April 7, 1959 D. N. W. BADCOCK 2,880,585

PERCUSSIVE TOOLS

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Fig. 1.

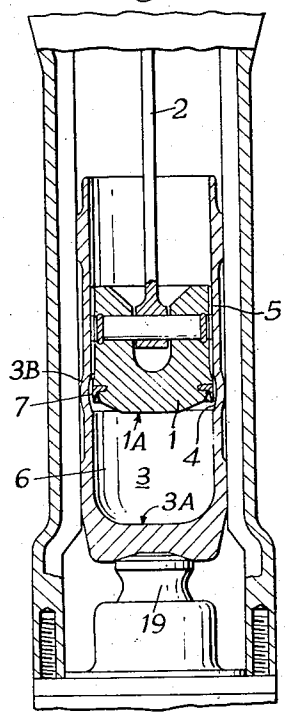


Fig. 2.

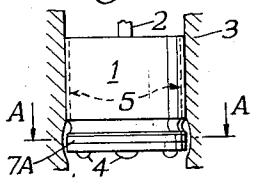


Fig. 3.

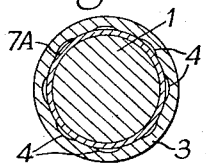
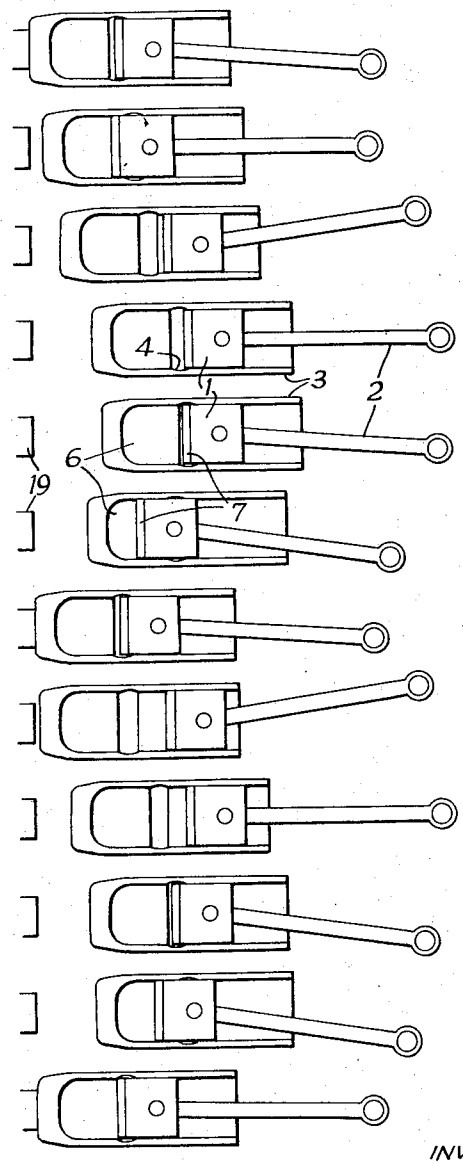


Fig. 4.



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PERCUSSIVE TOOLS

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Fig. 5.

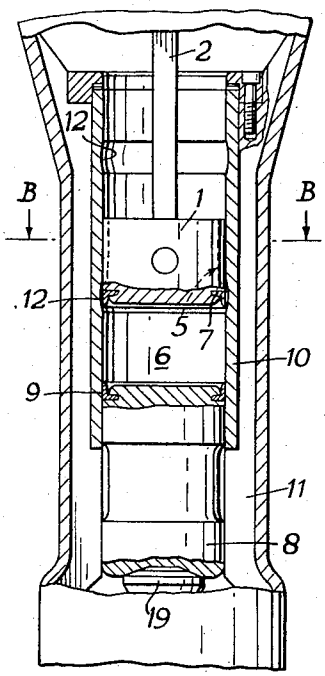

Fig. 6.

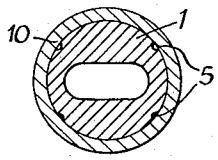

Fig. 7.

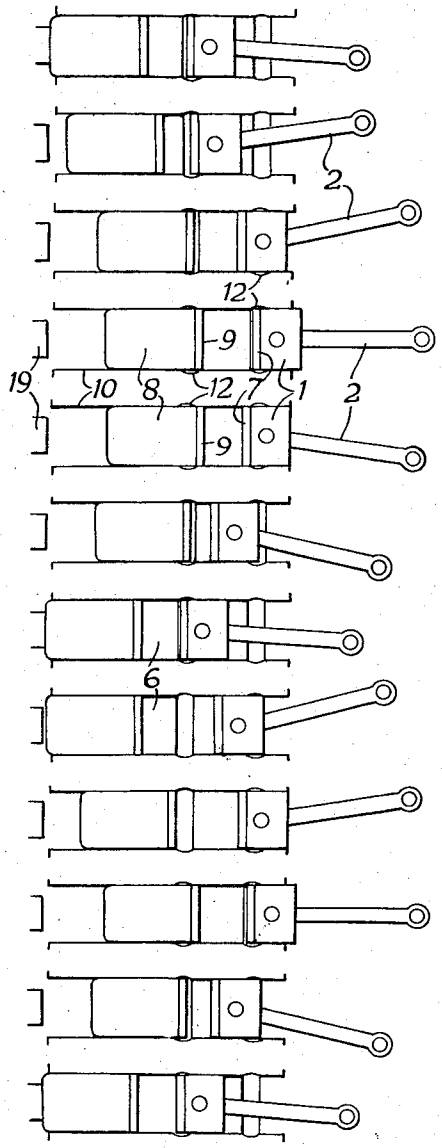

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Fig. 8.

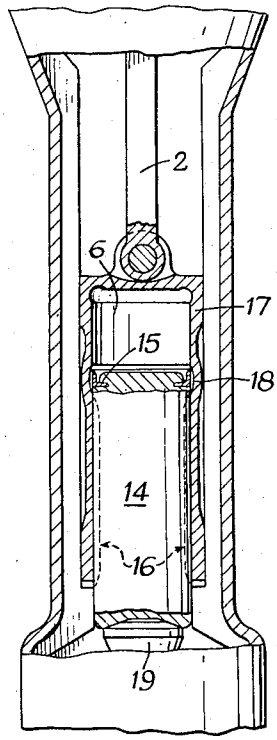
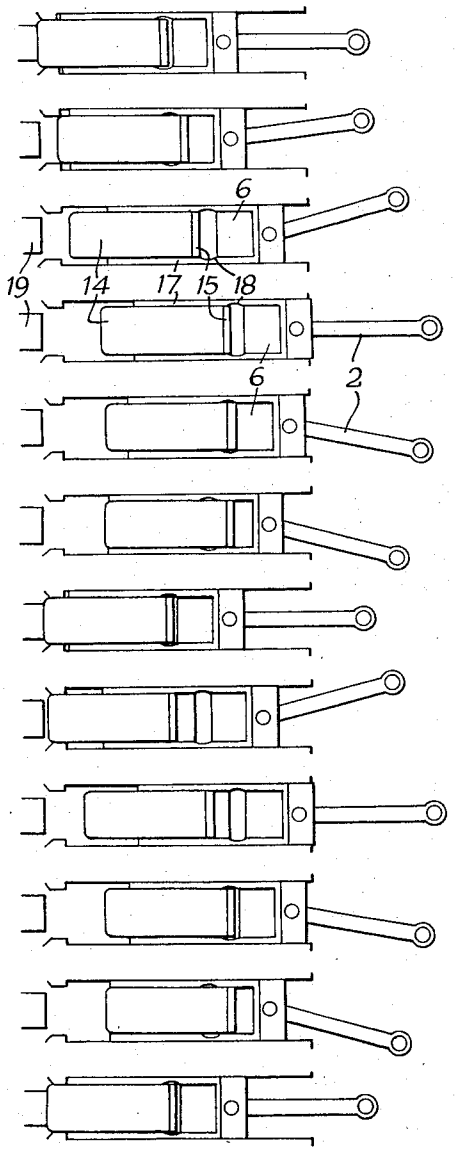


Fig. 9.



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2,880,585

PERCUSSIVE TOOLS

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Application July 11, 1955, Serial No. 521,301

9 Claims. (Cl. 60—62.5)

This invention relates to percussive tools of the type in which relatively movable co-operating members are co-axially mounted for reciprocation in a sleeve or casing, one of said members being a piston or a cylinder, hereinafter termed the "driver," which is adapted to be reciprocated positively to cause a "striker," usually the other of said members, to strike blows directly or indirectly on an implement held in its path.

The type of tool to which this invention relates may be further defined as one in which the opposing ends of the driver and the striker are contained throughout a complete working cycle of operations within a cylindrical wall (which may form an integral part of the driver or of the striker) so as to form an air chamber.

The air in this chamber has a threefold function. It serves as a buffer to prevent contact between the inner end faces of the driver and the striker, it stores energy during that part of the working stroke in which the driver is travelling more rapidly than the striker, and it provides for continued acceleration of the striker during that part of the working stroke when the driver is decelerating.

In tools of this type it is necessary to avoid appreciable leakage of air during that part of the working stroke in which air is being compressed in the air chamber, and accordingly it is desirable to avoid the use of permanently open bleed holes in the chamber wall.

It is also necessary to provide for restoration of the quantity of air in the air chamber at least once during every cycle of operations to compensate for losses occurring due to the unavoidable, though slight leakage into or out of the air chamber. Additionally the return of the striker after the blow must be ensured under all conditions, that is, the return of the striker to a position relative to the driver such that the tool can continue to function.

The cylindrical chamber-forming wall in tools of this type has generally been pierced through with vents or ports for regulating the pneumatic conditions prevailing in the chamber during certain stages of the working cycle. The function of these vents or ports, sometimes referred to as equalising holes, is generally to maintain a volume of air in the chamber at a value which permits rhythmical functioning of the tool.

When hard solid work, such as a monolithic slab of concrete, particularly when unbroken or still in large mass form, is being subjected to impact blows from a percussive hammer or like tool of the type above defined, there is generally sufficient resiliency or reaction in the work being struck to cause the striker to rebound toward the retreating driver and thus take up a relative position well suited for effective operation of the tool.

It has been found, however, that this desirable rebound action does not always occur, especially when operating on soft or cracked material, such as is encountered largely in demolition work. In order to ensure the return of the striker in the absence of rebound, various means have been proposed, such as valves and/or return springs, and use has been made of positive air pressure created by the return stroke of the driver.

The main object of the present invention, however, is to provide, in a percussive tool, simple and durable means inherent in the mechanism to ensure that the striker moves toward the driver after delivering a blow, even though there is no substantial rebound from the work, without hampering the maintenance of the desired volume of air in the air chamber.

The abovementioned object is achieved by arranging the passages necessary for the transfer of air from one end of the driver or of the striker to the other end thereof, in such a manner that negative pressure exists in the air chamber when the striker tends to remain in its striking position during the upstroke of the positively reciprocated member.

When the passage or passages associated with the transfer of air are incorporated in the striking member, or those members in immediate contact with it, it is undesirable that these should take the form of transverse holes, which give rise to serious stress concentrations in the presence of the shock waves set up in these members.

Another object underlying the construction of any percussive tool according to this invention is to provide a mechanism of simple form, incorporating components of rugged design which are relatively free from stress concentrations associated with tools having components ported for air flow, and which is capable of striking blows on all kinds of work without the need of storing any of the energy of the blow to ensure the return of the striker when there is little rebound from the work.

Accordingly the present invention provides a percussive tool of the type set forth, wherein flow of air into and out of the air chamber is controlled by the co-operation of at least one longitudinal groove in the exterior surface of the driver or the striker, and of at least one annular groove in the interior surface of a cylinder which has an imperforate wall and encloses or constitutes part of the co-acting striker or driver.

Percussive tools constructed in accordance with this invention have proved by practical tests to avoid the following weaknesses often experienced with known constructions:

(*a*) The need for some means, other than a single column of air to raise the striker, in the absence of rebound from the work,

(*b*) Inefficiency due to the discharge of air at relatively high pressure during the whole or some part of the operational cycle,

(*c*) A relatively fragile design of striker, driver or sleeve liable to failure at the stress concentrations inevitably associated with the air ports necessary for equalising in this type of mechanism,

(*d*) The need for reducing considerably the energy of the blow to avoid the failures mentioned in (*c*), and

(*e*) The use of air-flow control valves, and of striker return springs, with all their inherent weaknesses.

The accompanying drawings illustrate, by way of example, three embodiments of the invention. In the drawings:

Figure 1 is an example of a tool, according to a first arrangement, that is, wherein the driver is in the form of a reciprocated piston and the striker is in the form of a free or a floating cylinder adapted to encircle the striker piston,

Figure 2 is a fragmentary view showing an alternative form of air transfer means (applicable to all three embodiments), and

Figure 3 is a cross section on line A—A of Figure 2,

Figure 4 is a series of diagrams illustrating various operational stages during two representative cycles of the tool shown in Figure 1,

Figure 5 is an example of a tool according to a second arrangement, wherein the driver is again in the

form of a reciprocated piston, but the striker is in the form of a free or floating piston, the driver and striker pistons both co-operating with a common fixed cylinder,

Figure 6 is a cross section on line B—B of Figure 5,

Figure 7 is a series of diagrams illustrating various operational stages during two representative cycles of the tool shown in Figure 5,

Figure 8 is an example of a tool according to a third arrangement wherein the driver is in the form of a reciprocated cylinder and the striker is in the form of a free or floating piston adapted to slide within the driver cylinder, and

Figure 9 is a series of diagrams illustrating various operational stages during two representative cycles of the tool shown in Figure 8.

In the first arrangement (Figures 1 to 4) the driver piston **1** is positively reciprocated by any suitable prime mover or power unit, such as an electric motor, through motion-transmitting means comprising or constituted by a connecting rod **2**, and slides within the striker cylinder **3**. The air transfer passages are conveniently constituted by a shallow internal annular recess **4** within the striker cylinder **3** which co-operates with diametrically opposed longitudinal surface grooves **5** on the piston. In order to prevent undue leakage of air from the air chamber **6** formed between opposing end faces **1A** and **3A** of the driver and striker respectively and within the cylinder wall **3B**, one or more packing rings, such as a cup-type rubber ring **7**, encircles the driver piston **1**. It may be preferable when using an orthodox piston ring (as shown in Figures 2 and 3) for the striker recess to be, in effect, circumferentially interrupted, so that the piston ring **7A** cannot expand into the striker recess **4**; for convenience, especially in the diagrams constituting Figures 4, 7 and 9, the striker recess **4** and its equivalent are shown as continuous recesses. The surface grooves **5** extend longitudinally of the piston **1** from a position inwards of the inner end of the piston crown **1A**, that is, the grooves **5** terminate short of the packing ring **7** or **7A**.

In order substantially to maintain the mean thickness of the wall of the striker cylinder **3** an external peripheral ridge **3B** is provided in alignment with the recess **4**.

In the second arrangement (Figures 5, 6 and 7) the driver is of substantially the same form as the driver piston **1** in Figures 1 to 4, and, with its packing ring **7** and longitudinal grooves **5**, bear corresponding reference numbers, but the striker **8** is of free or floating piston form and is provided with a packing ring **9** equivalent to the driver packing ring **7**. The two pistons **1** and **8** are slidably supported in a common fixed cylinder **10**; during times when the striker piston **8** is situated partly outside the cylinder **10** (as in Figure 5, for example) it is supported by internal longitudinal ribs **11** constituting a parallel-bore slideway.

The cylinder **10** is provided with two internal recesses **12**, equivalent to recesses **4** in Figure 1.

In the third arrangement (Figures 8 and 9) a striker piston **14** with a packing ring **15**, is again employed, and is also formed with longitudinal grooves **16** equivalent to grooves **5** in Figures 1 and 5; as shown in Figure 8, the grooves **16** need not extend the full length of the piston **14**. The striker piston **14** is accommodated within a driver cylinder **17** provided with a internal peripheral recess **18** equivalent to recesses **4** and **12** in Figures 1 and 5 respectively.

In each of the three arrangements illustrated (see Figures 1, 5 and 8) the striker delivers blows to an implement (not shown) via a transmitter **19**, but this is not always necessary; in some cases the impact may be applied direct to the implement.

Figures 4, 7 and 9 each represent diagrammatically the relative positions of the co-acting components of the constructions of tools according to the three arrangements illustrated in Figures 1, 5 and 8, under varying conditions of rebound, and, for convenience, the working cycle in each arrangement has been divided into twelve stages.

In general the operational cycles of the three arrangements are very similar, the differences occurring between some of the stages arising mainly from differences of construction.

In each one of these cases (see Figures 4, 7 and 9) the cycle is considered, for convenience, as commencing at stage **1** where a blow occurs on resilient work and the air pressure within the tool reverts to normal through the system of recesses **4** and grooves **5** (Fig. 1), **12, 5** (Fig. 5) and **18, 16** (Fig. 8).

In stage **2** the striker rebounds from the work with considerable energy thus compressing air in the chamber **6**, thereby tending to check the striker (i.e. cylinder **3**, or piston **8** or **14**, Figures 1, 5 and 8 respectively). After the crank pin passes "bottom dead centre" some of the rebound energy is transferred to the prime mover via the air in the air chamber.

Stage **3** finds the striker still rising due to rebound energy not transferred to the prime mover, with some assistance from suction due to the rising driver (piston **5** in Figure 1 or **5**, or cylinder **17** in Figure 8).

Stages **4** and **5** may be considered as covering the period during which the striker and the driver are moving relatively toward each other, with reversion of pressure to normal through the groove system provided, at some point during this period. More particularly, in the first and third arrangements (Figures 4 and 9) stage **4** covers the period during which the striker cylinder **3** or piston **14** respectively is rising towards an almost stationary driver piston and in the second arrangement (Figure 7) stage **4** also covers the period during which the striker is rising towards the almost stationary driver piston, but with the air pressure reverting to normal through the appropriate groove system, whereas stage **5** in all three arrangements covers a period during which the driver is descending towards the striker, the air pressure reverting to normal during this stage in the first and third arrangements.

The next four stages are substantially the same in all three arrangements, that is, during stage **6** the driver is following and tending to overtake the descending striker so that air is compressed in chamber **6**, during stage **7** the blow occurs on non-resilient work with pressure reverting to normal through the groove system; during stage **8** the striker, unassisted by rebound, commences to rise owing to the creating of a suction effect in the chamber **6** due to the rising driver and during stage **9** the striker continues to rise due to suction.

During stage **10** the striker is rising towards the driver, with pressure reverting to normal through the groove system, with the difference that in the first and third arrangements the driver piston **1** and driver cylinder **17** respectively are descending towards the associated striker whereas in the second arrangement the driver piston **1** and driver cylinder **17** respectively are descending towards the associated striker whereas in the second arrangement the driver piston **1** is almost stationary.

Finally in stage **11** the driver is following and tending to overtake the descending striker, so that air is compressed in chamber **6**, and in stage **12**, a blow again occurs, attended by reversion of air pressure to normal through the groove system.

It is to be understood that the actions stated as occurring during the various stages are primarily intended to illustrate the operations of the tools, and to establish the operational features common to the three arrangements shown; the actual actions and the relative lengths of the various stages will depend largely on the nature of the work being attacked and may slightly vary during the progress of the work.

I claim:

1. A percussive tool of the type set forth, comprising a casing having at one end a tool holder, a cylindrical

member slidable longitudinally within said casing and having an imperforate side wall formed with an internal annular recess, a piston member in snug-fitting telescopic engagement in said cylindrical member to form therewithin an air chamber, said piston member having a surface groove extending longitudinally from a position inwards of the inner end of said piston member and cooperating with said annular recess to cut off escape of air from said air chamber when the inner end of said longitudinal surface groove moves inwards beyond said annular recess to trap a cushion of air in said air chamber, one of said members constituting a striker and the other of said members constituting a driver, and power means on said casing for reciprocating said driver.

2. A percussive tool as claimed in claim 1, wherein said cylindrical member has an external annular ridge aligned with said internal annular recess to maintain substantially the mean thickness of the wall of said cylindrical member.

3. A percussive tool as claimed in claim 1, wherein said casing has a plurality of longitudinal slideways therein, and said cylindrical member has longitudinally spaced enlarged cylindrical bearing surfaces of equal diameter and an external annular ridge aligned with said internal annular recess, said annular ridge having an overall diameter not exceeding the diameter of said bearing surfaces.

4. A percussive tool of the type set forth, comprising a casing having at one end a tool holder, a striker of cylindrical pot form having an internal annular recess and mounted for free reciprocation within said casing, a co-axial driver of piston form slidably mounted within said cylindrical striker, said driver having at least one longitudinal surface groove extending longitudinally from a position inwards of the inner end of said piston member and cooperating with said striker annular recess to control flow of air into and out of an air chamber formed between the base of the encircling striker cylinder and the crown of the driver piston, and power means on said casing for reciprocating said driver.

5. A percussive tool of the type set forth, comprising a casing having at one end a tool holder, a driver of cylindrical pot form having an internal annular recess and slidably mounted in said casing, a co-axial striker of piston form mounted for free reciprocation within said driver and having at least one longitudinal surface groove extending longitudinally from a position inwards of the inner end of said piston member and cooperating with said driver annular recess to control flow of air into and out of an air chamber formed between the outer end of said striker piston and the base of said driver cylinder, and power means on said casing for reciprocating said driver.

6. A percussive tool of the type set forth, comprising a casing having at one end a tool holder, an open-ended cylinder fixed within said casing and having a pair of longitudinally spaced internal annular recesses, a striker of plunger form mounted for free reciprocation within one end of said cylinder a driver of piston form slidably mounted within the other end of said cylinder and having at least one longitudinal surface groove cooperating with said cylinder annular recesses to control flow of air into and out of an air chamber formed between the outer end of said striker plunger and the crown of said driver piston, and power means on said casing for reciprocating said driver.

7. A percussive tool of the type set forth, comprising a casing having at one end a tool holder, two co-axially arranged telescopically slidable cylindrical members forming an air chamber having an imperforate wall, one of said members being of cylindrical pot form and having an annular recess therein and the other of said members being of piston form, packing means on the inner end of said piston member, said piston member having longitudinal grooves therein extending from behind said packing means toward the outer end of said piston member and cooperating with said annular recess to control flow of air into and out of said chamber, and power means on said casing for reciprocating one of said members to constitute a driver.

8. A percussive tool of the type set forth, comprising a casing having longitudinal slideways, therein, a tool holder at one end of said casing, a first cylindrical member of pot form reciprocable within said casing slideways and having an imperforate side wall and crown and provided with an internal annular recess therein substantially midway of its length, a second cylindrical member of piston form telescopically mounted for reciprocatory movement within said first cylindrical member to form therewith an air chamber, a packing ring encircling the inner end of said second member, said second member having extending part way along its length to terminate short of said packing ring two longitudinal grooves cooperating with said annular recess in said first cylindrical member to control flow of air into and out of said air chamber which is entirely closed when the front face of said second cylindrical member has moved beyond said annular recess of said first cylindrical member, and power means for imparting reciprocatory movement to one of said cylindrical members.

9. A percussive tool of the type set forth, comprising in combination, a casing having a plurality of internal ribs constituting a parallel-bore slideway; a tool holder mounted on the lower end of said casing; power means at the upper end of said casing; a pot-like cylindrical striker with an imperforate side wall having intermediately of its length an internal annular recess and a corresponding external ridge to maintain uniform wall thickness, and an imperforate base facing toward and adapted for delivering impact blows to said tool holder, said striker having adjacent opposite ends thereof cylindrical bearing surfaces with an overall diameter not less than that of said ridge, and being slidable along said slideways; a piston-like driver slidable within said striker and having longitudinal surface grooves opening out at the outer end of said piston and extending to run out before reaching said piston inner end; packing means encircling said piston inner end and situated beyond the run-out ends of said grooves, and linkage connecting said power means to said driver to impart reciprocatory motion to the latter, said piston-like driver and pot-like striker together constituting an air chamber vented through said annular recess and longitudinal grooves when in register and a cushion of air being trapped in said chamber when said driver packing means passes inwardly beyond said striker annular recess.

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