Aug. 24, 1948.

R. WORTH

2,447,886

POWER HAMMER

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3 Sheets-Sheet 1

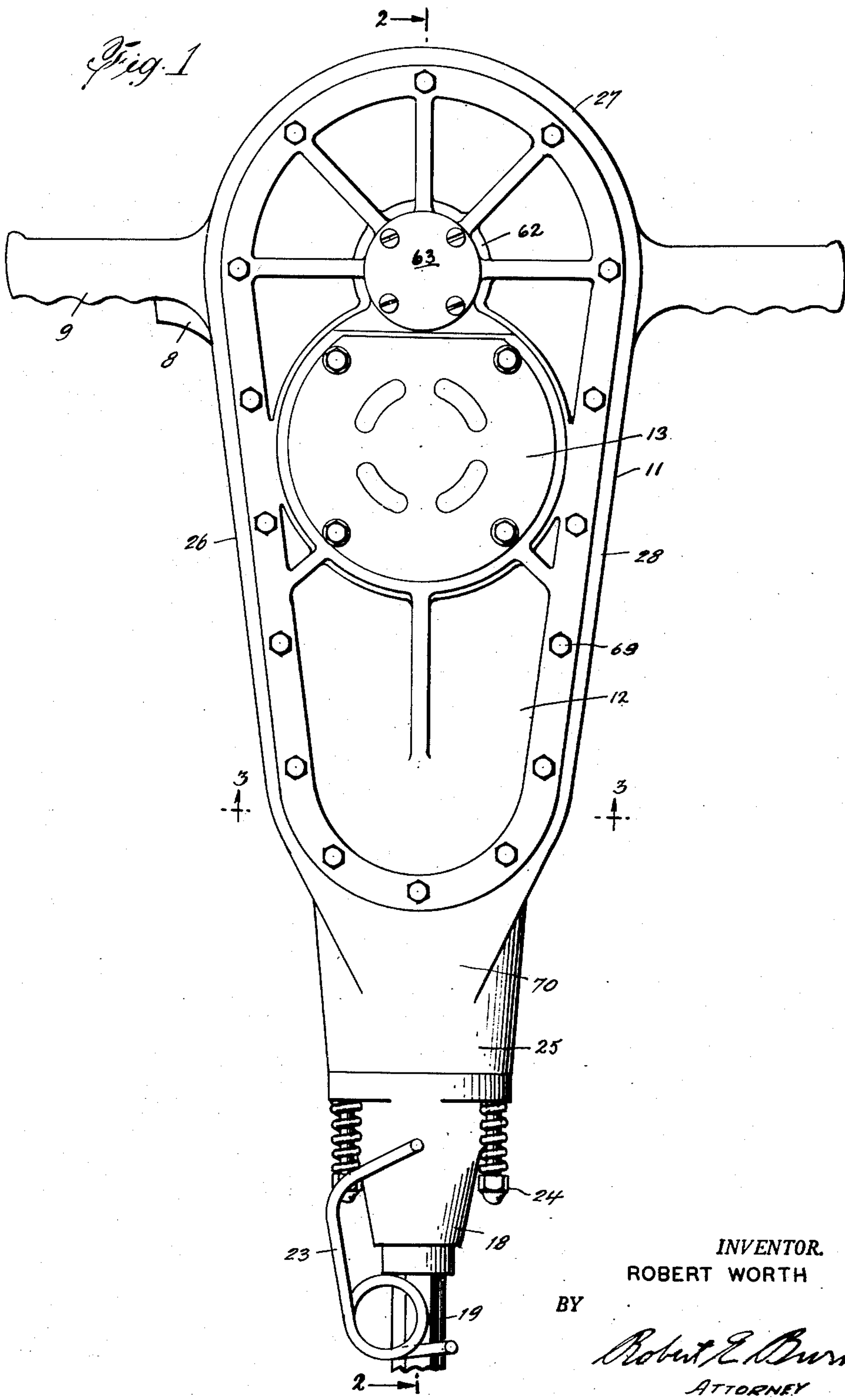

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Fig. 2

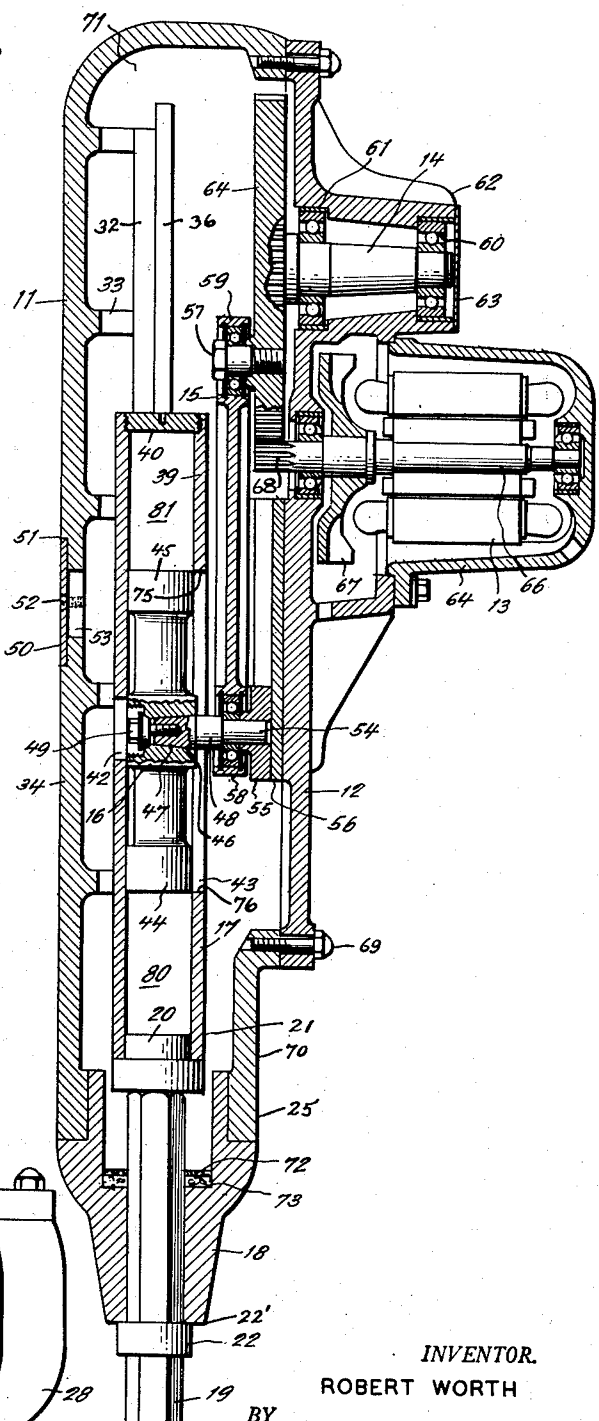
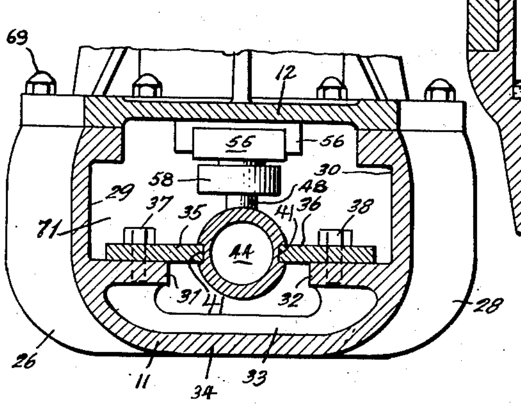


Fig. 3



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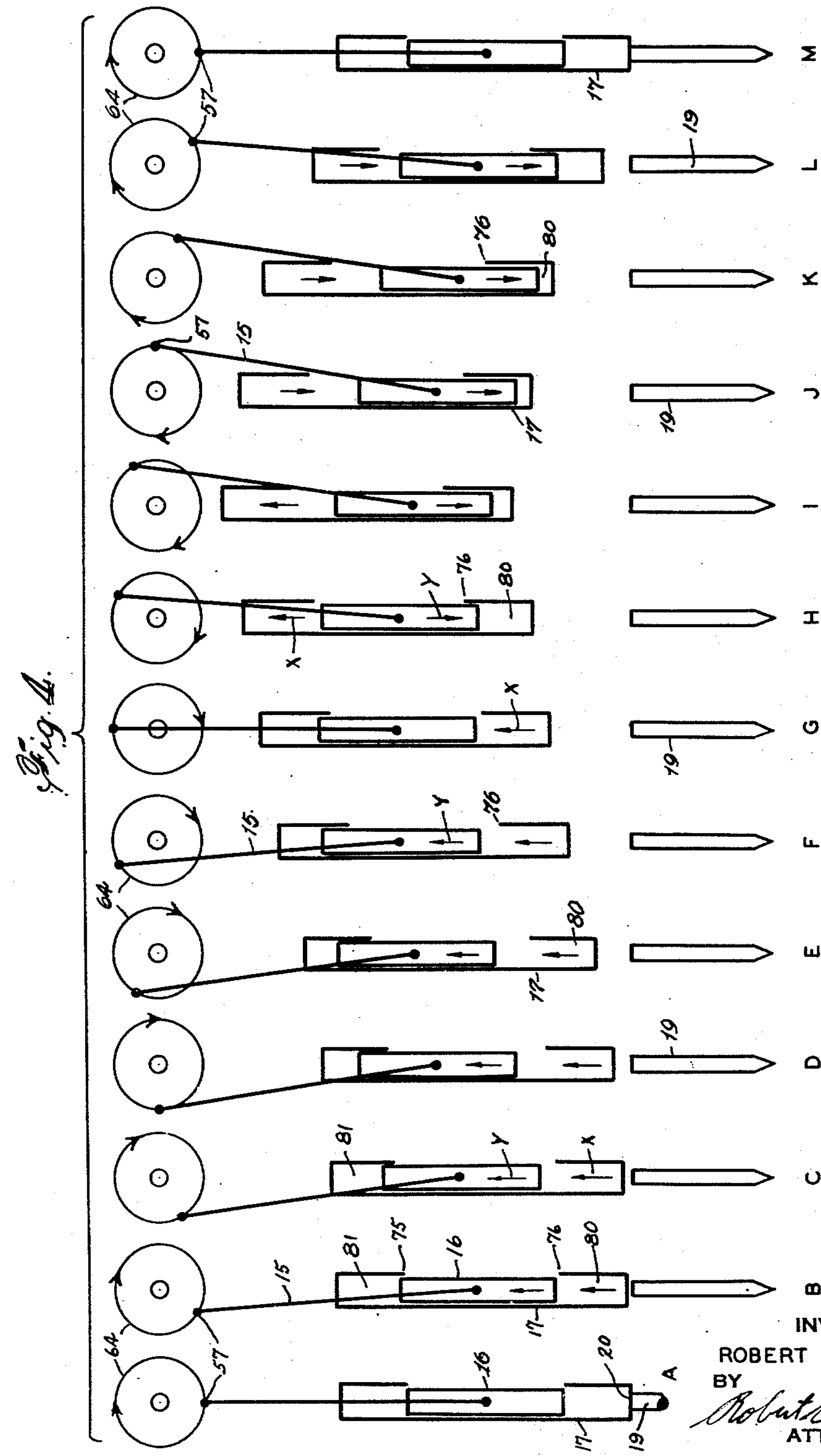

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2,447,886

POWER HAMMER

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10 Claims. (Cl. 125—33)

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This invention relates generally to impact devices as embodied for example in power hammers used for pavement breaking, rock drilling, pile driving, riveting or the like, hereinafter referred to generically as power hammers.

Where heavy hammering operations are required such as those in connection with the breaking of pavements, excavating, riveting, cutting, drilling and the like, it is desirable that a tool be used which is relatively light in weight in proportion to the power delivered, easily maneuverable, and highly portable.

Power hammers have been operated in the past by pneumatic pressure, directly driven by internal combustion engines, or by electrically powered means. The air driven hammers have a number of disadvantages including the requirement of expensive and bulky compressor equipment, clumsy air pressure lines communicating from the compressor to the tool, and relatively low efficiency since, in order to get an effective blow, compressed air tools must apply full air pressure through the entire stroke of the piston, discharging the only partially used air, still under pressure, at the end of the stroke.

Presently available power hammers which are driven by self-contained internal combustion engines have the disadvantges of fire hazard, discomfort for the operator in warm weather, hard starting, erratic operation under changing conditions, and high maintenance cost owing to the high wear produced in this type of mechanism. Further, they are heavy and bulky for the power delivered.

In electrically driven power hammers, the rotary motion of an electric motor is converted into reciprocatory movement of an impact or striking element. While electrically operated hammers have many advantages over air driven hammers and those driven directly by internal combustion engines, the electric hammers heretofore available have been open to the objection of relative low operating efficiency. This has resulted in the hammer being ineffective for the intended work or alternatively in the need for such a large electric motor as to render the device heavy and clumsy to handle and expensive to operate. Moreover, previous electrically driven devices of this class have required frequent servicing and repair owing to the utilization of packings, elastic elements and other parts subject to wear and fatigue and have been subject to the further disadvantage that shock from the impact element is transmitted back to the motor and driving mechanism with deleterious results. While the problems of overcoming these objections have long existed and many attempts have been made to solve them, no satisfactory solution has heretofore been found.

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It is an object of the present invention to overcome the disadvantages of the prior art devices and provide a power driven hammer of superior performance and operating at a relatively high efficiency. The high efficiency attained by the arrangement of parts and cycle of operation in converting the rotary motion of the motor into reciprocatory motion of an impact element in accordance with the invention results in delivering an impact of maximum effectiveness. The effectiveness of the impact is increased by the fact that energy is stored substantially throughout the cycle so as to utilize the continuous power output of the motor and full use is made of this stored energy in the delivery of the blow.

The present invention thus makes possible the construction of a heavy duty hammer that is relatively light weight and compact in size. Moreover, the construction and cycle of operation in accordance with the invention results in cooler running and in longer life with a minimum of servicing or repair. A further advantage of the invention is that the transmission of shock back into the operating parts and structure of the hammer is minimized. This not only contributes to the long life of the hammer and freedom from mechanical failure but also reduces operator fatigue.

These and other objects and advantages of the invention will appear more fully from the following description and claims and from the accompanying drawings which show by way of example an embodiment selected to illustrate my invention.

In the drawings:

Fig. 1 is a front elevational view of a power hammer showing an embodiment of the invention in which an electric motor is used as a power source.

Fig. 2 is a longitudinal sectional view as seen from the plane 2—2 on Fig. 1.

Fig. 3 is a sectional view as seen from the plane 3—3 on Fig. 2.

Fig. 4 is a schematic view showing the position of the parts through a cycle of operation of the hammer.

The embodiment of my invention illustrated in the drawings includes a main casing or housing 11, a removable cover plate 12, a driving motor 13, a counter-shaft 14, a connecting rod 15, a piston 16, a cylinder 17 and a front head 18.

The front head 18 is adapted to maintain any suitable tool bit such as the tool bit 19, in a position to be struck by the ram head 20 on the lower or work end 21 of the cylinder 17. As best seen in Fig. 1 the tool 19 may be provided with a collar 22 by means of which it is maintained against the lower or outer end 22 of the front head 18 by the use of the spring retainer 23 in a well known manner. The front head 18 may be connected in any suitable manner as by the springs and bolts 24 to the lower or work end 25 of the main casing 11.

The general configuration of the walls 26, 27, and 28 of the casing 11 is seen in Figs. 1, 2 and 3. Extending inwardly toward each other from the opposed inner surfaces 29 and 30 of the walls 26 and 28 are the ledges 31 and 32 supported by ribs 33. The ribs 33 not only serve to maintain the ledges 31 and 32 in alignment with respect to each other, but also reenforce the wall 34. A pair of tracks 35 and 36 are secured to the ledges 31 and 32 preferably in an adjustable and detachable manner as for example by the use of the bolts 37 and 38 which extend through openings in the tracks and screw into threaded holes in the ledges 31, 32. The tracks 35, 36 engage grooves 41 provided in the opposite sides of the cylinder 17 to support the cylinder for reciprocation in a lengthwise direction. The cylinder is removable from the casing 11 by removing the front head 18, or by removing one or both of the tracks 35, 36.

The cylinder 17 is closed at its inner or upper end 39, preferably by a threaded plug 40, and is closed at its lower or work end by the ram head 20. Substantially midway of the length of the cylinder, that is to say midway of the hollow portion thereof, the cylinder is provided with an opening 42 and an elongated slot 43. The slot 43 is preferably substantially equal to or slightly greater than the length of the piston 16. As seen in Fig. 2, the opening 42 is diametrically opposite the slot 43.

The piston 16 is of the double ended or double headed type and includes a lower or ram piston head 44 and an upper or cylinder retracting head 45. The central portion of the piston 16 is provided with an opening 46 formed preferably by oppositely disposed bores which converge toward each other. These bores may be of conical shape. The larger bore, disposed in the direction of the motor 13, is adapted to receive the tapered end 47 of a pin 48. The tapered end of the pin 48 is detachably secured endwise in the opening 46 by a screw and circular wedge or cone structure generally indicated by reference character 49. The screw engages a correspondingly threaded hole in the end of the pin 48, and the head of the screw, which may be hexagonal as shown, is accessible through the opening 42 when the piston is in its midway position and through an opening 53 in the wall 34 of the casing 11 when the detachable cover plate 50 is removed. The cover plate 50 may be maintained in position in the circular rabbet 51 in any suitable manner as by the use of screws 52 which engage threaded holes in said rabbet. The bolt 49 is brought from the position shown in Fig. 2 into juxtaposition with the opening 53 by rotation of the countershaft 14 through part of a revolution.

The opposite end 54 of the pin 48 is disposed within a cross head 55 mounted for slidable reciprocation in a guide 56 which is secured to the inner surface of the cover plate 12. The pin 48, and hence the cross head 55 and piston 16, are reciprocated longitudinally of the casing 11 by the connecting rod 15, one end 58 of which engages said pin and the other end 59 of which engages a wrist pin or stud 57 mounted eccentrically of the countershaft 14. The countershaft is journalled by bearings 60 and 61 in a housing portion 62 of the cover plate 12 and access thereto may be gained through a removable cover 63. The inner end of the countershaft 14 has secured thereto a gear 64 which carries the aforementioned stud 57.

The driving motor 13 is preferably of an induction type electric motor running at a substantially constant speed and the casing 65 of said motor is preferably directly secured to the cover plate 12. The motor shaft 66 may carry a fan 67 which serves to cool the motor and at the inner end of said shaft a pinion 68 is provided. The pinion 68 meshes with the gear 64 on the countershaft 14. The motor bearings, the bearings 61 and 62 of the countershaft and the connecting rod bearings, may be of the ball type as shown. The cover plate carrying the motor and the countershaft and gear 64 is maintained in position by a series of bolts 69 which engage corresponding portions of the casing 11 and particularly the walls 26, 27, 28 and 70.

Lubrication may be supplied to the operating parts in the chamber 71 inside the casing 11 by any suitable method such as a visible drip oiler or a pressure lubricator (not shown), and excess oil may leak out through the felt dust filters 72 and 73.

As presently understood, the operation of the power hammer in accordance with my invention is as follows: Assuming the parts to be in the position shown in Fig. 2 and indicated schematically at A in Fig. 4, the ram head 20 of the cylinder 15 which acts as an impact element, has struck its blow upon the inner end of the shank of the tool 19 and the piston 16 is at the bottom of its stroke. When the blow is struck, the cylinder 17 rebounds from the tool 19 and its upward motion is assisted by the fact that the connecting rod 15 has begun to pull the piston upwardly as shown at B in Fig. 4. This upward movement of the piston causes the upper end of the piston to move past the upper end 75 of the slot 43 in the cylinder so that the upper chamber 81 of the cylinder is hermetically sealed. Movement of the lower end of the piston upwardly past the lower end 76 of the slot 83 permits air at atmospheric pressure to enter the chamber 80 in the lower portion of the cylinder. At C in Fig. 4 the upward movement of the piston 16 and cylinder 17 continues as indicated respectively by the arrows X and Y. As the gear 64 is driven at substantially constant speed the movement of the piston 16 is approximately sinusoidal so that the piston is accelerated during its movement from the position shown at A in Fig. 4 to the position shown at D. The cylinder 17 is also being accelerated in its upward movement but because of its inertia it is accelerated less rapidly than the piston so that the air in chamber 81 is progressively compressed.

At E in Fig. 4 the piston has begun to decelerate while the cylinder continues to accelerate so that the two are moving upwardly at approximately the same speed. The air in chamber 81 is maintained under compression and may be slightly more compressed at E than at D. The deceleration of the piston continues at F and the air that has been compressed in chamber 81 now begins to expand to cause the upward movement and acceleration of the cylinder 17 to continue. At G the stud 57 has travelled through substantially 180° and the piston 16 has reached the top of its stroke, but the cylinder 17 continues to move upwardly.

The piston now begins to move downwardly as indicated at H while the inertia of the cylinder causes it to continue to move upwardly, the limit of its upward movement being reached approximately at the position shown at I in Fig. 4. It will be noted that during the phases shown at H and I the cylinder and piston are moving in opposite directions. At approximately the position shown at H the piston closes the port at the lower end 76 of the slot 43 in the cylinder and begins to compress the air in the chamber 80 while the upper chamber 81 is opened to atmospheric pressure. Maximum compression in the chamber 80 occurs approximately at J where the piston has reached its greatest speed of movement in the direction of the tool 19. Between J and K the cylinder and piston move substantially together so that the air in chamber 80 is maintained under high compression and the driving force of the rapidly moving piston is transmitted through this compressed air to the cylinder. At L the piston is slowing down but the air under compression in chamber 80 forces the cylinder to travel at still greater speed in the direction of the tool 19 and increases the momentum which the cylinder already has. The cylinder attains its maximum speed at the lower end of its stroke where it strikes the tool 19 as indicated at M and thereby transmits its kinetic energy to the tool.

It will be seen from Fig. 4 of the drawings and from the above description that in the portion of the cycle from A to E (Fig. 4) the energy derived from the driving motor is converted into kinetic energy of the piston 16 and cylinder 17 in their upward acceleration and movement, and into potential energy represented by the compression of air in the chamber 81. Between E and G the energy of the compressed air in chamber 81 is converted by expansion of the air into increased kinetic energy of the cylinder 17. The kinetic energy of the cylinder is still further increased by the continued upward movement of the piston 16 against the resistance of the expanding air. In the phase between G and I the energy of the motor is utilized in accelerating the downward movement of the piston and in compressing the air in chamber 80 while the kinetic energy of the cylinder 17 is also converted into potential energy of the compressed air. During the portion of the cycle from J to M, the potential energy of the compressed air in chamber 80 is converted by complete expansion of the air into kinetic energy of the cylinder 17. The kinetic energy of the cylinder is still further increased by the continued energy input represented by the movement of the piston 16 downwardly against the resistance of the air in chamber 80. At the instant of impact, shown at M in Fig. 4, the piston has reached the end of its downward stroke and the expansion of air in chamber 80 is completed. The energy input throughout the cycle has thus been converted into kinetic energy of the cylinder 17. The full utilization of the energy available to produce maximum velocity of the impact element 17 at the instant of impact results in the delivery of a highly effective blow on the tool 19 and represents maximum efficiency in the cycle of operation.

The compression and expansion of the air in chambers 80 and 81 is approximately adiabatic,

the temperature of the air being increased during compression and decreased during expansion. Heat transmitted to the walls of the chamber during compression is hence withdrawn by the expansion of the air in the succeeding portion of the cycle. It will thus be seen that the complete expansion of the air in chamber 80 prior to impact not only results in high efficiency of the operating cycle as pointed out above but also contributes to the cool running of the apparatus.

In order to obtain the greatest efficiency it is desirable that the speed of the motor, the radius of the orbital travel of the stud 57, and the weight of the piston and cylinder be so correlated that a resonant condition exists and the maximum transfer of energy takes place from the rotating stud 57 to the cylinder and tool. As will be seen from Fig. 4, the cylinder 17 lags behind the piston 16 in its movement throughout the cycle except at the moment of impact as illustrated at A and M when the cylinder and piston are both at the bottom of their respective strokes. By reason of the relative movement of the cylinder and piston, the stroke of the cylinder is substantially greater than that of the piston.

At the instant of impact as shown at M in Fig. 4 the piston and cylinder are in neutral relation to one another. The piston is momentarily stationary, having reached the bottom of its stroke, and is substantially centered in the cylinder The air in chamber 80 has been fully expanded and the compression of air in chamber 81 has not yet begun so that both chambers are substantially at atmospheric pressure and are preferably open to the atmosphere through the ends 75 and 76 of the slot 43 in the cylinder wall. This neutral relationship of the cylinder and piston at the instant of impact minimizes transmission of the shock of impact back through the piston and operating mechanism of the hammer and not only decreases wear and tear on the hammer itself but also reduces operator fatigue.

The slot 43 in the side wall of the cylinder 17 not only accommodates the pin 48 by means of which the piston 16 is reciprocated but also serves the purpose of providing communication between the chambers 80 and 81 and the surrounding atmosphere when the ends of the slots are alternately uncovered by the piston. The large area passageways thus afforded permits free flow of air into and out of the cylinder and thus avoids objectionable attenuation or damping of the operation even at relatively high speeds. Moreover, by driving the piston in the manner shown and described the effective area of both ends of the piston can be made the same and the need of packing or other devices to prevent leakage of air around a piston rod is avoided. A more compact arrangement of the device is made possible since the cylinder—which has a longer stroke than the piston—can project up beyond the crank pin 57 by means of which the piston is reciprocated.

As power hammers are frequently used in dust-laden atmosphere, the chamber 71 of the casing 11 (Fig. 2) that contains the cylinder 17, piston 16 and driving mechanism is preferably completely closed so as substantially to exclude the outside atmosphere. By reason of the high efficiency and cool running properties of the hammer in accordance with the present invention, such enclosure is possible without overheating. It will be noted that the cylinder 17 is guided in its reciprocatory movement by the inwardly projecting tracks 35 and 36 (Fig. 3) and that the walls of the chamber 71 are spaced a substantial distance from the cylinder so as to provide freedom of movement of the cylinder without appreciable resistance or damping by the air in the chamber 71. This contributes still further to the high efficiency of the apparatus.

Although the operating mechanism of the hammer is completely enclosed it is nevertheless readily accessible for inspection. By removing the cover plates 12 and 50 and the tool retainer 18 and unscrewing the bolt 49, all the operating parts can be disassembled from the casing 11. The connecting rod 15, gear 64 and cross head 55 with pin 48 come off with the cover plate 12 and motor 13 while the cylinder 17 can slide out through the open end of the casing.

Operation of the embodiment shown is a simple matter, as the same may be manually grasped by the handles 8 and 9 and the circuit from an electrical conductor (not shown) may be closed to the motor 13 by the trigger switch 8.

In view of the relatively high efficiency of my device, no forced ventilation is required and overheating has not been encountered. Thus the relatively sealed unit is protected from dust laden air.

I wish it to be understood that I do not desire to be limited to the exact details of construction shown and described, for obvious modifications will occur to a person skilled in the art. It should be further understood that while an electric motor is illustrated in the drawings, my invention is not limited as to the type of motor or power source that is used to drive the hammer.

What I claim and desire to secure by Letters Patent is:

1. A power hammer comprising a cylinder closed at both ends and acting as a ram, guide means for removably supporting the cylinder for reciprocal movement, a double-ended piston slidably disposed within said cylinder, a rotary crank, a constant speed motor driving said crank, and connecting means between said crank and said piston, whereby rotary motion of the crank is transmitted to said piston to reciprocate the same.

2. A power hammer construction comprising a hollow casing, a track in said casing, a hollow cylinder slidable along and guided by said track, with substantial space between the side walls of said cylinder and said casing, a piston slidable within said cylinder, rotary crank, a motor for driving said crank and a connecting rod joining said crank and said piston, whereby rotary motion of the crank is transmitted to the piston to move the same in a reciprocatory manner and said piston acts to move said cylinder alternately in opposite directions by the compression of an elastic fluid disposed within the cylinder.

3. An electrically driven power hammer comprising a casing, a tool support connected to said casing, a tool movably mounted within said support, a pair of tracks in said casing, a cylinder having closed ends and a slot in a side wall thereof, said cylinder being slidable along said tracks with substantial space between the side walls of said cylinder and said casing, a piston slidable within said cylinder, a pin extending from said piston through said slot, a movable stud, electrically driven means to move said stud, and connecting means joining said stud and said pin to transmit power to said piston to move the piston alternately in opposite directions.

4. A power driven hammer comprising a hollow cylindrical impact member substantially closed at both ends, a closed chamber enclosing said cylinder with substantial space between the side walls of the cylinder and the walls of the chamber, a track guiding said cylinder for reciprocation in said chamber, a piston in said cylinder, rotary power driven means for reciprocating said piston and thereby imparting resonant reciprocatory movement to said cylinder by the compression of air alternately in opposite ends of the cylinder, said cylinder being freely movable in the space inside the chamber substantially without damping.

5. A power driven hammer comprising a hollow cylindrical impact member closed at both ends to provide compression chambers at opposite ends of said member and having a slot in a side wall intermediate said compression chambers, means for guiding said cylinder for reciprocatory movement, a piston in said cylinder and power driven means extending through said slot for reciprocating said piston and thereby transmitting reciprocatory movement to said cylinder by the compression of air alternately in said opposed compression chambers, opposite ends of said slot being alternately uncovered by said piston in its reciprocation to open said compression chambers alternately to the surrounding atmosphere.

6. A power driven hammer comprising a hollow cylindrical impact member closed at both ends to provide compression chambers at opposite ends thereof, means for guiding said cylinder for free reciprocatory movement, a piston in said cylinder and power driven means for reciprocating said piston to transmit resonant reciprocatory movement to said cylinder solely by the compression and subsequent expansion of air alternately in said opposed compression chambers.

7. A power driven hammer comprising a hollow cylindrical impact member having compression chambers at opposite ends thereof, the side wall of said cylinder being apertured intermediate said compression chambers to provide communication with the surrounding atmosphere, a tool, means for holding said tool in position to be struck by said cylinder, a piston in said cylinder, said piston being of a length approximately equal to the distance between said compression chambers, and power driven means for reciprocating said piston and thereby transmitting resonant reciprocatory motion to said cylinder by the compression and subsequent expansion of air alternately in said opposed compression chambers to cause said cylinder to strike said tool, the relation and arrangement of the parts being such that the air in both of said chambers is substantially fully expanded at the instant of impact.

8. In a power driven impact tool, the combination with a casing and a tool, of a pair of reciprocable elements comprising a cylinder having compression chambers at opposite ends thereof and an intermediate portion open to the surrounding atmosphere, and a double-ended piston operable in said cylinder, which elements are reciprocable in said casing and are also reciprocable relative to each other, a rotary crank, a motor for rotating said crank and means for connecting said crank with one of said elements to reciprocate said element to compress air alternately in said opposed compression chambers and thereby transmit energy to the other of said elements by the alternate compression and subsequent expansion of the air in said chambers to cause said latter element to reciprocate in pre-

determined phase relation with said first element and to strike the tool at an instant when said first element is at the end of its stroke and substantially full expansion of the air in both of said compression chambers has occurred.

9. In a power driven impact tool, the combination with a casing, of a pair of reciprocable elements comprising a cylinder having compression chambers at opposite ends thereof and a longitudinal slot in the side wall of the cylinder extending between said chambers, and a double-ended piston reciprocable in said cylinder and having a length between opposite piston heads approximately equal to the length of said slot, means for guiding said cylinder for reciprocatory movement, and power driven means for reciprocating one of said elements and thereby transmitting reciprocatory movement to the other of said elements by the compression and subsequent expansion of air alternately in said opposed compression chambers, opposite ends of said slot being alternately uncovered by said piston to open said compression chambers alternately to the surrounding atmosphere.

10. In a power driven impact tool, the combination with a casing, of a pair of reciprocable elements comprising a cylinder having compression chambers at opposite ends thereof and an intermediate portion open to the surrounding atmosphere, and a double-ended piston reciprocable in said cylinder, the inside length of the cylinder being substantially equal to the sum of the length of the piston between opposite piston heads and the combined length of the compression chambers, and power driven means for reciprocating one of said elements and thereby transmitting reciprocatory movement to the other of said elements by the compression and subsequent full expansion of air alternately in said opposed compression chambers.

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