G. J. SPOHRER.

STARTER FOR INTERNAL COMBUSTION ENGINES.

APPLICATION FILED JAN. 12, 1914.

Patented Mar. 16, 1915

5 SHEETS—SHEET 1.

1,132,224.

Fig. 1.

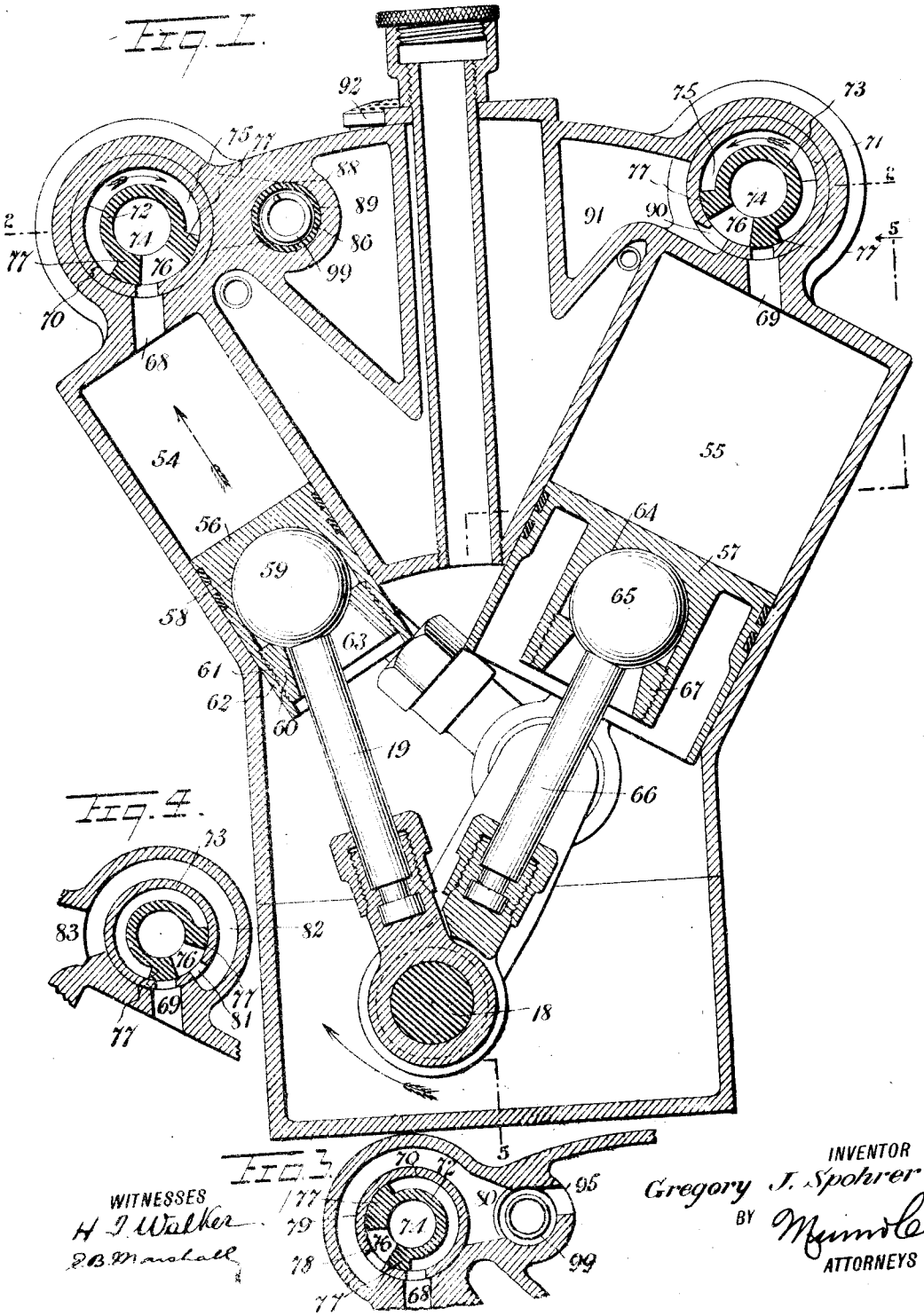


Fig. 4.

Fig. 3.

WITNESSES

H. J. Walker

R. B. Marshall

INVENTOR

Gregory J. Spohrer

BY Munn & Co.

ATTORNEYS

G. J. SPOHRER.

STARTER FOR INTERNAL COMBUSTION ENGINES.

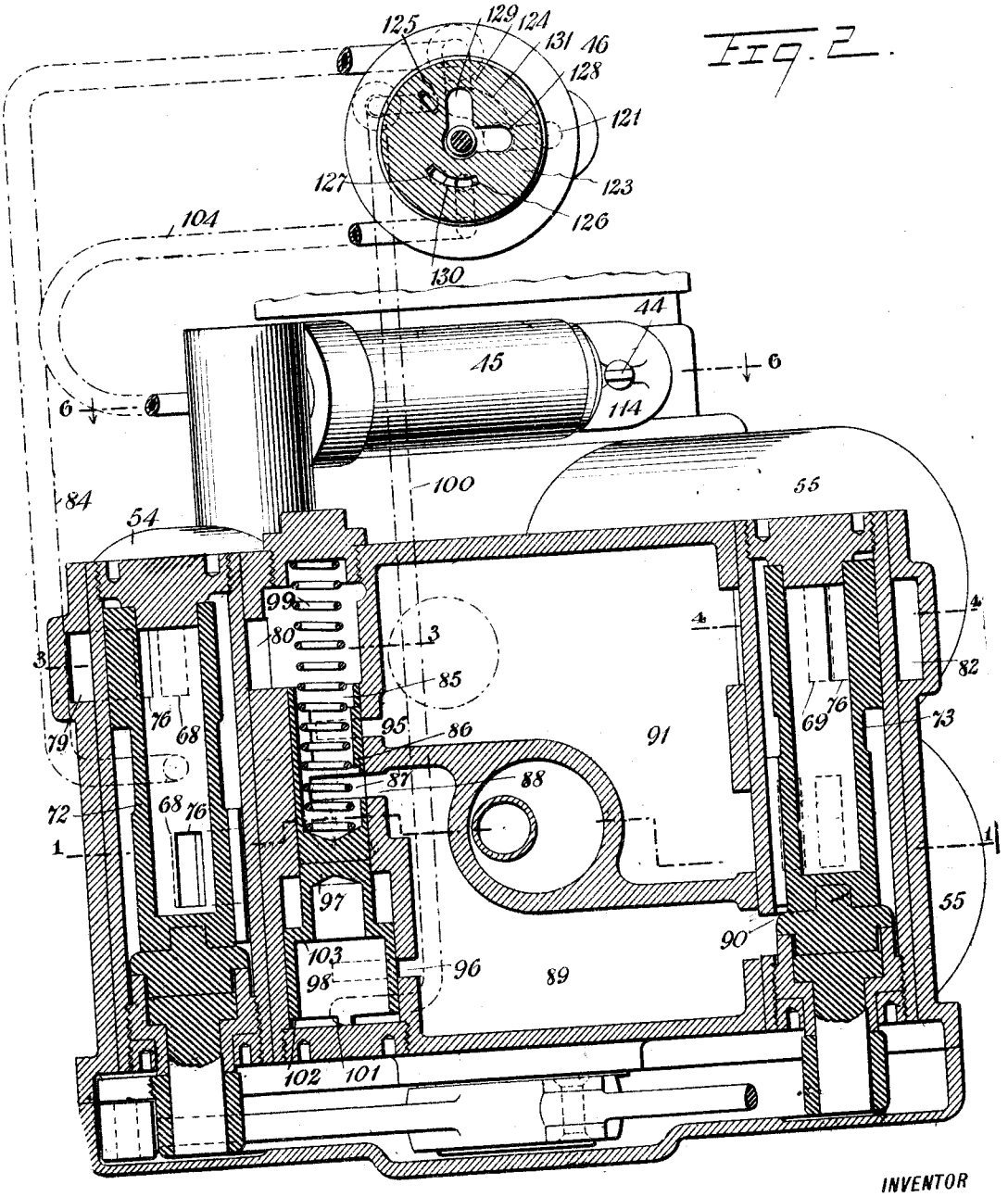
APPLICATION FILED JAN. 12, 1914.

Patented Mar. 16, 1915.

5 SHEETS—SHEET 2.

1,132,224.

Fig. 2.



WITNESSES

H. J. Walker

R. B. Marshall

INVENTOR

Gregory J. Spohrer

BY Munn & Co.

ATTORNEYS

G. J. SPOHRER.

STARTER FOR INTERNAL COMBUSTION ENGINES.

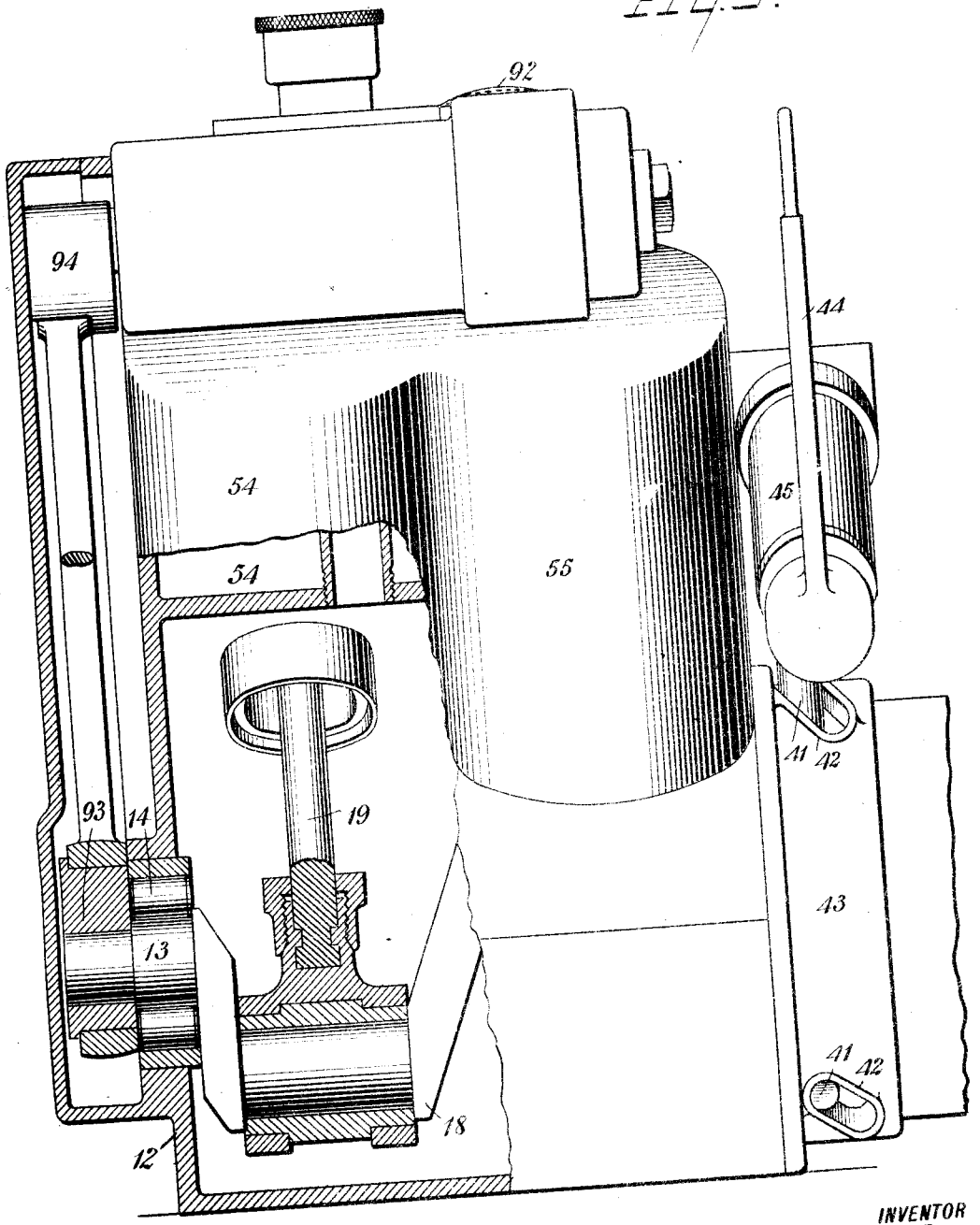
APPLICATION FILED JAN. 12, 1914.

Patented Mar. 16, 1915.

5 SHEETS—SHEET 3.

1,132,224.

Fig. 5.



WITNESSES

H. D. Walker

P. B. Marshall

INVENTOR

Gregory J. Spohrer

BY Munn & Co.

ATTORNEYS

G. J. SPOHRER.

STARTER FOR INTERNAL COMBUSTION ENGINES.

APPLICATION FILED JAN. 12, 1914.

Patented Mar. 16, 1915.

1,132,224.

5 SHEETS—SHEET 4.

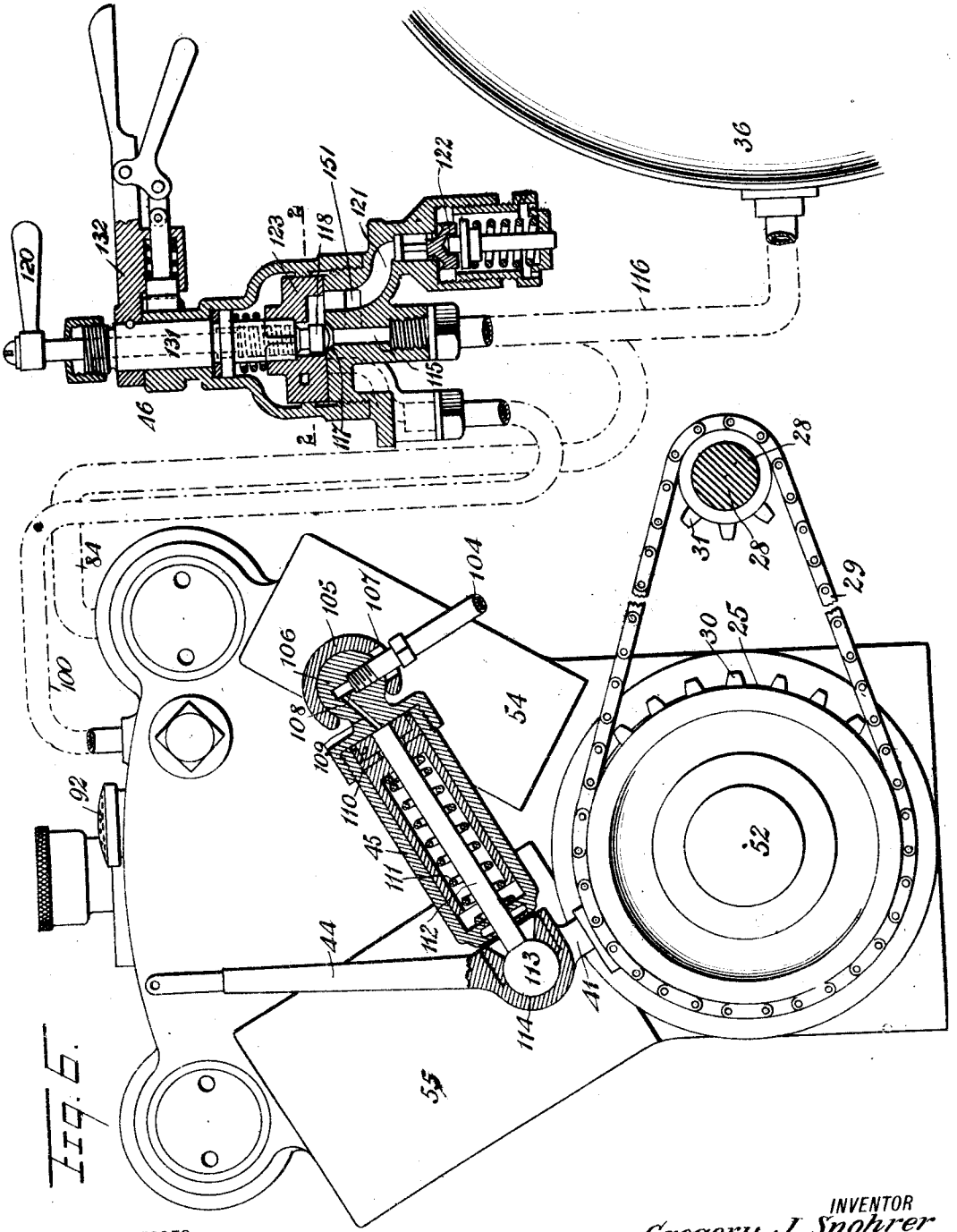


Fig. 5.

WITNESSES

H. J. Walker

E. B. Marshall

INVENTOR

Gregory J. Spohrer

BY Munn & Co.

ATTORNEYS

G. J. SPOHRER.

STARTER FOR INTERNAL COMBUSTION ENGINES.

APPLICATION FILED JAN. 12, 1914.

1,132,224.

Patented **Mar. 16, 1915.**

5 SHEETS—SHEET 5.

Fig. 7.

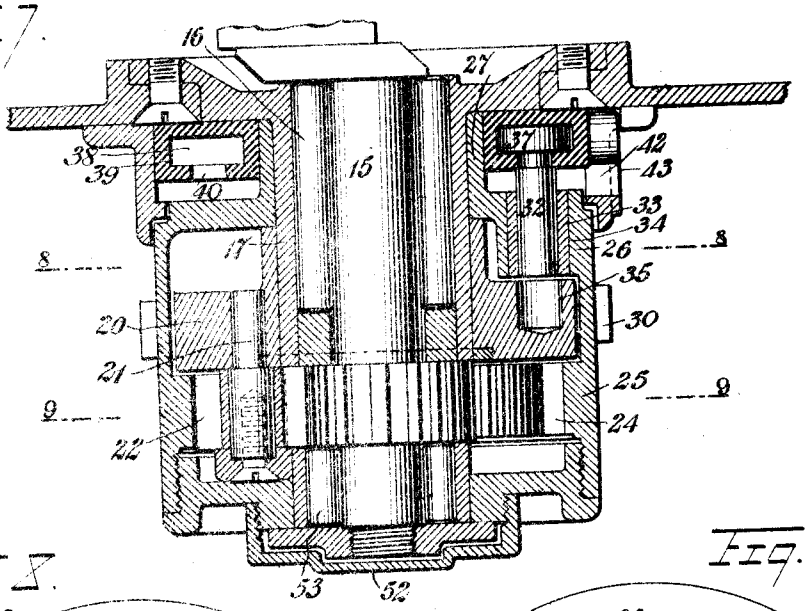


Fig. 8.

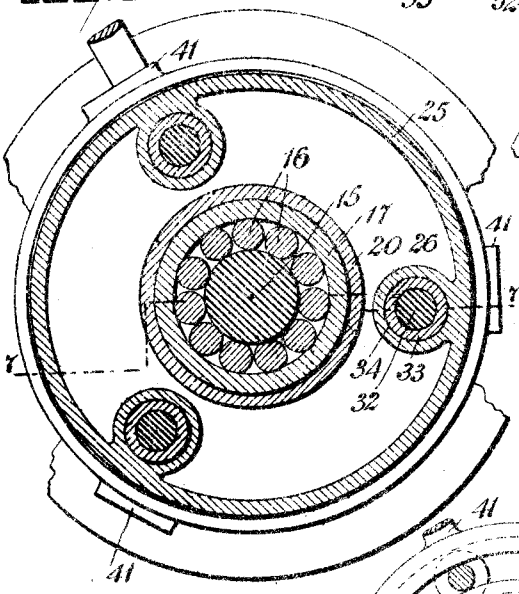
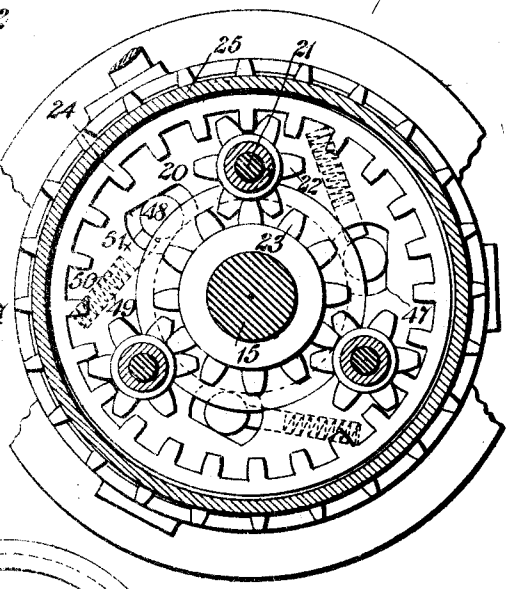


Fig. 9.



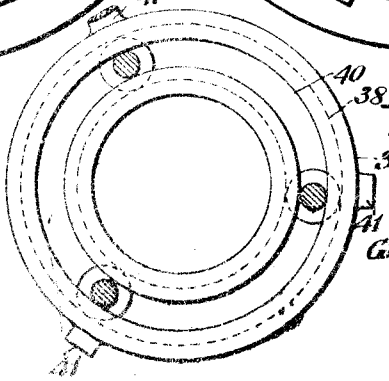


Fig. 10.

WITNESSES

H. J. Walker

E. B. Marshall

INVENTOR

Gregory J. Spohrer

BY Munn & Co.

ATTORNEYS

UNITED STATES PATENT OFFICE.

GREGORY JOHN SPOHRER, OF EAST ORANGE, NEW JERSEY, ASSIGNOR, BY DIRECT AND MESNE ASSIGNMENTS, TO MOTOR COMPRESSOR COMPANY, OF WILMINGTON, DELAWARE, A CORPORATION OF DELAWARE.

STARTER FOR INTERNAL-COMBUSTION ENGINES.

1,132,224. Specification of Letters Patent. **Patented Mar. 16, 1915.**

Application filed January 12, 1914. Serial No. 811,579.

To all whom it may concern:

Be it known that I, GREGORY J. SPOHRER, a citizen of the United States, and a resident of East Orange, in the county of Essex and State of New Jersey, have invented a new and Improved Starter for Internal-Combustion Engines, of which the following is a full, clear, and exact description.

My invention has for its object to provide a starter which may be used on all types of internal combustion engines, but which is particularly useful for starting an automobile engine from the driver's seat of the automobile by means of a master pneumatic valve.

Another object of the invention is to provide a compound motor for rotating the engine shaft for starting the engine, this motor being adapted to be driven by the internal combustion engine for acting as a compound pump to compress air in a tank for use in subsequently starting the engine.

Still another object of the invention is to provide means for conveying the compressed air from the tank directly to all the motor cylinders so that in emergencies and when the greatest power is required, the motor will act as one of a simple type and not as one of a compound type, it being at the same time possible to change the flow of the air while the motor is running, so that the air will exhaust from the high pressure cylinders to the low pressure cylinders and the motor will act as a compound one.

Still another object of the invention is to provide means for driving the shaft of the convertible motor-compressor in one direction from the engine shaft when the latter is rotating in its normal direction and for causing the motor-compressor, when operating as a motor with its shaft rotating in the opposite direction, to drive the engine shaft in the said normal direction.

Still other objects of the invention will appear in the following specification in which the preferred form of my invention is described.

In the drawings similar reference characters refer to similar parts in all the views in which—

Figure 1 is a sectional view on the line 1—1 of Figure 2; Fig. 2 is a sectional plan view on the line 2—2 in Fig. 1; Fig. 3 is a sectional view on the line 3—3 of Fig. 2; Fig. 4 is a sectional view on the line 4—4 of Fig. 2; Fig. 5 is a sectional view on the line 5—5 of Fig. 1; Fig. 6 is a view showing the ram on the line 6—6 of Fig. 2, and also showing a sectional elevation of the master valve; Fig. 7 is a sectional view on the line 7—7 of Fig. 8 showing the transmission member; Fig. 8 is a sectional view on the line 8—8 of Fig. 7; Fig. 9 is a sectional view on the line 9—9 of Fig. 7; and Fig. 10 is a view showing in elevation the collar for operating the pins, the pins being shown in sections.

In order to economize effort in the use of internal combustion engines, it is advisable to provide a mechanical starter which will act whenever required and one which will be inexpensive to operate and maintain in working condition.

The use of compressed air as a starting medium has been proposed heretofore, but the devices provided for this purpose involving motor mechanism for driving the engine shaft and compressor mechanism for furnishing a supply of compressed air have not been considered satisfactory. If of sufficiently light weight and simplicity of construction to adapt them for use on motor vehicles, they have not been capable of starting an engine of sufficiently large size or of compressing air to the desired high degree.

The present invention is directed to the provision of a convertible motor-compressor consisting of a single device which will operate both as a motor to drive the engine shaft and as a compressor to compress air, this single device being of very light weight, small size and simple construction and at the same time being capable of starting an engine of relatively large size and of compressing air to such a high degree as will permit of starting the engine a plurality of times between successive compressing operations. To this end, the convertible motor-compressor is of the compound type as with such a compound compressor, air may be readily compressed to a relatively high degree. The device also operates as a compound motor when employed for starting the engine. Means are provided, however, for enabling the motor to operate as a simple motor rather than a compound one when starting an engine, this capacity for run-

ning as a simple motor being specially desirable since the motor must start up under a heavy load and at times, the parts of the motor may be in such position at the instant of starting as would prevent the pressure of the motive fluid from being effective to the full extent. The mechanism by which provision is made for starting the compound motor as a simple motor is such as will permit of changing over from simple operation to compound operation readily and practically instantaneously so that immediately after starting the motor driving the engine shaft as a simple motor, the operation may be continued with the motor running compound. The mechanism for operating the motor either simple or compound is so constructed that not only is air at the full pressure introduced into the low pressure cylinder and exhausted therefrom, but also the high pressure air introduced into the high pressure cylinder is exhausted from that cylinder to the atmosphere when the motor is running as a simple motor instead of being exhausted into the low pressure cylinder as it is when the motor is operated as a compound motor.

Another feature of the present invention resides in the provision of special means for connecting the motor-compressor to the engine shaft. The shaft of a gas engine, particularly such a gas engine as is commonly employed to drive a motor vehicle, rotates always in the same direction. I have found it desirable, however, in the interest of simplicity of construction, light weight and efficiency of operation, that the shaft of the motor-compressor should turn in one direction when the device is operating as a motor, and in the opposite direction when it is operating as a compressor. I have, therefore, provided a connecting mechanism between the shaft of the motor-compressor and the shaft of the engine whereby the shaft of the motor-compressor will turn in one direction to drive the engine shaft and whereby the shaft of the motor-compressor will turn in the opposite direction when the engine shaft is driving the motor-compressor as a motor. In the preferred embodiment of the invention, the changes in the gearing connecting the shaft of the motor-compressor and the engine shaft necessary to cause these two shafts to operate in the same direction when one of them is the driving member and in opposite directions when the other is the driving member are preferably effected automatically. This automatic operation of the gearing may be effected in various ways, for instance, either pneumatically or mechanically, a pneumatic means being shown in the present instance.

By referring to the drawings it will be seen that a casing 12 is provided; and that one end of the shaft 13 is journaled in roller bearings 14 in the casing 12. The other end 15 of this shaft 13 as shown in Figs. 7, 8 and 9 of the drawings is journaled in the roller bearings 16 and disposed within the sleeve 17 which forms a continuation of the casing 12. This shaft 13 is provided with cranks 18 which are connected with piston rods 19 in a manner which will be subsequently described. Mounted for rotation on the sleeve 17 is a plate 20 and mounted on the plate 20 by means of the pins 21 are three pinions 22, these pinions 22 being best shown in Fig. 9 of the drawings. Meshing with these pinions 22 there is a gear 23 which is mounted on the end 15 of the shaft 13. These pinions 22 not only mesh with the gear 23 on the end 15 of the shaft 13, but they also mesh with the internal gear 24 on the drum 25, this drum 25 having an inwardly directed portion 26 and a bearing portion 27 mounted on the sleeve 17 at the inner side of the plate 20. It will be understood that both the plate 20 and the drum are held in rotary position by the sleeve 17 and that both the plate 20 and the drum 25 are free to rotate on the said sleeve. This drum 25 is connected with the internal combustion engine shaft 28 by means of the sprocket chain 29 which engages the sprocket teeth 30 on the drum 25 and the sprocket teeth 31 on the internal combustion engine shaft 28. In this manner the drum 25 is connected with the engine shaft 28 at all times; the drum 25 will be rotated when the engine shaft 28 is running and the engine shaft 28 will be rotated by the drum 25 when the latter is operated to start the internal combustion engine.

When the shaft 28 of the internal combustion engine is rotating under normal conditions, the parts of the transmission mechanism will be in the position indicated in Fig. 7 of the drawings. But when it is desired to operate the device as an air compressor, the pins 32, which are disposed in the bushings 33 in the orifices 34 in the inwardly directed portion 26 of the drum 25, will be moved into the orifices 35 in the plate 20 to connect the plate 20 with the drum 25, so that the plate 20 will be rotated with the drum 25 by means of the sprocket teeth and chain which have been described. As the plate 20 rotates with the drum 25, the pinions 22 will be held by the inner gear 24 from rotating on their pins 21, and as the pinions 22 not only mesh with the inner gear 24, but also with the gear 23 on the end 15 of the shaft 13, the shaft 15 will be rotated in the same direction as the drum 25. In this way the device will be operated as a compressor to compress air in the tank 36 shown in Fig. 6 of the drawings.

The means for operating the pins 32 is shown in Figs. 5, 6, 7, 8, 9 and 10 of the drawings. By referring to Fig. 7 of the

drawings, it will be seen that the pins 32 have heads 37 which are disposed in the annular channel 38 of the collar 39, the collar 39 having an annular slot 40 through which the pins extend. It will, therefore, be seen that with the rotation of the drum 25, the pins 32 will be carried around the axis of the shaft 13, the heads 37 of the pins 32 traveling in the annular channel 38 and the annular slot 40. The collars 39 has radially disposed lugs 41 which extend into inclined guideways 42 in an extension 43 of the casing 12, and when the collar 39 is rotated it will be thrust forward or rearward to move the pins 32 into or out of the orifices 35 in the plate 20 as may be desired. One of the lugs 41 has secured to it a lever 44 by means of which the collar 39 may be rotated manually as desired. It should be understood that in the ordinary operation of the device the collar 39 will be rotated by means of the ram or plunger 45 which is controlled by the operator through the master valve 46.

When the device is used to rotate the shaft 28 to start the internal combustion engine, it is of course, necessary to rotate the shaft 13, and by means of the transmission mechanism, the drum 25, which is connected with the engine shaft 28 by the sprocket teeth and chain previously described.

The convertible motor-compressor is so constructed that when used as a motor, its shaft rotates in one direction and when used as a compressor, its shaft rotates in the opposite direction. But since the engine shaft 28 turns always in the same direction, it is necessary, when using the motor-compressor as a motor, that the shaft 13, turning in one direction, should drive the drum 25 in the opposite direction. This is accomplished by providing the plate 20 with a plurality of elongated tangentially disposed slots 47, these slots 47 extending to the sleeve 17. In the slots are rollers 48 which, with the slots 47 and the sleeve 17, form a ratchet means for permitting the rotation of the plate 20 in one direction while preventing the rotation of the plate 20 in the opposite direction. With the rotation of the shaft 13 and its end 15 in the reverse direction, the gear 23 which engages the pinion 22, will rotate the pinions and the plate 20 on which they are mounted with the shaft 13 until the plate is bound by the engagement of the rollers 48 with the sides of the slots 47 and the sleeve 17. This will prevent further rotation of the plate 20, and as the shaft 13, with its end 15, continues to rotate, it will rotate the pinions 22, on their pintles 21 so as to rotate the drum 25 in its normal direction as is desired. As the engine shaft 28 is rotated with the rotation of the drum 25 and the sprocket teeth and chain, it will tend to start the internal combustion engine, and with the running of the internal combustion engine, the shaft 28 will be given a greater speed which will rotate the drum 25 faster than it has been rotated by means of the shaft 13 and its end 15. As soon as the drum 25 is rotated at a speed greater than the speed at which it is rotated by the shaft 13, the pinions 22 will be rotated by the inner gear 24 around the gear 23 to move the plate 20 out of binding engagement with the rollers 48 and the sleeve 17, the plate 20 thereby being permitted to rotate. The supply of compressed air flowing to the starter device may then be cut off and the tank 36 may be recharged in the manner which has been described. Ordinarily, it is possible to compress sufficient air in the tank 36 to start the internal combustion engine several times. In the plate 20 are channels 49 in which are disposed springs 50, acting against plungers 51 which engage the rollers 48 for holding the rollers 48 yieldingly in their normal position. The drum 25 has a dust cap 52 for closing the terminal of the shaft end 15, the drum 25 also being provided with roller bearings 53 in which the end 15 of the shaft is journaled beyond the gear 23.

The shaft 13 is driven by the means which will now be described, when the device is used to start the internal combustion engine, the said means also acting as a compressor which is driven by the shaft 13 to compress and store air in the tank 36. On referring to Fig. 1 of the drawings, it will be seen that a compound motor is provided for rotating the shaft 13, this compound motor serving as a compressor when required. The motor has two high pressure cylinders 54 and two low pressure cylinders 55, there being a piston 56 in each of the high pressure cylinders and a piston 57 in each of the low pressure cylinders. Each of the pistons 56 has a concave bearing surface 58, against which is disposed the rounded head 59 of the piston rod 19, each of the rounded heads 59 being held against the bearing surface 58 by means of the member 60 which has an outer thread 61 meshing with an inner thread 62 at the lower portion of each of the pistons 56. The member 60 has an opening 63 which diverges outwardly so that the piston may have ample room for free movement as the crank 18 rotates. In a similar manner the low pressure pistons 57 in each of the low pressure cylinders 55, has a concave bearing surface 64 against which is disposed a rounded head 65 of a piston rod 66, the rounded head 65 being held against the concave bearing surface 64 by a member 67 which corresponds with the member 60.

Each of the high pressure cylinders 54 has a port 68 and each of the low pressure cylinders 55 has a port 69, the ports 68 opening into the valve chamber 70 and the ports 69 opening into the valve chamber 71 A rock-

ing valve 72 is disposed in the valve chamber 70 and a rocking valve 73 is disposed in the valve chamber 71. Each of the valves 72 and 73 has a central exhaust passage 74 and an annular inlet passage 75. The exhaust passages 74 are adapted to communicate with the ports 68 and 69 in the cylinders 54 and 55 by means of valve ports 76 at the sides of which the valves 72 and 73 have extensions 77 which engage the sides of the valve chambers 70 and 71 and prevent communication between the annular inlet 75 and the exhaust passages 74. The port 76 in the valve 72 which communicates with one of the high pressure cylinders 54, not only serves to communicate with the high pressure cylinders 54 through the port 68 therein, but it also serves to communicate with the port 78 in the valve chamber 70 to connect the exhaust passage 74 in the valve 72 with the exhaust passage 79, leading around the valve chamber 70 to the port 80. In the same manner one of the ports 76 of the valve 73, not only serves to communicate with one of the low pressure cylinders 55 through its port 69, but it also serves to communicate with the port 81, leading to the exhaust passage 82 around the valve chamber 72 to the port 83.

When the motor is used to start the internal combustion engine. the compressed air flows to the valve chamber 75 through the pipe 84 and with the rocking of the valve 72, by the means which will shortly be described, the compressed air will be fed through the port 68 to the high pressure cylinders 54 to operate the pistons 56, the exhaust passing through the ports 68 and 76, to the exhaust passage 74, and from the exhaust passage 74 through one of the ports 76, the port 78, the passage 79 and to the port 80. The exhaust from the high pressure cylinders will then pass through a hollow portion 85 of the valve member 86 to the port 87 of the valve member through the said port 87 to the port 88 in the casing to the passage 89 in the casing and to the port 90 in the casing, leading to the valve chambers 71 around the valve 73. The compressed air, which has been exhausted from the high pressure cylinders 54, will then be fed to the low pressure cylinders 55 by means of the rocking valve 73 which will permit the air to pass at the sides of the extension 77 to the port 69, the air passing therethrough to act against the pistons 57, the air then passing through the port 69 to the exhaust passage 74 and then from the exhaust passage 74 through one of the ports 76 to the passage 82 and the port 83, the air then passing to the muffler compartment 91 and the exhaust 92, it being understood that when the device is used as a compressor, the exhaust 92 will act as an inlet. With the normal running of the device to start the internal combustion engine, the air will pass in the manner which has been described, and the valves 72 and 73 will be rocked by the eccentric 93 on the shaft 13 by the cranks 94 on the valve members 72 and 73.

Experiments have shown that at certain times much greater power is required to start internal combustion engines than at other times, and as a means of obtaining this, additional-power valve mechanism is provided which will convert the motor from one of a compound type to one of a simple type. This result is obtained in a very simple manner by moving the valve 86 until the port 87 communicates with the port 95 in the casing leading to the muffler compartment 91, this movement of the valve 86 closing the port 88 and opening a port 96 which communicates with the passage 89, the closing of the port 88 and the opening of the port 95 permitting the exhaust from the high pressure cylinders 54 to pass direct to the muffler compartment 91, the exhaust from the high pressure cylinders being prevented from reaching the passage 89 because of the closing of the port 88. The valve 86 is held yieldingly in a normal position as shown in Fig. 2 of the drawings by the spring 99, but when it is desired to convert the motor from a compound one to a motor of a simple type, air is permitted to flow through the pipe or conduit 100 to the port 101, this air acting against the surfaces 102, 103 and the wall 97 of the valve to move the valve 86 to close the port 88 and open the ports 95 and 96, the air from the port 101 then flowing through the port 96, the passage 89 and the port 90 to act directly on the pistons in the cylinders 55. When the passage of air through the conduit or pipe 100 is cut off, the spring 99 will return the valve 86 to the normal position shown in Fig. 2 of the drawings.

The passage of air through the pipes or conduits 84 and 100, is controlled by the master valve 46, and this master valve 46 also serves to control the operation of the ram 45, air being conveyed from the master valve 46 to the ram 45 by means of the conduit or pipe 104 which is preferably flexible so that it will not interfere with the movement of the ram 45 in its bearing 105, the ram 45 having a rounded head 106 journaled in its bearing 105. The pipe or conduit 104 passes through an opening 107 in the bearing 105 and into the opening 108 in the head 106, the air passing through this opening 108 down the opening 109 to the plunger 110 with which the ram is provided. This plunger 110 is held yieldingly in the position shown in Fig. 6 of the drawings by means of the spring 111. The plunger 110 which is secured to the rod 112 has a rounded head 113 which is journaled in a rounded bearing 114 at the base of the lever 44.

When the air in the tank 36 is compressed even slightly, the operation of the device may be controlled at the master valve 46, this master valve 46 having a central channel 115 which communicates with the pipe 116 leading to the tank 36. This channel 115 has a seat 117 against which the valve member 118 may be seated to prevent any escape of air from the tank 36. This valve member 118 is operated by the valve spindle having thereon an operating lever 120.

When the valve member 118 is raised from the seat 117 and the rotary valve member 123 is in the position shown in Figs. 2 and 6 of the drawings, the air is permitted to flow through the passage 121 to the safety valve member 122. The master valve 46 has another port 124 which communicates with the conduit or pipe 84 and a port 125 which communicates with the conduit or pipe 100. The port 124 in the master-valve is connected to the passage 121 by a short connecting passage 151 shown in Figs. 2 and 6. In addition the master valve has a port 126 which communicates with the pipe or conduit 104 and an exhaust port 127 communicating with the atmosphere. The rotary valve member 123 has ports 128 and 129 which lead from the valve seat 117, these ports 128 and 129 being extended at right angles to each other. The rotary valve member 123 also has a passage 130 for connecting the ports 126 and 127 when the rotary valve member 123 is in the position shown in the drawings. Secured to the rotary valve member 123 is a sleeve 131 through which the valve spindle extends, the hand lever 132 being secured to the sleeve 131 for rotating the rotary valve member 123. The hand lever 132 may be locked relatively to the casing of the master valve 46 by the means shown in Fig. 6 of the drawings or in any other suitable manner.

When using the device for the first time, and before air has been compressed in the tank 36, the internal combustion engine is started by a crank secured to the shaft 28. When the engine is running, the hand lever 44 is operated to rotate the collar 39 with the lugs 41 lying in the inclined guideways 42 to move the collar 39 longitudinally of the axis of the shaft 13 for carrying the pins 32 into the orifices 35 in the plate 20. This will lock the plate 20 for rotation with the drum 25, and as the pinions 22, which are mounted on the plate 20, are prevented from rotating, they will rotate the shaft 13 by means of the gearing 23 secured to the end 15 thereof. With this rotation of the shaft 13, the pistons 56 and 57 will be reciprocated to force air through the conduit or pipe 84 to and through the master valve 46 and through the pipe or conduit 116 to the tank 36. During the reciprocation of the pistons 56 and 57, the valve members 72 and 73 will be rocked by means of the eccentric rods and cranks which have been described. During the compression of air in the storage tank 36, the rotary valve member 123 should be in a position where the port 128 will communicate with the port 126. This is desired so that as the pressure increases in the tank 36, this pressure may be exerted on the piston 110 through the pipe or conduit 104. The air forced through the pipe 84 will pass through the port 124 and around the passage 131 to the passage 121, and from this passage 121 through the port 129 to the pipe or conduit 116. When the pressure in the tank 36 has increased to a pre-determined point, any excess thereof will be permitted to escape by the safety valve member 123. To prevent any further pumping of the air and forcing it into the tank 36, the chauffeur forces the valve 118 against its seat 117 to close the passages 115 leading to the pipe or conduit 116. The rotary valve member 123 is then rotated by means of the hand lever 132 to the position shown in Fig. 2 of the drawings, where the passage 130 in the rotary valve member 123, connects the ports 126 and 127 to permit the air, which has been acting against the piston 110 to escape to the atmosphere. When this has taken place, the spring 111 will force the piston 110 to the position shown in Fig. 6 of the drawings, thereby rotating the collar 39 to the position shown in Fig. 7 of the drawings and withdrawing the pins 32 from the orifices 35. It will be understood that when there is any compressed air in the tank 36, it is unnecessary to operate the hand lever 44 to move the collar 39 in the manner described, for by rotating the rotary valve member 123, to a position where its port 128 communicates with the port 126, compressed air will be permitted to flow to the ram 45 and against the piston 110 to rotate the collar 39.

To use the device to start the internal combustion engine, the rotary valve member 123 is moved to the position shown in Fig. 2 of the drawings, and the valve member 118 is raised from its seat 117. The air will then flow through the pipe 84 to the valve chamber 75 to operate the motor. Often times in starting the device it is necessary to exert an unusual force, and when this is desired, the rotary valve member 123 may be moved so that its port 129 will communicate not only with the port 124, but also with the port 125. This will convey air to the valve chamber 75 and it will also convey air to the port 101 through the pipe or conduit 100 to operate the valve 86 to close the port 88 and open the ports 95 and 96 so that the motor will act as one of a simple type. It will be seen that the chauffeur by operating the master valve 46, may control the operation of the device so as to cause it to act as a com-

pressor, to act as a compound motor or to act as a simple motor. When the device is acting as a simple motor, not only is high pressure air admitted to the low pressure cylinders, but also the high pressure cylinders are caused to exhaust to atmosphere instead of to the receiver from which air passes to the low pressure cylinders.

Having thus described my invention I claim as new and desire to secure by Letters Patent:

1. In a starter for internal combustion engines, the combination of a cylinder, a second cylinder, means for conveying a fluid under pressure to the first cylinder, a passage for conveying the exhaust of the first cylinder to an inlet of the second cylinder, and pneumatic means for closing the passage between the cylinders and supplying the inlet of the second cylinder direct with the fluid under pressure.

2. In a starter for internal combustion engines, the combination of a cylinder, a piston in the cylinder, a second cylinder, a piston, means for conveying a fluid under pressure to the first cylinder, there being a passage for conveying the exhaust from the first cylinder to an inlet in the second cylinder, a valve member for closing the passage and for opening communication to the second cylinder and means for conveying a fluid under pressure to the valve member for operating the latter, and for supplying the passage therewith.

3. In a starter for internal combustion engines, the combination of a cylinder, a piston for acting therein, a second cylinder, a piston for acting therein, a shaft, means for connecting the pistons to the shaft, means for conveying a fluid under pressure to the first cylinder, a casing having a port leading from the exhaust to the first cylinder, to a second port leading to the atmosphere, a third port leading to an inlet in the second cylinder, a fourth port leading to the inlet of the second cylinder, a valve for normally closing the second and fourth ports with the first and third ports open, and means for conveying a fluid under pressure to the valve to close the third mentioned port and open the second and fourth mentioned ports.

4. In a starter for internal combustion engines, the combination of a cylinder, a piston in the cylinder, a second cylinder, a piston, means for conveying a fluid under pressure to the first cylinder, a casing having a port leading from the exhaust of the first cylinder, there being in the casing a port leading to the atmosphere, a third port leading from the first port to an inlet in the second cylinder, and a fourth port leading to an inlet in the second cylinder, means for conveying a fluid under pressure to the fourth mentioned port, a valve normally closing the second and fourth mentioned ports and operable under pressure of the fluid for closing the third port and opening the second and fourth ports.

5. In a starter for internal combustion engines, the combination of a cylinder, a piston therein, a second cylinder, a piston in the second cylinder, a shaft, means for connecting the pistons to the shaft, a casing having a guideway with a port leading thereto from the first cylinder, a second port leading to the atmosphere, a third port leading to an inlet in the second mentioned cylinder, and a fourth port leading to the said inlet in the second mentioned cylinder, a valve in the guideway for normally closing the second and fourth mentioned ports for opening communication between the first and third mentioned ports, a spring for holding the valve in a normal position, and communicating means to operate the latter and to close the third port and open the second and fourth mentioned ports to open communication between the first and second ports and from the communicating means to the fourth mentioned port.

6. In a starter for internal combustion engines, the combination of a convertible air compressor and motor device having two cylinders, a pneumatic means for converting the device, a conduit leading to the pneumatic means, a second conduit leading to one of the cylinders, a third conduit connecting the exhaust of the last mentioned cylinder with the inlet of the other cylinder, a valve for closing the third mentioned conduit and a fourth conduit for conveying a fluid under pressure for operating the valve and for supplying the said other cylinder through its said inlet.

7. In a starter for internal combustion engines, the combination of a convertible air compressor and motor device having two cylinders, a pneumatic means for converting the device, a conduit leading to the pneumatic means, a second conduit leading to one of the cylinders, a third conduit connecting the exhaust of the last mentioned cylinder with the inlet of the other cylinder, a valve for closing the third conduit, a fourth conduit for conveying a fluid under pressure for operating the valve and to the said inlet, a tank communicating with the first, second and fourth conduits, and a master valve for commanding communication through the first, second and fourth conduits.

8. A starter for internal combustion engines comprising the combination of a multi-cylinder, convertible motor-compressor mechanism having a shaft which turns in one direction when said mechanism is operated as a motor and in the opposite direction when said mechanism is operated as a compressor, a second shaft adapted to drive and be driven by said shaft, a tank connected to said mechanism, a valve in the connection from the

tank to said mechanism, means for changing said mechanism, when operating as a motor, from a compound motor to a simple motor and vice versa, means for connecting said shafts for simultaneous rotation in the same direction, and means for connecting said shafts through speed-reducing gearing for simultaneous rotation in opposite directions; substantially as described.

9. A starter for an internal combustion engine comprising the combination of a multi-cylinder, convertible motor-compressor mechanism operating in one direction as a motor and in the opposite direction as a compressor, a tank connected to said mechanism, a shaft adapted to be connected to said mechanism to drive and to be driven by it, pneumatically-controlled gearing for connecting said shaft to the shaft of said mechanism for simultaneous operation in the same direction, gearing for connecting said shafts through speed-reducing and reversing gears for simultaneous operation in opposite directions, valve mechanism in the connection from the tank to said mechanism for causing compound operation of said mechanism as a motor and means for operating said valve mechanism to cause said mechanism to operate as a simple motor by admitting air from the tank to all cylinders of said mechanism and exhausting the air from all of the cylinders to the atmosphere; substantially as described.

10. A starter for an internal combustion engine comprising the combination of a multi-cylinder, convertible motor-compressor mechanism having a shaft, a second shaft adapted to drive and be driven by said shaft, a tank connected to said mechanism, a valve in said connection from the tank to said mechanism for admitting air to the latter to operate it as a compound motor, means for operating said valve to admit air from said tank to all cylinders of said mechanism to operate the latter as a simple motor with all cylinders exhausting to the atmosphere, means for connecting said shafts for simultaneous rotation in the same direction, and means for connecting said shafts through speed-reducing gearing for simultaneous rotation in opposite directions; substantially as described.

11. A starter for internal combustion engines comprising the combination of a multi-cylinder, convertible motor-compressor mechanism, a tank connected thereto, a valve in the connection from said mechanism to the tank, a shaft connected to said mechanism and adapted to drive and be driven by it and pneumatically actuated devices for changing said mechanism, when operating as a motor, from a compound motor to a simple motor; substantially as described.

12. A starter for internal combustion engines comprising the combination of a multi-cylinder, convertible motor-compressor mechanism, a tank connected thereto, a valve in the connection from said mechanism to the tank, a shaft connected to said mechanism and adapted to drive and be driven by it, and means actuated by movement of the movable member of said valve for changing said mechanism, when operating as a motor, from a compound motor to a simple motor and vice versa; substantially as described.

13. A starter for internal combustion engines comprising the combination of a multi-cylinder, convertible motor-compressor mechanism, a tank connected thereto, a valve in the connection from said mechanism to the tank, a shaft connected to said mechanism and adapted to drive and be driven by it, means actuated by movement of the movable member of said valve for connecting the tank to said mechanism to operate the latter as a motor, and means actuated by movement of said member, while holding the connection from the tank to said mechanism open, for changing said mechanism from a compound motor to a simple motor; substantially as described.

14. A starter for internal combustion engines comprising the combination of a multi-cylinder, convertible motor-compressor mechanism having a shaft, a second shaft adapted to drive and be driven by said shaft, a tank connected to said mechanism, a valve in the connection from the tank to said mechanism, pneumatically actuated devices for causing said mechanism, when operating as a motor, to operate as a simple motor or as a compound motor at will, means for connecting said shafts for simultaneous rotation in the same direction and means for connecting said shafts through speed-reducing gearing for simultaneous rotation in opposite directions; substantially as described.

15. A starter for internal combustion engines comprising the combination of a multi-cylinder, convertible motor-compressor mechanism having a shaft, a second shaft adapted to drive and be driven by said shaft, a tank connected to said mechanism, a valve in the connection from the tank to said mechanism, means actuated by movement of the movable member of said valve for causing said mechanism to operate as a simple motor or as a compound motor at will, means for connecting said shafts for simultaneous rotation in the same direction and means for connecting said shafts through speed-reducing gearing for simultaneous operation in opposite directions; substantially as described.

16. A starter for internal combustion engines comprising the combination of a multi-cylinder, convertible motor-compressor mechanism having a shaft, a second shaft adapted to drive and be driven by said shaft, a tank connected to said mechanism,

a valve in the connection from the tank to said mechanism, means actuated by movement of the movable member of the valve for connecting the tank to said mechanism to operate the latter as a motor, means actuated by movement of said valve-member while holding the connection from the tank to said mechanism open for causing said mechanism to operate as a simple motor or as a compound motor at will, means for connecting said shafts for simultaneous rotation in the same direction and means for connecting said shafts through speed-reducing gearing for simultaneous rotation in opposite directions; substantially as described.

17. A starter for internal combustion engines comprising the combination of a multi-cylinder, convertible motor-compressor mechanism having a shaft, a second shaft adapted to drive and be driven by said shaft, a tank connected to said mechanism, a valve in the connection from the tank to said mechanism, means actuated by movement of the movable member of said valve for causing said mechanism to operate as a simple motor by admitting air from the tank to all cylinders of the mechanism and exhausting the air from all the cylinders to the atmosphere or to operate as a compound motor at will, means for connecting said shafts for simultaneous rotation in the same direction and means for connecting said shafts through speed-reducing gearing for simultaneous rotation in opposite directions; substantially as described.

18. A starter for internal combustion engines comprising the combination of a multi-cylinder, convertible motor-compressor mechanism, a tank connected thereto, a shaft adapted to be connected to said mechanism to drive and be driven by it, a valve in the connection from the tank to said mechanism, means actuated by movement of the movable member of said valve for admitting air from the tank to said mechanism to operate the latter as a motor and means actuated by movement of said movable valve-member, while holding the connection from the tank to said mechanism open, for operating said mechanism as a compound motor or for operating it as a simple motor by admitting air from the tank to all cylinders of the mechanism and exhausting the air from all of the cylinders to the atmosphere; substantially as described.

19. A starter for an internal combustion engine comprising the combination of a convertible motor-compressor mechanism having a shaft which rotates in one direction when said mechanism is operating as a motor and in the opposite direction when said mechanism is operating as a compressor, a tank connected to said mechanism, a second shaft adapted to drive and be driven by said shaft, means for connecting said shafts for simultaneous rotation in the same direction, means for connecting said shafts through speed-reducing gearing for rotation in opposite directions and pneumatically controlled devices for actuating one or the other of said means at will to establish the desired connection; substantially as described.

20. A starter for an internal combustion engine comprising the combination of a convertible motor-compressor mechanism having a shaft which rotates in one direction when said mechanism is operated as a motor and in the opposite direction when said mechanism is operated as a compressor, a second shaft adapted to drive and be driven by said shaft, means for connecting said shafts for simultaneous rotation in the same direction, means for connecting said shafts through speed-reducing gearing for simultaneous rotation in opposite directions, a tank, a conduit leading from the tank to said mechanism, a valve in said conduit, and pneumatically-controlled means operated by movement of the movable member of said valve for making one or the other of said connecting means operable at will; substantially as described.

21. A starter for internal combustion engines comprising the combination of a multi-cylinder, convertible motor-compressor mechanism having a shaft, a second shaft adapted to drive and be driven by said shaft, means for connecting said shafts, a tank connected to said mechanism, a valve in the connection from the tank to said mechanism, means actuated by movement of the movable member of the valve for operating said mechanism as a compressor, as a simple motor or as a compound motor, and means operated by movement of the movable member of the valve for actuating said connecting means; substantially as described.

22. A starter for internal combustion engines comprising the combination of a multi-cylinder, convertible motor-compressor mechanism having a shaft, a second shaft adapted to drive and be driven by said shaft, means for connecting said shafts, a tank connected to said mechanism, a valve in the connection from the tank to said mechanism, means actuated by movement of the movable member of the valve for operating said mechanism as a compressor, as a simple motor or as a compound motor, and pneumatic means actuated by movement of the movable member of said valve for operating said connecting means to cause said shafts to rotate in the same direction at the same speed or to rotate in opposite directions at different speeds; substantially as described.

23. A starter for an internal combustion engine comprising the combination of a convertible, motor-compressor mechanism having a shaft, a second shaft adapted to drive and be driven by said shaft, connecting gearing between said shafts, a tank, a connection from the tank to said mechanism, a valve in said connection having a movable member movable to two positions for operating said mechanism as a motor and as a compressor, a pneumatic controller for said connecting gearing, means actuated by movement of the movable member of the valve to the position for operating said mechanism as a motor for connecting said tank to said controller and means actuated by movement of the movable member of the valve to a position for operating said mechanism as a compressor for disconnecting said tank from said controller; substantially as described.

24. A starter for an internal combustion engine comprising the combination of a convertible, motor-compressor mechanism having a shaft, a second shaft, means for connecting said shafts for rotation in the same direction, means for connecting said shafts for rotation in opposite directions, one of said connecting means including speed-reducing gearing, a tank connected to said mechanism, a valve in the connection from the tank to said mechanism having a valve-member movable into position for operating said mechanism as a motor and into position for operating said mechanism as a compressor, and means controlled by movement of said valve-member to one or the other of its two positions for causing one or the other of said connecting means to become operative; substantially as described.

25. A starter for an internal combustion engine comprising the combination of a compound, convertible motor-compressor mechanism having a shaft, a second shaft, means for connecting said shafts for rotation in the same direction, means for connecting said shafts for rotation in opposite directions, one of said connecting means including speed-reducing gearing, a tank, a connection from the tank to said mechanism, a valve therein having a valve-member movable to position for operating said mechanism as a motor and to position for operating said mechanism as a compressor, means controlled by movement of said valve-member to one or the other of said two positions for causing one or the other of said connecting means to become operative, and means controlled by the position of said valve-member for operating said mechanism as a motor either simple or compound; substantially as described.

26. A starter for an internal combustion engine comprising the combination of a convertible, motor-compressor mechanism having a shaft, a tank, a connection from the tank to said mechanism, a master-valve in said connection, a rotary member adapted to drive and be driven by the shaft of said mechanism, means controlled by the master-valve for connecting said mechanism to said tank to compress and store air in the tank and for simultaneously connecting said shaft and said rotary member for simultaneous rotation in the same direction, and means controlled by said master-valve for connecting said tank to said mechanism to operate the mechanism as a motor and for simultaneously connecting said shaft to said rotary member through a speed-reducing and reversing-gear; substantially as described.

27. A starter for an internal combustion engine comprising the combination of a multi-cylinder, convertible motor-compressor mechanism having a shaft, a tank, a connection from the tank to said mechanism, a master-valve in said connection, a rotary member adapted to drive and be driven by said shaft, means controlled by the position of said master-valve for connecting the tank to said mechanism to receive air therefrom and for simultaneously connecting said shaft and said rotary member for simultaneous rotation in the same direction, means controlled by the position of said master-valve for connecting the tank to said mechanism to supply air to the mechanism and for simultaneously connecting said shaft and said rotary member through a speed-reducing and reversing gear, and means controlled by the position of the master-valve for supplying air from the tank to all of the cylinders of said mechanism for operation of the mechanism as a simple motor or for supplying air to certain of the cylinders and causing it to pass from them to other cylinders for operation of the mechanism as a compound motor; substantially as described.

28. A starter for an internal combustion engine comprising the combination of a multi-cylinder, convertible motor-compressor mechanism, a shaft adapted to drive and be driven by the same, a tank connected to said mechanism, and a master-valve in the connection from the tank to said mechanism movable to a position for operation of said mechanism as a compressor, to a position for operation of said mechanism as a compound motor and to a position for operation of said mechanism as a simple motor; substantially as described.

29. A starter for an internal combustion engine comprising the combination of a multi-cylinder, convertible motor-compressor mechanism, a shaft adapted to drive and be driven by the same, a tank connected to said mechanism, a master-valve in the connection from the tank to said mechanism movable to a position for operation of said

mechanism as a compressor, to a position for operation of said mechanism as a compound motor and to a position for operation of said mechanism as a simple motor, connections between said mechanism and said shaft and means for actuating said connections under the control of said master-valve; substantially as described.

In testimony whereof I have signed my name to this specification in the presence of the two subscribing witnesses.

GREGORY JOHN SPOHRER.

Witnesses:
EVERARD B. MARSHALL,
GEORGE H. EMSLIE.