EXPLOSION-OPERATED TOOLS

Filed Aug. 16, 1950 5 Sheets-Sheet 1

Fig.1

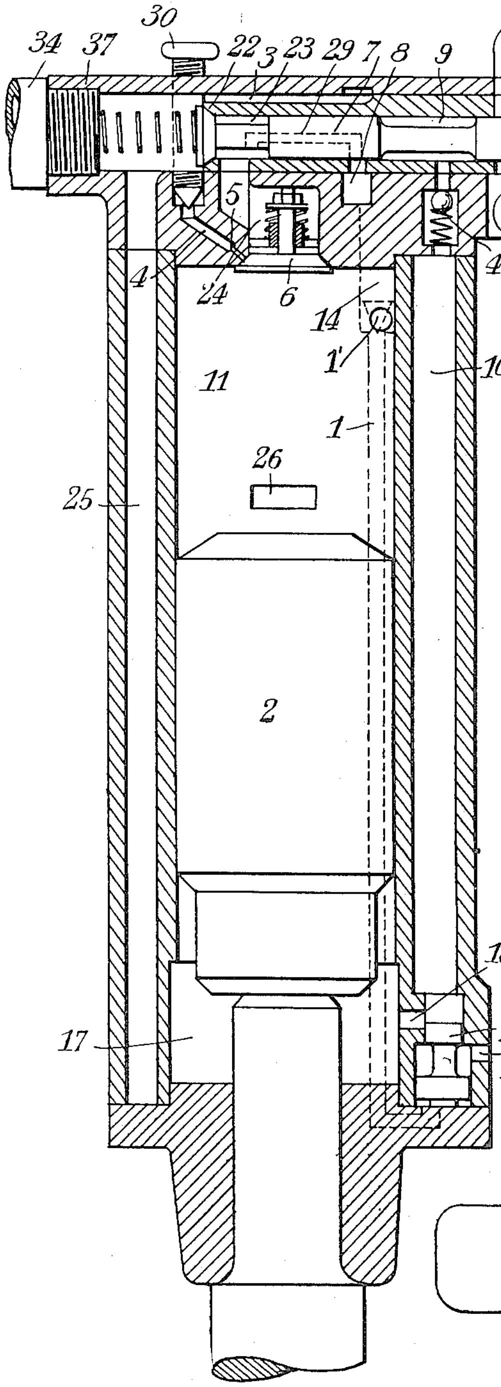

Fig.3

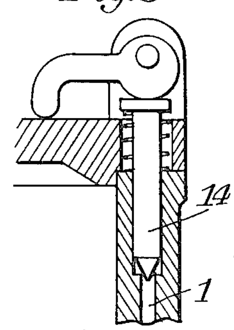

Fig.4

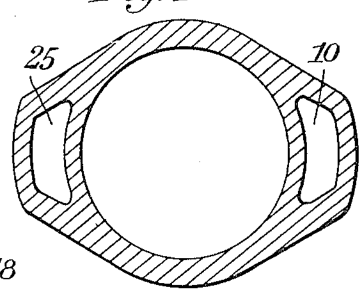

Fig.5

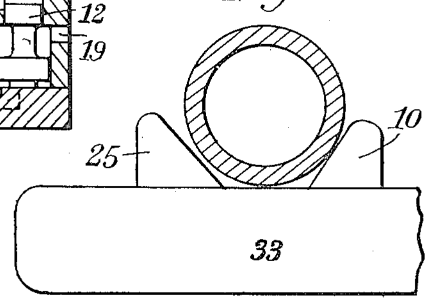

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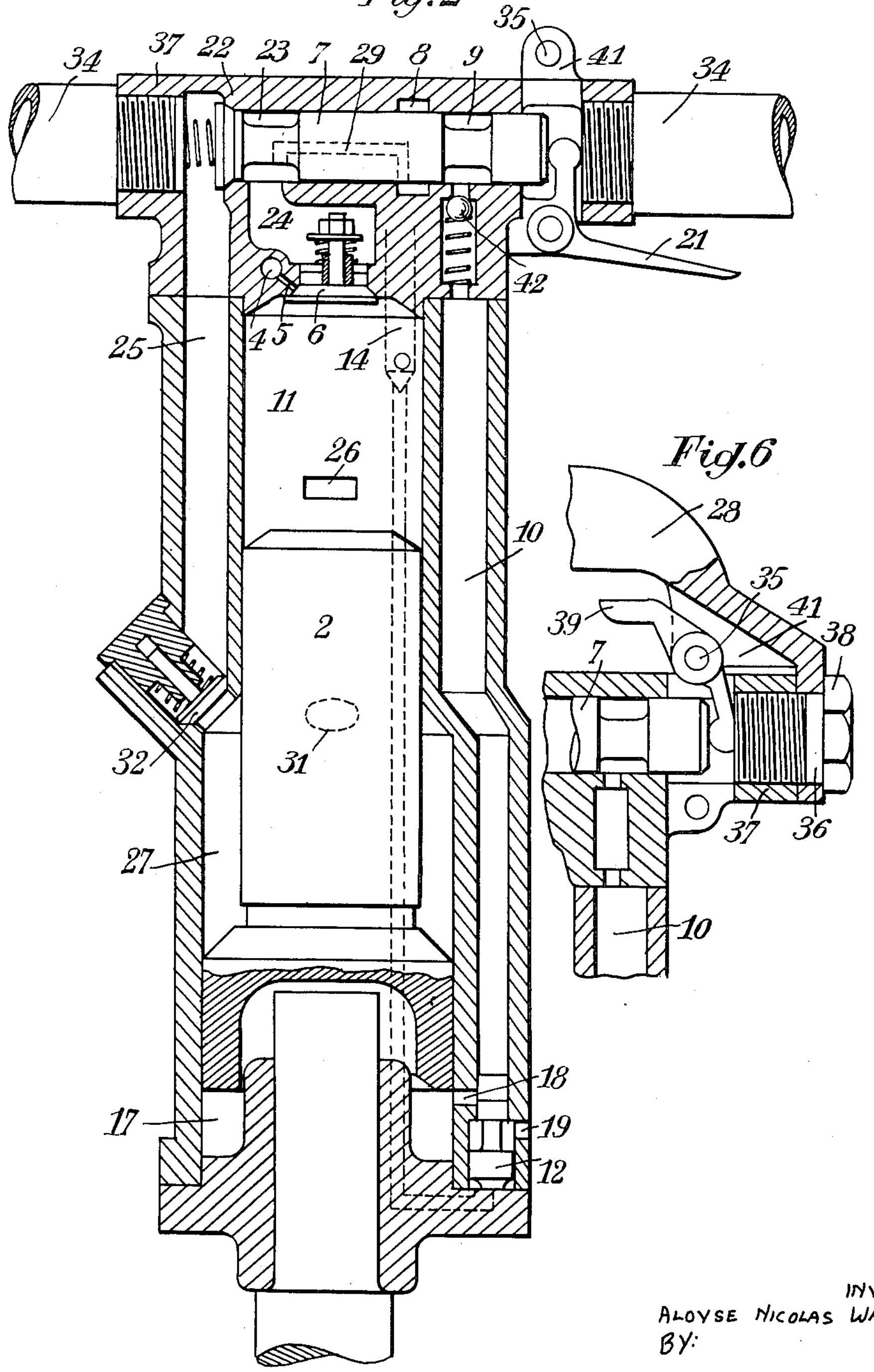
Fig. 2



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EXPLOSION-OPERATED TOOLS

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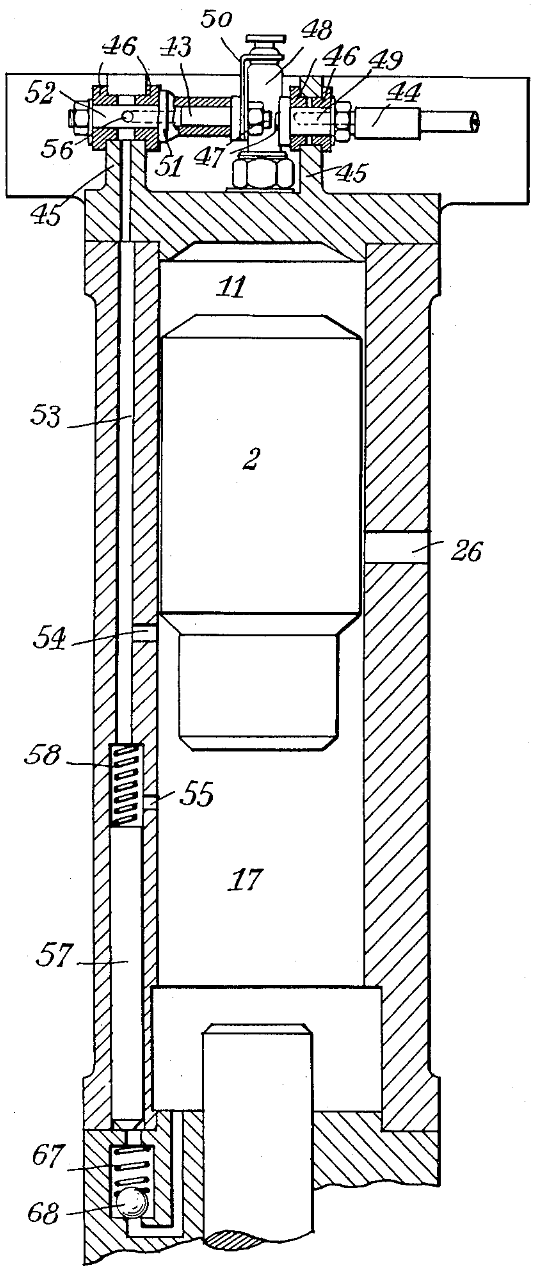
Fig. 7



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EXPLOSION-OPERATED TOOLS

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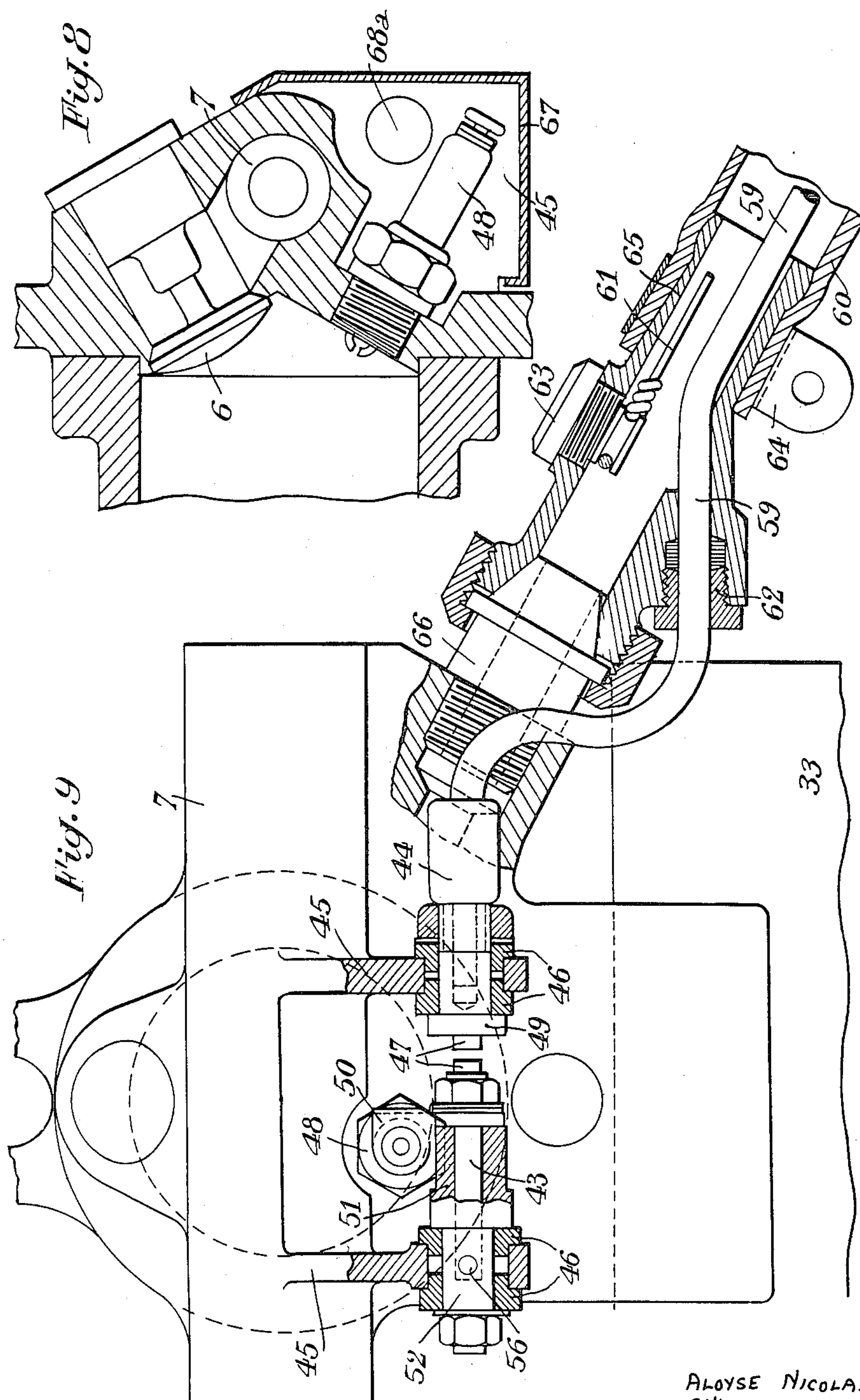

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EXPLOSION-OPERATED TOOLS

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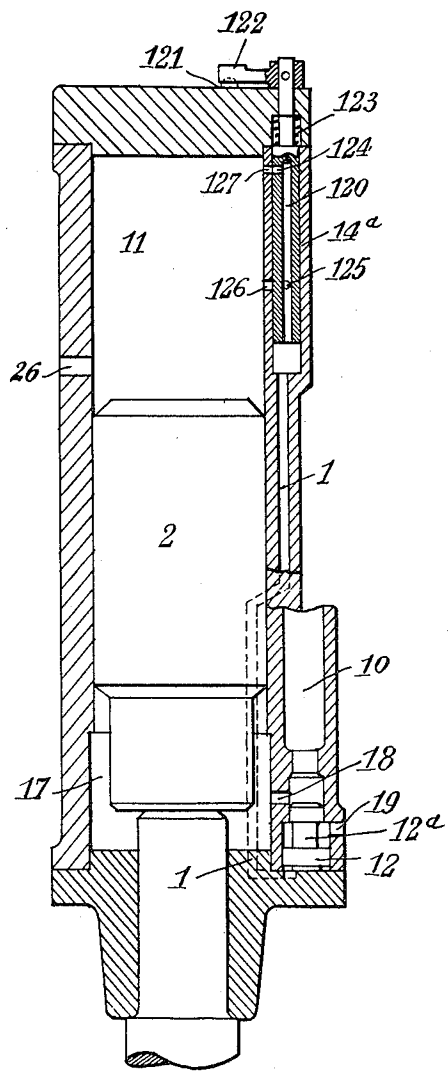
Fig. 10



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United States Patent Office

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Patented Jan. 10, 1956

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EXPLOSION-OPERATED TOOLS

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Application August 16, 1950, Serial No. 179,680

Claims priority, application Luxembourg August 24, 1949

2 Claims. (Cl. 123—7)

The present invention relates to explosion operated tools, such as rammers and the like, where the piston is driven by a compressed fluid derived from an independent source.

One of the objects of the present invention is to provide a tool capable of being operated with a relatively low pressure fluid so that the compressor apparatus which provides the fluid may be quite small and in fact portable.

Another object of the present invention is to provide a tool wherein the pressure fluid is not completely exhausted and is repeatedly used in the operation of the tool.

It is also an object of the present invention to provide a tool capable of accomplishing the above objects and at the same time being made up of simply and ruggedly constructed parts which are very reliable in operation.

With the above objects in view the present invention mainly consists of a power tool which includes a cylinder and a piston mounted for reciprocating movement in the cylinder. A valve means is mounted on one end of the cylinder for admitting compressed air into the cylinder at one side of the piston, and a duct means communicates with the valve means and an opposite end of the cylinder for admitting compressed air to this opposite end of the cylinder and to the other side of the piston for moving the latter when starting the tool.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantage thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings, in which:

Fig. 1 shows a sectional, elevational view of a portable tool with a smooth cylindrical piston;

Fig. 2 shows a sectional elevational view of a tool having a stepped piston;

Fig. 3 is a fragmentary, partly sectional view of a detail of the apparatus illustrated in Fig. 1;

Fig. 4 is a sectional plan view of one possible cylinder construction;

Fig. 5 is a diagrammatic plan view partly in section, showing another possible arrangement of the structure shown in Fig. 4;

Fig. 6 shows a fragmentary, partly sectional view of a detail of another embodiment of the structure illustrated in Figs. 1 and 2;

Fig. 7 shows a sectional, elevational view of the tool of Fig. 1 and illustrates the ignition arrangement therefor;

Fig. 8 shows a fragmentary, partly sectional view of an arrangement of a valve and spark plug on the cylinder head of the tool;

Fig. 9 is a partly sectional view of an ignition assembly for a tool constructed as shown in any of the preceding figures; and

Fig. 10 is a sectional elevational view of still another embodiment of the tool illustrated in Fig. 1.

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Referring now to the drawings, and to Fig. 1 in particular, it will be seen that the tool of the invention includes a cylinder, the cross sectional shape of which is shown most clearly in Fig. 4. The cylinder, as shown in Fig. 1, has a piston **2** slidable therein for transmitting a force to the rammer or other implement fixed to the bottom end of the cylinder and extending into the bottom chamber **17** of the cylinder, as is evident from Fig. 1. Within the cylinder is located the combustion chamber **11** which is shown in Fig. 1 above the piston **2**. The wall of the cylinder is formed with an exhaust opening **26** which communicates with the outer atmosphere, and Fig. 7, which is a sectional view of the structure of the invention taken at right angles to the section of Fig. 1, clearly shows together with Fig. 1 the arrangement and location of the exhaust port **26**. As is evident from Figs. 1 and 4 chambers **10** and **25** are located at opposite sides of the cylinder and extend axially along the same, these chambers serving a purpose described below.

At the head end of the cylinder there is located a valve **6** for admitting a charge to the combustion chamber **11**. This valve **6** is automatically urged to its closed position shown in Fig. 1 by a coil spring engaging a washer which surrounds the stem of valve **6** to urge the latter onto the valve seat shown in Fig. 1. The valve **6** is located within a valve chamber **24** which communicates with an annular groove **23** formed on a slide valve member **7** which is slidably mounted within a bore of the cylinder head, as shown in Fig. 1. The slide valve member **7** includes an additional annular groove **9**, as is shown in Fig. 1, as well as a passage **29** leading from groove **23** to a part of member **7** which, in the position of Fig. 1, communicates with an annular space **8** formed in the cylinder head and communicating with a line leading from a tank of compressed air, this line and tank of compressed air not being illustrated in the drawings. Thus, the space **8** forms a chamber which receives compressed air to be used for operating the tool. The left end of member **7** is in the form of a valve **22**, and a spring clearly shown in the upper left portion of Fig. 1 urges member **7** to the right, as viewed in Fig. 1, to hold the valve **22** closed so as to cut off communication between valve chamber **24** and the elongated chamber **25** in the position of the parts shown in Fig. 1.

The cylinder head is further formed with a passage communicating on the one hand with groove **9** and on the other hand with the elongated chamber **10**, and this passage is closed by a spring-pressed ball valve **42**, as shown in Fig. 1. The bottom of chamber **10** communicates through passage **18** with the chamber **17** and the bottom of chamber **10** also houses a piston **12** for sliding movement. A further passage **19** provides communication between the atmosphere and the bottommost part of chamber **10** which is closed off by the piston **12**. From the bottom end of chamber **10** a passage **1** leads upwardly through the wall of the cylinder to a passage in the head of the cylinder which houses a needle valve member **14**, the details of which are most clearly shown in Fig. 3. As is evident from Fig. 3 the needle valve member **14** is urged upwardly from a position closing the passage **1** by a spring. The top end of the needle valve **14** is located at the top exterior face of the tool behind the plane thereof which is shown in Fig. 1, and a manually operable cam is turnably supported on top of the tool in engagement with the needle valve **14**, as is evident from Fig. 3. Thus, when the operator turns the cam of Fig. 3 in a clockwise direction, as viewed in Fig. 3, the spring shown in Fig. 3 will raise the valve **14** to open the passage **1**. The passage **1** is then placed in communication with the outlet **1'** shown in Fig. 1 at the top end of chamber **11**. Thus, by opening the valve **14** fluid in the chamber **11** will be directed along passage **1** to the bottom of piston **12** for a purpose described below.

The cylinder head is further formed with a fuel passage

4 which communicates with an outlet nozzle 5 which terminates at the seat of valve 6. The fuel passage 4 is closed by a needle valve 30 which is threaded into the cylinder head and may be manually turned so as to be opened to a desired extent. The conduit which communicates with the passage 4 for supplying fuel thereto is not shown.

As was mentioned above, Fig. 7 illustrates further the structure of Fig. 1 in a plane at right angles to the plane of Fig. 1, and Fig. 7 shows in particular the ignition apparatus, this ignition apparatus being further illustrated in Fig. 9 of the drawings which shows the ignition structure in plan view. Thus, referring to Figs. 7 and 9 it will be seen that the combustible fuel air mixture in chamber 11 is ignited by conventional spark plug 48 mounted on the cylinder head. The circuit to the spark plug is closed when the contacts 47 engage each other. The right contact 47 of Fig. 7 is carried by a block 49 which is in turn supported by bushings 46 of electric insulating material which are supported in a suitable opening of a lug 45 of the cylinder head. A contact member 44 extends into the block 49 and is fixed thereto for carrying current to the block 49 and right contact 47 of Fig. 7. As is evident from Fig. 9, the member 44 is located at one end of a cable 59 which is housed within a rubber tube 60 for protective purposes. A nipple 66 is threaded to the cylinder head, as shown in Fig. 9, and the cable 59 extends outwardly through the nipple 66 and through a sealed opening of a member 65 through the latter along the interior of sheath 60. This member 65 is fixed to the nipple 66 through the threaded connection clearly illustrated in Fig. 9, and a tubular plug 62 presses suitable packing members about the cable 59 to seal the point where the latter extends through the connecting member 65. The sheath 60 is connected to member 65 through a strip 64 of conventional construction, and the member 65 is further formed with a threaded bore in which a plug 63 is located, this plug 63 being connected to a bare conductor 61 which extends through the sheath 60 to the exterior thereof and provides a ground connection for the circuit.

The left contact 47 as viewed in Figs. 7 and 9, is located at an end of a piston 43 which is connected to an electrically conductive leaf spring 50 which electrically connects this left contact 47 to the spark plug and which urges the piston 43 to the left, as viewed in Fig. 7, so as to urge the contacts 47 apart from each other. The piston 43 is slidably located within a cylinder 51 which has a reduced end 52 also carried by bushings 46 of insulating material in a bore of a lug 45 on the cylinder head. The interior of cylinder 51 communicates with a bore 56 which in turn communicates with a passage 53 shown in Fig. 7 as extending axially along the cylinder of the tool, an upper passage 54 and a lower passage 55 communicating with this passage 53. Furthermore, the enlarged lower portion of passage 53 includes a needle valve member 57 and a spring 58 urging member 57 downwardly, as viewed in Fig. 7. As is evident from Fig. 7 the lower portion 17 of the cylinder communicates through a suitable bore with a ball valve 68 urged to its closed position by a spring 67, so that when the ball 68 is lifted from its seat fluid from the lower cylinder portion 17 will engage the bottom end of member 57 to urge the latter upwardly against the action of spring 58.

The above-described structure operates as follows:

When the apparatus is not in use a valve in the line which supplies compressed air to the chamber 8 is closed so that the entire apparatus is inactive. When it is desired to start the apparatus this valve is opened so that compressed air flows to the chamber 8. It will be noted that with nothing more than the supply of compressed air to the chamber 8, when the parts are in their rest position, shown in Fig. 1, this compressed air will flow along the passage 29 of slide valve member 7 to the valve chamber 24 and will open the valve 6 against the action of its spring so that the compressed air will

fill the combustion chamber 11 and move the piston 2 to the position shown in Fig. 1 which is the proper position of the piston 2 for starting of the apparatus. It will be noted that this compressed air will move the piston 2 until the exhaust port 26 is uncovered so that the compressed air in chamber 11 thus escapes to the atmosphere through the port 26. The purpose of this arrangement is to guarantee that the piston 2 will be properly located upon starting up of the apparatus. Thus, even if the tool is not held in the position shown in the drawings, that is, if it is upside down or extends horizontally, the piston 2 will still be moved to the position shown in Fig. 1. Then the needle valve 30 is turned to supply fuel to the mixture, and the air flowing past the valve 6 into the chamber 11 will intimately mix with the atomized fuel issuing from the nozzle 5 to introduce the combustible mixture to the combustion chamber 11. Once the operation has started up the needle valve 30 may be adjusted to supply the desired amount of fuel.

Then the opertaor turns the bell crank lever 21 which is shown in Fig. 1 adjacent to the right hand handle part 34 of Fig. 1. In Fig. 1 two handle parts 34 are shown threadedly connected to opposite threaded ends 37 of the cylinder head, and the bell crank 21 is turnably carried by the cylinder head in the position shown in Fig. 1 so that when the operator turns the lever 21 in a counterclockwise direction, as shown in Fig. 1, the valve 7 will be moved to the left, thus placing the chamber 8 in communication with passage 10 through the groove 9 and valve 42 and thus opening the valve 22 so that compressed air which fills the chamber 25, which thus forms a reservoir of compressed air, flows very smoothly through the valve chamber 24 and valve 6 into the combustion chamber 11.

It is assumed that at this time the cam of Fig. 3 is in the position illustrated so that the passage 1 is closed and does not enter into the operation.

Thus, compressed air will now flow through the valve 42 downwardly along the passage 10 to the passage 18 and into the lower portion 17 of the cylinder to raise the piston 2, the pressure above the piston being less than that in chamber 17 at this time because of the temporary communication of combustion chamber 11 with the atmosphere through the exhaust port 26. Thus, the pressure fluid supplied through passage 10 engages the bottom face of the piston and raises the latter above the exhaust port 26 until the pressure on opposite sides of the piston 2 is equalized.

Referring to Fig. 7, it will be seen that when the piston 2 has been lifted in this manner sufficiently to uncover the passage 55, compressed air will flow from chamber 17 along the passage 53 and through outlet 56 into the cylinder 51 to move the piston 43 to the right, as viewed in Fig. 7, so that the contacts 47 engage each other and the spark plug 48 then ignites the mixture in combustion chamber 11 to drive the piston 2 downwardly into engagement with the implement carried by the bottom end of the cylinder.

The downward movement of the piston 2 causes the exhaust port 26 to again become uncovered so that the exhaust gases are discharged through port 26 to the atmosphere, and it will be noted that the downward movement of piston 2 will compress the fluid in passage 10 so as to close valve 42 and so as to provide in the passage 10 a reservoir of compressed fluid which will start the piston 2 up again to repeat the above cycle of operations very rapidly. Thus, as long as the lever 21 is held in the position where chamber 10 communicates with chamber 8, the tool will continue to operate in the manner described above, the piston 2 descending to apply a blow to the implement and being immediately thrown back whereupon the combustible mixture is again exploded to drive the piston 2 down again. Upon release of the lever 21, the spring shown at the upper left of Fig. 1 will automatically move the valve 7 to the right, as viewed in Fig. 1, to cut off communication between chambers **8** and **10** so that a fresh supply of compressed air will not flow to the chamber **10** and thus, the piston **2** will not again be raised to continue the above cycle of operations. The operator may then shut off the supply of compressed air to the chamber **8**.

When the apparatus is just starting up, the pressure in chamber **17** is relatively low, and the passage **55** of Fig. 7 guarantees that air under pressure will be supplied to the piston **43** for igniting the mixture. However, when the device is underway, the pressure in chamber **17** builds up sufficiently to open valve **68** and to move member **57** upwardly against the action of spring **58** to close the passage **55**, and at this time the pressure in chamber **17** will be required to raise the piston **2** to the position shown in Fig. 7 so that fluid under pressure will be able to flow through port **54** along passage **53** to energize the spark plug **48**. Thus, the arrangement of passages **54** and **55** and elements **57**, **58** and **67**, **68** automatically increases the stroke of the piston after the device has operated through enough strokes to build up in chamber **17** a pressure sufficient to close the passage **55**.

It will be noted that with the above operations the force of the impact is diminished by the fact that the downward movement of the piston **2** compresses air in the passage **10**. If it is desired to increase the force of the impact, the cam of Fig. 3 is turned so as to allow the needle valve **14** to be raised by its spring and open the passage **1** to communication with the opening **1'** in the combustion chamber **11**. The result of this arrangement is that during upward movement of the piston **2** as the pressure in the combustion chamber **11** builds up part of the fluid under pressure will move through the opening **1'** along the passage **1** to the underside of piston **12** to raise the latter. It will be noted that this piston **12** has an intermediate portion of reduced cross section in the form of an annular groove which provides communication between passages **18** and **19** when the piston **12** is thus raised. Therefore, when the explosion in combustion chamber **11** occurs the passages **18** and **19** will communicate with each other, and since passage **19** communicates with the outer atmosphere, the resistance to downward movement of the piston **2** will be greatly reduced and the impact will therefore be greatly increased. As soon as the piston **2** uncovers the exhaust port **26**, the pressure in passage **1** will of course fall off and the piston **12** will drop, the latter being under the action of the fluid pressure in the passage **10**, so that at this time the passage **18** will provide communication between passage **10** and chamber **17** to again raise the piston **2** and repeat the above cycle of operations.

Fig. 5 of the drawings shows a variation according to which the passages **25** and **10** are carried by the fuel tank **33** which holds fuel to be supplied to the passage **4**. In this way the cylinder, which is located between the passages **25** and **10** of Fig. 5 in the manner shown in Fig. 5 is protected by these passages **25** and **10**.

Fig. 8 of the drawings also shows a variation according to which the valve **6** is located on the side of valve **7** opposite from the spark plug **48** in the manner shown in Fig. 8. Fig. 8 further shows a member **67** carried by the lugs **45** to protect the spark plug **48** and the ignition device **68*a***.

Fig. 10 shows an arrangement where instead of the cam and needle valve **14** of Fig. 3, a member **14*a*** with a central bore **120** therein is turnably mounted on the apparatus in the passage **1** and has a lever **122** fixed thereto and adapted to be located in notches **121** on the top of the cylinder head. A spring **123** urges the member **120** and lever **122** downwardly to maintain the lever **122** within a desired notch **121**. The member **14*a*** is formed with a pair of passages **124** and **125** which are angularly displaced through **90°** with respect to each other and which communicate with the bore **120**, the top end of this bore being closed and the bottom end of this bore being open as viewed in Fig. 10. The cylinder is formed in chamber **11** with a pair of passages **126** and **127**, respectively located at the elevation of passages **125** and **124**. Thus, through the medium of lever **122** the operator may angularly turn the member **14*a*** to selectively place passage **127** in communication with bore **120** through passage **124** or passage **126** in communication with bore **120** through passage **125**, or both of the passages **126** and **127** may be closed.

With the passages **126** and **127** closed, the device operates in the same way as when the passage **1** of Fig. 1 is closed. With the parts in the position shown in Fig. 10 where the passages **124** and **127** are aligned and communicate with each other, the structure of Fig. 10 will operate substantially in the same manner as the structure of Fig. 1. However, when passages **125** and **126** are in communication with each other, it will be noted that the passage **126** will be closed by piston **2** until the piston **2** has moved downwardly sufficiently to uncover the passage **126**, and thus the piston **12** will not be raised until the piston **2** has already moved through some distance downwardly along its working stroke. Once the passage **126** is thus uncovered, the piston **12** is raised to place the annular groove **12*a*** of piston **12** in communication with passages **18** and **19** so that the resistance of the fluid in chamber **17** to downward movement of the piston **2** is reduced only during the latter part of the downward movement of piston **2** when the passages **125** and **126** are placed in communication with each other. Thus, the embodiment of Fig. 10 produces the same results as the embodiment of Fig. 1 and in addition provides through the passages **125** and **126** an intermediate stage where the impact of piston **2** is between that where the passage **1** is completely closed and where it communicates with the top end of chamber **11**.

As was mentioned above, the device of the invention may be held in a vertical downward position during operation, as shown in Fig. 1, or it may also extend horizontally or upwardly. The handles **34** of Fig. 1 are inconvenient for holding the device horizontally or upwardly, and thus the handle **28** of Fig 6 may replace the handles **34** of Fig. 1 when the device is to be held in a horizontally or upwardly extending position. The handles **34** are simply screwed out of the threaded aperture **37** and the U-shaped handle **28** is placed over the apertures **37** and the plugs **38** are then screwed into these apertures through the bores **36** at the opposite ends of handle **28** to connect the latter to the device. The pivot pin of lever **21** is removed together with the lever **21** when handle **28** is attached to the apparatus, and in its place the lugs **40** of Fig. 1 are provided with a pivot pin **35** which extends through a lever **39** which is turned by the operator toward the handle **28** in a clockwise direction, as viewed in Fig. 6, to accomplish the same results as the lever **21**. The lugs **40** extend on opposite sides of a member **41** fixed to the handle **28** and supporting the pivot pin **35**, so that the lugs **40** and member **41** prevent turning of handle **28** on the apparatus.

The embodiment of Fig. 2 differs from that of Fig. 1 in that the piston **2** as well as the cylinder are stepped as shown in Fig. 2 so that an annular chamber **27** is located about the piston **2**. Furthermore, with the arrangement of Fig. 2 there is no passage **3** providing communication between chambers **8** and **25**, as is the case with Fig. 1. Also, the embodiment of Fig. 2 includes a spring-pressed valve **32** for automatically allowing air to pass from chamber **27** into chamber **25** when the pressure of the air in chamber **27** is sufficient to overcome the pressure of the spring of valve **32**, and when the member **7** of Fig. 2 is moved to the left by lever **21**, the valve chamber **24** can derive compressed air only from the chamber **25**. In addition, the embodiment of Fig. 2 includes a valve **31** similar to the valve **6** in that it allows compressed air to flow into but not out of the chamber **27**, this valve **31**, which may have the same construction as valve **6**, communicating with the source of compressed air in the same way that chamber **8** communicates therewith. With the embodiment of Fig. 2, the fluid in chamber **17** will act on a far greater area to raise the piston **2** upwardly in chamber **11** which has a smaller cross sectional area than chamber **17**.

The embodiment of Fig. 2 operates as follows:

A valve in the line from the compressed air tank is opened to supply air under pressure to chamber **8** as well as to chamber **27** through valve **31**, and thus the piston **2** will automatically be located in the starting position of Fig. 2. The needle valve for regulating the flow of fuel through passage **4** and nozzle **5** is then opened in the same way as was described above in connection with Fig. 1. Then the operator turns the lever **21** in a counterclockwise direction to start the apparatus. Thus, the member **7** will be moved to the left to close the right end of passage **29**, so that chamber **8** no longer communicates with chamber **24**, and instead to place chamber **24** in communication with chamber **25** through the opening of valve **23**. At the same time, the groove **9** places the chamber **8** in communication with chamber **10** through the valve **42** so that compressed air flows along chamber **10** through passage **18** through chamber **17** to raise the piston **2**. Thus, the volume of chamber **27** is reduced to increase the pressure of the air therein so as to close valve **31** and open valve **32** to thus supply chamber **25** with compressed air from chamber **27**, and this compressed air of course may flow to chamber **24** to be mixed with the fuel issuing from nozzle **5** upon passage through the valve **6**. When the piston **2** has uncovered the passage **55** shown in Fig. 7, the combustible mixture will of course be ignited and the above-described operations will start, the embodiment of Fig. 2 then continuing to operate in the same way as was described above. It will be noted that the embodiment of Fig. 2 is also provided with a needel valve **14** and passage **1** as well as piston **12** and passage **19** for controlling the force of the impact of the piston on the implement carried by the bottom end of the cylinder.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of explosion operated tools differing from the types described above.

While the invention has been illustrated and described as embodied in explosion operated fluid pressure tools, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. An internal combustion tool, comprising in combination, a cylinder having a head end in which combustion takes place; a piston mounted in said cylinder for reciprocating movement therein; a first duct located on the outside of said cylinder, extending along the length thereof, and communicating with the bottom end of said cylinder so that when compressed air is supplied to said duct, compressed air will flow to said bottom end of said cylinder to start the tool, said first duct being formed with a bore adjacent said bottom end of said cylinder and communicating with the atmosphere; a valve member located adjacent said bore of said first duct and being mounted in the latter for slidable movement between a lower position where said bore is kept out of communication with said cylinder by said valve member and an upper position where said bore communicates with the bottom end of said cylinder; a second duct communicating at one end thereof with the head of said cylinder and at an opposite end thereof with said first duct at a point beneath said valve member so that when said piston moves away from the head end of said cylinder after combustion in said head end and uncovers said one end of said second duct, the compressed gases in said head end of said cylinder flow through said second duct to the underside of said valve member to move the same to said upper position thereof so as to place the bottom end of said cylinder in communication with the atmosphere through said bore of said first duct and thereby eliminate resistance to movement of said piston by an explosion in the head end of said cylinder.

2. A tool as defined in claim 1 and wherein an adjustable needle valve is provided in said second duct adjacent said one end thereof to meter the flow of gases through said second duct.

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