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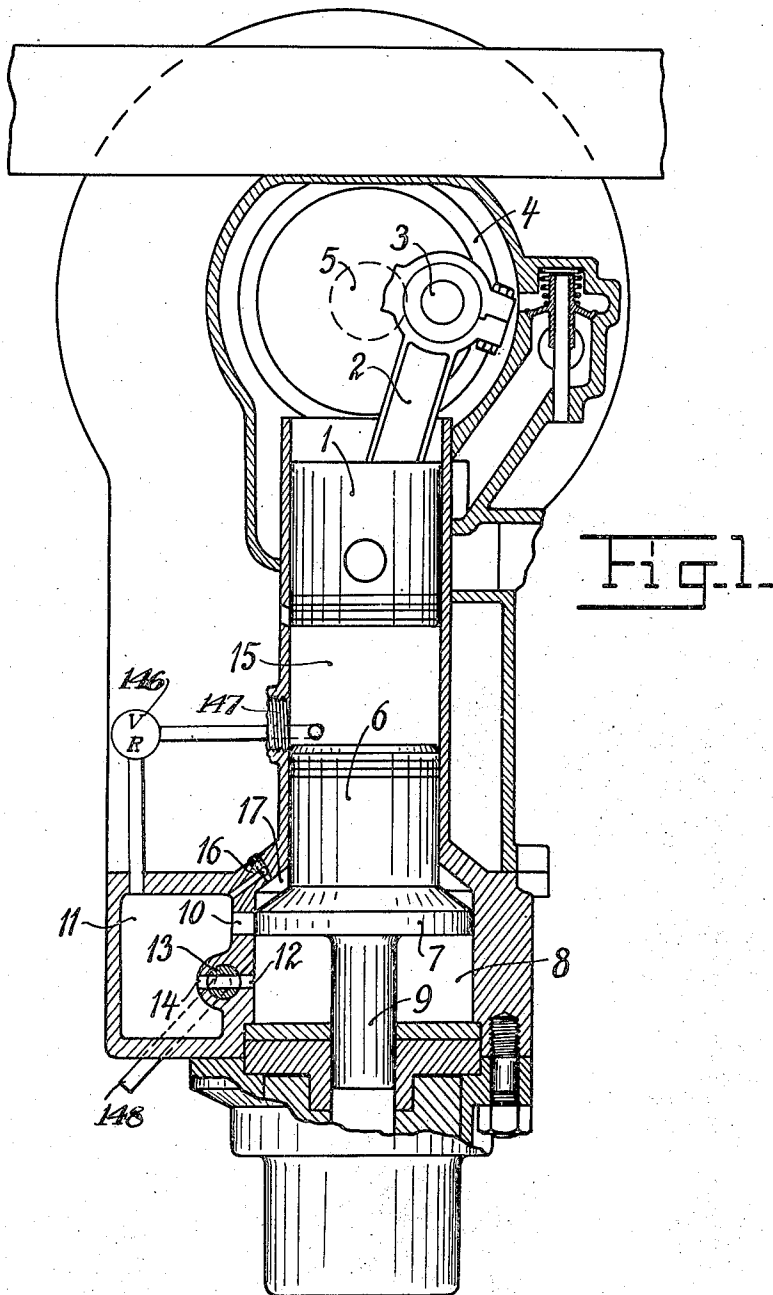
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1,920,765

PERCUSSION TOOL

Filed April 30, 1930

6 Sheets-Sheet 1



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6 Sheets-Sheet 2

Fig. 2.

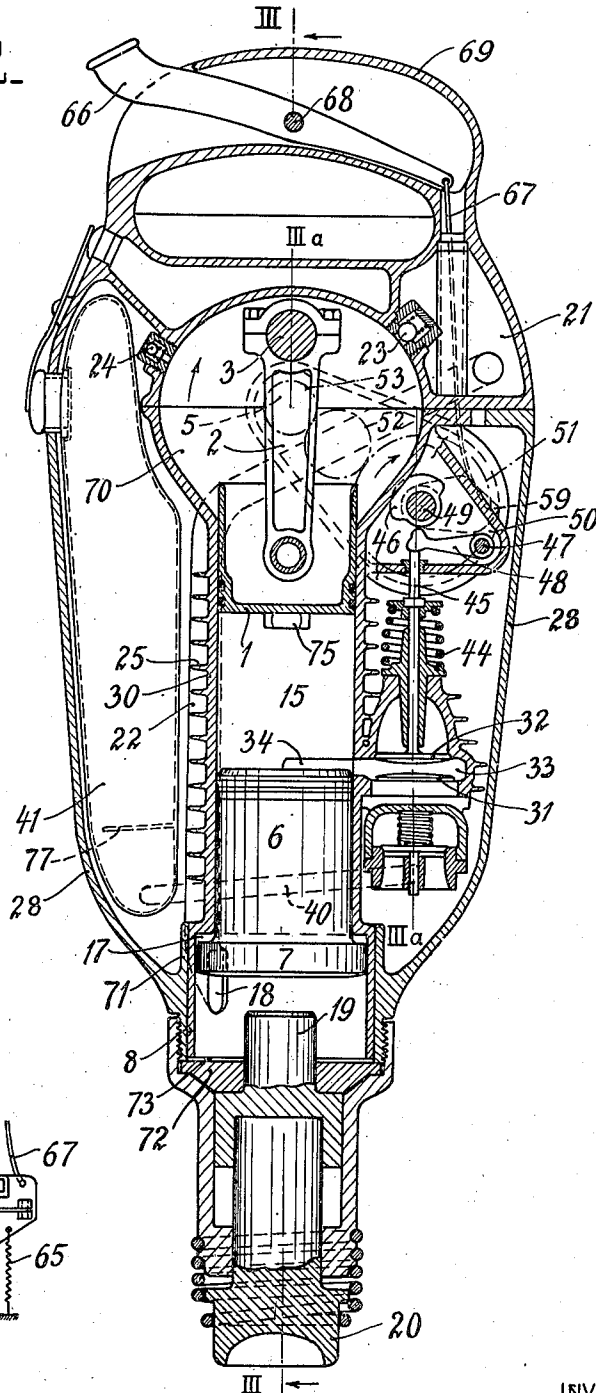
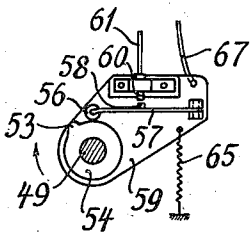


Fig. 4.



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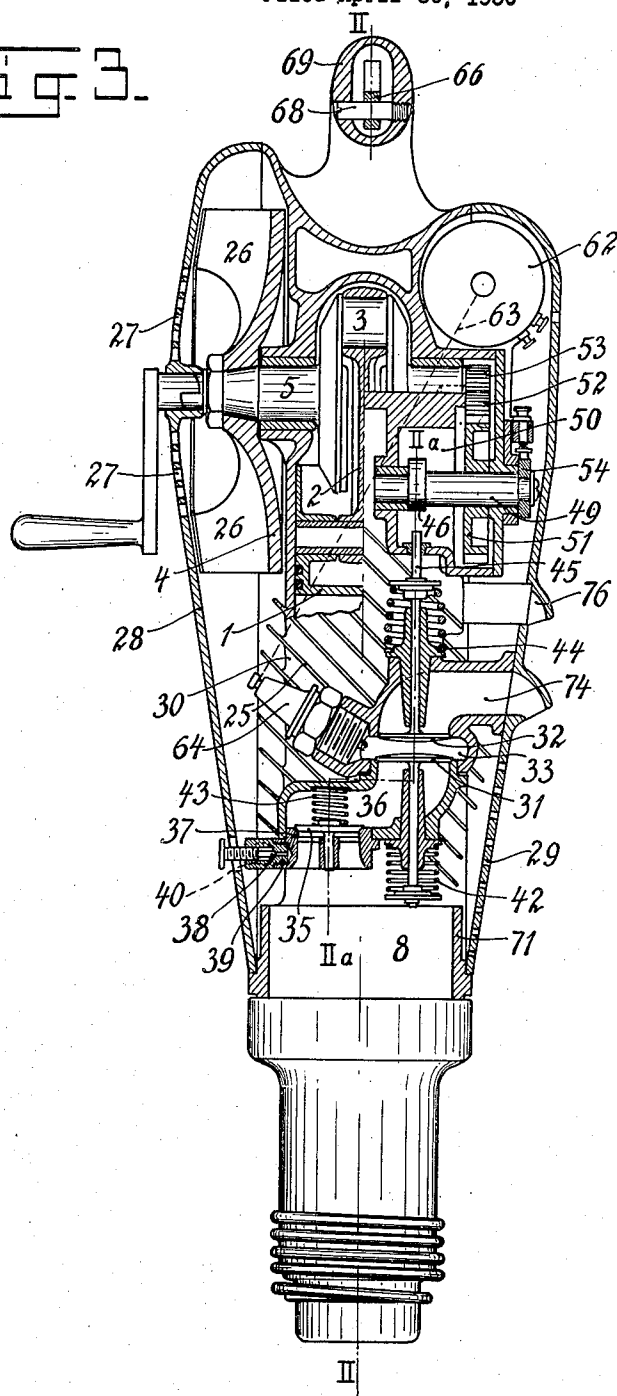
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Fig. 3.



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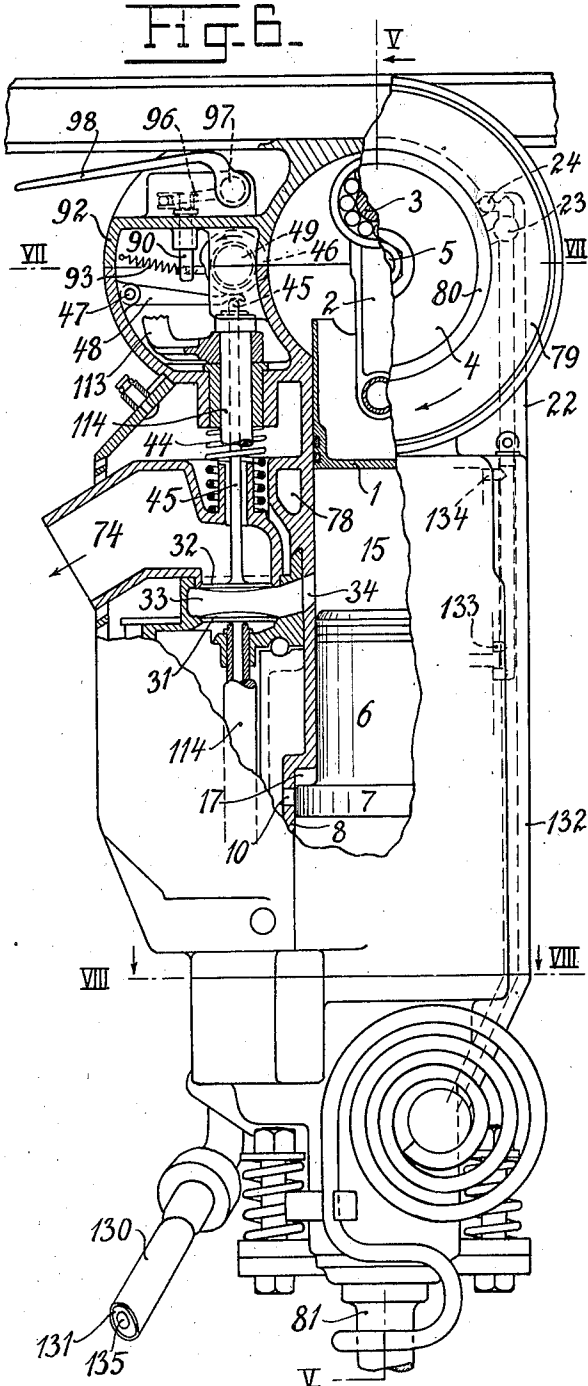
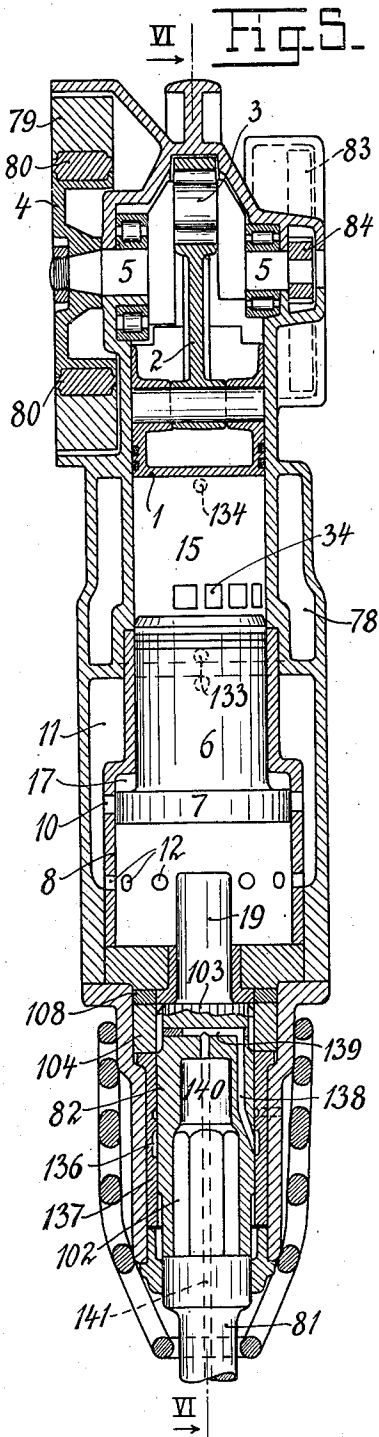
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PERCUSSION TOOL

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Fig. 7

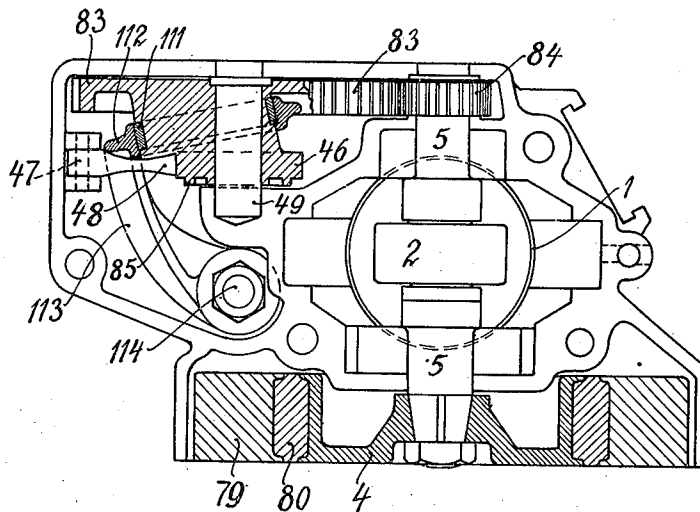


Fig. 9.

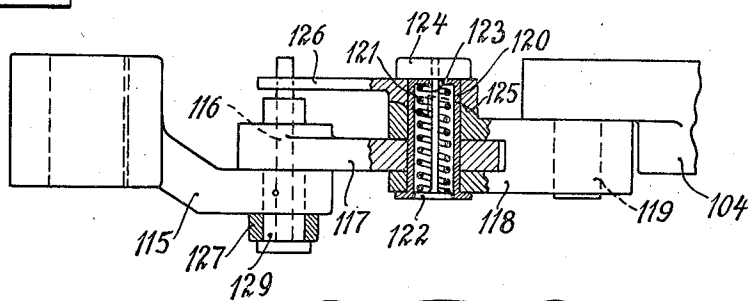
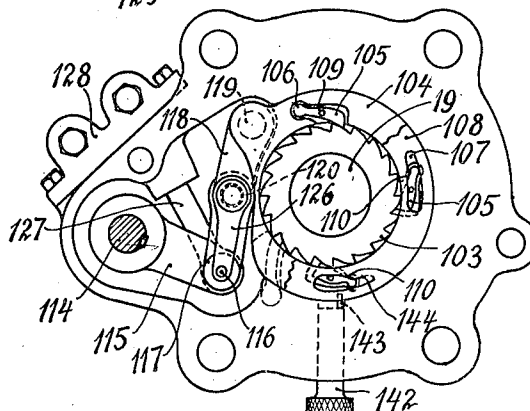


Fig. 8.



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Fig. 10.

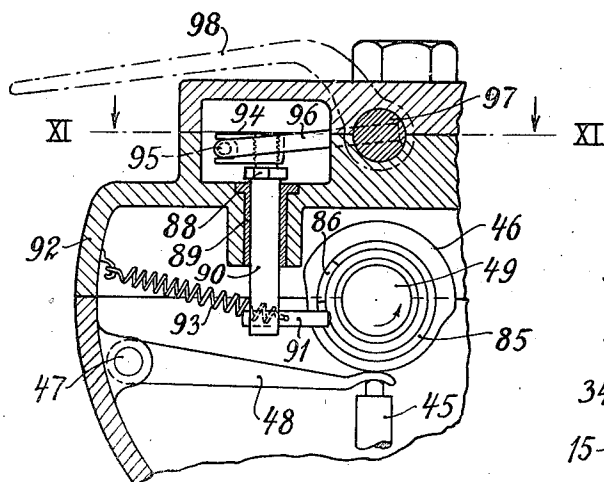


Fig. 12.

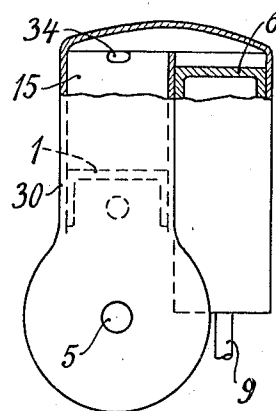
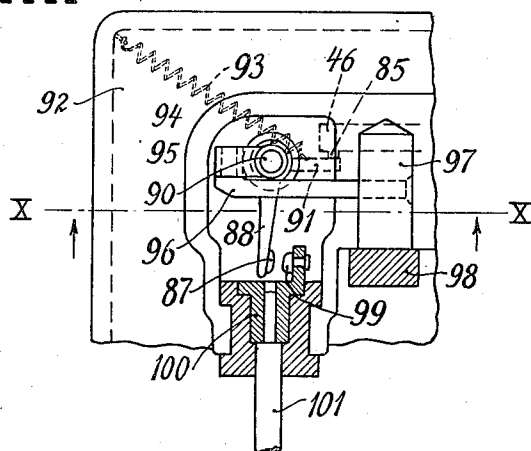


Fig. 11.



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UNITED STATES PATENT OFFICE

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PERCUSSION TOOL

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Application April 30, 1930, Serial No. 448,460, and
in Germany May 7, 1929

14 Claims. (Cl. 123—7)

The present invention relates to the kind of percussion tools with freely flying percussion piston, wherein the working blow is effected by means of the pressure developed in an explosion or internal combustion engine, viz: developed by the gases of combustion in the said engine. The engine serves simultaneously to produce and maintain a certain over-pressure in a gas or air chamber (auxiliary pressure-chamber).

According to the invention there are arranged between the said chamber and the percussion piston cylinder a connecting channel having such a position that the piston during its working stroke closes this channel before arriving at the end of its stroke and confines thereby within the cylinder end a body of gas or air serving to efficiently and yieldingly stop the piston, particularly in case the tool has been withdrawn and is operating idly. Without such an efficient gas cushion of a completely confined body of gas, the pressure of which increases constantly during the rest of the piston stroke, the percussion piston would when operating idly, strike violently in its cylinder bottom and explode the cylinder by the great forces developed in the explosion engine.

The percussion piston is preferably made as a stepped piston having two portions of different diameter. Thereby is also obtained in a simple manner a gas cushion stopping the piston, when returning after the operating stroke partly by the influence of the recoil from the anvil and partly by the gas pressure in the said auxiliary chamber.

In connection with this kind of percussion tools only two-cycle engines have been used hitherto. I use preferably four, six or eight-cycle engines, because I have discovered that thereby special advantages are obtained which cannot be obtained by two-cycle engines. This will be explained more fully hereinafter.

My invention comprises further certain features which enable an easy manual control of the ignition according to the impact of the percussion piston, further a safe control of the exhaust valve of the engine, further an efficient circulation of air or cooling water to maintain the engine suitably cooled during its operation, partly an automatic rotation of the tool or steel proper (drill) and partly an automatic stopping of this rotation in case the drill should exert, opposite the rotation, a resistance exceeding a predetermined limit. Other features of the invention will appear from the detailed description.

My invention is illustrated in the annexed drawings in four embodiments in Fig. 1, Figs. 2-4, Figs. 5-11 and Fig. 12 respectively.

Fig. 1 is an elevation of a two-cycle engine substantially in vertical longitudinal section on

the common axis of the engine and percussion piston cylinder.

Fig. 2 is a longitudinal section of a six-cycle engine substantially on the line II—II of Fig. 3 one part of Fig. 2 being however a section on the broken line IIa—IIa of Fig. 3.

Fig. 3 is a side view of the tool seen perpendicularly to the plane of Fig. 2, the left hand half being substantially a section on the line III—III of Fig. 2. The right hand half is, however, a section substantially on the broken line IIIa—IIIa of Fig. 2.

Fig. 4 shows, drawn to a larger scale, a detail view of the mechanism for adjusting the ignition point.

Fig. 5 is a longitudinal section of the third embodiment on the line V—V of Fig. 6.

Fig. 6 shows the eight-cycle engine of Fig. 5 seen from the left and partly in section on the line VI—VI of Fig. 5.

Figs. 7-11 are drawn to larger scales.

Fig. 7 is a plan view substantially in section on the line VII—VII of Fig. 6.

Fig. 8 is a plan view of the parts located under the line VIII—VIII of Fig. 6.

Fig. 9 shows, drawn to a larger scale, a development of the yielding mechanism transmitting motion to the ratchet ring for automatically stepwise rotating the drill.

Fig. 10 shows the mechanism for manually adjusting the ignition in the eight-cycle engine shown in Figs. 6-7. This figure is substantially a vertical section on the line X—X of Fig. 11.

Fig. 11 is a plan view of the parts located below the line XI—XI of Fig. 10.

Fig. 12 shows diagrammatically, partly in section, a modified arrangement of the engine cylinder relatively to the percussion piston cylinder, to be used preferably in stationary engines of larger dimensions.

In the embodiment shown in Fig. 1, the percussion piston is operated by means of a two-cycle motor. The motor piston 1 is by the connecting rod 2 connected in ordinary manner with the crank 3 of a shaft 5 provided with fly wheel 4. As usual the motor has a carburettor, sparking plug and exhaust valve. The arrangement of these parts may be the ordinary one and is not described in connection with Fig. 1.

The percussion piston is made with two steps 6, 7 of different diameter. The upper part 6 operates in the extension of the motor cylinder. The lower widened part 7 operates in a percussion chamber 8 of a corresponding bore, and the percussion bar 9 connected to the piston serves to transmit the percussion to the drill (not shown).

The chamber or cylinder 8 communicates through ports 10, 12 with an auxiliary or pressure chamber 11, which for instance through

pipe 145 and a suitable reduction valve 146 may be connected so with the compression chamber of the engine that the pressure in chamber 11 in spite of leakage, is maintained at a predetermined value. The chamber 11 may be connected with a pump or another source of pressure for the same purpose.

The port 10 is located at a suitable distance from the upper part of chamber 8, so that the large piston step 7 during its upward stroke establishes a connection between chambers 11 and 8, whereas during the downward stroke a connection is established between chambers 11 and 17.

Port 12 which is located at some distance above the bottom of cylinder 8 may be controlled by a cock 13 arranged in housing 14. 15 denotes the explosion chamber having a treaded lateral bore 147, into which the sparking plug (not shown) is to be screwed, for instance a plug like 64 in Figure 3.

The operation is as follows:—

Piston 1 is assumed to be in its top position ("top position" meaning that most distant from shaft 5 and "bottom position" that next to said shaft), wherein chamber 17 is nearly reduced to nil, because gases therein during the upward travel of piston 7 have been expelled through the upwardly opening non-return valve 16. When the piston 1 moves towards percussion piston 6, 7 during the compression stroke, piston 6 is firstly maintained for a very short time in raised position, because chamber 11 communicates through port 10 with cylinder 8 below piston 7 and because upon a downward motion of piston 7 a suction tends to arise in chamber 17. By the explosion in chamber 15, the counter-forces of the percussion piston 6, 7 are rapidly overcome, and said piston is flung downwards. During this motion port 10 is passed by the piston step 7, whereby now gas under pressure flows from chamber 11 through port 10 into chamber 17, whereby the suction effect therein ceases. The gas under pressure below the piston is now firstly forced through port 12 back into chamber 11 ordinarily until the drill is hit by the percussion bar 9. However, should the drill not exert any counter-pressure, a gas cushion is formed, when the piston step 7 has passed by the port 12. This cushion prevents any harmful shock of the percussion piston against the bottom of cylinder 8. After the stroke this gas cushion will assist in carrying the piston 6, 7 back to its upper position. Also the gas under pressure passing in through port 12 acts upon a larger area than the gas within chamber 17. When during the upward stroke the piston step 7 has passed by port 10, the gas will be confined around the small piston step 6 and is now compressed so as to form a cushion. Towards the end of the stroke, however, the non-return valve 16 opens, whereby the gas contents in chamber 17 is emptied into chamber 11.

The action of chamber 8 is adjusted by cock 13, because the counter-pressure in chamber 8 depends upon the area of the cock 13 through which the gas expels into chamber 11.

If it is desired to let the machine operate idly, the cock 13 is preferably closed completely for instance by a handle 148. Thereby the percussion piston 6, 7 will not at all enter in contact with the drill.

The chamber 11 receives preferably gas under

pressure from the compression space 15 of the motor through a reduction valve 146. But as the gas consumption is quite small, the pressure may also be easily maintained by another source. If chamber 11 is fed by the compressed motor gases, the percussion piston may, for instance by means of the drill, be raised from the bottom of cylinder 8 before starting, because said piston can be flung back upwardly only, when it has once moved a certain distance towards the bottom.

It is formerly known to effect the return motion of the percussion piston by gas under pressure which is present in an auxiliary chamber similar to chamber 11. However, in the construction shown in Fig. 1, the port 12 communicating with said chamber is closed completely before the end of the working stroke of the piston, whereby the piston, as already explained, operates against an efficient gas cushion which stops the piston rapidly, if it operates idly. This is important particularly in automatic tools, wherein the driving force is an explosion motor. If no efficient gas cushion were present in the lower end of the cylinder 8 of the piston 6, 7, the piston when operating idly would strike violently in the cylinder bottom and break the cylinder.

Another important feature consists in the piston 6, 7 being made in two steps and the annular space 17, formed in cylinder 8 around the small piston step 6, communicating through port 10 with the auxiliary pressure chamber 11. Thereby the percussion piston obtains in a simple manner a gas cushion also at the opposite side of the large step 7, and I obtain an efficient checking of the piston on either side, even if the machines operates idly.

As mentioned above it is formerly known to drive percussion hammers etc. by means of two-cycle explosion motors.

I have discovered, however, that a much better efficiency is obtained by using a four, six, eight etc. cycle engine. The use of engines of this kind for the operation of automatic percussion tools constitute a further important feature of my invention.

By way of example Figs. 2, 3 and 4 illustrate a six-cycle motor as a driving device for a riveting hammer.

In these figures the numerals 1, 2, 3, 4, 5, 6, 7, 8 and 17 have the same meaning as in Fig. 1. Instead of two ports 10, 12, the wall of cylinder 8 is provided with a larger single port 18 of a suitable axial length. This port ends at a suitable distance from the bottom of cylinder 8, preferably approximately in level with the top surface of anvil 19 forming the top portion of the riveting hammer 20. The upper part of port 18 ends at a suitable distance from the top of cylinder 8. Thereby the percussion piston 6, 7 is protected by gas cushions on both sides just as described hereinbefore.

The port 18 communicates with the pressure chamber 21 which is arranged at the upper part of the machine as shown to the right in Fig. 2. The connection is a bent pipe 22 passing from 18 to 21 and enclosed in the machine cap. The pressure chamber 21 receives air from the crank chamber 70 through a non-return valve 23. 24 denotes the suction valve of this chamber.

The common cylinder 30 of motor piston 1 and percussion piston 6 has exterior air cooling ribs 25. The fly wheel 4 keyed to the crank

shaft 5 is made as a fan with vanes 26 drawing in air from the atmosphere through holes 27 in the upper part of cap 28 and blowing out this air through lower holes 29 past the ribs 25 on cylinder 30 inside cap 28.

The inlet valve 31 of the motor and its cam-controlled exhaust valve 32 open to a common valve chest 33 communicating through the inlet port 34 with the top of the explosion chamber 15 of cylinder 30. In addition to valve 31 an air suction valve 35 is arranged which tends to close the valve chest 36 of valve 31 and on whose seat a fine benzine channel 37 ends.

Said channel is controlled by a needle valve 38, the housing 39 of which communicates through a pipe 40 (see Fig. 2) with the bottom part of a benzine tank 41 confined within cap 28. Weak springs 42, 43 press the valves 31 and 35 respectively against their seats with a suitable pressure, and a spring 44 maintains the exhaust valve 32 on its seat. Its valve stem 45 is controlled by a cam 46 by a lever 48 pivoted at 47.

Cam 46 is keyed to a shaft 49 enclosed in a housing 50 and connected by a train of gears 51, 52, 53 with the motor shaft 5, the ratio of gearing between shafts 5 and 49 being as 3:1, i. e. shaft 49 makes one revolution each time shaft 5 makes three revolutions. The raised portion of cam 46 comprises such an angle as to maintain valve 32 in open position approximately during three of the six strokes of piston 1. This is explained more fully later on.

Outside the housing 50 shaft 49 is provided with a cam 54 (see also Fig. 4) having a projection 53 operating a roller 56 attached to a spring 57 carrying an electric contact 58 and fixed to an arm 59 turnable about the axis of shaft 49. Said arm has a stationary counter contact 60 insulated from arm 59 and connected by electric lead 61 with one terminal of a battery (not shown) having its other terminal connected with arm 59 or contact 58 through the metal of the machine. In the circuit also a primary coil is connected as usual. This coil and its appertaining secondary coil are indicated diagrammatically at 62 (upper part of Fig. 3). One terminal of the secondary coil is connected by lead 63 with the sparking plug 64 in ordinary manner, so that the plug produces an igniting spark each time the current is broken which was closed between contacts 58 and 60, consequently each time projection 55 passes by roller 56.

As mentioned, the arm 59 is pivoted, and a spring 65 tends to pull it downwards, whereas it may be swung upwards by means of a handle 66 (topmost in Fig. 2). Its exterior end may be manipulated manually by the operator. The inner end of said handle is connected by a wire 67 with arm 59.

Thus by pressing upon lever 66 the operator may adjust the angular position of arm 59 or roller 56 relative to projection 53 whereby the time of firing of plug 64 varied with respect to the movement of piston 1. Lever 66 is pivoted on a pin 68 in the upper handle portion 69 of the machine.

As shown in Fig. 2 the lower extension 8 of the cylinder 30 projects slidably into a surrounding sleeve 71 attached to the lower end of the exterior machine cap 28. Its lower part is closed by a bottom piece 72, through which the anvil 19 projects upwards. Between the inner top face of bottom piece 72 and the lower end

of cylinder 8 there is a small gap 73 permitting the necessary heat extension of cylinders 30 and 8. As said above, the cylinder 30 has a top port 34. When valve 32 is open, the gases are blown by way of port 34, housing 33 valve 32 and exhaust channel 74 out into the atmosphere. But cylinder 30 has also a bottom port 75 putting it in communication with the atmosphere through a lateral channel 76 (see Fig. 3) each time the motor piston 1 is adjacent its bottom position (Fig. 2.).

The machine shown in Figs. 2-4 operates as follows:

Normally a pressure of about 0.6 atm. is to prevail in the air chamber 21. In Fig. 2 the piston 1 has just completed its first stroke (suction stroke), whereby valves 35 and 31 have been raised, and air by way of 35, 36, 31, 33, 34 has been sucked into the space 15 of cylinder 30. Simultaneously a benzine quantity regulated by needle 38 has been sucked from tank 41 through pipe 40, valve chest 39, past needle 38 and through the small bore 37 to the seat of air valve 35 and into the cylinder space 15 together with the air. In addition, in the piston position shown an extra quantity of fresh air is passed through 76 and 75 into the bottom of space 15. The exhaust valve 32 has been closed by cam 46 just before the suction stroke commenced, and the percussion piston 6,7 remains from before at rest in raised position on account of the pressure on the underside. From the preceding explosion the shaft 5 with fly wheel 4 and fan 26 have a sufficient kinetic energy left to effect the succeeding compression. Fig. 2 shows the arm 59 in position for a top ignition, whereas arm 59 in Fig. 4 is in position for about 90° advanced ignition.

It is presumed that arm 59 is adjusted as shown in Fig. 4, the operator having pressed down lever 66 to a corresponding degree.

The piston 1 now commences its second stroke (compression stroke), driven by the energy left in the fly wheel and the other rotating members from the foregoing explosion. Consequently the piston 1 moves downwards (see Fig. 2). As soon as port 75 has been closed the compression commences. When the crank 3 has turned through 90° from the position shown in Fig. 2, the cam projection 53—which in the meantime has reached the roller 56 and lifted it, consequently closed the primary current of the induction coil 62—releases the roller, whereby the primary current is interrupted. Therefore, the secondary circuit comprising the spark plug 64 produces the spark igniting the explosive charge contained in chamber 15 and still only halfway compressed. During the development of the combustion and explosion, the piston 1 is forced further down to its top position. During the compression stroke cam 46 turns through 60° without opening exhaust valve 32, and crank 3 is now positioned diametrically opposite the position shown in Fig. 2. Then the third (explosion) stroke commences, during which the crank turns through further 180° and cam 46 through 60° and piston 1 is now again in bottom position. Immediately before this position, the port 75 has opened and cam 46 has opened the exhaust valve 32. The combustion gases therefore will escape from both ends of chamber 15 which is thereby emptied rapidly, and the pressure decreases nearly momentarily down to atmospheric pressure. This fact enables a rapid rotation of the motor. The opened valve 32 re-

mains opened by cam 46 during the three succeeding strokes, so that the motor cannot draw in air and benzine through valve 31. But during these three strokes (fourth, fifth and sixth) the piston 1 will scavenge the chamber 15 by fresh air, thereby cooling the cylinder 30. At the end of the sixth stroke, cam 46 again closes exhaust valve 32, and the next working cycle may now commence with the suction stroke.

The operating piston 1 during the compression stroke, particularly from the moment of advanced ignition, exerts driving power upon the percussion piston 6, 7 located in top position. But as said piston is made with a large mass, it requires a certain time to be put in motion. Presuming the motor makes 3000 revolutions (6000 strokes) a minute, the whole compression stroke requires 1/100 second and its second half from advanced ignition requires about 1/200 second. The percussion piston is so dimensioned in weight that it strikes the anvil 19 approximately at the same moment as the piston 1 is in top position, consequently at the end of the compression stroke. From this follows that the percussion piston during about 1/200 second or less has moved downwards with constantly increasing velocity and strikes with its highest velocity the anvil 19, where it gives off the most part of its living force. Simultaneously the air cushion below the large step 7 is compressed. Therefore, at the next moment the percussion piston is flung upwards driven partly by the air cushion below it and partly by the recoil from the anvil. As this reversing of the piston requires a certain time, it reaches its top position (as shown in Fig. 2) only when the driving piston 1 has nearly completed its expansion stroke. During this movement the percussion piston has therefore assisted in imparting energy to the driving piston, whereby the rotating members have the necessary living force required for the rest of the cycle and for the next compression stroke.

Thus it will be seen that both pistons move in substantially the same direction during compression and expansion strokes of the driving piston. Then the percussion piston 6, 7 remains at rest during the four next strokes of the driving piston. This action of the motor is specially advantageous, and the percussion piston will deliver short, distinct and ardent blows on the anvil at suitable intervals. By means of the arm 66 the operator may easily regulate this condition by feeling, and experience has shown that such a safe regulation is impossible in two-cycle motors. Already four-cycle motors enable a safe regulation but six or eight-cycle is preferable.

Simultaneously a very efficient air cooling of the motor is obtained, and in small hammers water cooling may therefore be avoided, or the motor may operate more rapidly or with a higher pressure, from which follows smaller dimensions at the same percussion force of the tool. An advanced ignition of between 90° and 50° will be suitable.

In the lower portion of the benzine tank 41 a nearly horizontal partition wall may be arranged as indicated at 77 (Fig. 2), thus at a short distance above the outlet to the benzine pipe 40. Thereby lowermost in the benzine tank 41 a small chamber is formed wherein the benzine will accumulate, when the tank has a small benzine quantity and wherein the ben-

zine is prevented from flowing back into the main portion of the tank, if the tool is used in horizontal position.

In the tool construction shown in Figs. 5-11 the percussion piston 6, 7 is driven by an eight-cycle motor, wherein the explosion chamber 15 is provided with water jacket 78 (Fig. 5). This motor is in several respects constructed similar to the six-cycle motor described above, and the parts are denoted by corresponding numerals, and a special description of these parts is therefore unnecessary.

The fly wheel 4 as seen in Fig. 5, is provided with an exterior heavy ring 79, and between this and the central part a ring 80 of a suitable resilient material, for instance rubber, is interposed. Thereby the largest fly wheel mass is prevented from being deleteriously influenced by the shocks coming from the boring bit 81, the upper end of which projects as usually with the lower extension 82 of the anvil 19.

The cam shaft 49 of the exhaust valve 32 (Figs. 6 and 7) carries a cam 46 turnable thereon and made integral with a large gear wheel 83 driven from a pinion 84 keyed to the crank shaft 5. The ratio of gearing between the two gears 84 and 83 is as 1:4. Consequently, the cam 46 makes one revolution at each four revolutions of the motor shaft 5.

The cam 46 is so shaped as to maintain the exhaust valve closed during suction, compression and expansion strokes of the motor piston 1 but open during the succeeding five idle strokes. The projecting portion of cam 46 therefore embraces about $\frac{5}{8}$ of 360° as indicated in Fig. 6.

The cam 46 has at one end face a projecting cam ring 85 (Figs. 7, 10) cut away on a short portion 86. This ring is intended to control the ignition contact 87, (Fig. 11) carried by an arm 88 attached on the upper end of a turnable vertical pin 90 the lower end of which carries a lateral pin 91. The latter projects laterally past the cam ring 85 and is connected with one end of a tension spring 93 fastened at its other end to the metal of the motor cover 92 as shown in Fig. 10. The pin 90 may be moved up and down in its sleeve by a fork 94 attached to its top and receiving a projection 95 of a lever 96 fastened on a short shaft 97 journaled in the motor covers. Such shaft projects through its aperture (Fig. 11) and carries outside it an operating arm 98.

The contact 87 is located directly opposite a stationary counter contact 99 (Fig. 11) attached to a sleeve 100 which is surrounded by an insulating sleeve and electrically connected to an insulated conductor 101, whereas contact 87 is connected to the metal of the engine. As will be seen the spring 93 tends to move contact 87 against contact 99, but this is prevented by cam ring 85 pressing upon pin 91 during the most part of the revolution of the ring. However, when the cut 86 of said ring passes by pin 91, spring 93 closes contact between 87 and 99, and shortly thereafter the ring 85 again interrupts this contact, whereby the sparking plug produces as usually the spark igniting the explosive charge in chamber 15.

The ignition point is regulated by arm 98. By its swinging the height of pin 91 relatively to cut 86 of cam ring 85 may be varied. If arm 98 is swung upwards, also pin 91 is raised,

whereby the motor is ignited at a more advanced point of time.

Also in eight-cycle motors the mass of the percussion piston 6, 7 is so dimensioned as compared with the velocity of driving piston 1 and size of explosive charge that a 90°-50° advanced ignition causes the percussion piston to operate in similar manner as explained above for the six-cycle motor.

As mentioned before the boring bit 81 projects into sleeve 82 forming the lower extension of anvil 19. The upper end 102 of the bit is hexagonal (Fig. 5), whereby a rotation of sleeve 82 is transmitted to the bit. Such a rotation is to take place after each time the percussion piston 6, 7 has delivered a blow upon the anvil and has returned upwards. For this purpose the sleeve 82 is provided in its upper end with pawl teeth 103 (Fig. 5 and 8) and surrounded by a pawl ring 104, wherein three pawls 105 are pivoted. These pawls turn in a vertical bore 106 and are pressed by a blade spring (not shown) against the pawl teeth. Each pawl 105 has a pin 109 projecting up into a guide slot 107 made in a stationary ring 108. This is journaled above the pawl ring 104 (Fig. 5), and a portion thereof is seen in Fig. 8. The slot 107 has next to centre of the ring an inclined portion 110 acting on pin 109, when pawl ring 104 is oscillated. In Fig. 8 the pawls 105 mesh with the teeth 103, but when ring 104 with pawls is turned counter-clockwise through a small angle, pin 109 of each pawl during the last part of the rotation slides along the inclined plane 110 and passes beyond it. Thereby the pawl is moved out of mesh with the pawl teeth 103, because the guiding slot 107 has a face 144, upon which the pin 109 ascends and which is located so distant from the centre that it maintains the pawl out of mesh with the pawl teeth during the period, wherein the percussion piston performs its working stroke and then returns into initial position. By means of a reversible pin 142 operable from outside the operator may put the pawls 105 out of action, permanently. When pin 142 is turned a half revolution from the position shown in Fig. 8, a small projection 143 thereof will rotate the ring 108 through a small angle clockwise, whereby the guiding faces 144 maintain the pawls out of mesh during the whole angular range which the ring 104 is rotated from the lever 115.

The oscillating motion of pawl ring 104 is derived from a cam 111 (Fig. 7) mounted on gear wheel 83 and surrounded by a ring 112. This ring is attached to the end of an arm 113 fastened to a vertical shaft 114 (Figs. 6, 7, 8) journaled in the machine frame and extending from its upper part down to the boring sleeve, where it carries a side arm 115 (Figs. 8, 9) which through pin 116 and two links 117, 118 and pivot 119 is connected with pawl ring 104. As gear wheel 83 makes one complete revolution during eight strokes of working piston 1, the cam 111 will swing arm 113 and through the parts 114, 115, 116, 117, 118 also rotate pawl ring 104 once to and fro during the same period, whereby the boring bit 81 is rotated through a predetermined angle once in each working cycle of the motor. The cams 111 and 46 are so angularly displaced in relation to one another that pawl ring 104 rotates pawl wheel 103 and boring bit 81 during the idle strokes of the motor but maintains the pawls 105 out of engagement with wheel 103 by means of controlling

faces 110, 114 and pawl pins 109 during the compression and expansion strokes of the motor.

Figs. 8 and 9 show a mechanism preventing breakage in the transmission members, between arm 115 and pawl ring 104 in case the boring bit should bite and therefore cannot be rotated. This mechanism consists in a friction resistance interposed between the links 117 and 118, and it is shown in a developed state and in a larger scale in Fig. 9. The connection between the links 117 and 118 consists of a pivot sleeve 112 with an interior compression spring 121. One end thereof has an inner abutment with the sleeve 120 and its other end presses against the head 112 of a pin 123 projecting through sleeve 120 and provided outside it with a ring 124. The link 118 is forked, and one fork branch has exteriorly three or four inclined teeth 125 in engagement with correspondingly shaped teeth upon an arm 126 surrounding one end of sleeve 120 between teeth 125 and ring 124. The other end of arm 126 surrounds the pin 116. The pins 116, 119 and sleeve 120 are not located in one and the same line, but the axis of sleeve 120 is located somewhat outside the plane through the axis of pins 116 and 119. (See Fig. 8.)

If pawl ring 104 exerts too high a resistance to clockwise rotation, pin 119 lies stationary, but if now pin 116 is moved towards pin 119, the frictional resistance on the teeth 125 is overcome and the sleeve 120 swings out from the centre of the pawl wheel, the spring 121 being compressed. The members 117, 118 thus form an elbow bending out at a certain resistance of the pawl ring 104 or the boring bit.

The arm 115 also serves to drive the pump for circulating cooling water of the motor. In Fig. 8, 127 denotes the pump piston stem and 128 the pump housing. The stem 127 surrounds a sleeve 129 (Fig. 9) on the lower end of pin 116, so that the pump receives two strokes each time arm 115 is swung to and fro. The pump serves to pass cooling water from the exterior space 131 (Figure 6 below) of the hose 130 through one channel in a pipe 132 and through a port 133 into water jacket 78, further out therefrom through another port 134 (Fig. 5) and through another channel in pipe 132 back to hose 130 and out again through its central channel 135. A part of the pump water is also passed into an annular channel 136 in a sleeve 137 (Fig. 5) surrounding the boring bit sleeve 82. From annular channel 136 the water passes up into channels 138, 139 in sleeve 82 into its central space 140 and further into the bore hole through the central channel 141 of the bit 81.

Obviously instead of benzine as a driving medium for the explosion motor, any other suitable driving medium may be used such as gas, subdivided petroleum etc.

Furthermore, the invention may be utilized in transportable tools as described and in stationary hammers of larger or less dimensions similar to the well-known steam or air hammers.

Hereinbefore the motor cylinder is described as being located in alignment with the percussion piston cylinder. Of course, this is not necessary. Especially in large stationary machines it may be advantageous to arrange the motor cylinder at the side of the percussion piston cylinder, both cylinder axes being parallel as indicated diagrammatically in Fig. 12.

What is claimed

1. In a percussion tool, the combination of means forming a percussion chamber, and in-

cluding walls defining opposite ends of the chamber, a freely movable reciprocable percussion piston having a relatively large area portion slidable in the percussion chamber, relatively small area portion protruding therefrom through one of the end walls, said small area portion adapted to be exposed to exterior explosive means to move the piston on its actuating stroke, and a percussion bar of relatively small cross sectional area compared to said large area portion and projecting centrally therefrom through the other end wall, means providing an auxiliary pressure containing chamber having longitudinally spaced apart ports placing the same in communication with the portions of the percussion chamber on opposite sides of said large area portion of the piston, said piston controlling said ports and acting when closing either port to close the portion of the percussion chamber between said large area portion and the adjacent end wall to form a cushioning chamber in advance of said large area portion of the piston in each of its reciprocatory directions of movement.

2. In a device of the class described, the combination of a cylinder having a motor piston working therein at one end of the cylinder, a freely floating differential percussion piston having a small end working in the other end of the cylinder, the space between the pistons providing an explosion space, a percussion chamber in which the large end of the piston reciprocates, a source of fluid pressure supplied from said explosion space, means controlled by the large end of the percussion piston for alternately opening said source to opposite sides of the same and said large end in its movement towards one end of the percussion chamber intercepting communication between the pressure source and said percussion chamber and forming at said end a closed cushioning space for cushioning the movement of the percussion piston in its movement towards said end.

3. In a percussion tool, the combination of an explosion chamber enlarged at one end to form a percussion chamber, a freely floating differential percussion piston having its smaller end slidable in the explosion chamber and its larger end slidable in the percussion chamber and provided with a percussion bar constituting an extension from the larger end of the piston, a pressure chamber, a pair of ports placing the percussion and pressure chambers in communication, said ports being spaced apart along the length of the percussion chamber, each in spaced relation to the adjacent end of the percussion chamber, said larger end alternately closing and opening one of the ports in its movement towards and from one end of its stroke and said larger end when in position closing said port providing a closed cushioning space between itself and the adjacent end of the percussion chamber.

4. In a percussion tool, the combination of means forming a percussion chamber, a freely movable differential percussion piston having its larger end mounted for reciprocatory movement in said chamber, one end of the percussion chamber and a part of said piston forming therebetween an annular cushioning space for cushioning the movement of the piston as it moves towards said end of the percussion chamber, explosive means acting on the smaller end of the piston for actuating the same, a pressure chamber and a valve controlled passageway be-

tween the pressure chamber and said cushioning space for permitting air in said cushioning space to be forced by the piston back into said pressure chamber, means controlled by the position of the piston for opening and closing fluid communication between the pressure chamber and the cushioning space.

5. In a percussion tool, the combination of means forming a percussion chamber, a freely flying percussion piston mounted for reciprocatory movement in said chamber, an internal combustion engine having its explosion chamber open to said piston to actuate the same, a pressure chamber, a port providing fluid communication between the percussion and pressure chambers, said port located adjacent to and spaced slightly from that end of the percussion chamber which faces the piston at the return or rebound from its working stroke, and said piston acting to control said port to govern the admission of pressure from the pressure chamber into the percussion chamber and said piston when disposed in position closing the port coacting with said end of the percussion chamber to form a closed cushioning space to resiliently cushion the piston as it moves towards said end and a valve controlled outlet leading from said end of the percussion chamber.

6. In a percussion tool, the combination of means forming a percussion chamber, a freely flying percussion piston mounted for reciprocatory movement in said chamber, an internal combustion engine having its explosion chamber open to said piston to actuate the same, a pressure chamber, a port providing fluid communication between the percussion and pressure chambers, said port located adjacent to and spaced slightly from that end of the percussion chamber which faces the piston at the return or rebound from its working stroke, and said piston acting to control said port to govern the admission of pressure from the pressure chamber into the percussion chamber and said piston when disposed in position closing the port coacting with said end of the percussion chamber to form a closed cushioning space to resiliently cushion the piston as it moves towards said end.

7. In a percussion tool, the combination of means forming a percussion chamber, a freely movable differential percussion piston having its larger end mounted for reciprocatory movement in said chamber, means for cushioning the final movements of the piston in both directions, an internal combustion engine operatively connected to the smaller end of the piston for actuating the same on its working stroke and for supplying said cushioning means with operative pressure, a conduit between the engine and cushioning means, and a reduction valve in said conduit.

8. In a percussion tool, the combination of means forming a percussion chamber, a freely movable percussion piston mounted thereon for reciprocatory movement, an explosive engine operatively connected to reciprocate the piston, means including a source of fluid pressure supplied from said engine and controlled by the position of the piston as it approaches opposite ends of its stroke for cushioning the piston as it approaches the ends of its stroke and valvular means for controlling the cushioning pressure acting on the piston.

9. In a percussion tool, the combination of a freely movable percussion piston, capable of re-

bounding freely after the completion of its actuating stroke, an internal combustion engine operatively connected to move the piston on its actuating stroke, pneumatic means operatively controlled by the piston for cushioning the rebound of the piston and valvular means for controlling the pressure of said pneumatic means.

10. In a percussion tool, the combination of means forming a percussion chamber, and including walls closing opposite ends of the chamber, a freely movable reciprocable percussion piston having a relatively large area portion slidable in the percussion chamber, relatively small area portion protruding therefrom through one of the end walls, said small area portion adapted to be exposed to exterior explosive means to move the piston on its actuating stroke, and a percussion bar protruding integrally from said large area portion through the other end wall, means providing a pressure chamber having longitudinally spaced apart ports placing the pressure chamber in communication with the portions of the percussion chamber on opposite sides of said large area portions of the piston, said piston controlling said ports and acting when closing either port to close the portion of the percussion chamber between itself and the adjacent end wall to form a cushioning chamber in advance of the piston in each of its reciprocatory directions of movement.

11. In a device of the class described, the combination of a cylinder, a freely moving percussion piston mounted for reciprocatory movement in one end of the cylinder, means within the cylinder forming an explosion in rear of the piston, for moving the piston on its actuating stroke and pneumatic cushioning means supplied with pressure from said explosion chamber for cushioning the movement of the piston as it approaches both ends of its travel, and means controlled to operate in a timed sequence with the movement of the piston for admitting and releasing pressure on opposite sides of the same.

12. In a device of the class described, an integral cylindrical member provided with a bore including a portion of relatively small diameter and a portion of relatively large diameter, a wall connecting said large and small diametered portions, said small diameter portion providing an

explosion chamber, and a differential percussion piston having its smaller end sliding in said small diameter portion and its larger end sliding in said large diameter portion, the space between the larger end of the piston and said connecting wall forming an annular piston cushioning space.

13. In a percussion tool, the combination of means forming a percussion chamber and including walls closing opposite ends of the chamber, a freely movable reciprocable percussion piston having a relatively large area portion slidable in the percussion chamber, a relatively small area portion protruding therefrom through one of the end walls, said small area portion adapted to be exposed to exterior explosion means to move the piston on its actuating stroke, a percussion bar connected with said large area portion and protruding through the other end wall, means providing a pressure chamber having a port placing the pressure chamber in combination with the portions of the percussion chamber on opposite sides of said large area portion of the piston, said piston controlling said port and acting when closing either end of the port to close the portion of the percussion chamber between itself and the adjacent end wall to form a cushioning chamber in advance of the piston in each of its reciprocatory directions of movement.

14. In a percussion tool, the combination with an internal combustion engine operable on cycles comprising more than three strokes, and including a cylinder having an engine piston mounted for reciprocatory movement in one end and a freely moving percussion piston mounted for reciprocatory movement in the other end of the cylinder and said pistons coacting to form the explosion chamber of the engine therebetween, means forming an auxiliary pressure chamber, a conduit including a valve between the explosion chamber and the auxiliary pressure chamber, the end portions of the cylinder and the percussion piston coacting to form cushioning chambers for the percussion piston and supplied by pressure from said auxiliary pressure chamber and operatively disposed to cushion the movement of the percussion piston as it approaches the ends of its reciprocatory movement.

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