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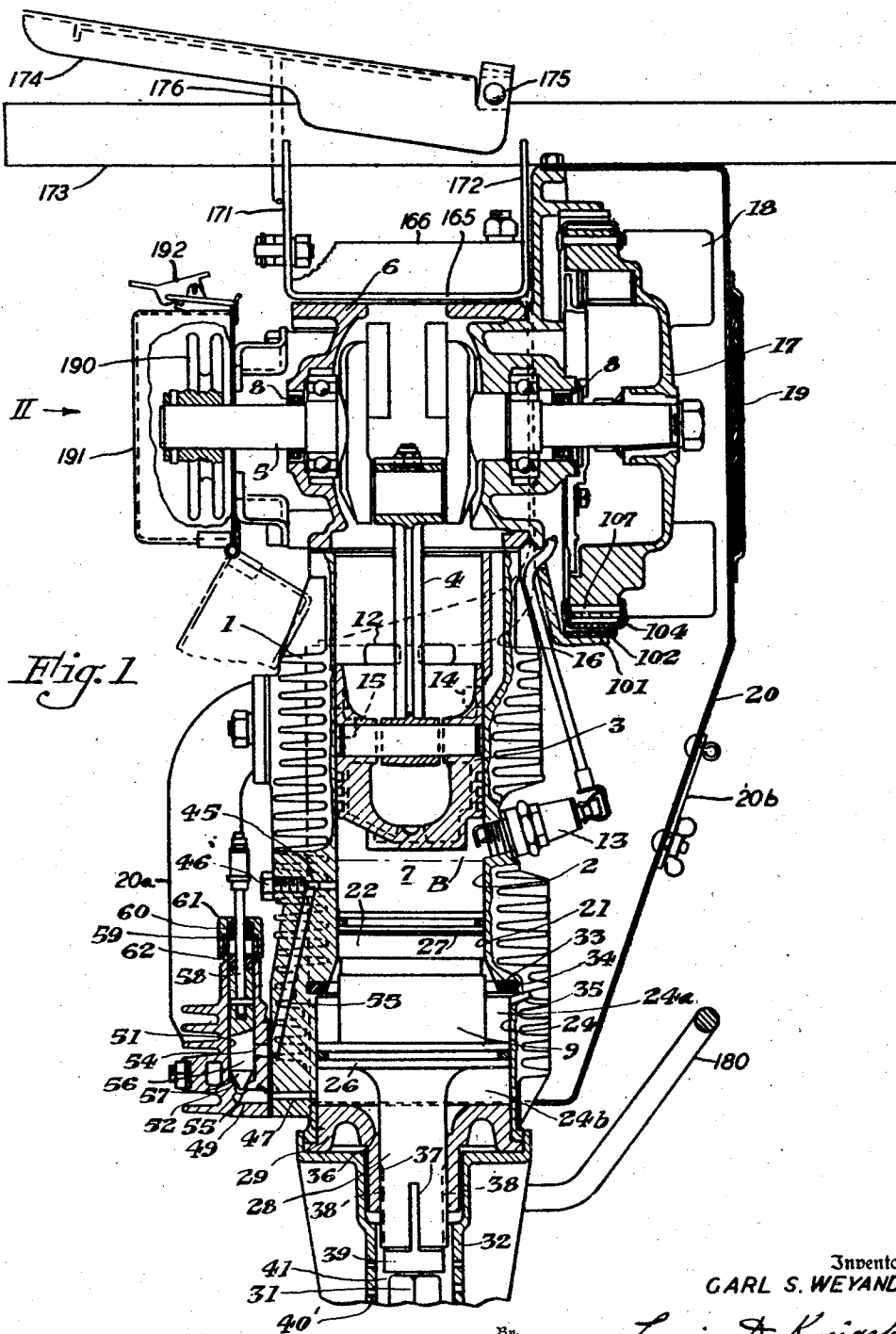
C. S. WEYANDT

2,433,007

INTERNAL-COMBUSTION PERCUSSION TOOL

Filed July 30, 1943

4 Sheets-Sheet 1



Inventor
CARL S. WEYANDT

Levia J. Konigsford

Attorney

Dec. 23, 1947.

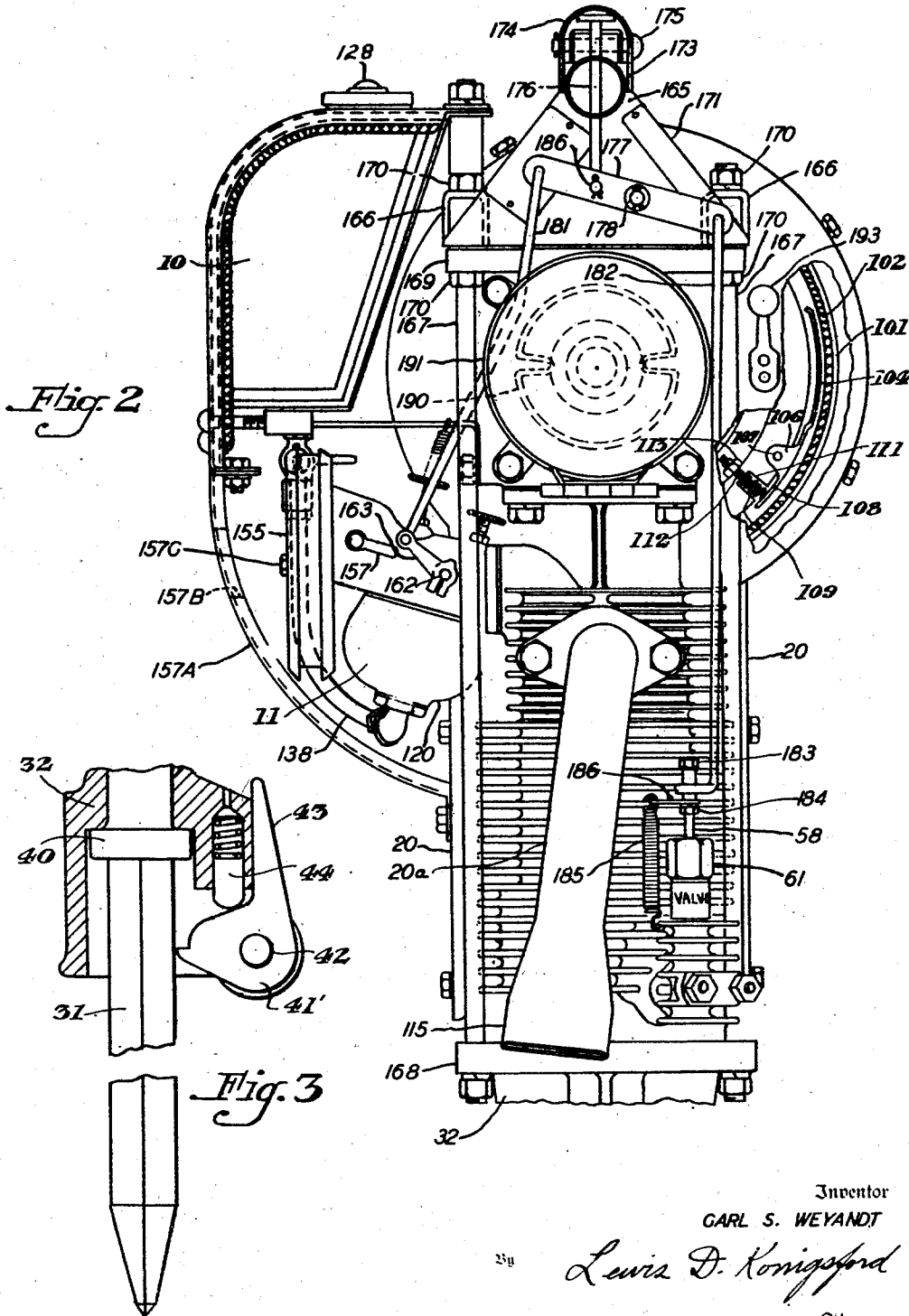
C. S. WEYANDT

2,433,007

INTERNAL-COMBUSTION PERCUSSION TOOL

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4 Sheets-Sheet 2



Inventor

GARL S. WEYANDT

Lewis D. Konigsford

Attorney

Dec. 23, 1947.

C. S. WEYANDT

2,433,007

INTERNAL-COMBUSTION PERCUSSION TOOL

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4 Sheets-Sheet 3

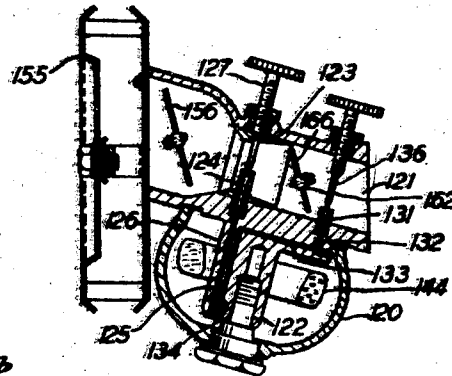
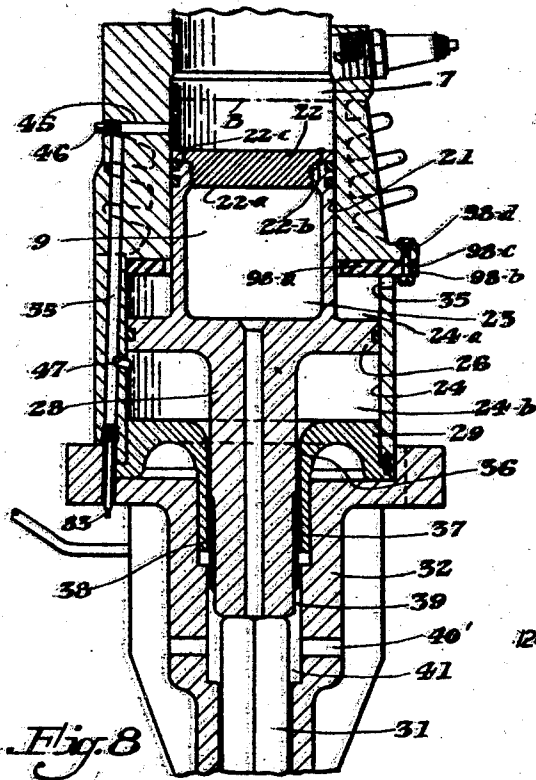


Fig. 4

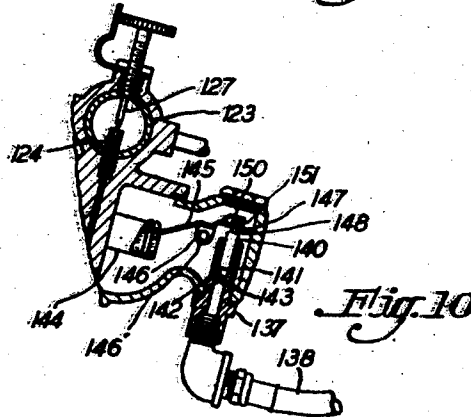


Fig. 10

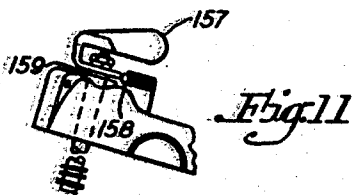


Fig. 11

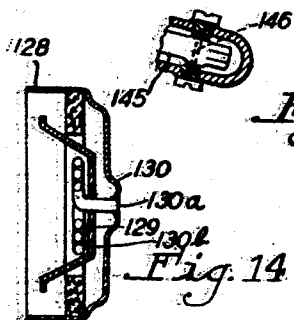


Fig. 14

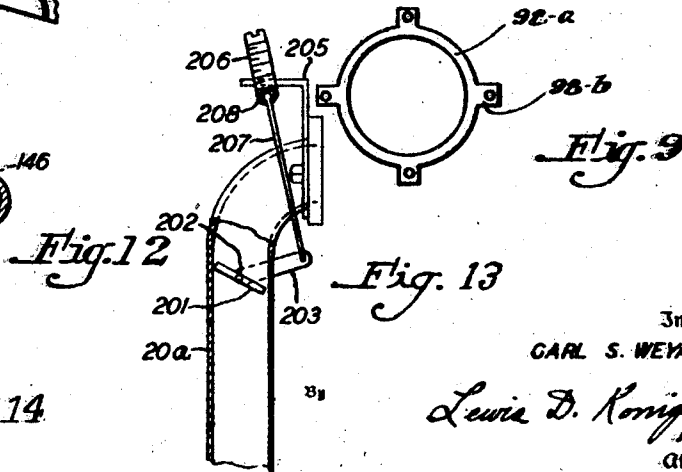


Fig. 9

Fig. 13

Inventor

CARL S. WEYANDT

Lewis D. Konigsmann

Attorney

Dec. 23, 1947.

C. S. WEYANDT

2,433,007

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4 Sheets-Sheet 4

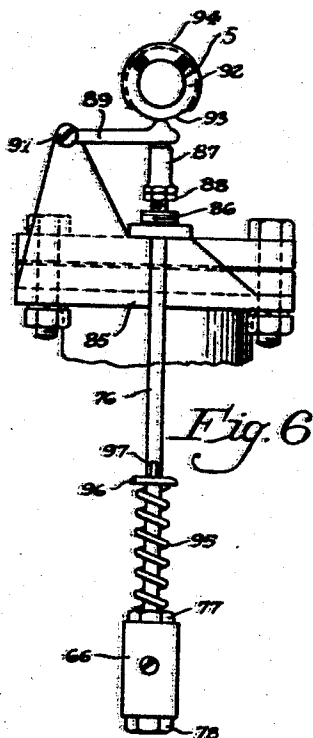


Fig. 6

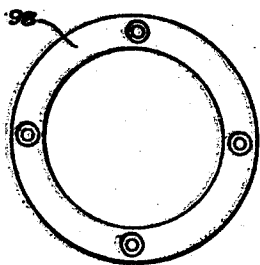


Fig. 7

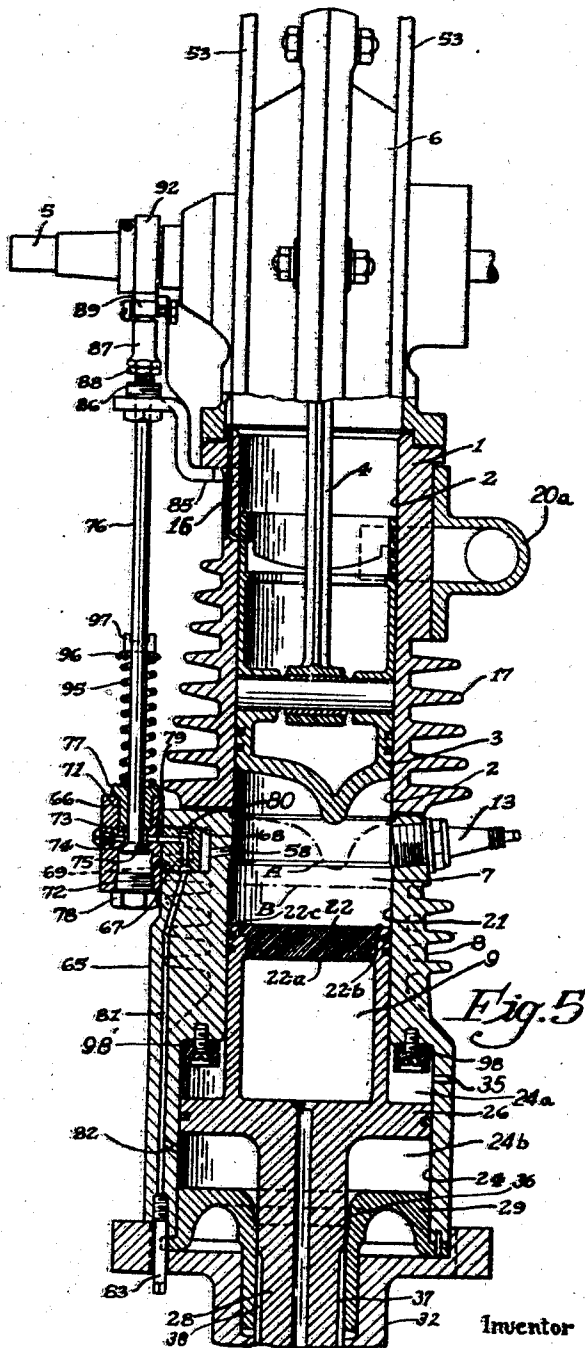


Fig. 5

By

Inventor
CARL S. WEYANDT

Lewis D. Konigsford

Attorney

UNITED STATES PATENT OFFICE

2,433,007

INTERNAL-COMBUSTION PERCUSSION TOOL

Carl S. Weyandt, Indiana, Pa.

Application July 30, 1943, Serial No. 496,709

16 Claims. (Cl. 123-7)

1 The present invention relates to percussion tools operated by internal combustion of a fuel, and relates particularly to such tools employing a free working piston.

Heretofore it has been proposed to provide a percussion tool of this type having a captive piston which controls the combustion of the fuel and a free differential piston which is impacted against the tool by the combustion of the fuel and is returned by the pressure of the exhaust gases, the return stroke being cushioned by a gas cushion. However, I have found that in operation the reciprocation of the differential or working piston is irregular so that the blows delivered thereby are not uniform, nor is the maximum power of the apparatus developed. Furthermore, it becomes difficult to supply oil to the walls of the differential cylinder, so that the life of the apparatus is considerably shortened due to the great wear on the working piston and its cylinder walls.

It is an object of this invention to improve the operation of percussion tools of this type to provide a more uniform operation of the working piston.

Another object is to increase the efficiency of the apparatus by increasing the power of the working piston.

Another object of this invention is to provide a device of this kind in which the action of the working piston may be controlled independently of the idling piston.

Still another object is the provision of an apparatus of this type which may be operated in vertical or horizontal position.

A further object of this invention is to provide a device of this kind in which the timing action of the working piston may be self-controlled.

According to one feature of the present invention, I provide in an internal combustion percussion tool having an idling piston and a differential working piston driven in one direction by combustion of the fuel and returned by the pressure of exhaust gas, a cushioning means for the return stroke of the working piston which enables the working piston to return to substantially the same position at the commencement of each working stroke. This is accomplished, for example, by the provision of a buffer of resilient solid material for limiting the return stroke of the working piston. Suitable resilient solid materials for this purpose are the so called synthetic rubbers, particularly those which are oil resistant, and which are polymers of butadiene, its homologues and substitution products, 55

2 or copolymers thereof with acrylonitrile or other unsaturated compounds having an unsaturated linkage adjacent the end carbon atom. Examples of such materials commercially available are "Neoprene" which is a polymer of chlorine substituted butadiene, namely chloro-2-butadiene-1,3, and "Cogene" and "Ameripol" which I believe to be copolymers of butadiene with acrylonitrile in various proportions. Such materials do not disintegrate under repeated impacts and are resistant to gasoline, oil and grease and heat. The buffer may be applied to such apparatus in which the exhaust return port in the combustion chamber is controlled either by the working piston or by the idling piston.

The timing of the idling piston preferably is controlled by imposing a load thereon, and in the preferred embodiment this load is imposed by a centrifugal governor or brake which controls the speed of rotation of the crankshaft and thus controls the frequency of reciprocation of the idling piston.

By providing a special carburetor the apparatus may be used in practically a horizontal position. The special carburetor has the fuel outlet to the motor at the middle of the fuel bowl the axis of which is inclined to the axis of the motor and adjacent the bottom so that the outlet always will be under the fuel level, and the fuel level is controlled by an annular type float so that it will be effective in all positions of the apparatus.

For a detailed description of the invention, reference is had to the following specification taken in connection with the accompanying drawing, wherein preferred embodiments of the invention are shown by way of example, and wherein:

Figure 1 is a side view partly in vertical section and with parts broken away of a preferred embodiment of the invention,

Figure 2 is a side view taken in the direction of the arrow II in Figure 1,

Figure 3 is a vertical section of the lower portion of the embodiment shown in Figure 1,

Figure 4 is a vertical sectional view of the carburetor,

Figure 5 is a vertical sectional view of a portion of a modification,

Figure 6 is a side elevation of a detail of the modification shown in Figure 5,

Figure 7 is a bottom view of a detail,

Figure 8 is a vertical sectional view of a further modification,

Figure 9 is a top view of a detail,

Figure 10 is a vertical sectional view of a detail of the carburetor,

Figure 11 shows the choke valve operating handle,

Figure 12 shows the mounting of the float lever,

Figure 13 shows a modified exhaust conduit, and

Figure 14 shows a detail of the fuel tank cap.

Referring to the drawing, Figure 1, there is shown a casting or motor block 1 of cast iron having heat radiating fins and having a bore 2 therein which provides a chamber or cylinder in which the piston 3, which is called an idling piston, is adapted to reciprocate. This piston is suitably connected, as by a connecting rod 4, with the crankshaft 5 journaled in suitable ball bearings in the crankcase 6 bolted to housing 1, and the crankshaft bearings are sealed by suitable seals 8. The lower part of the housing accommodates a working piston 9 to be later described in detail, and the middle part 7 of the housing serves as a combustion chamber.

Gasoline, containing oil for lubrication of the moving parts of the apparatus, is contained in a tank 10 (Fig. 2) suitably attached to the apparatus, and is mixed with air in a carburetor 11 of suitable construction to be later described in detail. On the down stroke of piston 3 a mixture of air and gasoline is drawn into the piston chamber 2 through the divided intake port 12 which is uncovered by the piston skirt near the lower end of its stroke, and when the piston moves upwardly it compresses the fuel charge in the crankcase 6. As the piston continues to move upwardly it first uncovers the exhaust port 15 and then uncovers the intake port 14, thus forcing the combustible charge from the crankcase through the conduit 16 and port 14 into the combustion chamber 7, the piston head being suitably baffled to prevent the incoming fuel being discharged through the exhaust port. The crank returns the piston to compress the charge in combustion chamber 7, which is ignited by the spark plug 13, the electric current for operating the spark plug being obtained from a combination magneto and flywheel 17 on the crankshaft 5. A fan 18 on the crankshaft draws air through a suitable screen 19 and forces a draft of cooling air against the fins on the motor block, a shroud or housing 20 being provided to deflect the air downward and against the fins. An external line 20a is connected to the exhaust port 15 to deflect the exhaust downward. The shroud or housing 20 is located to guide the cooling air substantially horizontally between the fins on the motor block, the air entering the housing on the spark plug side and leaving on the exhaust pipe side. An opening covered by a removable plate 20b may be provided to allow access to the spark plug.

The bore 21 in the casing below the combustion chamber constitutes a prolongation of bore 2 and receives the smaller end 22 of the hollow steel working piston 9, which is hardened and has a highly polished working surface, and a counter-bore 24 in the casing receives the enlarged portion 26 of the piston 9 which divides counterbore 24 into chambers 24a and 24b. The enlarged portion 26 preferably has twice the area of end 22 which may be of any size desired, and need not be, but preferably is, the same diameter as piston 3. Suitable rings and an oil groove 27 may be provided to form a sealing contact between the piston 9 and the walls of chambers 21 and 24. I prefer to provide a working clearance between

the piston and its chamber of about 0.005 inch to prevent seizing at the elevated temperature created in operation. Piston 9 has an extension 28 which passes with a close fit through a guide bushing 29 of tool steel or other suitable material and is adapted to strike the end of a tool 31 of any kind, such as a drill or tamper bar, loosely received in the tool holder 32 and longitudinally movable therein. Guide bushing 29 is clamped between the block 1 and the flanged tool holder or sleeve 32 in any suitable manner, and a dowel may be provided for proper positioning thereof. The working piston 9 preferably is guided in its reciprocation by the stem or extension 28 working in guide bushing 29 and the smaller end 22 working in bore 21, and the enlarged portion 26 need not have an accurately controlled clearance with the cylinder wall 24 as it carries a sealing ring of known construction which extends beyond the surface thereof and contacts the bore.

A buffer ring 33 is located in a recess 34 at the upper end of cylinder 24 which has one or more openings 35 to provide a relatively free passage of air to and from the upper end 24a of cylinder 24 to allow the piston to contact the buffer and to assist in cooling the buffer. Buffer 33 preferably is composed of a synthetic rubber material, the materials known as "Cogene" or "Ameripol" and having a durometer hardness of about 50 to 80 having been found especially suitable. I prefer material having a durometer hardness of about 65. These materials are believed to be polymerized compounds of butadiene with acrylonitrile and are sold under the above trade names by Goodyear Rubber Co. and Goodrich Tire and Rubber Company, respectively.

The guide bushing 29 is recessed at 36 to cooperate with a slot 37 and two slots 38 located in the end of member 28 which merge with the reduced end 39 thereof in chamber 41, and suitable holes 40 in holder 32 allow escape of gas therefrom to the atmosphere. Slot 37 is of such length that when the working piston is at the upper limit of its stroke its upper end is uncovered by the recess 36 so that slot 37 and both slots 38 in this position register with the bottom of recess 36 and thus provides a relatively free escape for gas from the chamber 24b to the chamber 41 at the top of tool 31. On the downward stroke slot 37 first moves out of registry with depression 36 thus cutting down the rate of escape of gas from chamber 24b and then slots 38 move out of register so that all slots are disconnected from chamber 24b when the extension 28 impacts the tool. Should the tool be raised from the work during operation there is thus provided a gas cushion trapped in the lower end of chamber 24b to prevent the piston impacting the housing.

The tool 31 has flange 40 and a retainer 41' is provided to prevent accidental removal of the tool as shown in Fig. 3. If it is desired to move or change the tool, the retainer may be pivoted about the pivot 42 by the handle 43 until the spring detent 44 moves outwardly to hold the retainer retracted, whereupon the tool may be removed or replaced. The retainer then can be returned to operative position by means of the handle 43.

A bore 45 in the block 1 below the combustion chamber 7 opens into the cylinder 21 and has its outer end closed by a screw 46 which may be removed to allow cleaning of the bore. The location of bore 45 preferably is such that in the normal impacting position of piston 9 on the down stroke it is uncovered by the smaller end 22, and when the piston 9 is at its upper limit

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it is covered thereby. Another bore 47 connects with the lower chamber 24b near its bottom and is located below the normal lowermost position reached by the working piston 9. A control valve housing 48 with suitable cooling fins thereon is suitably bolted to the block and has a passage 49 registering with bore 47 and a vertical bore 51 terminating in a valve seat 52 with a valve opening 53 therethrough. A horizontal bore 54 connects at one end with bore 51 and at the other end registers with a bore 55 which thus joins bores 45 and 54. A valve piston 56 in bore 51 has tapered valve end 57 adapted to seat on seat 52 in the lowermost position of the valve piston. A rod 58 connects with the valve piston and extends from the valve housing 48 through a packing washer 59, packing 60 and nut 61, and a plug 62 of resilient heat and oil resisting resilient material seals the upper end of bore 51. Plug 62 preferably is made of synthetic rubber material, such as polymerized butadiene or a copolymer with acrylonitrile. When piston valve 56 is raised sufficiently to bring plug 62 against washer 59 the tapered end 57 uncovers bore 54 thus providing a passageway from chamber 24b through bores 47, 49, valve orifice 53 and bores 51, 54, 55 and 45 into chamber 21, and at the same time plug 62 seals the stem 58 to prevent leakage of gas. This control valve construction is preferred as its movement between opened and closed positions is a sliding one which breaks loose carbon deposits to allow the valve free to move.

The operation of the apparatus so far described now will be explained. The lowermost positions of pistons 3 and 9 is approximately shown in Figure 1, and the uppermost position of piston 9 is indicated approximately by the dot and dash line B. Piston 3 works in cylinder 2, and is forced upwardly by ignition of a combustible charge in firing chamber 7. At the same time the explosion of the fuel charge forces piston 9 downwardly until extension 28 strikes the end of tool 31, the slots 37 and 38 in the extension 28 allowing the air or gas in chamber 24b to escape rapidly at the initial part of this movement until slots 37 and 38 respectively cease to register with recess 36 near the end of this movement just prior to impact with the tool. Assuming valve piston 56 is in its uppermost position when the port 45 is uncovered by piston 9 on its downward movement, which occurs after the explosion takes place and after slots 37 and 38 are out of registry with recess 36, the high pressure exhaust gas is conducted through passages 45, 55, 54, bore 51, orifice 53 and passages 49 and 47 to the lower chamber 24b and the gas pressure returns the working piston 9 to its upper position against buffer 33 and thus causes the piston to close against port 45 to trap the exhaust gas in chamber 24b. Upward movement of piston 9 brings grooves 38 into registry with the recess 36 near the lower end of its stroke, and thus allows the exhaust gas in chamber 24b to bleed out through grooves 38, chamber 41, and ports 42. Finally groove 37 registers with depression 36, thus decreasing the pressure in chamber 24b.

The exhaust port 15 is first uncovered by the head of piston 3 and then the intake port 14 is uncovered so that a fresh explosive charge is forced into the chamber 2 through passage 16. The crankshaft and flywheel return the piston 3 to compress the fuel charge, but because of the larger area of piston 26 compared with the end 22, and notwithstanding the slow bleed

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through groove 37, the pressure in chamber 24b remains sufficient to hold the piston 9 at approximately its uppermost position against buffer 33 until the next explosion, which preferably occurs when the crank and piston 3 are about 40° before the dead center position. The buffer 33 is provided to cushion the impact of piston 22 at the upper end of its stroke, and the openings 35 permit relatively free entrance and escape of air to the chamber 24a above piston 26.

I prefer to have port 45 controlled by the working piston 9, the weight of which is experimentally determined for best operation, as a uniform idling operation of the working piston 9 is thus obtained and the working piston is each time uniformly returned and held in its uppermost position in readiness for the next explosion, the number of strokes of the working piston being synchronized with those of the idling piston.

The power of the apparatus is also increased by advancing the ignition so as to cause it to occur about 10° to about 45° or 50° before dead center. In this way the working piston and the idling piston are moving in the same direction so that a greater proportion of the explosion force is applied to the working piston. Furthermore by having the exhaust gas passage for returning the working piston controlled by the working piston and advancing ignition to about 35° to 40° before dead center, a higher pressure is transmitted to the piston return chamber 24b than if this passage were controlled by the idling piston. This is because the port 45 is uncovered sooner and exposes a higher pressure than if the idling piston 3 passed through dead center and then uncovered this port. This increases the power of the apparatus, or if desired, a lighter weight apparatus can be made by having a lower ratio between the area of the top surface of the smaller end 22 of the working piston and the effective area of the lower surface of the enlarged portion 26. Thus, I may use a ratio of about 1 to 1.3 for a light weight apparatus, and a ratio of 1 to 2 for heavier more powerful apparatus, although the preferred ratio is about 1 to 1.5.

When actually working, the desired synchronism may not be obtained under all conditions, due to the reactive influence of the tool upon the working piston, but the buffer 33 to a large extent compensates for such variations. The buffer provides a more uniform action than an air cushion, and by allowing the working piston to assume a higher position than is possible by an air cushion, a greater compression ratio of the fuel is obtained with resulting increase in power of the apparatus. Also I am able to lubricate the walls of the differential cylinder by the oil dissolved in the fuel. The failure to provide adequate lubrication of the working piston in prior devices, I believe, is due to the scavenging action of the combustion which burns the oil off the cylinder wall, and is overcome by the use of a solid resilient buffer by allowing the piston to rise further and thus protect the lubricant on the cylinder wall. An air cushion tends to hold the working piston away from its uppermost position, and furthermore, air leakage will vary the upper position of the working piston. Another possible explanation is that the pressure of the air cushion resists the downward flow of oil on the cylinder wall. Whatever may be the explanation, I find that by substantially eliminating the air cushion for the return stroke of the working piston and providing a buffer of solid compressible material, I obtain an im-

provement in the operation and lubrication of the apparatus. I prefer to use a buffer of "Ameripol" for this purpose, but other synthetic or artificial rubber materials have been found to have an excellent durability under impact for this purpose and provide substantially noiseless buffing action. The compression of the gas in chamber 24b below the piston 9, by reason of grooves 27 and 38 moving out of registration with recess 36, provide a cushioning action to cushion the stroke of the working piston when the tool is raised from the work.

In the modification shown in Figures 5 to 7 wherein like parts are correspondingly numbered, the lower portion 65 of the casing for housing the working piston is separate from the upper part 1 and is suitably secured thereto to enable drilling the various passages required. A valve block 66 has a threaded boss 67 threaded into a bore 68 in the lower casing 65 and passage 58 communicates with a passage 69 therein. The valve block has threaded bores 71 and 72 at its ends and a connecting portion or chamber 73 to provide a valve seat 74.

The working piston 9 is made hollow and is closed at its upper end by a plug 22a threaded against a shoulder 22b and welded at 22c. In the valve block 66a valve 75 of the poppet type is seated on the seat 74 and has a stem 76 extending through the bushing 77, the opposite bore 72 being closed by a cap screw 78. An L-shaped passage 79 in the threaded boss 67 leads to annular groove 80 and connects chamber 73 with the longitudinal passage 81 which connects by port 82 with the lower portion 24b of chamber 24. A threaded plug 83 closes the end of passage 81 and may be removed to allow the cleaning of the passage.

A bracket 85 extends from adjacent the upper end of the motor block 1 and carries a guide bushing 86 through which extends the valve stem 76 terminating in an adjustable head 87 held in place by a lock nut 88. A tappet 89 is pivoted at 91 to the bracket 85 and is interposed between cam 92 secured on crankshaft 5 and head 87. Cam 92 has a depressed portion 93 and an elevated portion 94. A spring 95 abuts a collar 96 held on the lower portion of the valve stem 76 by a retainer 97, the lower end of the spring abutting the bushing 77. An annular buffer 98 is secured at the upper end of chamber 24a in any suitable manner as by countersunk screws 98' and a passage 35 allows free entrance and escape of air from this chamber.

In operation passage 58 is closed from passage 82 by valve 75 held closed by spring 95 and the pressure of gas on the valve, and when an explosion in chamber 7 occurs the working piston 9 is driven downward to bring extension 28 into forcible contact with the tool 31, the grooves 37 and 38 allowing escape of air or gas from chamber 24b at the initial part of this movement, all as previously described. At the same time, captive piston 3 is driven upward to rotate the crankshaft 5, which rotates cam 92. Cam 92 is positioned so that shortly after the explosion the elevated portion 94 contacts head 87 through tappet 89 to depress the valve stem 76 and hold valve 75 open, thus allowing exhaust gas to enter chamber 24b and force piston 9 upward. Valve 75 may be kept open until just prior to the next explosion, when it is closed by the spring 95 and depressed portion 93 of the cam 92 on crankshaft 5, or by adjusting the head 87, or by doing both, to cause the valve to open at the proper

time, and to close at the proper time. In this way a smooth, uniform operation of the working piston may be obtained.

In the modification shown in Figures 8 and 9, wherein like parts are correspondingly numbered, the valve housing 48 and its valve 56 shown in Figs. 1 and 2 are eliminated. In this modification the bore 45 closed at its end by a plug 46 connects with the bore 51 which is closed at its lower end by a plug 83 threaded therein, and the bore 47 directly connects bore 81 with the lower chamber 24b. The buffer 98a has lugs 98b extending through suitable apertures in the lower cylinder wall 24, and the buffer is secured in position by bolts 98c passing therethrough and through suitable lugs 98d on the block.

Referring to the modification shown in Figs. 1 and 2, the fly wheel 17 is encircled by a band 101 which has a friction brake lining 102 pressed therein. The fly wheel carries at its periphery a brake shoe 104, which preferably is of hardened steel and has turned over apertured lugs 106 by which it is pivoted to the periphery of the fly wheel by a pin 107 passing therethrough and through the lugs. The brake shoe carries an extension 108 which is engaged by one end of a spring 109, in a recess 111 in the fly wheel periphery, and the opposite end of the spring engages an adjustment screw 112 threaded into the periphery of the fly wheel and locked in position by a nut 113.

In operation the brake shoe 104 is pivoted outwardly by centrifugal force to engage brake lining 102 and thus automatically apply a load on the idling piston 3. If the piston 3 did not carry a load it would tend to increase its frequency of reciprocation until it was no longer in synchronism with the reciprocation of the working piston so that the apparatus would be erratic in operation and would tend to overheat. By adjusting the pressure of spring 109 against extension 108 by means of screw 112 the brake shoe 104 applies the proper load upon the idling piston to maintain it in synchronism with the working piston and prevent overheating. It will be understood that if desired the brake shoe 104 may be manually pressed against the brake band, in which case the band preferably is mounted on the flywheel and the shoe mounted on the casing 101, and is operated by a wire or lever, or the like.

In a two cycle engine which is not working against a load, the maximum speed is limited by the friction losses and other no load losses including inertia of the moving parts, and I prefer to limit the ungoverned maximum speed of the idling piston by controlling the exhaust opening to slightly higher than desired, and employ the brake means or governor above described to obtain the desired or optimum working speed. This conveniently is done by flattening the end 115 of the exhaust conduit, deflector or muffler 20a to provide the desired area of opening. Or if desired, an adjustable valve 201 as shown in Figure 13 in the conduit 20a is provided on a valve stem 202 extending therethrough to the exterior and having an arm 203 secured thereto. An extension 205 suitably clamped to the conduit carries a threaded bushing 206, and wire 207 has a ball 208 at one end swivelled in the bushing and at its other end is connected to arm 203. By adjusting bushing 306 the extent of opening in the exhaust conduit 20a may be varied to vary the maximum speed of the idling piston. For example for breaking concrete with a "bull point" tool,

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I prefer to have the idling piston crankshaft operate at about 2200 R. P. M. This may be accomplished with a three inch cylinder bore, which has an area of about 7.065 square inches, equipped with a muffler having an exhaust opening of about .3633 square inch. For drilling, a higher speed, such as 2400 to 2500 R. P. M. is preferred, and in such case an exhaust opening of about one half square inch is desirable. The adjustable exhaust valve 201 or the end 115 of the exhaust muffler thus may be adjusted for varying the maximum ungoverned speed of the idling piston crankshaft. However, the exhaust opening is maintained small enough so as to avoid excessive blowing out of the lubricating oil, which would interfere with the proper lubrication of the pistons.

The carburetor 11 is shown in detail in Figures 4, 10, 11 and 12 and comprises a bowl 120 secured to the inlet manifold 121 by a screw 122. The inlet manifold contains a Venturi or similar restriction 123 with a tube 124 at the throat thereof, and a bore 125 extending through boss 126 on the manifold communicates therewith and terminates adjacent the bottom of the supply bowl 120. The opening in tube 124 may be regulated by a needle valve 127 threaded into a threaded bore at the opposite side of the manifold. Beyond the Venturi restriction 124 is a second tube 131 threaded into the wall of the manifold and connected to bores 132, 133 and 134 to a point near the bottom of the bowl. The opening in tube 131 is regulated by a needle valve 136. The flow of air through manifold 121 applies a suction action to tubes 125 and 134 that draws a jet of fuel into the manifold to mix with the air. The bore 134 supplies fuel at idling speed, and the bore 125 supplemented somewhat by bore 134 supplies fuel to the inlet at operating speed.

Fuel is supplied to the inlet bowl 120 through an inlet nozzle 137 connected by a tube 138 to the fuel tank 10, and a valve 140 guided in a tube 141 has a tapered end 142 adapted to engage a tapered seat 143 to control the fuel supplied to the bowl 120. The valve 140 is governed by an annular float 144 having a connecting arm 145 secured thereto and pivoted on a pivot pin 146, passing through tabs 146' and having a forked end 147 which engages a stem 148 on the valve 140 terminating in a head 150. An extension 151 of the lever engages the head 150 to force the valve against its seat, and the forked end 147 engages the head 150 to move the valve off its seat, the stem 148 being long enough to allow lost motion. Fuel tank 10 is closed by a cap 128 designed to allow air to enter the tank to replace the fuel, but prevent spilling of fuel from the air inlet due to vibration of the apparatus during operation. As shown in Figure 14 a tube 129 is coiled about inside cap 128 and has its one end 130 soldered at an air opening 130a in the cap, the opposite end 130b being free and at the center. This provides a barrier which prevents flow of fuel through the tube 129 and out of opening 130a but allows air to enter.

By having the bores 125 and 134 entering the supply bowl adjacent the bottom and close to the medial vertical axis of the bowl which is inclined with respect to the axis of the motor and by employing an annular float it is possible to operate the apparatus in practically horizontal position as well as in vertical position and still obtain a supply of fuel in the inlet manifold 121 because the annular float remains at all times in contact with the fuel in the bowl to regulate the inlet

valve 140. An air cleaner 155 may be provided on the air inlet pipe 121, and a butterfly choke valve 156 in the inlet pipe 121 may be adjusted by lever 157 (Fig. 2) to reduce the air supply for starting. The air cleaner 155 and carburetor bowl 120 are protected by a guard plate or housing 157a suitably held in place and having a hand hole 157b therein for access to a bolt 157c which holds the air cleaner 155 in place.

A spring pressed ball detent 158 cooperating with a peripherally notched plate 159 holds the choke valve in full open position as shown in Fig. 11. A throttling valve 161 of the butterfly type is located on stem 162 between the idling fuel inlet bore 131 and operating fuel inlet bore 124. This shaft extends through the inlet pipe and has an arm 163 (Fig. 2) suitably fastened thereto. A plate or bracket 165 has inverted channel shaped reinforcing members 166 at each side, and the long stay bolts 167 pass through the flange 168 of tool holder 32, through the flange 169 on the upper end of the crankcase 6, and through plate or bracket 165 and reinforcing channel members 166, and nuts 170 thereon hold the plate 165 in assembled position. The ends 171 and 172 of the plate are turned up and a handle bar 173 is welded thereto. The handle 180 provided on housing 32 at the bottom together with handle bar 173 provides for carrying or manipulating the apparatus. A hand throttle lever 174 is pivoted at 175 to the handle bar and a push rod 176 passes through a suitable hole in the handle bar so as to be engaged thereby and be depressed when lever 174 is depressed. A link 177 is pivoted at a bolt 178 in end 171 and at one end is fastened a rod 181 connected to the lever 163 of the throttle valve. The opposite end of link 177 is connected to a rod 182 secured between stop nuts 183 and 184 on the valve plunger rod 58 and a spring 185 secured to an extension 186 on rod 58 biases the valve rod 58 down. Push rod 176 is secured to link 177 at 186 so that when the rod is depressed by lever 174 the rod 181 opens the throttle valve while rod 182 is raised, and as rod 182 has a lost motion connection with valve rod 58, valve 56 remains closed until the throttle valve has been opened. A hand pressure lever 174 is preferred for operating the throttle valve 161 and valve 56 as this is less tiring than one requiring a twist of the wrist to operate. A starting pulley 190 is secured to the end of crankshaft 5 and is enclosed in a housing 191 having a hinged cover held by hasp 192. The apparatus may be started by winding a rope on pulley 190 and giving it a quick tug, meanwhile choking the motor by choke lever 157 as required. In open position the housing 191 falls down as shown in dot and dash lines so as to be out of the way. The apparatus may be stopped by depressing key 193 shown in Fig. 2 to short circuit the magneto.

The operation of the complete apparatus now will be described. Upon rotation of the crankshaft by the cranking wheel or pulley 190 and choking the apparatus by the choke lever 157 as required a mixture of air and fuel is drawn into the crankcase 6 and when the piston 3 moves up toward the crankcase and uncovers port 14 a fuel charge is forced through passage 16 into intake port 14 and into the cylinder 2. As the piston moves down toward the combustion chamber 7 the fuel charge is compressed and is ignited at about 40° before dead center of crankshaft 5. The explosion resulting therefrom forces piston 3 downwardly until extension 28 strikes the end 75 of tool 31 as previously described and when port

45 is uncovered the exhaust gas is conducted to the lower chamber 24b and returns the working piston to its upper limit against buffer 33. In the meantime idling piston 3 moves up until its head first uncovers exhaust port 15 and there uncovers intake 14 to introduce a fresh fuel charge into the combustion chamber, the crank returning the idling piston to compress the charge. Should the idling piston operate too rapidly and tend to get out of synchronism with the operating piston the brake shoe 104 is pivoted outwardly by centrifugal force to engage brake lining 102 and thus automatically apply a load on the crankshaft 5 of idling piston 3 which reduces its speed. Thus when the fuel supply to the motor is increased the force of the explosion against piston 9 is also increased, but the speed of operation of piston 9 is not greatly increased so that the two pistons are maintained very nearly in synchronism. If exact synchronism is desired the brake may be adjusted manually or automatically.

The supply of fuel to the apparatus is controlled by pressing down pivoted lever 174 to open throttle valve 166 and increase the fuel supplied to the combustion chamber. The connection between throttle valve 166 and valve 56 is such that valve 56 remains closed until throttle valve 166 has been opened sufficiently to have the idling piston operation at desired speed after which opening of valve 56 causes exhaust gas to be supplied to chamber 24a to cause operation of piston 9.

This application is a continuation in part of my application for Internal-combustion operated percussion tool, Serial No. 380,578, filed February 26, 1941, which in turn is a continuation in part of my application Serial No. 360,903, filed October 12, 1940, for Internal combustion operated percussion tool, both now abandoned.

What I claim as my invention and desire to secure by United States Letters Patent is:

1. In an internal combustion percussion tool, the combination of a combustion chamber, a timing piston reciprocable in said chamber, a second larger chamber connected with the combustion chamber, a differential area percussion working piston having its smaller portion operating in the combustion chamber and its larger portion operating in said larger chamber, a passage connecting the combustion chamber and the larger chamber beyond the larger end of the working piston, and means responsive to the smaller portion of the working piston for controlling the admission of gas from the combustion chamber to said larger chamber in timed relation with the operation of the timing piston.

2. In an internal combustion percussion tool, the combination of a combustion chamber, a timing piston reciprocable in said combustion chamber, a second larger chamber in communication with the combustion chamber, a differential area percussion working piston having its smaller portion operating in said combustion chamber and having its larger portion operating in said larger chamber and adapted to impact a tool near the end of its working stroke, a passageway connected to the larger chamber beyond the larger end of the working piston, a port in the combustion chamber connected to the passageway and adapted to be uncovered by the smaller portion of the working piston for controlling the admission of gas from the combustion chamber to the larger chamber and an atmosphere

larger end of the working piston controlled by the working piston.

3. In an internal combustion percussion tool, the combination of a combustion chamber, a timing piston reciprocable in said chamber, a second larger chamber connected with the combustion chamber, a differential area working piston having its small end operating in said combustion chamber and having its larger end operating in said larger chamber, means arranged to receive the impact of the larger end of the working piston to perform useful work and cause the piston to rebound, a passage connecting the combustion chamber and the larger chamber beyond the larger end of the piston, means responsive to the smaller portion of the working piston for controlling said passage, a solid resilient buffer of synthetically polymerized resilient material in the larger chamber interposed between the larger and the smaller ends of the working piston to cause the piston to rebound with greater force on its power stroke, a continuously open passage to atmosphere providing for intake and exhausting of air to the larger chamber between the larger and smaller ends of the working piston, and exhaust port means to atmosphere connected to said larger chamber to effect a gradual escape of the gases from beyond the larger end of the working piston when the latter nears the limit of its return stroke and to provide substantially increased rate in the escape of the gases as the working piston approaches said limit.

4. In an internal combustion percussion tool, the combination of a combustion chamber, a timing piston reciprocable in said chamber, a second larger chamber connected with the combustion chamber, a free differential area percussion working piston having its small end operating in said combustion chamber and having its larger end operating in said larger chamber, means arranged to receive the impact of the larger end of the working piston to perform useful work and cause the piston to rebound, a passage connected from said combustion chamber into said larger chamber beyond the larger end of the piston, a solid buffer of synthetically polymerized resilient material in the larger chamber interposed between the larger and smaller ends of the working piston to cause the piston to rebound with greater force on its power stroke, a continuously open passage to atmosphere providing for intake and exhausting air to and from the larger chamber between the larger and smaller ends of the working piston, said first mentioned passage being controlled by the small end of the working piston to control the admission of gas from the combustion chamber to the larger chamber.

5. In an internal combustion percussion tool, the combination of a differential diameter cylinder, a differential diameter percussion working piston operating in said cylinder, a timing piston reciprocable in the small portion of said cylinder, a combustion chamber defined by the walls of the cylinder and the adjacent ends of the pistons, means to supply and ignite fuel in the combustion chamber in timed relation with the operation of the timing piston to operate both pistons for producing useful work, a passageway from the combustion chamber to beyond the larger end of the working piston, means responsive to the smaller portion of the

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passageway to beyond the larger end of the working piston whereby to synchronize the working piston with the timing piston, and means responsive to the working piston for exhausting the gas from beyond the larger end of the working piston.

6. In an internal combustion percussion tool, the combination of a combustion chamber in a cylinder, a timing piston operable as a two-cycle engine in said cylinder, a differential cylinder connected to said combustion chamber comprising connected large and small sections, a differential area percussion working piston in said differential cylinder sections having the smaller end operating in the combustion chamber and the larger end operating in the large section, said smaller cylinder section having a port covered by the working piston in its upper position and uncovered in its lower position, said port being connected by a passage to the larger section beyond the larger end of the working piston, said working piston having an extension at the larger end, a guide bushing for said extension, and co-operating escape ports on the extension and guide bushing to provide an exhaust for a substantial time during the initial portion of the working stroke.

7. In an internal combustion percussion tool, the combination of a combustion chamber, a timing piston reciprocable in said chamber to control the combustion of fuel therein, a tool-actuating working piston reciprocable in said chamber and operated by the combustion of fuel therein, and centrifugal brake means arranged to apply a load on the timing piston to control the speed thereof and regulate the frequency of reciprocation of the working piston.

8. In an internal combustion percussion tool, the combination of a combustion chamber, a timing piston reciprocable in said chamber to control the combustion of fuel therein, a tool-actuating working piston reciprocable in said chamber and operated by the combustion of fuel therein, and brake means arranged to apply a load on the timing piston to control the speed thereof and regulate the frequency of reciprocation of the working piston.

9. In an internal combustion percussion tool, the combination of a combustion chamber, a timing piston reciprocable in said chamber to control the combustion of fuel therein, a tool-actuating working piston reciprocable in said chamber and driven in working direction by the combustion of fuel in said chamber and returned by exhaust gas, and brake means arranged to apply a load on the timing piston to control the speed thereof and regulate the frequency of reciprocation of the working piston.

10. A percussion tool comprising a casing providing a combustion chamber, a carburetor for supplying fuel to said chamber, a timing piston to control ignition of fuel in said chamber, a working piston operated by combustion of said fuel, means for employing exhaust gas to cause return movement of the working piston and including a valve, manual means to control the supply of fuel to the combustion chamber, and a lost motion connection between said valve and said manual means to prevent the operation of the working piston until the timing piston is operating at a predetermined speed.

11. In an internal combustion percussion tool, the combination of an internal combustion engine having a timing piston and a percussion working piston operating in predetermined timed relation with respect to one another in a com-

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bustion chamber, means to supply and ignite fuel in the combustion chamber in timed relation with the operation of the timing piston to transmit energy to both pistons for producing work, and means independent of normal fuel supply and normal ignition operative, in case the working piston gets out of step with the timing piston as when the former is subjected to a material reduction in load causing a transfer of the energy of combustion to the timing piston and resulting in over-speed, to check the speed of the racing timing piston while combustion subsists to bring the working piston into step with the timing piston to produce work.

12. In an internal combustion percussion tool, the combination of an internal combustion engine having a timing piston and a percussion working piston operating in predetermined timed relation with respect to one another in a combustion chamber, means to supply and ignite fuel in the combustion chamber in timed relation with the operation of the timing piston to transmit energy to both pistons for producing work, and brake means operative, in case the working piston gets out of step with the timing piston as when the former is subjected to a material reduction in load causing a transfer of the energy of combustion to the timing piston and resulting in over-speed, to check the speed of the racing timing piston while combustion subsists to bring the working piston into step with the timing piston to produce work.

13. In an internal combustion percussion tool, the combination of an internal combustion engine having a timing piston and a percussion working piston operating in predetermined timed relation with respect to one another in a combustion chamber, means to supply and ignite fuel in the combustion chamber in timed relation with the operation of the timing piston to transmit energy to both pistons for producing work, and means in the exhaust of the combustion chamber operative, in case the working piston gets out of step with the timing piston as when the former is subjected to a material reduction in load causing a transfer of the energy of combustion to the timing piston and resulting in over-speed, to check the speed of the racing timing piston while combustion subsists to bring the working piston into step with the timing piston to produce work.

14. In an internal combustion percussion tool, the combination of a casing providing a combustion chamber, a timing piston reciprocable in said chamber, a second larger chamber connected to the combustion chamber, a differential area working piston having its smaller end exposed to and reciprocating in said combustion chamber and having its larger end operating in said larger chamber, a guide stem extending from the larger end of said piston, and a guide bore receiving said stem whereby said working piston is guided by said stem and by the smaller end of the piston, a passage between the combustion chamber and said large chamber, means responsive to the smaller end of the working piston for controlling the admission of gas from the combustion chamber through said passage to the larger chamber to return the working piston, means to exhaust the gas from the large chamber and the passage during a greater portion of the return stroke of the working piston, and a passage providing for the intake and exhaust of air to the larger chamber between the larger and smaller ends of the working piston.

15. In an internal combustion percussion tool,

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the combination of a casing providing a combustion chamber, a timing piston reciprocable in said chamber, a second larger chamber connected to the combustion chamber, a differential area working piston having one end exposed to said combustion chamber and having its larger end operating in said larger chamber, a passageway controlled by the smaller end of the working piston to supply gas under pressure from the combustion chamber to said larger chamber, a valve in said passageway to open or close the same, a throttle arranged to regulate the supply of fuel to the combustion chamber to operate said pistons, and means connecting the throttle with the valve to open the latter when the throttle is actuated.

16. In an internal combustion percussion tool, the combination of a combustion chamber, a timing piston reciprocable in the combustion chamber to control the supply of fuel and its ignition and to control the atmospheric exhaust of products of combustion from the combustion chamber, a tool-actuating working piston reciprocable in the combustion chamber and driven in a working direction by the combustion of fuel and returned by exhaust gas, means to regulate the

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atmospheric exhaust from the combustion chamber to limit the speed of operation of the timing piston, and brake means to apply a load on the timing piston to control the speed thereof below said limit and regulate the frequency of reciprocation of the working piston.

CARL S. WEYANDT.

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