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POWER HAMMER FOR SWAGING STEEL

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2 Sheets-Sheet 1

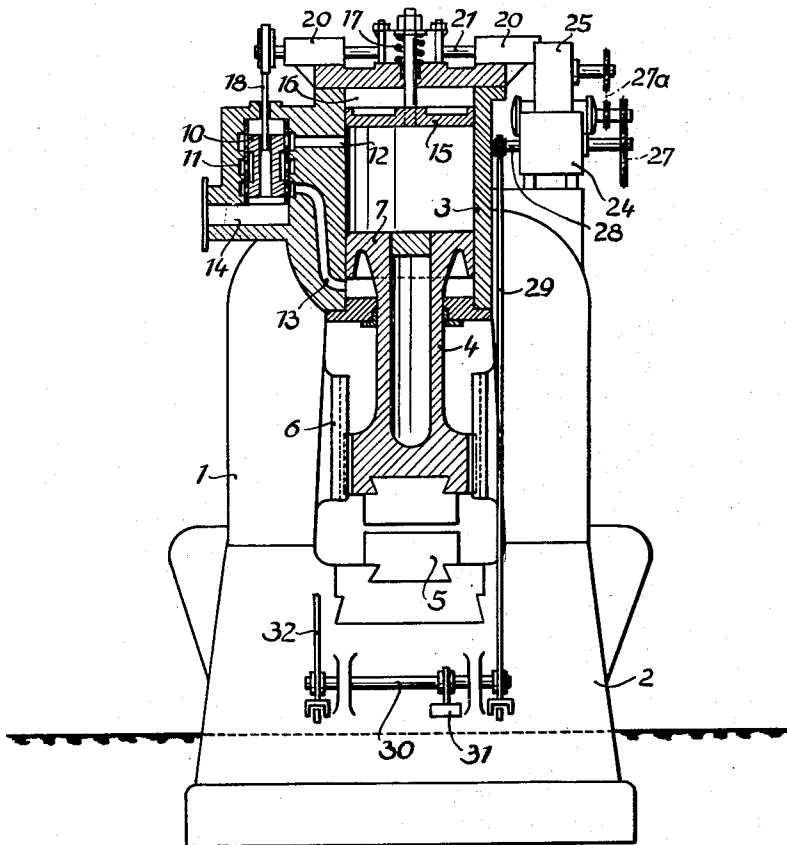


Fig. 1

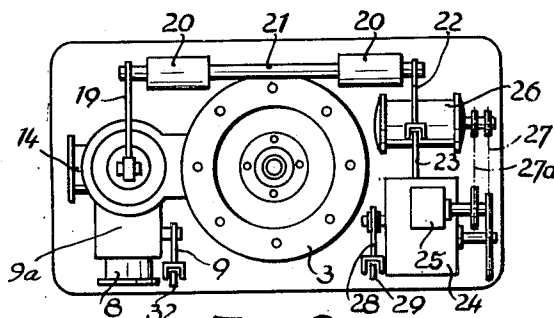


Fig. 2

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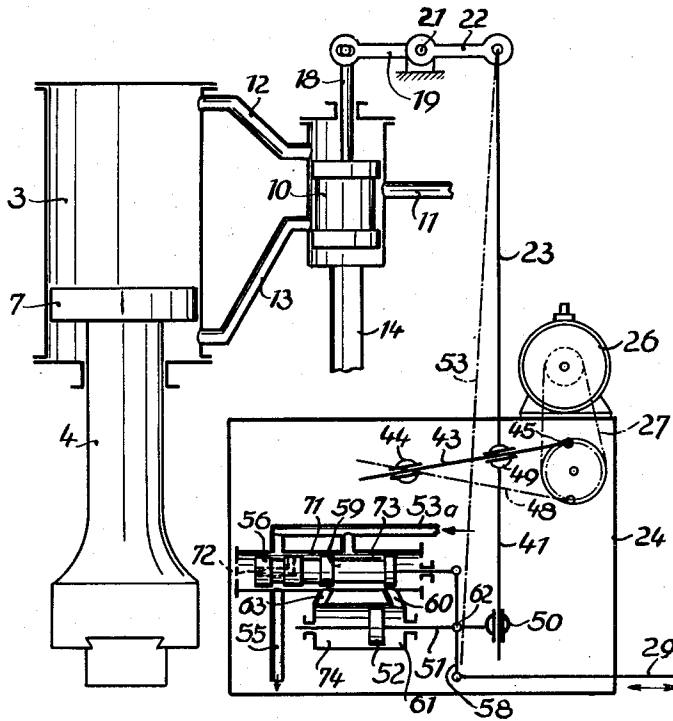


Fig. 3

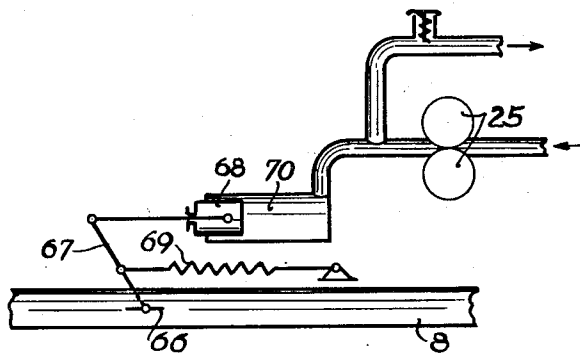


Fig. 4

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POWER HAMMER FOR SWAGING STEEL

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This invention relates to a new and improved power hammer.

More particularly, the present invention pertains to fluid driven power hammers having high striking rates for performing die forging and rolling operations.

Heretofore, power hammers used for swaging steel and iron, known as belt driven or board drop hammers with a ram stroke of approximately five to ten feet, operated with a striking rate of about 30–50 strokes per minute. Later, the so-called fast swage hammer was developed, which operated by steam or compressed air and the ram was both raised and thrust down by the gaseous pressure at a rate of 100–130 strokes per minute. Subsequently, higher striking rate resulted from the development of the air swage hammer which is provided with a built-in air pump and operates with a compressed air column operating between the striking ram and the air pump. The air swage hammer enabled a maximum striking rate of about 150 strokes per minute to be obtained.

It has been recognized by those skilled in the art of metal working that modern forging methods by means of multiple purpose dies such, for example, as rolling, bending, blanking, and finishing without re-heating, make it essential that the different operations should follow one another with great rapidity so that as little heat as possible is lost. It is particularly important that the heat loss of the workpiece be low during rolling operations for the reason that this operation, when conducted by the use of a forging hammer, requires many light blows in quick succession. Moreover, it must be endeavored to compensate for the heat lost by radiation and by conduction between the workpiece and the die. This compensation is only possible if new heat is created by applying the necessary blow energy. If this energy is applied in a sufficiently short time interval, loss of heat due to radiation and conduction will be compensated by heat gained through the forming operations.

Under certain conditions of service, difficulty has been experienced in the operation of hammers customarily employed in the aforementioned operations for the reason that, when the workpiece is removed from the die, the lower portion of the workpiece has been found to be considerably cooler than the upper portion thereof. This cooler lower portion causes a high forming resistance to be produced within the workpiece which, in turn, results in an unsatisfactory rate of wear on the die. Furthermore, as will be readily appreciated by those skilled in

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the metal forming art, the protruding portions of the die employed with the foregoing hammers get warm quickly and tend to lose their stability and must, in time, be discarded, this unsatisfactory condition being particularly destructive to the bottom die.

Accordingly, one object of the present invention is the development of an improved power hammer for forming hot materials with which one can form considerably larger workpieces than with the power hammers having a striking head of the same weight usually employed hitherto.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Figure 1 is a view partly in side elevation and partly in vertical section of a steam driven power hammer constructed in accordance with the present invention;

Figure 2 is a top plan view of the power hammer of Figure 1;

Figure 3 is a vertical view diagrammatically illustrating the control device for the hammer of Figure 1; and

Figure 4 diagrammatically illustrates the manner in which a servo mechanism may be employed for controlling the throttle valve arranged in the fluid conduit leading to the driving or ram cylinder of the steam hammer.

Before proceeding with the detailed description of my invention, the salient features and advantages thereof will be mentioned briefly in order that the invention may be more fully understood as the description proceeds.

The basic inventive concept of the present apparatus is the application of such an amount of heat to the workpiece, during forming operations, that the unavoidable heat losses therein are completely or substantially compensated, the temperature of the workpiece during treatment in the power hammer being accordingly maintained for a longer time in the region in which the workpiece is easily formable. This is achieved by a corresponding increase in the mechanical energy secondarily supplied to the material being formed by the striking ram. The rate of striking of the ram of the power hammer, herein disclosed, during the swaging of steel or iron, for example, is increased by a factor of two or three times the rate of striking hitherto used, that is, to at least 300 blows per minute or more. By reason of the high amount of secondarily supplied energy, the heat of the

workpiece, which is preheated in any convenient manner, is substantially maintained and in some circumstances may even be increased in excess of its preheated temperature. In any case, the heat supplied to the workpiece is such that its forming in the die takes place much more easily than hitherto. Further, the production time is shortened as a result of the increased striking rate which also reduces cooling losses. The wear and tear of the dies is considerably reduced by the employment of the process according to my invention. In addition, it is possible to produce, with a relatively light hammer, parts for which a considerably heavier hammer was previously needed.

The advantages of the invention are demonstrated particularly in the production of swaged parts direct from billets in multiple impression dies such, for example, as in the production of connecting rods for combustion engines. For this type of production the die has on the one side thereof a roll impression in which, by rotation of the billet, the distribution of the material for the big end, the shaft and the small end of the rods is effected. After this pre-distributed rolling operation the material is struck in the die and thereby finished. The quicker these operations follow each other and the smaller the heat loss of the billet during rolling, the easier is the subsequent swaging.

The invention further includes the provision of a new and improved power hammer which is particularly suited for carrying out the foregoing forging process in which heat loss in the workpiece is, from a practical aspect, entirely eliminated. With the power hammers known hitherto in which the movement of the control member was effected by means of curved levers by the striking ram, the high rate of striking which is achieved by the invention could not be obtained as the momentum of the moving parts of the control gear was too high. In accordance with the present invention, as will more readily appear as the description proceeds, the movement of a distributing slide valve is effected by the operation of a special control gear which is governed by any suitable power source independent of the hammer drive, such as an electric motor. The novel control gear, hereinafter described in detail, permits striking rates of 300 strikes per minute and, in some installations, even greater striking rates. It will be readily appreciated that such striking rates make for efficiencies hitherto unknown in the forging and rolling art and the foregoing disadvantages of the power hammers heretofore employed in this art are obviated.

According to another feature of the instant invention, the adjustment of the stroke of the distributing slide valve of the power hammer is effected by means of a device actuated hydraulically, or in any other suitable manner, and which operates in the manner of a servo mechanism manually controlled by a hand or pedal lever actuated by the operator. One means found suitable for imparting movement to and regulating the stroke length of the distributing slide valve is a reciprocable rod pivotally connected to the distributing slide valve through a rocker arm and which is driven in any desirable manner such, for example, as by a crank wheel rotated at a constant speed. On this reciprocable bar there is provided a slide shoe and by moving this slide shoe by means of the aforementioned servo mechanism, the stroke of the distributing slide valve of the power hammer and consequently the

speed of reciprocation of the ram of the hammer may be varied to as large or as small an extent as is desired.

Referring now to the accompanying drawings in which like reference numerals are employed to designate like parts, and more particularly to Figures 1 and 2 thereof, it will be observed that the steam hammer of my invention is provided with the usual arch-shaped frame the arms 1 which are fixed in any conventional manner to the base 2. The driving cylinder 3 is carried between the frame arms 1. The upper end of the striking ram or top 4 is slidably disposed within cylinder 3 to function as a fluid driven piston member for effecting the hammer blows of the hammer against the material placed on the anvil 5, the hammer being carried by the lower end of the striking ram. The ram 4 is vertically movable in the guides 6 of the frame arms 1. The piston 7 is actuated when a fluid under pressure such as steam, for example, is supplied through the pipe 8, Figure 2. A conventional throttle valve, as indicated at 9a, of any type suitable for the purpose is provided in the said pipe 8. The control of the throttle valve 9a is accomplished by means of the valve control lever 9. A distributing slide valve 10 is provided adjacent and on the downstream side of the throttle valve for the purpose of alternately connecting the live steam passage 11, which is connected to pipe 8, with the chamber above the ram piston by way of passage 12 and with the chamber below the ram piston by way of passage 13. The exhaust steam escapes through pipe 14.

At the upper end of the driving cylinder 3 there is provided a drag piston 15 which functions to damp the upward movement of the ram 4. A pressure medium, such as steam at suitable pressure, for example, is introduced into the chamber 16 above the drag piston in order that drag piston may produce an effective damping action on the piston 7 as the latter moves upwardly within the cylinder. The downward movement of the drag piston 15 is resiliently opposed by a spring 17 compressively disposed about the piston rod of the drag piston.

The operating rod 18 of the slide valve 10 is actuated by the rocker arm 19 which is fixed on one end of a shaft 21 carried in a pair of sleeve bearings 20, as is best indicated in Figure 2. The bearings 20 may be fixedly mounted in any suitable manner to the upper end plate of the driving cylinder 3. At the other end of shaft 21 there is provided another rocker arm 22 which is pivotally connected to one end of rod 23, the other end of rod 23 being connected to a control gear arranged in housing 24 in a manner to be more fully explained hereinafter. A pressure pump 25 is mounted on the control gear housing 24 in such a position that the control gear and the pressure pump can be driven by the same prime mover such as motor 26, for example, by means of a pair of endless belts 27 and 27a.

The control gear can be controlled by the operator of the hammer by means of lever 28, best viewed in Figure 1, to which the upper end of the vertical rod 29 is connected. The lower end of rod 29 is connected through a suitable lever arm secured to the right hand end, as viewed in Fig. 1, of a rotatably mounted shaft 30 upon which pedal lever 31 is carried. The throttle valve 9a actuating rod 32 is pivotally connected at the upper end thereof to the throttle valve lever 9, mentioned hereinbefore, and is pivotally secured at the lower end thereof to a suitable

lever arm fixedly mounted on the left hand end, as viewed in Figure 1, of shaft 30.

The structure of the control gear disposed in housing 24, and the manner in which the control gear cooperates with other elements of structure of the power hammer is diagrammatically illustrated in Figure 3. As is readily apparent from an inspection of Figure 3 and as described hereinbefore in connection with Figure 2, the piston rod 18 of the distributing slide valve 10 is linked to rocker arm 19 which is mounted on one end of shaft 21 for rotation therewith, the other rocker arm 22 being similarly mounted to the other end of shaft 21. The reciprocable rod 23, which extends into the control gear housing is pivotally connected to rocker arm 22 to effect oscillatory movement thereof when rod 23 is reciprocated in the manner described hereinafter.

The control gear herein disclosed is completely submerged in an oil bath within casing 24. Rod 43 is disposed within the control gear casing 24 and is slidably carried by a pivotally mounted sleeve 44 so as to be capable of oscillatory movement. The other end of rod 43 is pivotally connected to a crank wheel 45 which is rotated at a constant speed by means of the electric motor 26 and the belt drive 27. The rod 43, therefore, oscillates within the range indicated by the dotted lines 48 at one limit of oscillation and the position in which the rod is shown at the other limit of oscillation. A freely movable slide shoe 49 is carried by the oscillating rod 43 and is pivotally connected to lower end of rod 23 and to the upper end of rod 41. Under certain conditions of service, it may be found desirable to employ a single rod instead of the two rods 23 and 41. Under these conditions, the lower end of the single rod would be operatively received within the slide shoe 50, the upper end thereof would be connected to rocker arm 22, and the intermediate portion thereof would be pivotally connected to slide shoe 49. The lower end of the rod 41 is pivotally carried and longitudinally movable in a slide shoe 50 which is mounted on the outer end of piston rod 51 of an auxiliary control piston 52. As is readily apparent in Figure 3, the actuation of the auxiliary control piston 52 permits the points of engagement of the piston rod 51 and the oscillating rod 43 with the rod 41 and, therefore, the stroke of the distributing valve 10 to be varied. In other words, as is indicated by the dotted line 53, upon a pivotal movement of rod 41 to the left in response to a movement of the auxiliary control piston 52 to the left, the stroke of the distributing valve 10 will be decreased relative to the stroke when rod 41 is in the vertical position shown in Figure 3. Any suitable fluid such, for example, as oil at a suitable pressure is supplied by pump 25, Figures 1 and 2, and flows through the pipe 53a, and is utilized for the purpose of actuating the auxiliary control piston 52. When the control device is not actuated, the oil can pass freely through the pipe 53a into the discharge pipe 55. The flow through pressure pipe 53a is controlled by a slide valve 56 which is reciprocated when rod 29 and its double lever 58 are actuated. The double lever 58 is pivotally secured to piston rod 51 at point 62.

If for example, the rod 29 moves toward the left, as viewed in Figure 3, the slide valve 56 controlling the pressure oil discharge moves toward the right and thus closes the outlet pipe 54. At the same time, however, the auxiliary regulating slide valve 59 is moved toward the

right and opens the passage 60 leading into the cylinder chamber on the right end of the auxiliary control piston 52. The pressure oil which passes in this manner into the cylinder chamber 61 moves the auxiliary control piston 52 towards the left until the inlet passage 60 is again closed by the actuation of the auxiliary regulating slide valve 59.

The double lever 58 acts as a return. For example, should the rod 29 be actuated in one direction, the auxiliary regulating slide valve 59 will be moved from the position shown in Figure 3 to the right or left, as the case may be, so that either the supply channel 60 or 63 will be opened to effect a charging of one side or the other of the auxiliary regulating piston 52 with the pressure medium, the regulating slide valve 59 always being moved in the opposite direction to the direction in which the auxiliary control piston 52 is moved for any one movement of rod 29. Should rod 29 be actuated in an opposite direction the pressure medium supply channel 60 or 63, as the case may be, is again closed so that the auxiliary control piston 52 comes to rest. Simultaneously therewith, the pressure oil discharge passage 55 is again opened to permit the free circulation of the pressure medium through inlet pipe 53a and the discharge pipe 55.

The exhaust fluid from cylinder chamber 61 is discharged through passage 60 into the cylinder 73 which is open at both its ends. The exhaust fluid from cylinder chamber 74 discharges through passages 63, 71, and an L-shaped channel 72, which channel is provided in the slide valve 56.

The operation of the hammer illustrated in the drawings will now be briefly described as follows:

In order to understand the operation of the hammer system, it will be helpful to consider the ram 4 as being in an initially raised position so that the piece to be treated may be placed on the anvil 5. When the operator actuates the pedal 31, the throttle valve in the steam pipe 8 is fully opened by means of the rod 32 and lever 9.

It will be further considered that by actuating the pedal 31 the piston rod 51 is in the position shown in Figure 3 so that the reciprocable rod 23 and consequently the distributing slide valve 10 reciprocate with a certain length stroke, the number of strokes per minute, of course, being dependent upon the rated speed of the motor 26 and the relative diameters of the drive pulley of the motor and the driven wheel 45.

Under these assumed conditions, a certain quantity of steam is introduced through passage 11 and then alternately through passages 12 and 13, respectively so that the ram 4 performs the desired blows on the pieces to be formed as by forging, for example.

When the pedal 31 is partially lifted, the rod 29 will move the lever 58 in a clockwise direction, as viewed in Figure 3, the throttle valve disposed in the steam pipe 8 being still in its open position. The lever 58 moves the slide valves 56 and 59 to the right and the pressure medium enters through passage 60 into the cylinder chamber 61 whereupon the piston 52 is moved to the left. Piston rod 51 moves the rod 41 to the left to the position indicated in Figure 3 by the broken line 53. The movement of rod 41 to its broken line position produces a reduction in the length of the stroke of the rod 23 and the valve 10 connected thereto so that during each

stroke a reduced quantity of steam is introduced into the cylinder of the ram 4. Consequently, the blows of the ram will be not so heavy as before and the number of blows per minute will remain unchanged. At the same time, the movement of the pivot connection 62 causes the regulating slide valve 59 to be moved to the left to a position which will close passage 61 so that no further oil can enter cylinder chamber 61, thereby causing piston 52 to retain its position until further actuation of the rod 29 occurs.

When the pedal 31 is further released or lifted the sliding shoe 49 is moved farther to the left on the oscillating rod 43 to the position of shortest length of reciprocal movement of the rocker arm actuating rod 23. In this position of rod 23, the slide valve 10 is almost stationary and in such a position as to cause steam from channel 11 to flow into the bottom cylinder chamber beneath the piston 7 of the ram. Since the steam cannot escape from that bottom chamber the ram will be held in its raised position.

With the control arrangement illustrated in Figure 3, the movement of the distributing slide valve 10 can be exactly regulated by actuations of the rod 29 without substantial expenditure of power.

In order to achieve the necessary high rate of striking, the power hammer must, among other necessary features, be provided with large piston surfaces. If an interruption occurs in the drive of the control gear such, for example, as if the current for the electric driving motor fails, the stroke rate of the distributing slide valve 10 falls sharply and the charge for the ram cylinder chamber rises correspondingly. This results in an increased lifting and forcing down of the ram whereby the limits of the permissible loading of the ram and its driving parts can be exceeded.

In order to avoid this possible difficulty, the invention includes means for regulating the cut-off of the pressure medium to the hammer which means is positioned in the pressure medium supply pipe 8 to the hammer and is actuated when, because of some operating condition, the hammer stalls or the speed of rotation of the control gear is reduced.

Such a device is shown diagrammatically in Figure 4. A throttle valve 66 is provided in the pressure medium pipe 8 leading to the distributing slide valve 10 for the driving cylinder of the ram. A piston 68 is connected to the throttle valve actuating lever 67. Piston 68 is actuated by pressure oil supplied by pump 25. Spring 69 is connected to lever 67 to urge the valve 66 into its closed position. The cylinder 70 of the piston 68 is supplied with oil or the like by the pump 25, the drive of which is connected with motor 26 by belt 27a, as is most clearly indicated in Figures 1 and 2. Should a decrease in the speed of rotation of the pump 25 and control gear occur, the oil pressure produced by the pump 25 will not be sufficient to maintain the throttle valve 66 in the open position against the action of the spring 69 and valve 66 closes to thereby prevent an overloading of the hammer.

Briefly stated in summary, the advantageous results accomplished by using the new and improved type of construction of the power hammer enables such a hammer, the ram of which has for example, a weight of about 1100 pounds, to swage very simply a complicated workpiece for which a power hammer with a ram weight of between about 2200 and 3300 pounds was previously required. Moreover, the workpieces come from

the die practically as hot as they do from the furnace.

In contradistinction to the forging hammers of the prior art, the rapid manner in which the hammer of the present invention imparts blows to the material being worked and the heat added to the material as a consequence of blows of such rapidity results in maintaining the forging temperature substantially constant throughout the material and equal to the temperature of the material when it was removed from the furnace. In other words, the forging remains hot while the die remains cold thereby markedly increasing the service life of the dies.

Another advantage of the instant invention over the hammers heretofore employed in forging operations is that the tearing strain is much smaller for ten light blows than it is for four heavy blows during the same time interval. In addition the hammer of the present invention is capable of forging much more heavy and complicated forgings than slower acting conventional hammers having the same blow energy.

While the invention has been described with reference to a certain preferred example thereof which gives satisfactory results, it will be understood by those skilled in the art to which the invention pertains that various changes and modifications may be made without departing from the spirit and scope of the invention, and it is my intention, therefore, to cover in the appended claims all such changes and modifications.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

I claim:

1. In a hydro-pneumatic, material-forming hammer system, the combination of a ram cylinder operatively connected in fluid communication with a first source of energy, a reciprocable ram for imparting hammer blows upon material to form the latter, a portion of said ram being slidably carried within said cylinder, a distributing slide valve cylinder connected between and in fluid communication with said ram and said source of fluid, a distributing slide valve slidably carried within said slide valve cylinder and shiftable to a plurality of positions for regulating the quantity of fluid flow from said first source of energy to the ram, means for controlling the movement of said valve, said means including linkage means connected at one end thereof to said slide valve, a constant speed prime mover operatively connected to a second source of energy, means connected in driven relation to said prime mover and in driving relation to said linkage means for effecting reciprocal movement of a portion of said linkage means and of the distributing slide valve, means connected to said linkage means for altering the length of stroke of the distributing slide valve, said last-named means including a pump driven by said prime mover and connected in fluid communication with a source of fluid, an external control means mounted for manual actuation by the operator of the system, a regulating slide valve cylinder connected in fluid communication with a third source of energy produced by said pump, a regulating slide valve slidably carried within said regulating slide valve cylinder and mechanically connected to said external control means, a control cylinder in fluid communication with said regulating slide valve, and a fluid driven control piston slidably carried within said control cylinder and mechanically connected to said linkage means and to said external control means for

shifting the position of said portion of said linkage means to thereby alter the length of stroke of the distributing slide valve in response to an actuation of the external control means and the regulating slide valve mechanically connected therewith.

2. A hydro-pneumatic hammer system according to claim 1 further characterized as comprising a throttle valve connected in fluid communication with and between said ram and said first source of energy, a reciprocable piston connected on one side thereof in fluid driven relation to said third source of energy produced by said pump and mechanically connected on the other side thereof to said throttle valve, said piston being operable to maintain said throttle valve in an open position when said pump is driven at a predetermined speed by said prime mover, and means connected to the throttle valve for resiliently urging the throttle valve to a closed position in response to a decrease in the energy of said second source and a resulting decrease in the driven speed of the pump below said predetermined speed.

3. Control gear for a fluid driven power hammer of the character disclosed comprising a constant speed prime mover connected to a first source of energy, a slide valve cylinder in fluid communication with and positioned between the ram of the hammer and a second source of energy, a distributing slide valve slidably carried within said slide valve cylinder, means mechanically connecting said prime mover to said distributing slide valve for producing reciprocal movement of the slide valve, an external control means positioned for actuation by the operator of the hammer, and means operatively connected to a third source of energy and additionally connected to and movable in response to actuations of said external control means, said last-named means being connected to said first-named means for altering the disposition thereof relative to the slide valve to thereby alter the length of stroke of the slide valve in response to actuation of said external control means by the operator.

4. Control gear for a power hammer according to claim 3 further characterized as comprising a valve operatively disposed within the supply line of said second source of energy, and means operatively connected to said prime mover for actuating said valve to a closed position in response to a reduction in the operating speed of the prime mover.

5. In a control gear for a fluid driven power hammer having a fluid distributing slide valve connected between the source of fluid and the ram of the hammer comprising linkage means connectable at one end thereof to said distributing slide valve of the hammer, a constant speed prime mover, means connected in driven relation to said prime mover and in driving relation to said linkage means for effecting reciprocal movement of a portion of said linkage means, means connected to said linkage means for altering the length of stroke thereof, said last-named means including a pump, an external control means mounted for manual actuation by the operator of the control gear, a regulating slide valve connected in fluid communication with said pump and mechanically connected to said external control means, and a fluid driven control piston in fluid communication with said regulating slide valve and mechanically connected to said linkage means and to said external control means for shifting the position of said portion of said link-

age means to thereby alter the length of stroke of said linkage means in response to an actuation of the external control means and the regulating slide valve mechanically connected therewith.

6. A control gear according to claim 5 further characterized as comprising a throttle valve connected in fluid communication with and between the distributing valve of the hammer and the source of fluid for the hammer, a reciprocable piston connected on one side thereof in fluid driven relation to said pump and mechanically connected on the other side thereof to said throttle valve, said piston being operable to maintain said throttle valve in an open position when said pump is driven at a predetermined speed by said prime mover, and means connected to the throttle valve for resiliently urging the throttle to a closed position in response to a decrease in the driven speed of the pump below said predetermined speed.

7. Control gear for a hydro-pneumatic hammer comprising a distributing slide valve cylinder having fluid inlet and outlet passages and in fluid communication with the ram of the hammer, a distributing slide valve disposed within said cylinder for reciprocal movement therein and for effecting reciprocal movement of said ram, a rocker arm pivotally carried by the hammer and having one end thereof pivotally connected to said slide valve, a rocker arm actuating rod pivotally connected at one end thereof to the other end of said rocker arm, a constant speed prime mover, a crank wheel connected in driven relation to said prime mover, a drive rod connected at one end thereof to said crank wheel and pivotally and slidably carried near the other end thereof for permitting said drive rod to oscillate in accordance with the rotational movement of said crank wheel, said drive rod being pivotally and slidably connected to said rocker arm actuating rod for reciprocating the latter in response to oscillatory movement of the drive rod, a control lever pivotally mounted on the exterior wall portion of the hammer housing for actuation by the hammer operator, a pump connected in driven relation to said prime mover, an open-ended regulating slide valve cylinder connected in fluid communication with said pump and being submerged in a fluid bath, a regulating slide valve slidably carried by said regulating slide valve cylinder, a control cylinder in fluid communication with said regulating slide valve cylinder, a control piston carried within said control cylinder and pivotally and slidably connected to said rocker arm actuating rod and pivotally connected to said control lever, said regulating slide valve being pivotally connected to said control lever, said fluid communication between said regulating slide valve cylinder and said pump and between said control cylinder and said regulating slide valve cylinder providing a path of flow for fluid under pressure to move the control piston to thereby move said rocker arm actuating rod in a direction transverse to the direction of reciprocal movement thereof to alter the length of stroke of the rocker arm actuating rod and the distributing slide valve when the hammer operator actuates the control lever to move the regulating slide valve, and means for stopping the operation of the hammer when the speed of said prime mover is diminished.

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