Aug. 22, 1939. J. HOLLOWAY 2,170,757

POWER HAMMER

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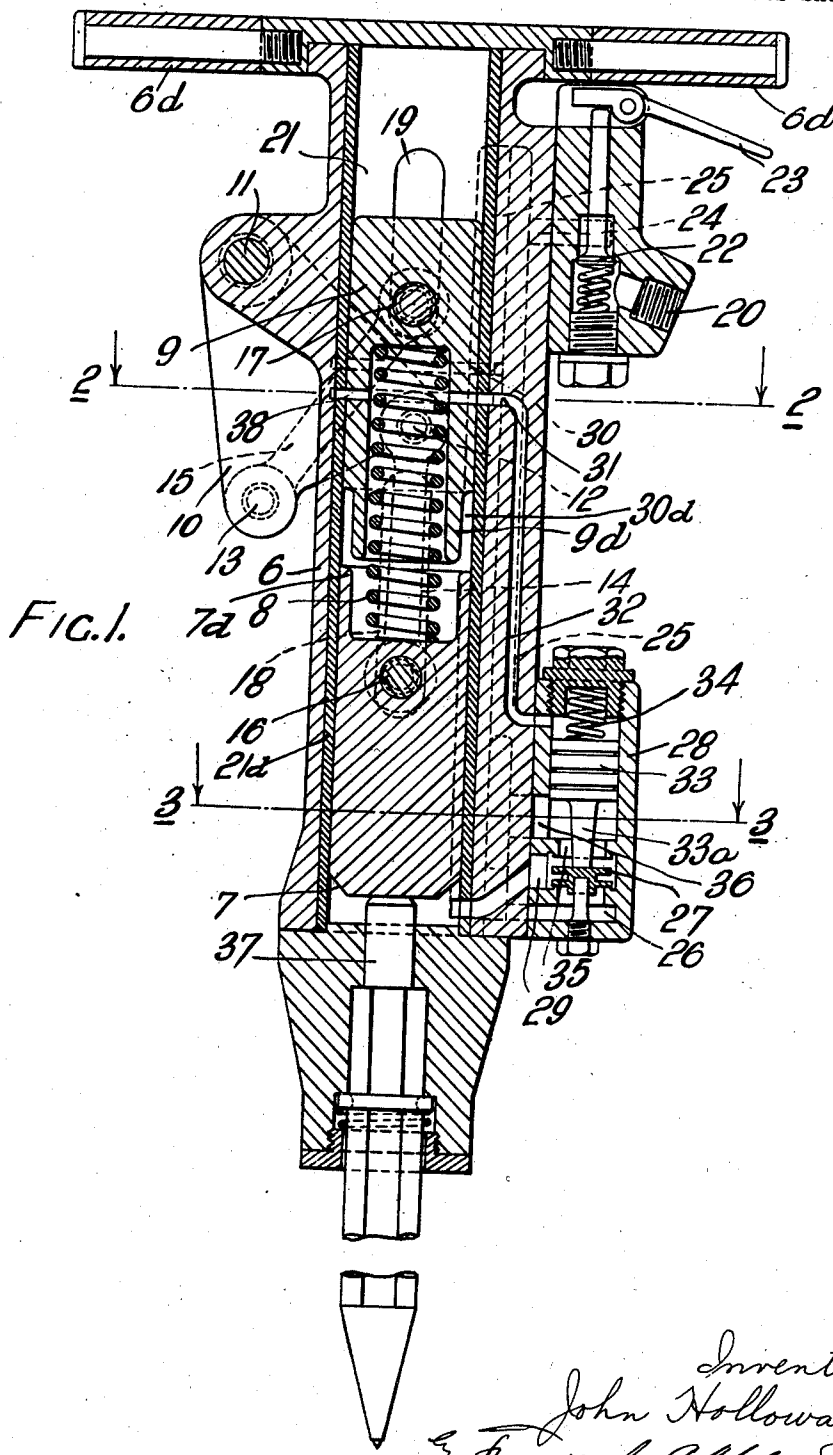



FIG. 1.

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POWER HAMMER

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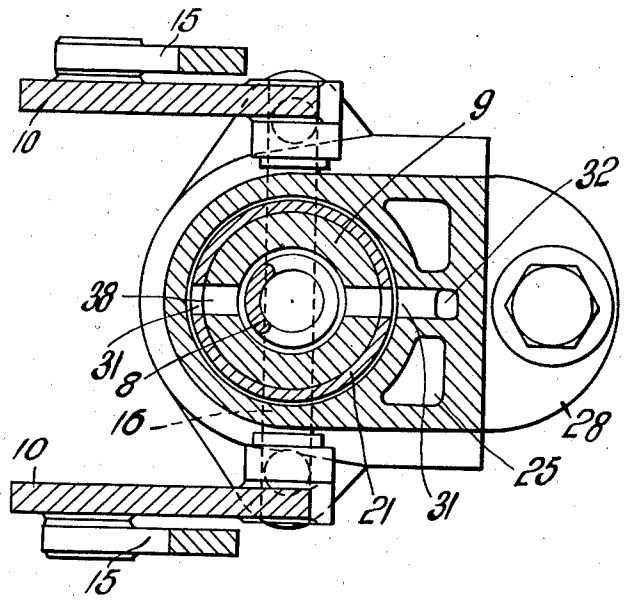



FIG. 2.

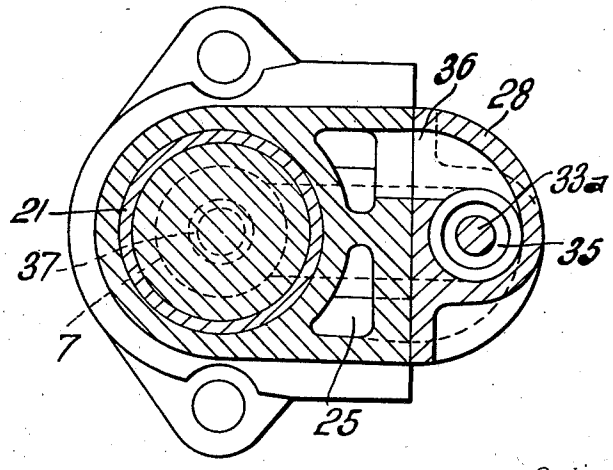



FIG. 3.

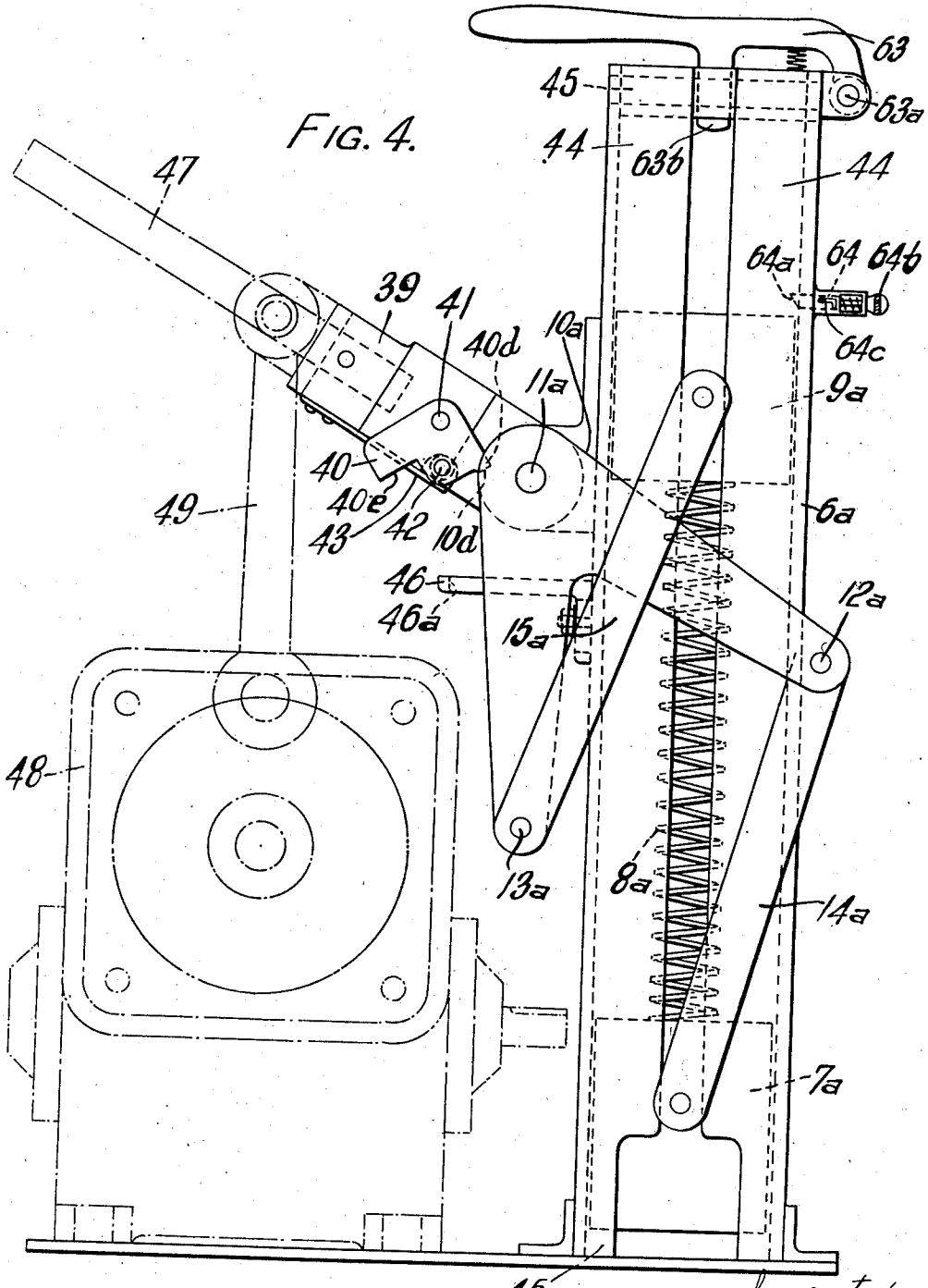
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POWER HAMMER

Filed July 28, 1936 4 Sheets-Sheet 3

FIG. 4.




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POWER HAMMER

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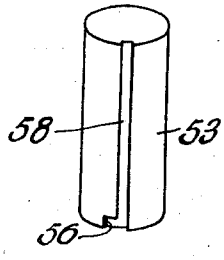



FIG. 6.

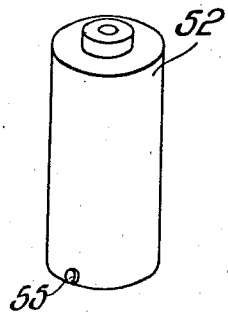



FIG. 7

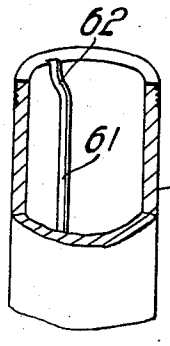



FIG. 8.

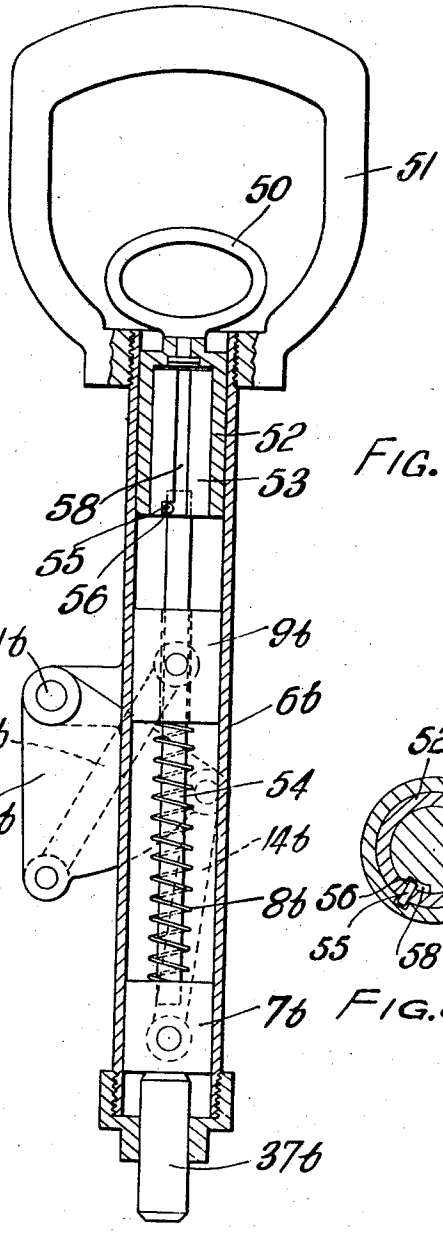



FIG. 5.

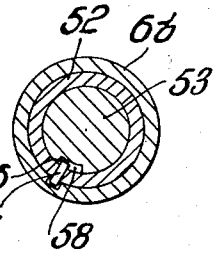



FIG. 9.

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Patented Aug. 22, 1939 2,170,757

# UNITED STATES PATENT OFFICE

2,170,757

## POWER HAMMER

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Application July 28, 1936, Serial No. 93,075
In Great Britain July 30, 1935

21 Claims. (Cl. 125—33)

This invention relates to power hammers or like machines which are mechanically operated to perform work by delivering blows as from a hammer such for example as pile drivers, rammers, stamping machines, forging presses and heading machines and generally to mechanism for delivering impulsive forces hereinafter referred to as power hammers.

The primary object of the invention is to provide new or improved means for operating such machines which will render the machines substantially non-reactive in use, and allowing the machines to be constructed in light metals such as aluminium alloy. This combination is of particular advantage in the case of hand operated pneumatic tools such as road breaking drills, hand riveting machines and the like, because of the ease with which they can be manipulated and the resulting freedom from vibration and recoil.

Another object of the invention is to compress an elastic medium between two bodies or pistons which are mechanically interconnected by means adapted to bring the bodies or pistons into a substantially, but preferably not completely, balanced condition, the said means being employed to balance the forces and/or the stored energy and, operating in conjunction with other mechanism hereinafter described, to permit the stored energy to be used for performing the work of hammering or the like in the machine wherein the energy is stored whereby the aforesaid non-reactive property is secured.

The invention consists of a power hammer or the like comprising two moving bodies or pistons connected through means allowing them to move in the same direction at differential speeds, the arrangement being such that with the faster-moving body or piston overtaking the slower-moving body or piston work is performed upon an elastic medium between the two moving bodies or pistons to store energy in the medium which at a predetermined point in the stroke of the moving bodies or pistons is utilized to return or to assist in returning the moving bodies or pistons at a greatly accelerated speed to their original positions resulting in the delivery of an impulsive force.

It will be understood that the mechanism may be operated by manual or by motive power and also that the moving bodies may be fashioned or shaped as desired, or may be attached to tools or the like, according to the nature of the work and the use for which the mechanism is to be employed.

Several embodiments of the invention will now be more particularly described, by way of example, with reference to the accompanying drawings in which:—

Figure 1 is a vertical section through a power hammer made according to the invention and showing the same applied to a pneumatically operated road-breaking drill,

Figure 2 is a cross section through the machine casing on the line 2—2 of Figure 1 on an enlarged scale showing the arrangement of the inlet and exhaust passages therein,

Figure 3 is a cross section on the line 3—3 of Figure 1 on an enlarged scale showing the disposition of the exhaust port,

Figure 4 is a diagrammatic view of a hand or power operated hammer in which the moving bodies or pistons are reciprocated through the means connecting them together,

Figure 5 is a vertical section through a hand operated riveting hammer embodying the invention, and

Figures 6 to 9 are detail views on an enlarged scale of parts of the hammer shown in Figure 5.

Referring to Figures 1 to 3, the road-breaking drill shown therein comprises a casing 6 including a handle 6*d* and the moving bodies consist of pistons 7 and 9 movable in a cylinder 21 which is preferably formed with a liner 21*d* provided in the casing 6. A compression coil spring 8 is located between the pistons 7 and 9 and in the embodiment shown constitutes part of the elastic medium in which energy is stored, the other part being the air between the two pistons. It will be understood that alternatively any suitable compressible fluid may be employed as the elastic medium between the two pistons with or without a spring such as 8, as desired. The lower part of the piston 9 is formed with a reduced skirt at 9*d* to allow it to telescope into the skirt 7*d* of the lower piston 7 to seal the space wherein the compression spring 8 is contained from the relatively small annular space 30*d* between the piston skirts and the wall of the cylinder 21. A bell crank lever 10 is fulcrumed at 11 on the casing 6 and to angularly spaced points 12 and 13 of the bell crank lever, links 14 and 15 are pivotally connected, being attached at their opposite ends to gudgeon pins 16 and 17 respectively of the pistons 7 and 9. The bell crank lever 10 and links 14 and 15 are preferably duplicated so that they are symmetrical with the vertical centre line of the casing 6 to ensure smooth working, the ends of the gudgeon pins 16 and 17 projecting through slots 18 and 19 respectively in the casing and having a link 14 or 15 connected thereto respec-

tively at each end. It will be understood that the whole of the outside mechanism such as the bell crank lever 10 and links 14 and 15 may be enclosed in an outer cover or shield for protection.

The lower piston 7 constitutes the hammer head of the tool or the member which directly or indirectly strikes the blow, the upper piston 9 constituting what may be termed a balance piston as referred to hereinafter. With the pistons at the bottom of their strokes the positions of the bell crank lever 10 and links 14 and 15 are as shown in Figure 1, the links being of such length that the spring 8 is as nearly as desired relieved of compression. It will be noted that with the pistons in the positions shown, the pivot 13 lies nearly vertically below the fulcrum 11 while a line running through the pivot 12 and fulcrum 11 makes an angle of about 40° below a horizontal line drawn through the fulcrum. Now the bell crank lever 10 may be considered as two rigidly connected levers or arms the ends of which are defined by the points 11 and 13 and 11 and 12 respectively the former constituting what may be termed a balance arm due to its connection to the balance piston 9 and the latter constituting a power arm due to its connection to the hammer head or power piston 7. It will be seen on reference to Figure 1 that if the bell crank lever 10 be rotated upwards through an arc of, say, 60° the power arm 11, 12 of the bell crank will move the piston 7 in a vertical direction a distance almost equal to the radius of the pivot 12 from the fulcrum 11 whereas the balance arm 11, 13 due to the same rotation of the bell crank will move the piston 9 in a vertical direction a distance only approximately half that covered by the piston 7, and the difference between the strokes of the two pistons represents the amount the spring 8 is compressed.

It will be appreciated that if the bell crank lever 10 is rotated beyond the position indicated above, a position will be reached in which the power and balance arms of the bell crank will be standing at equal angles to the horizontal and their leverages about the fulcrum 11 will be equal so that the energy stored in the spring 8 is balanced. It will be seen that when the bell crank is moved to a position where the power and balance arms are not quite at equal angles to the horizontal, the leverages are unequal and out of balance, so that when the balance arm is moved back towards the initial position shown in Figure 1 its leverage about the fulcrum 11 rapidly decreases while the leverage of the power arm tends to increase, with the result that the piston 7 descends with the force of the energy stored in the spring 8.

When compressed air is used for power, the operation of the machine is as follows:—

Compressed air enters the drill casing 6 by the connection 20, passes through a valve 22 when the latter is depressed by the handle 23 under the control of the operative, and passes thence by a port 24 into an air chamber 25 running substantially the whole length of the casing 6, as shown. From the lower end of the air chamber 25 the compressed air is led through a port 26 to the underside of a control valve 27 working in a control valve chamber 28 carried by the casing 6. The pressure of the compressed air lifts the control valve 27 to uncover an inlet port 29 through which the air passes to the cylinder 21 beneath the piston 7 which rises against the resistance of the spring 8 and causes the piston 9 to travel in the same upward direction until the lower reduced portion 9*d* of the latter uncovers an air port 30 in the cylinder 21. Compressed air then passes from the air chamber 25 through the air port 30, into the annular space 30*d* between the piston skirts and the wall of the cylinder 21 (which space has been closed by the skirt 7*d* telescoping over the skirt 9*d* and is sealed off from the space containing the spring 8 whereby the consumption of compressed air is economized), to a port 31 through which it passes to a conduit 32 to the top of a piston 33 in the control valve chamber 28. The piston 33 has a stem 33*a* contacting with the top of the control valve 27 and held thereto by the pressure of a coil spring 34 so that the piston 33 and control valve 27 always move as a unit. The piston 33 is of larger cross-sectional area than the control valve 27 whereby the admission of compressed air through the conduit 32 mentioned above depresses the piston and the control valve 27 to close the latter onto its lower seating thereby closing the port 26, to cut off the compressed air from the cylinder 21 beneath the piston 7, and at the same time opening a port 35 allowing the air in the cylinder 21 to be exhausted therethrough to an exhaust port 36 and thence to atmosphere. At the same time, the pressure of the compressed air filling the space 30*d* between the pistons 7 and 9, due to the out of balance position of these latter, is added to the energy stored in the spring 8 and causes both pistons to descend, the lower piston 7 striking the tool 37 which may be a pick, as shown, or a chisel or rammer head and which projects into the bottom of the cylinder 21. As the piston 7 moves away from the piston 9 the space 30*d* is re-opened to the space containing the spring 8 and the compressed air exhausts thereinto from the space 30*d* and so to atmosphere by the slot 18. Due to the fact that the resistance to the movement of the piston 7 is effected by the piston 9 instead of by a stationary element such as a cylinder cover, there is no force exerted on the cylinder or casing to cause recoil such as is found on pneumatic hammers of the ordinary type and the casing 6 therefore remains substantially non-reactive. It will be seen that as the port 35 remains open during the descent of the pistons 7 and 9, there is no resistance to impede the accelerated speed at which the latter fall. At the moment when the blow is struck, that is when both pistons are at the bottom of their strokes, ports 38 in the piston 9 come opposite the port 31 and thereby compressed air escapes from the top of the piston 33 to atmosphere. The ports 38 in the piston 9 are positioned opposite the port 31 (Figure 2) so that they never open to the port 30, carrying compressed air from the air chamber 25. The pressure being released from the top of the piston 33, the compressed air forces open the control valve 27 thereby closing the port 35 leading to the exhaust port 36 and admitting compressed air into the bottom of the cylinder 21 beneath the piston 7 and the cycle of operations is then repeated.

When the machine described is to be employed as a rammer, for slower operation of the rammer head which replaces the pick 37, the valve 22 is not opened fully, thereby limiting the rate at which the compressed air passes into the cylinder 21 from the air inlet chamber 25, so that the speed of the pistons 7 and 9 and of the actuation of the rammer head may be regulated.

Figure 4 shows a hammer provided with oper-

ating mechanism according to the invention in which the actuation of the moving bodies or pistons 7a, 9a is effected from the fulcrum 11a of the lever 10a. The latter comprises a power arm 11a,—12a and a balance arm 11a,—13a as before and the machine is operated by applying the effort to the lever 10a instead of to the lower moving body or piston as in the embodiment previously described. The means by which the effort is applied to the lever 10a consist of a swivelling member or ratchet arm 39 pivotally mounted on the fulcrum 11a of the lever 10a and having a pawl 40 one end 40d of which is shaped to engage in a notch or step 10d cut in the hub of the lever 10a. The other end of the pawl 40 comprises a face 40e which is approximately at right angles to the operative face of the end 40d. Preferably the oscillatory lever 10a is duplicated as before, as is also the pawl 40 so that a pawl is carried at each side of the ratchet arm 39 upon a fulcrum 41, the pawls being connected together by a pin 42 against which a flat spring 43 bears to ensure that the pawls act upon the hub of the lever 10a, in unison. The ratchet arm 39 with the pawls 40 and spring 43 is similar in operation to an ordinary ratchet except that the pawls engage with the same notch or step 10d on the lever 10a at each stroke of the ratchet arm 39 and lever 10a, but a series of notches or steps may be employed in order to provide for variation of the length of stroke of the moving bodies or pistons. The latter in the embodiment shown in Figure 4 consists of lower and upper blocks 7a and 9a slidably carried in vertical channel members 44 provided with clamping means 45 at their upper and lower ends. The blocks 7a and 9a have a compression spring 8a located between them and are connected to the points 12a and 13a of the oscillatory lever 10a by links 14a and 15a in the same manner as are the pistons 7 and 9 to the lever 10 in the embodiment previously described. To throw the pawls 40 out of action when the desired point in the stroke of the blocks 7a and 9a is reached to leave the lower block 7a free to descend due to the energy stored in the spring 8a, a projection 46 is adjustably carried on the frame of the machine, being so arranged as to make contact with the faces 40e of the pawls when the ratchet arm 39 is moved downwards to cause the pawls to turn about the fulcrum 41 in a clockwise direction to take the ends 40d clear of the hub of the oscillatory lever 10a.

The ratchet arm may be operated by a hand lever 47 or by a prime mover 48 through a connecting rod 49.

In cases where a portable unit is desired the hammer frame may be attached to a base fitted with wheels, rollers or other means for locomotion. Likewise when the hammer is required for use on such work for instance as pile driving, or metal stamping, the power unit 48 may be mounted on or near the frame of the machine and connected to the oscillatory bell crank 10a by gearing or other suitable means.

Figure 5 shows a hammer intended for use where a succession of light hammer blows of a specified weight is required, such as in the heading of small rivets in somewhat delicate metal work, such as for example the metal bodies of aircraft. The hammer shown is hand operated, the pistons or blocks 7b and 9b being actuated by a finger grip 50 located within the handle 51 of the hammer. The pistons or sliding blocks 7b and 9b spring 8b, bell crank 10b, links 14b and 15b and tool 37b are similar to the corresponding parts of the embodiments already described. The finger grip 50 is swivelly connected to an outer piston 52 slidably mounted in the upper end of the hammer casing 6b, and an inner piston 53, over which the outer piston 52 is slidable, has a rod 54 rigidly connected thereto. The rod 54 passes loosely through the upper piston or block 9b and is connected at its lower end to the lower piston or block 7b. The outer piston 52 carries a substantially radially projecting stop pin 55 (Figures 5, 7 and 9) one end of which projects inwardly to engage with a notch 56 in the inner piston 53 to couple the latter to the outer piston 52 while the other end projects outwardly to engage in a groove 61 in the inner surface of the casing 6b. The groove 61 is mainly vertical but its upper end 62 curves in a counter-clockwise direction as shown in Figure 8. With the parts in the position shown in Figure 5 the operation of drawing the finger grip 50 upwards towards the handle 51 causes upward movement of the pistons or blocks 7b and 9b in the casing 6b towards a point of balance as described with reference to Figure 1. Before this point is reached however the inner piston 53 is uncoupled from the outer piston 52 due to the outer end of the stop pin 55 passing into the curved part 62 of the groove 61 whereby the piston 52 is rotated in a counter-clockwise direction resulting in the inner end of the stop pin 55 being removed from the notch 56 into a position opposite a vertical slot 58 in the inner piston 53. This uncoupling of the pistons 52 and 53 allows the inner piston 53 with the rod 54 and pistons or blocks 7b and 9b to descend under the influence of the compressed spring 8b, the lower piston or block 9b striking the riveting head 37b to deliver a blow.

Due to the non-reactive property of the riveting hammer described and to the definite and constant weight of blow delivered at each stroke irrespective of the manner of operation of the finger grip 50, it will be appreciated that the hammer is more efficient in use than the riveting hammers at present in use. Furthermore with the bell crank lever and linkage construction described, the leverage is increased as the balance arm of the bell crank lever approaches the original position of the power arm and the upward pull exerted on the spring 8b by the upper block 9b begins to approximate to the pull exerted on the lower block 7b by the operative so that as the point of trip is approached the operative is exerting little or no effort on the finger grip 50. This point is of importance as it enables the hammer to be used for work upon which it is impossible to use known constructions of riveting hammers.

If desired a safety device may be fitted to the machine, whether constructed as a riveting hammer or as a stamping or embossing machine, to prevent the piston or block 7a falling and delivering a blow before the piece on which work, such as stamping and embossing is to be done, has been properly set in position. In cases of this nature the bell crank 10a may be moved through the required arc to bring the balance piston or block 9a and the lower piston or block 7a into complete equilibrium, while the energy in the compressible medium remains stored. This may be achieved as shown in Figure 4 by adjusting the projection 46 to the position shown at 46a so that the system is not tripped until it reaches the point of equilibrium. It has already been shown that in this circumstance there will be no movement of the piston or block 7a and it will be

apparent that a further operation will be necessary to put the mechanism out of balance and allow the stored energy to be released, bringing down the piston or block 7*a*. The safety device may consist of a small lever 63 or similar attachment which may be pivoted to the casing 6*a* at 63*a*. To put the mechanism out of balance the lever 63 has to be moved by the machine operative about its pivot 63*a* so that a projection 63*b* strikes the top of the balance piston or block 9*a*. If desired however, a safety catch may be fitted in a convenient position as an alternative to bringing the mechanism to a point of balance and then moving it therefrom. This may be fashioned in the form of spring or weight loaded pawl 64 the nose 64*a* of which automatically snaps into place at the desired point of the stroke behind the piston or block 9*a* and prevents the latter from descending until the mechanism is tripped by the operative when the blow is required to be struck. Tripping may be effected by grasping the knob 64*b* and withdrawing the plunger nose from the path of the block 9*a*. The plunger may be locked in an inoperative position by a pin and slot device 64*c*. This arrangement applies to power operated machines as well as to those operated by hand.

When the mechanism is used on stamping or embossing machines, where it is necessary for the stamp and die component to be guided in perfect alignment, the members effecting this guiding may be made integral with the frame or body of the machine.

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

1. In a power hammer the combination of a support, two bodies slidable on said support, a lever mechanism to connect said bodies together and allow them to slide on said support in the same direction at differential speeds, an elastic medium between said bodies, means to cause said bodies to slide on said support to compress said elastic medium between the faster and the slower moving body, and means operative at a predetermined point in the stroke of the moving bodies to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

2. In a power hammer the combination of a support, two bodies slidable on said support, a lever and link mechanism to connect said bodies together and to allow them to slide on said support in the same direction at differential speeds, an elastic medium between said bodies, means to cause said bodies to slide on said support to compress said elastic medium between the faster and the slower moving body, and means operative at a predetermined point in the stroke of the moving bodies to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

3. In a power hammer the combination of a support, two bodies slidable on said support, a lever pivoted on said support, means to couple said bodies to said lever at different points giving said bodies a differential leverage about said pivot whereby said bodies are allowed to slide on said support in the same direction at differential speeds, an elastic medium between said bodies, means to cause said bodies to slide on said support to compress said elastic medium between the faster and the slower moving body, and means operative at a predetermined point in the stroke of the moving bodies to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

4. In a power hammer the combination of a support, two bodies slidable on said support, a lever pivoted on said support and having said bodies connected thereto at different points giving said bodies a differential leverage about said pivot whereby said bodies are allowed to slide on said support in the same direction at differential speeds, an elastic medium between said bodies, means to cause said bodies to slide on said support to compress said elastic medium between the faster and the slower moving body, and means operative at a predetermined point in the stroke of the moving bodies to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

5. In a power hammer the combination of a support, two bodies slidable on said support, a rockable member including two rigidly connected angularly disposed arms having a common fulcrum and operating on said bodies to allow them to slide on said support in the same direction at differential speeds during each stroke, said arms being located to cause the faster moving body to exert a greater leverage about the fulcrum than the slower moving body at the commencement of a stroke and the leverage of said faster moving body decreasing rapidly and the leverage of said slower moving body increasing slowly during the stroke until at the end of the stroke the leverages are almost equal, an elastic medium between said bodies, means to cause said bodies to slide on said support to compress said elastic medium between said faster and slower moving bodies, and means operative when said leverages are almost equal to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

6. In a power hammer the combination of a support, two bodies slidable on said support, a linkage connecting said bodies together and to allow them to slide on said support in the same direction at differential speeds whereby one body moves faster than the other, an elastic medium between said bodies, means to apply a driving force directly to said faster moving body to cause said bodies to slide on said support to compress said elastic medium between the faster and the slower moving body, and means operative at a predetermined point in the stroke of the moving bodies to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

7. In a power hammer the combination of a support, two bodies slidable on said support, a rockable member including two rigidly connected angularly disposed arms having a common fulcrum and operating on said bodies to allow them to slide on said support in the same direction at differential speeds during each stroke whereby one body moves faster than the other, said arms being located to cause the faster moving body to exert a greater leverage about the

fulcrum than the slower moving body at the commencement of a stroke and the leverage of said faster moving body decreasing rapidly and the leverage of said slower moving body increasing slowly during the stroke until at the end of the stroke the leverages are about equal, an elastic medium between said bodies, a ratchet arm having a connection with said rockable member, means to apply a driving force to said ratchet arm to rock said rockable member about its fulcrum to cause said bodies to slide on said support to compress said elastic medium between the faster and the slower moving body, and means operative at a predetermined point in the stroke of the moving bodies to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

8. In a power hammer the combination of a support, two bodies reciprocable on said support, a linkage connecting said bodies together and cause them to slide on said support in the same direction at differential speeds during each stroke, an elastic medium between said bodies, said elastic medium being compressed between the faster moving body and the slower moving body, and means for tripping said linkage when a point of leverage in which the bodies pull equally in opposite directions on said linkage is almost reached to release the energy stored in said elastic medium to accelerate the return of said faster moving body to its original position to deliver an impulsive force.

9. In a power hammer the combination of a cylinder, a power piston and a balance piston slidable in said cylinder, a linkage connecting said pistons together and allow said power piston to slide in said cylinder in the same direction as said balance piston at a higher speed than the latter during each stroke, an elastic medium between said pistons, drive means to cause said pistons to reciprocate in said cylinder to compress said elastic medium between said power piston and said balance piston against the resistance of said elastic medium, and means to trip said linkage at a predetermined point in the stroke to permit the energy stored in said elastic medium to be utilised to accelerate said power piston to its original position to deliver an impulsive force, the reaction to the force exerted being absorbed by said balance piston thereby rendering the hammer substantially non-reactive.

10. In a power hammer the combination of a cylinder, a power piston and a balance piston slidable in said cylinder, a linkage connecting said pistons together and allow said balance piston to slide in said cylinder in the same direction as said power piston at a lower speed than the latter, a spring located between said power and balance pistons, and a control valve controlling the introduction of fluid under pressure into said cylinder between a closed end thereof and said power piston, the pistons being moved by said fluid to compress said spring until said balance piston uncovers a port allowing fluid under pressure to enter said cylinder between said pistons and pass to said control valve which it actuates to cut off the supply of fluid to the space between said closed end of the cylinder and said power piston and simultaneously to open said space to exhaust, whereby said pistons are accelerated to their original positions where said power piston delivers an impulsive force under the influence of the pressure of said fluid admitted between said pistons and the energy stored in said spring.

11. In a power hammer according to claim 10 the combination wherein the pistons have reduced and skirted parts allowing said pistons to telescope and seal off a space containing said spring from an annular space formed between the wall of the cylinder, the reduced part of one piston and the skirt of the other piston, and enables fluid under pressure to enter said annular space which is connected with a port leading to said control valve.

12. In a power hammer the combination of a support, two bodies slidable on said support, a linkage connecting said bodies together and to allow them to slide on said support in the same direction at differential speeds whereby one of said bodies moves faster than the other, an elastic medium between said bodies, and manually operable means for reciprocating said bodies on said support including a manually operable element, means to couple one of said bodies to said manually operable element at the commencement of a stroke, and means to automatically uncouple said body from said manually operable element at a predetermined point in the stroke, said reciprocation compressing said elastic medium between the faster and the slower moving body and said uncoupling means acting to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

13. In a power hammer the combination of a support, two bodies slidable on said support, a motion-differentiating non-resilient linkage to connect said bodies together and to allow them to slide on said support in the same direction at differential speeds, an elastic medium between said bodies, means to cause said bodies to slide on said support to compress said elastic medium between the faster and the slower moving body until a point of balance is reached, and means to move said motion-differentiating non-resilient linkage from said point of balance to release the energy stored in said elastic medium and accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

14. In a power hammer the combination of a support, a ram movable on said support, a balance body also movable on said support, a lever system connecting said ram with said balance body so that the latter moves in the same direction as said ram but at a lower speed and drive means for said ram and balance body.

15. In a power hammer the combination of a support, two bodies slidable on said support, a bell crank lever pivoted on said support, means to couple said bodies each to one arm of said bell crank lever to give said bodies a differential leverage about said pivot whereby said bodies are allowed to slide on said support in the same direction at differenetial speeds, an elastic medium between said bodies, means to cause said bodies to slide on said support to compress said elastic medium between the faster and the slower moving body, and means operative at a predetermined point in the stroke of the moving bodies to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

16. In a power hammer the combination of a support, two bodies slidable on said support, a bell

crank lever pivoted on said support and having said bodies connected each to one arm of said bell crank lever to give said bodies a differential leverage about said pivot whereby said bodies are allowed to slide on said support in the same direction at differential speeds, an elastic medium between said bodies, means to cause said bodies to slide on said support to compress said elastic medium between the faster and the slower moving body, and means operative at a predetermined point in the stroke of the moving bodies to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

17. In a power hammer the combination of a support, two bodies slidable on said support, a motion-differentiating non-resilient linkage to connect said bodies together and to allow them to slide on said support in the same direction at differential speeds, an elastic medium between said bodies, means to cause said bodies to slide on said support to compress said elastic medium between the faster and the slower moving body, and means operative at a predetermined point in the stroke of the moving bodies to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

18. In a power hammer the combination of a support, two non-resiliently linked bodies reciprocable therein, drive means to cause said bodies to move in the same direction at different speeds during each stroke so that they alternately approach and recede from each other, an elastic medium between said bodies which is compressed between the faster and the slower moving body, and means operative at a predetermined point in the stroke of the moving bodies to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

19. In a power hammer the combination of a support, two bodies slidable on said support, a motion-differentiating non-resilient linkage to connect said bodies together and to allow them to slide on said support in the same direction at differential speeds, an elastic medium between said bodies, means to apply a driving force directly to one of said bodies to cause said bodies to slide on said support to compress said elastic medium between the faster and the slower moving body, and means operative at a predetermined point in the stroke of the moving bodies to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

20. In a power hammer the combination of a support, two bodies slidable on said support, a rockable member including two rigidly connected angularly disposed arms having a common fulcrum and operating on said bodies to allow them to slide on said support in the same direction at differential speeds during each stroke, said arms being located to cause the faster moving body to exert a greater leverage about the fulcrum than the slower moving body at the commencement of a stroke and the leverage of said faster moving body increasing rapidly and the leverage of said slower moving body increasing slowly until a point in the stroke is reached where the leverage of said faster moving body diminishes while the leverage of said slower moving body continues to increase during the stroke until at the end of the stroke the leverages are almost equal, an elastic medium between said bodies, means to cause said bodies to slide on said support to compress said elastic medium between said faster and slower moving bodies, and means operative when said leverages are almost equal to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

21. In a power hammer the combination of a support, two bodies slidable on said support, a rockable member including two rigidly connected angularly disposed arms having a common fulcrum and operating on said bodies to allow them to slide on said support in the same direction at differential speeds during each stroke, said arms being located to cause the faster moving body to exert a greater leverage about the fulcrum than the slower moving body at the commencement of a stroke and the leverage of said faster moving body increasing rapidly and the leverage of said slower moving body increasing slowly until a point in the stroke is reached where the leverage of said faster moving body diminishes while the leverage of said slower moving body continues to increase during the stroke until at the end of the stroke the leverages are about equal, an elastic medium between said bodies, a ratchet arm having a connection with said rockable member, means to apply a driving force to said ratchet arm to rock said rockable member about its fulcrum to cause said bodies to slide on said support to compress said elastic medium between the faster and the slower moving body, and means operative at a predetermined point in the stroke of the moving bodies to release the energy stored in said elastic medium to accelerate the return of said bodies to their original positions to cause the delivery of an impulsive force by said faster moving body.

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