7 of Fig. 6, looking in the direction of the arrows;

Fig. 8 is a view in perspective of the sealing rings employed about the tool shank;

Fig. 9 is an elevational view of the stop member employed in the valves;

Fig. 10 is a top plan view of the stop member;

Fig. 11 is a view in perspective of the valve disc;

Fig. 12 is an elevational medial cross-sectional view of the valve seat member;

Fig. 13 is a top plan view of the valve seat member;

Fig. 14 is an elevational cross-sectional view taken on the line 14—14 of Fig. 1, looking in the direction of the arrows;

Fig. 15 is a similar view taken upon the same line 15—15, looking in the direction of the arrows;

Fig. 16 is a diagrammatic view of the wiring diagram for the ignition circuits;

Fig. 17 is an elevational view taken from the handle end and looking toward the opposite end of the hammer;

Fig. 18 is an elevational cross-sectional view taken on the line 18—18 of Fig. 4, looking in the direction of the arrows;

Fig. 19 is a cross-sectional view of the handle and throttle lever taken on the line 19—19 of Fig. 4, looking in the direction of the arrows;

Fig. 20 is a side elevational view of a modified form of power hammer including starting mechanism which may be used for large power hammers;

Fig. 21 is a medial cross-sectional view taken on the line 21—21 of Fig. 20, looking in the direction of the arrows;

Fig. 22 is a bottom plan view of the starting valve mechanism taken on the line 22—22 of Fig. 21 looking in the direction of the arrows;

Fig. 23 is a cross-sectional view of the same mechanism taken on the line 23—23 of Fig. 22, looking in the direction of the arrows;

Fig. 24 is a side elevational view of the same mechanism, looking in the direction of the arrow 24 in Fig. 22;

Fig. 25 is a top plan view partially broken away to show the lubricating means and taken on the line 25—25 of Fig. 21, looking in the direction of the arrows;

Fig. 26 is a cross-sectional elevational view of the ignition mechanism and intake valve taken on the line 26—26 of Fig. 25, looking in the direction of the arrows; and

Fig. 27 is a medial cross-sectional view of the throttling mechanism, taken on the line 27—27 of Fig. 25, looking in the direction of the arrows.

It should be noted here that my internal combustion engine will operate upon almost any type of fuel gas, including gasoline, and other vapors formed by carburetion, illumination gas, natural gas, etc.

Referring to Figs. 1 to 6, 30 indicates in its entirety my internal combustion power hammer, which consists essentially of a cylinder 31, a piston 32, a tool 33, inlet valve means 34, check valves 35 and 36, an ignition switch 37 and a spark plug 38, all of which are intended to be indicated in their entirety by the foregoing numerals.

The cylinder 31 comprises a cast metal member having an accurately machined bore 39 which is closed at one end by a handle casting or cylinder head 40. The cylinder casting is provided with the usual cast metal fins 41 for increasing the radiation surface and is formed at its upper end with an L-head 42 providing a chamber 43 serving both for the purpose of an intake conduit and a part of the combustion chamber.

The cylinder casting 31 is preferably provided with conduits 44 and 45 formed within the cast metal walls of the cylinder and adapted to be used as intake and charge transfer conduits respectively in the operation of the internal combustion engine. Both the conduits 44 and 45 terminate at points 46 and 47 substantially above the lower end 48 of the cylinder 31 forming, with the tool shank 49 (further to be described) a closed chamber 50 which is adapted to entrap gases below the piston and to return the piston to compression position.

The intake conduit 44 which communicates with the cylinder at 46 is provided with a counter-bore 51 for the purpose of receiving the component parts of an intake valve indicated in its entirety at 34. The intake valve 34 may consist of a stop member 52 having a substantially circular base 53 with a central aperture 54 which registers with the conduit 46.

Projecting upwardly from the base 53 of the stop member are a plurality of spacing members 55 separated by slots 56. The spacing members 55 may be formed by slotting a cylindrical sleeve at the points 56, leaving the spacing members 55 upon the base member 53. Extending above the base of the slots 56 at each spacing member 55, is a substan-

tially triangular stop member 57 which is adapted to provide a support for a helical spring 58 and to form radial passages 59 below said stop members 57 and below a valve disc 60 even when the valve disc is in contact with the upper edge of the stop members. It will also be observed that the slots 56 provide longitudinal passages from the passages 59 about the edge of the valve disc 60 in any position of the valve disc.

The helical spring 58 may be constructed of any resilient metal such as steel or phosphor-bronze, while the valve disc 60 may consist of an extremely thin sheet metal member preferably of circular form and of a size adapted to fit loosely within the spacing members 55.

The valve seat member 61 comprises an annular metal member having a central aperture 62 bounded by a valve seat 63 having an upper flat surface adapted to cooperate with the valve disc 60 to close the aperture 62. The border of the valve seat member 61 is threaded as at 64 to fit within the threaded counter-bore 65 and the seat member is also provided with one or more kerfs 66.

The assembly of the valve members is as follows. The counter-bore 51 is adapted to receive the stop member 52 which fits closely in said counter-bore, the aperture 54 registering with the conduit 46. The spring 58 may be placed upon the stop members 57 and the valve disc 60 upon the spring, slightly compressing the spring.

Above the counter-bore 51 is an enlarged counter-bore 65 which is threaded to receive the valve seat member 61, which is threaded in until it engages the spacing members 55 and the valve seat 63 engages the valve disc 60. The upper edge of the valve seat member 61 should preferably not project substantially into the conduit 44. The open end of the threaded counter-bore 65 may then be closed by an ordinary screw plug having a threaded bottom 67 and a non-circular cap 68.

I desire it to be understood that my valves may be employed with or without the springs 58 and in another embodiment I have illustrated the valves without springs. The valve disc 60 may be made so thin and light that it will be quickly forced to its seat by the pressure of the gases within the cylinder or other chambers with which the valve communicates.

Referring to the valve 35, it will be observed that this valve is of similar construction with the exception that the valve seat member 61 is made without a threaded outer surface and adapted to fit snugly in the counter-bore 69. At the same time the base 53 of the stop member 52 is provided with a threaded outer surface 70 and with a kerf 71 so that the stop member 52 may be threaded into the enlarged threaded counter-bore 72 above the spring 73, valve disc 74 and valve seat member 61.

It will thus be observed that the check valve 35 is of similar construction to the intake valve 34 except that the valve disc 74 is adapted to seat in the opposite direction. The enlarged counter-bore 72 is likewise closed with a threaded plug 75.

At the upper end of the cylinder casting 31, the intake conduit 44 registers with an intake conduit 76 in the cylinder head which communicates with a lubrication conduit 77 and an intake conduit 78 extending across within the cylinder head and out of the lower portion of the handle. The conduit 78 is obstructed at 79 by the valve of a throttle mechanism (further to be described) and extends to a threaded outlet 80 which is in communication with a hose or other conduit 81 leading to a supply of gaseous fuel and air.

At the upper end of the cylinder casting 31, the conduit 45 is provided with a counter-bore 82 which is adapted to receive a check valve 36 similar in all respects to the check valve 35 already described.

The conduit 45 is in communication through the check valve 36 with the combustion chamber 43, permitting the flow of gases only in the direction of intake.

At the upper end of the cylinder casting 31 and about the L-head 42 there is provided an attaching flange 83 having a plurality of apertures for reception of bolts 84 for securing the cylinder head casting 40. The cylinder bore 39 may also be provided with a counter-bore 85 at its upper end for the reception of an aligning flange 86 of substantially cylindrical form, carried by the cylinder head casting 40 and adapted to fit within the counter-bore 85. The aligning flange 86 is cut away at one side 87 adjacent the L-head 42 and L-head chamber 43 to permit communication between this chamber and the cylinder bore 39.

The usual gasket 88 is interposed between the cylinder head 40 and the attachment flange 83 of the cylinder.

The cylinder head or handle casting 40 comprises a cast metal member provided with the conduits 76, 77 and 78 already described and formed with a hollow handle 89 adapted to enclose a lubrication device indicated in its entirety at 90 and control mechanism indicated at 91. The cylinder head casting is formed with a flat attachment flange 92 adapted to fit against the attachment flange 83 of the cylinder and with the aligning flange 86 previously described.

At the upper side of the handle there is provided a lubrication device comprising a chamber 93 for the lubricant and the chamber 93 may be formed with an open end 94 adapted to be closed by the flange 83 on the cylinder. The outer wall of the chamber 93 is provided with a threaded bore 95 adapted to

receive a valve plug. The valve plug consists of a threaded member having a stop flange 97 and an upper threaded portion for receiving an enclosing cap 99 having an air hole 100.

The valve plug 96 is also provided with a bore 101 adapted to be closed by a conical valve 102 carried by a stem 103 of smaller size than the bore 101. The bore 101 communicates with a counter-bore 104, forming a shoulder upon which rests a helical spring 105 arranged about the stem 103 and engaging the adjustable head 106 at the top of the stem 103. The spring 105 biases the valve 102 to closed position, but when a condition of sub-atmospheric pressure exists within the chamber 93, the valve 102 is actuated to open position, permitting the ingress of air and likewise permitting lubricant to pass out of an aperture 107 into the conduit 77.

It will thus be observed that since the lubricant reservoir 93 communicates with the intake conduit 44, a small quantity of lubricant will be sucked into the intake conduit and thence into the cylinder to which it is carried in a state of suspension during each intake of the internal combustion engine.

In order that the lubricant 108 may not all run into the conduit 77 during the filling of chamber 93, I provide a valve plug 109 between the chamber 93 and the conduit 77 and the valve plug 109 is provided with an aperture 107 closed by a conical valve 110.

The conical valve 110 is carried by a stem 111 which supports a spider 112 at its upper end and a spring 113 about the stem 111 is tensioned between the spider 112 and the plug 109. The spider 112 is provided with a plurality of legs 114 engaging the upper valve plug 96 in such manner that although the spring 113 biases the valve 110 to closed position, the legs 114 of the spider 112 engage the plug 96 and hold the valve 110 open whenever the upper valve plug 96 is in its proper position. But when the upper valve plug 96 is removed in order to fill the chamber 93, the valve 110 is immediately closed by the spring 113, thereby preventing flow of the lubricant into the intake conduit during the filling operation.

The cylinder head 40 is provided with a pair of threaded bores 115 and 116 adapted to receive the spark plug 38 and a pressure responsive ignition switch 37. In the present instance, the spark plug 38 is located within the bore 115, extending into the chamber 43 of the L-head, while the pressure responsive switch is located in the bore 116 substantially at the center of the end of the cylinder, but the location of these parts may be reversed if desired.

The spark plug 38 may be of any conventional type but is preferably small in size so as not to require too much space within the opening 117 of the handle. The ignition device 37 comprises a plug member 118 having a threaded portion 119 adapted to be received in the bore 116, and also having a stop flange 120.

The stop flange 120 supports by a pair of screw bolts 121, a sheet metal bridge 122 having a threaded aperture adapted to receive a threaded adjustment screw 124.

The adjustment screw is provided with a central aperture adapted to slidably receive the contact stem 125 which carries at its inner end, a pressure disc 126 and which has a helical spring 127 compressed between said disc and the adjustment screw 124. The plug 118 is provided with an inwardly projecting valve seat 128 having a flat seating surface adapted to cooperate with the pressure disc 126 to substantially close the central bore 129 in the plug 118.

The threaded bore 116 preferably terminates on the interior of the cylinder in a smooth counter-bore 130 in which the pressure disc 126 is adapted to slide like a piston, the difference in pressure between that within the cylinder and that without the cylinder being adapted to actuate the disc to close the ignition switch.

The plug 118 also supports by its annular flange 120 an insulating plate 131 carried by a pair of bolts 132 threaded into apertures in the flange 120. The insulating plate 131 comprises a flat plate of fiber board or other insulating material such as bakelite, having a pair of apertures adapted to receive the bolts 132 and secured to said bolts by a pair of nuts 133.

The insulating plate is also provided with an aperture for supporting a screw bolt 134 which carries a resilient sheet metal contact 135 immediately above the contact stem 125. The relation of the parts should be such that the stem 125 contacts with the insulated contact 135 before the pressure disc 126 engages the seat 128 and the resilience of the contact 135 permits engagement of the pressure disc with its seat. The compression of the spring 127 may be varied by the position of the adjustment screw 124 and the positon of the pressure disc 126 may be varied by adjusting a nut threaded on the stem 125.

In order to protect the hand of the operator from the electrical shocks, the spark plug 38 and ignition switch 37 are covered by a cup-shaped insulating cover member 137 secured to the cylinder head 40 by a plurality of screws passing through an attachment flange 138 into said cylinder head. The cover member 137 may be constructed of molded bakelite and is provided with a plurality of apertures 139 for ventilation and for passage of electrical conductors.

The cover 137 is cut away as at 140 to fit the exterior contour of the conduit 78.

The control mechanism 91 comprises a switch 141 and the throttle valve 79 which are

so inter-related that the switch 141 is closed and held in closed position while the throttle is simultaneously opened to the idling position. The switch 141 comprises a lever 142 which may consist of a pair of sheet metal plates secured together by a rivet 143 and pivotally supported upon a pin 144 passing through said lever and riveted in the opposite sides of the hollow handle as at 145. On each side of the lever 142 the pin 144 carries a spacing sleeve 146 adapted to keep the lever 142 in a central position and the handle is provided with a slot 147 through which the lever projects.

At the upper end the sheet metal plates of which the lever 142 is constructed, may be provided with an offset 148 and a parallel flange 149, each flange being provided with an aperture 150 adapted to receive the trunnion 151 of a pivot block 152. The pivot block 152 is provided with a transverse threaded bore 153 adapted to receive the threaded stem of a contact screw 154, said stem being provided with a thumb-piece 155 secured at its upper end and a set screw 156 for securing it within the pivot block 152.

A coil spring 157 has one end 158 secured in the pivot block 152 and after a plurality of turns about said pivot block, the opposite end is caught beneath the lever 142 as at 159 biasing the pivot block in a clockwise direction. Movement in this direction is however limited by engagement of the thumb-piece 155 with the lever 142.

Supported between the opposite walls of the hollow handle 89 is an insulated contact pin 160 surrounds at each end by an insulating sleeve and washer 161 and secured by a pair of nuts 162. The inner end of the contact bolt 141 is provided with a head 163 having a shoulder 164 which is adapted to hook behind the pin 160 effecting an electrical connection therewith and latching said contact bolt in closed circuit position. In this position the spring 157 will hold the contact bolt 141 against the contact pin 160 and the switch will be held in contacting position although the thumb is removed from the thumb-piece 155. It should be observed, however, that the thumb-piece 155 may be pressed in farther,—causing the contact bolt 141 to slide along against the contact pin 160, but maintaining a closed ignition circuit.

If necessary, the inner wall of the handle may be removed as at 165 to permit a greater range of opening for the throttle.

The conduit 78 is provided at the point 79 with a throttle which may be constructed as follows. The conduit 78 may have in its exterior wall a threaded bore 166 adapted to receive a threaded sleeve 167 having a sealing flange 168 and a central bore 169. The sleeve 167 is threaded into the bore 166 with a gasket 170 below the flange 168 to effect a gas-tight joint and the outer end of the sleeve is closed by a threaded plug 171 having a non-circular top 172 engaging a gasket 173.

The inner wall of the conduit 78 between said conduit and the hollow chamber 174 of the handle is provided with an aperture 175 communicating with a threaded counter-bore 176. The inner wall of the chamber 174 is also provided with a guide lug 177 having an aperture 178 aligned with the aperture 175, and these two apertures slidably receive the stem 179 of a piston valve 79.

In order to form a tight joint about the valve stem 179, a packing 180 may be provided in the counter-bore 176, said packing being compressed by a gland 181. The upper end of the stem 179 is threaded and provided with an adjustable cap nut 182 and a helical spring 183 is compressed between said cap nut and the lug 177, holding the piston valve 79 in its upper or closed position.

The lever 91 is provided with a bell crank extension 184 having a depression 185 adapted to receive the cap nut 182, and it will be evident that when the lever 91 is rotated in a counter-clockwise direction, the spring 183 will be compressed and the valve stem 179 will slide downward, moving the piston 79 below the apertures 186 in the sleeve 167 and opening the valve.

At an intermediate point between the cylinder head 40 and the intake port 46, the cylinder 31 is provided with one or more exhaust ports 187 comprising apertures in the wall of the cylinder, preferably round for convenience in drilling, and adapted to permit the exhaust gases to escape after the piston 32 has been moved by the explosion and expansion of the gases to a point where the piston uncovers the exhaust ports 187. The exact location of the exhaust ports may be varied, but the proportions shown in the drawings have been found to give good results.

The piston 32 comprises a substantially cylindrical member accurately machined to fit within the bore 39 of the cylinder and the piston may be provided with a plurality of circumferential oil grooves 188 and with the conventional piston rings if desired (as shown in Fig. 21). The end of the piston toward the tool 33 is preferably formed with a reduced portion 189 in order that the piston may operate efficiently, although its end may be slightly mushroomed by impact with the tool 33.

The end 48 of the cylinder 31 is provided with a reduced bore 190 which is adapted to slidably receive the shank 49 of a tool 33. The reduced bore 190 communicates at its opposite end with a counter-bore 192 forming an annular chamber 193 adapted to receive a plurality of split steel rings 194 which fit about the shank 49 and prevent leakage of the gases from the end of the cylinder about said shank. The split rings 194 are

preferably stamped from sheet metal in order to decrease the cost of manufacture and a greater number of rings may be employed if necessary, to effect a gas-tight joint about the shank 49. The rings 194 are of course arranged with the severed ends 195 staggered so as to reduce leakage, and the rings resiliently engage the shank of the tool.

The counter-bore 192 communicates with a threaded counter-bore 196 which is adapted to receive the threaded end 197 of tool holder 198. The tool holder 198 comprises a metal member having a cylindrical body 199 which carries at one end the reduced threaded portion 197 already described. The end of the cylinder casting 31 terminates in a flat seat 200 which is adapted to fit closely against a similar seat 201 located upon the tool holder 198 between the threaded portion 197 and the cylindrical body 199 and if desired, suitable gaskets may be interposed between the surfaces 200 and 201.

The length of the reduced threaded portion 197 is preferably such that the split rings 194 are close together when these elements are in assembled relation.

At its inner end, the tool holder 198 is provided with an accurately machined bore 202 which is adapted to slidably receive the shank 49 of the tool 33 and the bore 202 communicates with a counter-bore 203 which, together with the shank 49, forms an annular chamber 204 adapted to receive a helical spring 205 coiled about the shank 49 and bearing against a shoulder 206 at the upper end of said chamber. The tool 33 may have its head 207 formed in any conventional manner, such as a rivet set 208 as shown, a chisel, etc., and the head 207 is provided with a substantially cylindrical shank 49.

At a point intermediate the shank 49 and the head 207, preferably at the end of the counter-bore 203 when the shank is in the position shown in Fig. 6, the tool 33 is provided with a retaining member 209 preferably formed as an annular ring projecting from the shank 49, having a cylindrical surface 210 adapted to fit within the counter-bore 203. Extending from the inner edge of the cylindrical surface 210 is a substantially frustro-conical camming surface 211 terminating in a flat annular shoulder 212 which confines the spring 205 within the chamber 204. Extending from the outer edge of the cylindrical surface 210 is a similar frustro-conical camming surface 213 which terminates in a cylindrical surface 214 which may be larger than the shank 49.

The tool holder 198 is provided at a medial point in its length with an annular groove 215 preferably extending completely around the tool holder and adapted to receive an inwardly turned flange 216 upon a resilient collar 217.

The resilient collar 217 comprises a resilient sheet metal sleeve which is split from end to end as at 218 and tapered toward the end of the tool holder to provide a finished appearance. At one end the sleeve is provided with the inwardly projecting flange 216 and at the opposite end with an inwardly projecting flange 219 covering the end of the tool holder.

The flange 219 supports an inwardly tapering frustro-conical flange 220 which in turn carries an outwardly tapering frustro-conical flange 221. The resilient sleeve 217 is also provided with a plurality of slots 222 extending for a sufficient distance along the length of the sleeve to form a plurality of resilient fingers 223 having the frustro-conical camming surface 223 and 221 at their outer ends.

It will thus be observed that the tool 33 is held in the tool holder by engagement of the frustro-conical surface 220 on the fingers 223 with the camming surface 213 on the shank of the tool, but the tool may easily be removed by seizing the head 207 and pulling, whereupon the surface 213 will cam the fingers 223 outward, permitting removal of the tool. The spring 205 will be retained within the chamber 204 by the resilient fingers 223.

When the operator desires to change tools, he may remove the tool then in the holder by the method already described and the new tool may have its shank 49 inserted between the resilient fingers 223 into the bore 202 and the camming surface 211 will force the resilient fingers 223 apart until the cylindrical surface 209 has passed them, whereupon the fingers will again spring together, behind the surface 213 to retain the tool in proper position.

The spring 205 is under very little or no tension in the position shown in Fig. 6 so that the heavy spring does not force the tool out of the tool holder. When the power hammer is idling, the tool may be in the position of Fig. 6, but when the head 207 of the tool is pressed against the surface of the work, force exerted upon the handle of the hammer will cause the tool 33 to slide inward in its tool holder, projecting the shank 49 into the cylinder bore 39.

During this movement of the tool in the tool holder the resilient fingers 223 will slide on the cylindrical surface 214 and the spring 205 will resist inward movement of the shank. The amount of projection of the shank into the cylinder bore 39 will therefore depend upon the force exerted on the handle, and I am able to control the force of the blows delivered by the piston 32 to the tool 33 by projecting the shank of the tool to a greater or lesser distance into the cylinder bore as will be further described.

Referring to Fig. 16, I have here shown a conventional diagram for the ignition circuit

which may be described as follows. The coil 224 is the primary coil of an ignition transformer having a resilient armature 225 and a fixed contact 226. The coil 227 is the secondary or high tension coil and a source of electromotive force is indicated at 228. One end of the high tension coil 227 is connected by a conductor 229 to the central contact 230 of the spark plug 38, while the opposite end of the high tension coil is grounded by conductor 231 and conductor 142 to the frame of the hammer.

The movable contact 141 of the control switch is connected to the resilient contact 135 of the ignition switch. The movable contact stem 125 of the ignition switch is grounded to the frame of the hammer, being supported by metallic parts thereon. The one end of the low tension or primary coil 224 is connected by a conductor 233 to one pole of the battery 228 and the opposite pole of the battery 228 is connected by a conductor 234 to the fixed contact 160 of the control switch. The other end of the primary coil is connected to the armature 225.

The operation of such an ignition system is well known to those skilled in the art and forms no part of the present invention. It will be obvious that when the control switch 160, 141 is closed, the primary coil circuit will be under control of the ignition switch 135, 136 and closing of the latter contacts will cause the armature to buzz and generate high tension current in the coil 227, causing a spark to jump across the contacts of the spark plug 38.

The ignition coil and source of electromotive force are preferably located at a point remote from the power hammer so that only three conductors 229, 142 and 232 are required to establish communication between the ignition devices and the hammer. These conductors may be suitably concealed within the handle 89 from which they may pass through an insulated bushing 235 with a protective covering 236 about the conductors outside the power hammer.

The assembly of the foregoing parts will be obvious to those skilled in the art. The operation of my power hammer is as follows.

The power hammer must, of course, be supplied with an ignition device connected through the conductors 229, 142 and 234 and with a source of fuel and air supplied through the conduit 81. In order to start the hammer, the operator presses upon the thumb-piece 155, closing the ignition circuit at the control switch. The hammer then being held with its tool downward, the piston 32 will be at the bottom of the cylinder bore 39 adjacent the tool shank 49. If the tool end of the power hammer is then tilted upward, the piston 32 will fall by gravity to the handle end of the cylinder, creating a suction in the cylinder between the piston and the tool. This will suck in a charge of fuel through the conduits 81, 78 and 44 past the intake valve 34 which permits the charge to go into the cylinder, but prevents its return. If the power hammer is then again tilted with the tool end downward, the piston 32 will fall by gravity toward the tool 33, compressing the charge below the piston and forcing it through the check valve 35 into the conduit 45 past the check valve 36 into the upper end of the cylinder.

If the hammer is now again tilted with its tool upward, the piston will fall by gravity, compressing the charge in the combustion chamber, the conduit 45 being closed by the check valves 35 and 36. Compression of the charge in the combustion chamber will cause the gases to react against the pressure disc 126 of the ignition switch, bringing the contacts 135 and 125 together to close the ignition circuit, whereupon a spark will pass between the contacts of the spark plug, igniting the charge.

It should be noted that during this latter movement of the piston toward the piston head, a new charge has been sucked in through the intake valve 34. The explosion and expansion of the gases will impel the piston toward the tool end of the hammer with considerable force, but as the piston passes the transfer port 47, gases will be trapped between the piston and the tool shank in the chamber 50 and the compression of these gases will bring the piston to a stop and return the piston to the compression position.

During the movement of the piston toward the tool end of the hammer, the new charge is again forced through the conduit 45 into the combustion chamber and when the piston has passed the exhaust ports 187, the exhaust gases are permitted to escape, their discharge being aided by the forcing in of a new charge from the top of the combustion chamber.

This cycle will be repeated indefinitely and when the tool is in the position shown in Fig. 6, the piston will idle back and forth without impact upon the tool, being impelled in both directions by the action of the gases within the cylinder.

When it is desired to use the power hammer, the tool head 207 may be pressed against the working surface, compressing the spring 205 and projecting the shank 49 into the cylinder bore 39. This will cause the piston 32 to come into impact with the shank 49 of the tool and the force of the blow delivered varies with the amount of projection of the shank into the cylinder bore. Accordingly, if it is desired to give the tool harder blows, a greater force may be exerted upon the handle, compressing the spring 205 farther and projecting the shank 49 farther into the cylinder bore.

It should be noted that when this occurs, there is still an annular gas trapping space

about the inner end of the shank 49 and the gas trapped in this space is adapted to return the piston 32 to compression position.

The speed at which the piston 32 operates depends upon the amount of fuel supplied and the throttle lever 91 may be pressed in a counter-clockwise direction, opening the throttle valve 79 to a greater extent and increasing both the speed and power of the hammer. During the operation of the power hammer, lubricant is supplied from the reservoir 90 by means of the suction generated in the intake conduits and this lubricant is carried in a state of suspension into the cylinder.

The employement of the second check valve 36 in the conduit 45 prevents the compression of the charge within the conduit 45 and greatly increases the efficiency of the internal combustion engine. I desire it to be understood, however, that only one check valve may be employed, although it is preferable to increase the size of the conduit 45 and employ a check valve at each end.

It will thus be observed that I have invented a power hammer which has a minimum of moving parts and from which most of the conventional connecting mechanisms have been eliminated. The piston of my power hammer is impelled in both directions by the action of the gases within the cylinder and by means of the resilient tool supported I am enabled to control the force of the impact delivered to the tool by the piston. Many of the parts of the power hammers of the prior art have been eliminated, and their functions performed by a lesser number of reorganized elements, and the small number of moving parts in my power hammer renders it easy to keep in working order.

Referring to Figs. 20 to 27, I have here illustrated a modified form of my power hammer embodying a starting device which may be employed where the power hammer is too heavy to tilt back and forth in the manner previously described.

In this embodiment, the cylinder comprises a metal tube 240 having the charge transfer conduit 241 and the intake conduit 242 formed in its wall. The piston 243 is adapted to reciprocate in the cylinder bore 244 and is provided with piston rings 245 and a reduced hammer end 246.

At the tool end of the piston there is a counterbore 247 adapted to receive packing 248 compressed into place by a gland 249 and the shank 250 of the tool 251 is adapted to be slidably received in the bore 252 of the gland 249 and in the cylinder bore 244. The reduced end 246 of the piston is elongated in order to provide an annular space 253 in which the entrapped gases may be compressed when the piston strikes the shank 250 of the tool.

The end 254 of the cylinder is threaded to receive a sleeve 255 which sleeve is also adapted to engage the gland 249 by means of a shoulder 256 to compress the packing 248. The sleeve 255 is also provided with a smaller bore 257 of sufficient size to receive both the shank 250 and the coil spring 258.

The tool 251 may have its end 259 formed in any convenient manner, the tool illustrated being a chisel and the tool is provided with a cylindrical shank 250 and a transversely projecting annular shoulder 260 adapted to fit within the reduced bore 257 of the sleeve 255. The sleeve 255 is also provided with an inwardly turned flange 261 adapted to engage outside the annular shoulder 260 of the shank to retain the tool within the tool holder and the spring 258 is confined between the shoulder 260 and the gland 249.

The operation of this tool holder and power hammer is exactly as in the preceding case, the impact of the piston upon the tool being increased by pushing the tool against the work, compressing the spring 258 and projecting the shank 250 into the cylinder.

It will be noted from Fig. 6 that the shank 49 of the tool forms one of the movable walls of the fuel gas compression chamber 50. When the parts are in the position of Fig. 6, and the engine is operating, the gas entrapped in the chamber 50 below the port 46 acts to return the piston 32 by compression and rebound, and the engine operates while idling with the tool in the position of Fig. 6, without the piston striking the shank of the tool.

When the end 208 of the tool is brought into engagement with the work and pressure is exerted on the handle of the power hammer, or the power hammer is merely allowed to rest with its own weight supported on the tool, the shank 49 is projected into the gas compression space 50 of the cylinder, shortening the effective length of the cylinder, diminishing the size of the gas compression space 50, and producing the result of bringing the shank 49 into position to be struck by piston 32.

At any particular speed of operation of the piston 32, there is a corresponding point of location of the shank 49 at which the piston 32 will just strike the shank 49 with a light blow, the piston being returned by the gas compressed in the chamber 50 in the annular space surrounding the shank 49. If the shank 49 is projected still farther into chamber 50 by greater pressure on the handle, and compressing the spring 205, the piston 32 will strike a heavier blow against the shank 49 and the gases in the annular space surrounding the shank 49 in the gas compression chamber 50, will be compressed to a lesser extent, since the annular chamber will be longer on account of the insertion of shank 49 to a greater degree.

Under such conditions, the gas in chamber 50 will be compressed to a lesser extent, but the piston will be returned by rebound from

the shank 49 and from the compressed gas in the space 50, and the strength of the blow of the piston on the shank 49 may be very effectively regulated by the pressure on the handle of the hammer, which determines the compression of spring 205 and the projection of shank 49 into the cylinder.

The shank 49 in some measure decreases the length of the cylinder space, but does not change the effective length of the cylinder, since the expansion of the exploded gases has done its work and the gases are passing out of the exhaust ports 107 of Fig. 1, when the piston has passed these exhaust ports and approached the end of the cylinder shown in Fig. 6. The effect of the projection of the shank 49 into space 50 is therefore a bringing of the tool into the range of movement of the piston and a gradual application of the piston force to the tool instead of its application to the compression of gases solely in the space 50.

At its opposite end 262 the cylinder 240 is threaded to receive a threaded sleeve 263 which is also split as at 264 and provided with a bolt 265 passing through one of the split ends 266 of the sleeve and threaded in the other end 267 to clamp the sleeve 263 upon the cylinder 240. The sleeve 263 may carry an attaching flange 268 to which a cylinder head 269 may be secured by a plurality of bolts 270. The cylinder head comprises a cast metal piece having a central cylindrical plug 271 adapted to fit within the cylinder bore 244 and having annular flanges 272 projecting from said plug for attachment to the cylinder 240. The cylinder head 271 is also provided with conduits which will be described hereinafter.

The attaching flange 268 may be extended and bent upward as at 273 on both sides to form a support for a tubular handle 274 formed of a piece of pipe passing through the flanges 273 and riveted or otherwise secured therein.

At a point intermediate the cylinder head 271 and the intake port 275, the cylinder is provided with one or more exhaust apertures 276 as in the previous embodiment. The cylinder 240 is also provided with a threaded aperture 277 adjacent the cylinder head 271 for reception of a spark plug 278 of the usual type.

The cylinder head 271 carries an ignition switch which includes the resilient contact 279 and a stem contact 280.

The resilient contact 279 is insulated from the cylinder head and body of the power hammer by being supported upon an insulating post 281 constructed of bakelite or the like, having a screw bolt 282 molded in its lower end and threaded into the cylinder head 271 and carrying the contact 279 by means of a screw bolt 283 at its upper end. The other contact 280 comprises the stem of a pressure responsive device having a pressure disc 284 at its inner end within the cylinder bore 244 and the stem 280 is slidably supported within the cylinder head 271 as follows.

The cylinder head may be provided with a bore 285 and a counter-bore 286 adapted to receive a valve seat member 287 having an enlarged bore 288 adapted to receive the stem 280 with considerable clearance. The inner end of the valve seat member is provided with a flat annular seat 289 adapted to cooperate with the pressure disc 284 to close the bore 288 which extends to the outside of the cylinder and the valve seat member is also provided with an annular wall 290 surrounding the pressure disc 284 and having a slight clearance with said disc.

The walls 290 are also provided with a plurality of inwardly extending fingers 291 or a flange adapted to retain the disc 284 in the device shown in Fig. 26, but permitting a limited sliding movement of the disc and stem.

At the opposite end the sleeve 292 of the valve seat member is threaded as at 293 to be received in a gland 294 and the valve seat member may be secured on the cylinder head 271 by threading the gland 294 on the sleeve 293 and compressing gaskets 295 in the counter-bores 286 and 296. The threaded end 293 of the sleeve may also support a frame member 297 comprising a substantially U-shaped sheet metal member having threaded bores in each of its legs.

The lower leg is threaded upon the sleeve 293 while the upper leg supports a threaded member 299 having a central bore 300 adapted to slidably receive the stem 280. A spring 301 is compressed between a transverse pin 302 carried by the stem 280 and the threaded member 299. It will thus be observed that the compression of the spring 301 and consequently the pressure at which the ignition switch is actuated, may be adjusted by means of the threaded member 299, this member being secured in place by a lock nut 303. The operation of this ignition switch is exactly the same as in the previous embodiment. The electrical connections in this embodiment may also be made in the same manner.

Supported upon the cylinder head 271 by means of a plurality of screws 304 is a valve block 305 and the valve block 305 is provided with a substantially U-shaped conduit 306 having openings in the bottom of the block with a pair of intake valves 307 and 308. The intake valves 307 and 308 are adapted to seat in opposite directions so as to permit passage of fuel only in the direction shown by the arrow in Fig. 23 and the structure of these valves may be substantially similar to that already described, with the exception that the valve discs 309 do not require springs

to keep them in place when the power hammer is in operation.

At the yoke of the U-shaped conduit 306 it communicates with a smaller conduit 310 and the openings at 307, 308 and 310 register with corresponding openings in the cylinder head 271. Thus the cylinder head is provided with a transverse conduit 311 which terminates in an opening 312 communicating with the check valve 308 and the opposite end of the conduit 311 communicates with an L conduit 313 formed in a conduit block 314 which is secured to the outside of the cylinder head by screws 315.

The conduit block provides means for securing a tube 316 which leads to the source of supply of a mixture of fuel and air. The conduit 310 in the valve block 305 registers with the intake conduit 242 in the wall of the cylinder and with a registering conduit passing through the cylinder head 271. The conduit 310 is also in communication with a pump 317 by means of a conduit 318 in the cylinder head, conduit 319 in an L block 320 and a tube 321 leading to the bottom of the pump.

The pump 317 comprises a cylinder 322 adapted to slidably receive a piston 323 provided with a pair of oppositely directed leather cups 324. The piston 323 is carried by a piston rod 325 having a handle 326. The pump may be supported upon the power hammer by a bracket 327 at the bottom and by the supporting flange 268 at the top.

The piston head also supports a check valve fixture 328 which also carries a throttle 329. The check valve fixture 328 is provided with a transverse conduit 330, communicating with a charge transfer conduit 241 by means of a conduit 242 through the cylinder head. The check valve fixture is provided with a bore 331 slidably supporting a piston 329 which is adapted to close communication between the conduit 330 and a conduit 332 leading to a check valve 333. The check valve 333 communicates with a conduit 334 passing through the cylinder head and leading to the interior of the cylinder 244 above the piston 243.

The piston 329 is provided with a piston rod 335 carrying a finger piece 336 upon its threaded end 337. A threaded cap 338 upon the fixture 328 is provided with a central aperture 339 adapted to guide the piston rod and a coil spring 340 is compressed between the cap and the piston.

A shorter and stronger coil spring 341 is compressed between the thumb-piece 336 and the cap 338 and the relative tensions of the springs are such that the piston 329 is ordinarily maintained in slightly open position permitting flow of sufficient fuel to keep the internal combustion engine idling. The throttle may be closed by pressing down upon the finger piece 336 or opened to speed up the power hammer by pulling upward on the finger piece 336.

The check valve 333 may be similar in construction to those previously described, and it is adapted to permit flow of fuel in one direction only, that is, into the combustion chamber.

The fuel supply is also provided with means for supplying lubricant to the cylinder consisting of an oil cup 342 having an air hole 343 in its cap and having a spring pressed conical valve 344, similar to those already described, in a conduit 345 leading to the fuel supply conduit 306. The oil cup 342 is adapted to permit discharge of a small quantity of lubricant into the intake conduit whenever suction is generated in said conduit in a manner already described.

I desire it to be understood, however, that where a liquid fuel is employed with a carburetor, the lubricant may be mixed with the liquid in proper proportions and vaporized together with the liquid fuel.

The operation of this modified embodiment is as follows.

Assuming the parts to be in the position as shown in Fig. 21 with the handle 274 uppermost, the ignition switch should be turned on and a supply of fuel and air or oxygen provided at the conduit 316. The operator may then grasp the pump handle 326, pulling it upward and pushing it downward again with a very quick motion.

The cycle of events attendant on this pumping operation is as follows.

When the pump piston 323 is pulled upward, suction is created in the pump, drawing in a supply of fuel from the feed supply conduit 316 through conduits 313, 311, valve 308, conduit 306, conduit 310, conduit 318 and conduit 321. During this operation the intake valve 307 is sucked to the closed position as shown in Fig. 23 while the other valve 308 is opened. When the pump piston 323 is again quickly forced down in the pump, the charge of fuel in the pump and conduits is forced outward into the cylinder 240, discharging at the intake port 275 below the piston 243 through the following conduits.

Beginning at the pump 317, fuel passes through conduit 321, conduit 318, conduit 310, conduit 306, intake valve 307, conduit 242 into the cylinder 240.

During this pumping operation the throttle 329 should be open and as the intake port is substantially below the port of the transfer conduit, gases will be trapped below the piston as soon as it gets below the transfer conduit port, preventing the piston from closing the intake port 275. The pressure of fuel below the piston will then raise the piston to a point above the port of the transfer conduit 241 and the charge will pass across the cylinder into the transfer conduit 241 past the throttle 329 through conduit 241

into the cylinder, filling the cylinder and passing out of the exhaust ports 276. When the odor of the fuel charge from the exhaust ports indicates that the cylinder has been charged, the throttle 329 may be closed thereby closing the transfer conduit 350 and preventing further passage of gas into the upper part of the cylinder.

Upon giving the pump handle 326 another downward stroke, a charge of fuel will be forced in below the piston, driving the piston up and compressing the charge above the piston. After the piston has passed the exhaust ports, the charge above the piston will be compressed and the pressure of the compressed charge will actuate the pressure disc 284 closing the contacts in the primary circuit and causing a spark at the spark plug which will ignite the charge and drive the piston downward, at which time the throttle should be opened to permit the new charge to be driven into the upper end of the cylinder through the transfer conduit.

From this point on, the power hammer operates in the same manner as that previously described for the perferred embodiment, but it will be noted that in this case the throttle has been placed in the charge transfer conduit instead of the intake conduit and it is found that the throttle will control the speed and power of the hammer at either of these points.

While I have illustrated a preferred embodiment of my invention, many modifications may be made without departing from the spirit of the invention, and I do not wish to be limited to the precise details of construction set forth, but desire to avail myself of all changes within the scope of the appended claims.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States, is:

1. In an internal combustion engine, the combination of a cylinder having a piston dividing said cylinder into a combustion chamber and a pumping and cushioning chamber, said piston having an explosion stroke and a return stroke, ignition means in said combustion chamber for causing an explosion in the combustion chamber to actuate the piston on the explosion stroke, exhaust means for said combustion chamber, intake means for said pumping and cushioning chamber, means for transferring gas from said pumping and cushioning chamber to said combustion chamber, said gas being supplied with fuel prior to explosion in said combustion chamber, and means for entrapping gas in the cushioning end of said pumping and cushioning chamber at the end of the explosion stroke, whereby said piston compresses said gas and the piston is actuated in the opposite direction by expansion of said gas on the return stroke.

2. In an internal combustion engine the combination of a cylinder having a combustion chamber in one end and having a pumping and cushioning chamber at the other end, a piston slidably engaging the walls of said cylinder, between said combustion chamber and said pumping and cushioning chamber. said piston having an explosion stroke and a return stroke, said cylinder having an exhaust port located intermediate the ends of said cylinder, to be closed by said piston on the return stroke, and opened by said piston after predetermined movement of the piston in the explosion stroke, ignition means in said combustion chamber, intake means associated with said pumping and cushioning chamber whereby gas is taken into the pumping and cushioning chamber on the return stroke, and a gas transfer conduit extending from said pumping and cushioning chamber to said combustion chamber and adapted to effect a transfer of gas from said pumping and cushioning chamber to the combustion chamber on the explosion stroke, and fuel being admitted to the combustion chamber, said piston being driven in one direction by the explosion of the fuel gas caused by said ignition means resulting in the compression of gas in the cushioning end of said pumping and cushioning chamber, and said piston being returned in the opposite direction by the expansion of the gas which was compressed in the cushioning end of the pumping and cushioning chamber.

3. In an internal combustion engine, the combination of a cylinder having a combustion chamber at one end and having a pumping and cushioning chamber at the other end, a piston slidably engaging the walls of said cylinder between said combustion chamber and said pumping and cushioning chamber, said piston having an explosion stroke and a return stroke, said cylinder having an exhaust port located intermediate the ends of said cylinder, to be closed by said piston on the return stroke and to be opened by said piston after predetermined movement of the piston in the explosion stroke to effect exhaust, ignition means in said combustion chamber, said cylinder being provided with an intake port adapted to effect intake into said pumping and cushioning chamber on the return stroke, and a gas transfer conduit extending from said pumping and cushioning chamber to said combustion chamber and adapted to effect a transfer of gas from said pumping and cushioning chamber to the combustion chamber on the explosion stroke, said gas being supplied with fuel prior to its admission into the combustion chamber, said piston being driven in one direction by the explosion of the fuel gas caused by said ignition means, said transfer conduit having its port spaced from the end of said pumping and cushioning chamber, and said piston be-

ing adapted to close said latter port after predetermined movement of the piston in the explosion stroke, whereby gas is compressed in the cushioning end of the pumping and cushioning chamber at the end of the explosion stroke and said piston is returned in the opposite direction on the return stroke by the expansion of the gas compressed in the end of said pumping and cushioning chamber.

4. In an internal combustion engine the combination of a cylinder having a combustion chamber at one end and having a pumping and cushioning chamber at the other end, a piston slidably engaging the walls of said cylinder between said combustion chamber and said pumping and cushioning chamber, said piston having an explosion stroke and a return stroke, said cylinder having an exhaust port located intermediate the ends of said cylinder to be closed by said piston on the return stroke and opened by said piston after predetermined movement of the piston in the explosion stroke, ignition means in said combustion chamber, said cylinder being provided with an intake port adapted to effect intake into said pumping and cushioning chamber on the return stroke, and a gas transfer conduit extending from said pumping and cushioning chamber to said combustion chamber and adapted to effect a transfer of gas from said pumping and cushioning chamber to the combustion chamber on the explosion stroke to supply fuel to the combustion chamber, said piston being driven in one direction by the explosion of the fuel gas caused by said ignition means at predetermined compression, said transfer conduit having its port spaced from the end of said pumping and cushioning chamber, and said piston being adapted to close said latter port in the explosion stroke whereby gas is compressed in the pumping and cushioning chamber at the end of the explosion stroke, and said piston is returned in the opposite direction by the expansion of the gas compressed at the end of the explosion stroke, said ignition means comprising a source of electromotive force, a pair of spaced electrodes, and a pressure responsive electrical switch adapted to control the energization of said electrodes and to effect ignition at predetermined compression.

In witness whereof I hereunto subscribe my name this 17th day of March, 1928.

WILLIAM LUXMORE.