HYDRAULICALLY ACTUATED DROP HAMMER

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The present invention relates to an improvement in the art directed to drop hammers.

More particularly, this invention relates to a hydraulically actuated drop hammer in which a vertically movable tup cooperates with an anvil during a hammering operation.

Specifically, the invention is concerned with a hydraulically actuated drop hammer in which the tup is carried by the rod of a piston that is disposed in a vertically extending cylinder and which cylinder is provided at its lower end with an opening communicating with a fluid line or conduit through which liquid enters to raise the piston in its cylinder and through which liquid exhausts from the cylinder during a hammering operation. The hammer includes means for controlling the flow of liquid so as to alternately permit it to flow under pressure into the cylinder below the piston and to escape or exhaust from the cylinder. Further, the cylinder includes an upper wall or top construction that closes the space above the piston so that air or any other gaseous medium above the piston is compressed when the piston rises and expands as the piston descends.

In drop hammers of this type the fall of the tup is braked by the fact that during descent of the tup, the descending piston has to displace the liquid which raised the piston to its upper position.

Accordingly, the present invention has for an object to accelerate the descent of the tup and increase the energy of the blow, that is, the hammering impact of the tup and also to increase the number of blows struck per minute.

It is a further specific object of the invention to provide means operable to vary the speed of descent of the tup over wide limits and thus to also vary the energy of the blow or impact and the number of blows struck per minute.

It is a particular object of the invention to provide means operable to increase the quantity of air trapped above the piston at will, that is, as desired and a further feature of the invention consists in the particular construction of the means operable to increase the quantity of trapped air.

It is a more specific object of the invention to provide in combination with a hydraulically actuated drop hammer of the type in which a vertically movable tup cooperates with an anvil and in which a vertically disposed cylinder slidably receives a piston the rod of which carries the tup, a liquid flow initiating and control means operable to alternately introduce liquid under pressure into the lower portion of the cylinder to raise the piston and thus the tup and to permit exhaust of liquid from the cylinder so that the piston and thus the tup falls, and in falling displaces the liquid from beneath this piston, and a chamber means operably associated with the top of the cylinder and in valve controlled communication therewith, said chamber means accommodating a supply of gaseous medium under pressure whereby said medium can be selectively and controllably introduced into the upper portion of the cylinder to increase the quantity of gaseous medium acting on the top of the piston during its descent to augment the fall of gravity and thus increase the energy of the blow struck by the tup.

It is a still more specific object of the invention to provide a hydraulically actuated drop hammer including a vertically disposed cylinder, a piston movable in the cylinder, a tup carried by the piston, means operable to establish a flow of liquid under pressure into the lower portion of the cylinder to raise the piston and thus the tup including control means operable to rapidly exhaust liquid from the cylinder beneath the piston whereby the tup descends during a hammering operation, a partition means crossing the cylinder and defining a chamber above the upper position of the piston, valve controlled conduit means through the partition providing communication between the chamber and the cylinder subjacent partition operative to permit plural reciprocations of the piston to compress and supply the chamber with a quantity of compressed gaseous medium for subsequent controllable introduction through the partition means and into the cylinder above the piston to variably augment the gravitational descent thereof during hammering.

Further and more specific objects will be apparent from the following description taken in connection with the accompanying drawings illustrating two embodiments of the invention, and in which:

Figure 1 shows a drop hammer partly in elevation and partly in section;

Figure 1a is an enlarged vertical sectional view of the upper part of Figure 1; and,

Figure 2 shows a detail of Figure 1 on a larger scale.

A base 1 of the drop hammer supports an anvil 2 on to which a tup 3, guided for upward and downward movement in guiding rails 4, can drop. The guiding rails are mounted on two uprights 5 which together support a working cylinder 6 and an oil container or reservoir 7. The cylinder 6 is vertically disposed, secured to the uprights 5 by means not shown in the drawings, and accommodates a working piston 8 which is rigidly connected to the tup 3 through the intermediary of a piston rod 9. The arrangement is such that when the tup 3 is in its lowest position the lower face of piston 8 is slightly above an opening 10 through which liquid under pressure can be supplied to cylinder 6 beneath the piston 8 to raise the piston and from which the liquid is forced out of the cylinder when the piston descends during hammering.

A hydrostatic pump 11, for instance a gear pump, is used for establishing a flow of liquid under pressure. The pump 11 is coupled, through the intermediary of a clutch 12, with an electric motor 13 which receives current from electric leads 14, when a switch, not shown in the drawing is closed. The liquid for instance, oil, which fills the container 7 up to the level denoted at 16, is sucked out of the container through a suction or intake pipe 15 by the pump 11. The pump drives the oil through a pressure duct 17, passing behind the cylinder 6, into a chamber 17a branched from duct 17 and closed by a non-return or check-type inlet valve 18 which permits liquid under pressure to flow out of chamber 17a into pipe or duct portions 44, 45 described hereinafter and thus through opening 10 into the cylinder but prevents reverse flow of liquid from the cylinder back into chamber 17a and pressure duct 17. The pressure duct 17 extends beyond chamber 17a and terminates in a branched bypass portion 19 adapted to be controlled by a piston-type valve body 20. The valve body 20 is vertically movable.
in a cylinder portion 21 as described hereinafter. Therefore, when the by-pass portion 19 is open, the pump sucks oil through the intake pipe 15 and forces it to flow through the by-pass portion 19 and back into the container or reservoir 7. When the valve body 20 is lowered, its lower end 24 of the by-pass duct 23 is closed. If the by-pass duct 23 opens, the pump 11 continues to deliver then lifts the inlet valve 18 and flows upwards, out of the chamber 17a, into the pipe or duct portions 45 and 44 and thence through opening 10 into the cylinder 6. For upward and downward movement in the cylinder 21, the valve body 20 is articulated by means of a link 32 connected to a lever 23 rigid with a horizontally disposed rockshaft 24 which is turnably mounted in bearing supports 25 and 26. Therefore, as the rockshaft 24 is turned up or down, that is, clockwise or counterclockwise by means described hereinafter, the valve body 20 is moved upwards or downwards.

Two other valve control levers 27 and 28 are also rigidly secured to the rockshaft 24. They serve to actuate stroke-length controlling valve 29 and cylinder exhaust or outlet valve 30, respectively, which are described in detail hereinafter with reference to Figure 2. A rockshaft turning lever 31 is rigid with the rockshaft 24, and a control rod 32 is provided with a bifurcated end portion or fork 33 pivoted to the end of lever 31. A pin 34 passes through the bifurcated end or fork 33 and through the lever 31, and is mounted rigidly either in the lever 31 or in the fork 33, while the other of these two parts is rotatable about the pin 34. A stop or abutment 35 is adjustable clamped on the control rod 32 so that it can be fixed in different positions axially of control rod 32. A bell-crank lever 36 including arms 36a and 36b is rockable about a pivot 37 that is secured to one of the uprights 5. The weight of lever arm 36a tends to rotate the bell-crank lever arms 36a, 36b, in a counterclockwise direction. Lever arm 36a is provided on its free end with a blocking member or fork 38 by means of which the lever arm 36a can impinge against the stop 39 adjustable abutment 35. A fixed stop or abutment 39 is rigid with the upright 5 so that lever arm 36a, after a slight downward movement impinges against this fixed stop 39 to limit descent of the control rod 32 and thus counterclockwise turning of rockshaft 24. The lever arm 36a has a rounded end 40 which in the position shown in the drawing bears laterally against the stop 39. The stop 39 has an inclined cam surface 41 so arranged as to abut against the rounded end 40 of lever arm 36a. When the control rod 32 is moved upwards, so that the bell-crank lever arms 36a, 36b, the position of which was previously determined by the stop or fixed abutment 39, effect a slight rocking movement about the pivot 37, during which movement the fork 38 lifts the stop or abutment 35, and thus the control rod 32 into the position shown in the drawing. If these parts have not already been previously moved into the position shown in the drawing. In the position shown in the drawing, the rounded end 40 of lever arm 36a bears against the side of the stop, so that descent of the control rod 32 and its abutment 35 is blocked or prevented by the position of the bell-crank lever arms 36a, 36b.

The opening 10 in the lower part of the cylinder 6 is connected to an inlet pipe portion 44 brachched off of pipe portion 45 which is in communication with the chamber 17a downstream of the non-return oil or liquid inlet valve 18. A damping cylinder 46 is also connected to the pipe portion 44 through the intermediary of a branch pipe 47 and a damping piston 48 slides in the damping cylinder and makes a liquid-tight seal therein. The damping piston 48 is urged downwardly by a compression spring 49 which bears against the top of the damping cylinder 46. Damping piston 48 is moved upwards only when the oil pressure in the branch pipe 47 is so great as to be able to overcome the initial stress in the spring 49.

The pressure duct 17 carries, between the outlet of pump 11 and chamber 17a, a depending pipe 50 which accommodates a non-return, suction-operated liquid make-up valve 51 adapted to prevent oil or liquid flowing out of pressure duct 17, but which under certain circumstances permits oil to pass out of the container 7 into the duct 17. In the top of the container 7 is an opening 52, which produces the effect that the top surface of the oil in container 7 is always acted on by atmospheric pressure. In an alternative form of construction, however, the opening 52 could be provided above the surface of the oil level so that the oil level can be placed under air pressure varying, for instance, between two and four atmospheres as the height of the oil level changes.

The bottom end of the control rod 32 carries a fork 32a which is pivoted to a lever 53 rigid with another rockshaft 54 that is turnably mounted in bearings 55 mounted on the base 1 of the drop hammer. A pedal lever 56 is also non-rotatably secured to the rockshaft 54, so that when the operator presses the lever 56 with his foot the control rod 32 is raised and the valve controlling rockshaft 24 is turned.

The outlet valve controlling lever 23, rigid with rockshaft 24, has its lower end 24 bifurcated to form a fork 57 engageable beneath a cross-bar 58 rigid with the stem of a piston-type valve body 59. The outlet or exhaust valve generally denoted at 36 includes a casing portion at the terminal end of pipe portion 45 within which is a vertically disposed outlet pipe 60. The space around the outlet pipe is an annular chamber and a plurality of bores or openings 61 provide communication between the annular chamber and the outlet pipe 60. The valve body 59 controls fluid communication between pipe portion 45 and the outlet pipe 60. In the position shown in Figures 1 and 2, the fork 57 is not yet in contact with the cross-bar 58, and it will come into contact therewith only after the control rock shaft 24 has been turned or rotated slightly in the clockwise direction. When the rockshaft 24 rotates further, the fork 57 will lift the cross-bar 58 and therefore the valve body 59. As stated, piston-type valve body 59 slides in outlet pipe 60 and has a flange 60a bearing on the top end of this pipe, so that the piston-type valve body 59 cannot descend lower than the position shown in full lines in Figure 2. However, when the piston-type valve body 59 is raised so that its lower end surface is in the position 59b shown in dot-dash lines in Figure 2 the openings 61 are exposed. In this case, therefore, the oil in cylinder 6 and the pipe portions 44, 45 can flow out through the openings 61 into the outlet pipe 60 and downward into the container 7, so that the top descends abruptly.

Pipe portion 45 carries the casing 29' of stroke length controlling valve 29. A small pipe 63a provides communication between pipe portion 45 and valve casing 29'. The casing is provided with an outlet bore or opening 63 of small diameter to which a bleed pipe 64 is connected. The casing 29' is cylindrical, and a piston-type valve body 62 having a transverse bore 62a therethrough is slightly mounted therein for movement between a lower position, preventing passage of oil through valve casing 29 and an upper position placing bore 62a in register with pipe 63a, and the outlet bore opening 63. The bottom end 64a of the bleed pipe 64 is open and in free communication with the oil in the oil container 7. In the position shown in full lines in Figure 2, the valve body 62 closes the bore 63. However, when the valve body 62 is raised slightly, it exposes the outlet bore 63, so that when the pipe portion 45 can flow out of the bore 63 through bleed pipe 64 and into the oil container, thus allowing the top to slowly descend. The space above the valve body 62 communicates through a pipe 65 with the air space above the surface of the oil. A bore 29a in the lower end of valve casing 29, by a pipe not shown, places the space beneath valve body 62 in communication.
with atmosphere. The valve body 62 is mounted on a piston rod 66, the upper end of which is connected by pin 67 to two articulated links 68, which are themselves rotatable on a pin 69 mounted on the end of valve control lever 27. The cylinder 6 is elongated, and a transverse partition wall 71 dividing the cylinder into two portions, the lower portion accommodating piston 8 and the upper portion constituting an air-receiving chamber 75. In the partition wall 71 is mounted a manually operable air flow controlling valve 73, adjustable by means of a hand lever 72 between an open position shown in full lines, and a closed position shown in dot-dash lines, Figure 1a. The air chamber 75 above the partition wall 71 is also closed, and mounts a pressure gauge 74. In addition, the air chamber 75 has an outlet opening closed by a valve body 76, acted on by a compression spring 77 urging the valve body 76 into the closed position. On the valve body 76 there is a valve stem provided with a handle 78 so that the valve body can be manually lifted, not only by excess air pressure in the chamber 75 but also, when desired, by hand, against the action of the spring 77. The wall of the cylinder 6 has an opening 66 communicating with the space 70 above the piston, and with which is connected another casing 80. The casing 80 is disposed adjacent cylinder 6 and includes an air inlet chamber 80' and an air outlet conduit 88 through which air enters into air chamber 75. Between the air inlet chamber 80' and the air outlet 88 is a non-return air flow controlling valve 81 governing communication between the air inlet chamber 80', and the pressure chamber 75 when the pressure in the chamber 80' is greater than in the chamber 75. For this purpose, the stem of valve 81 carries a head 82 disposed outside the valve casing 80 against which head 82 can be engaged. This stop 83 is rotatable or rockably secured to the top end of the cylinder 6 and can be brought into one position in which it blocks upward movement of head 82 and thus prevents the valve 81 from opening, and another position in which it allows the non-return air flow controlling valve 81 to open. In the casing 80 there is a second non-return air check valve 84 which allows air to enter the chamber 80' from outside, but does not allow any air to escape from this chamber.

In the top right-hand portion of the drawing an apparatus is shown in dot-dash lines which can take the place of the casing 80 and valves therein, if a simple manner of operation of the hammer will suffice to meet the requirements. In this form of the invention the pipe 79, which is a pipe portion 79a, to which is connected an air flow controlling valve 85 that can be opened and closed as desired and which is in communication with a compressed air container 86 through a duct 87.

The manner of operation of the drop hammer will now be first of all explained without reference to the parts provided above the transverse partition wall 71. The valves 73 and 76 may be open.

When it is desired to operate the hammer, the motor 13 is started so that the pump 11 sucks oil through the intake pipe 15 and drives said oil through the pressure duct 17, chamber 17a, the non-return inlet valve 18, the inlet pipe portion 44 and the opening 10 to the underside of the piston 8. Consequently, the piston 8 rises into the position shown in the drawing, taking with it the top 3, the cam surface 41 of which, shortly before reaching the position shown in the drawing, rocks the bell-crank lever arms 36b, 36a slightly so that the fork 38 drops parallel to the adjustable stop or step 35, and thereby lifts the control rod 32. It turns the rockshaft 24 far enough to cause the valve body 20 to open the by-pass duct 19. Therefore, the oil now delivered by the pump 11 flows back into the container through the by-pass duct 19. Reverse flow of pressure oil from the cylinder 6 is not possible, since the non-return inlet valve 18 is closed, and neither of valve 30 and 29 are open. On the contrary, the valve bodies of these two valves are in the positions shown in full lines in Figure 2. If it is desired to drop the top 3 from a height less than that shown in the drawing, a slight pressure is exerted on the pedal lever 56, so that the rockshaft 54 turns and lifts the control rod 32. The latter then turns valve 30 counterclockwise, if it is sufficient to move the piston-type valve body 62 upwards to expose the opening 63 in casing 29. The exhaust or outlet valve 30 is not yet opened, since the ends of the fork 57 have not yet engaged and lifted the crossbar 58. The top 3, therefore, descends slowly as pressure fluid slowly escapes through the by-pass opening 63 or opening 65. If the operator now wishes to deliver a blow, he depresses the lever 56 abruptly and hard with his foot. This causes the control rod 32 to rise, and rapidly turn valve controlling rockshaft 24 so far that the outlet openings 61 in outlet pipe 60 are exposed by the resulting upward movement of piston-type valve body 59. The liquid undermentioned in the working piston 8 now flows through the large cross-sections of the openings and pipe portions 10, 44, 45, 61 and 60 so rapidly that the top 3 and piston 8 come down hard, almost at the speed of free fall. This dropping movement moreover, is not interrupted if the operator's foot releases the lever 56, since the outflowing liquid in pipe portion 45 and 60 has still so much pressure that it continues to keep the lower end surface 59a of the piston-type valve body 59 in the dot-dash line position 59b. After the rapid depression of the lever 56 the control rod 32 descends owing to its own weight and thereby turns the rockshaft 24, so that the lever 23 turns clockwise, causing link 22 to move valve body 20 down to close the by-pass duct 19. The valve body 59 is abruptly dragged down at, but not before the moment when the top 3 strikes the anvil 2. At this moment the vigorous flow of oil from the cylinder 6 ceases, so that the liquid still in the outlet pipe 60 must abruptly decrease its velocity, since it has behind it no flowing oil, or only the oil delivered by the pump 11. The sharp decrease in the velocity of the liquid in the outlet pipe 60 exerts a sucking action on the end surface 59a of the piston-type valve body 59, so that this valve body is dragged downwards and closes the outlet openings 61. As soon as the outlet openings 61 have closed, the liquid which the pump 11 continues to deliver has no outlet other than through opening 10 into the cylinder 6, so that the piston and the top 3 are raised again as soon as the blow has been completed.

When top 3 impacts a workpiece, it often rebounds upward, thus moving piston 8 upwards. During the rebound of the top 1 a vacuum may exist for a short time beneath the undersurface of piston 8 and if the supply of liquid from pump 11 is not sufficient to fill the thus enlarged space beneath piston 8, the non-return liquid make-up valve 51 opens due to the upward rebounding movement of piston 8, liquid being sucked out of the container 7 through pipe 59 and past this valve 51.

The damping cylinder performs the function of damping sudden violent surges that may occur for instance when the valve body 20 closes abruptly. The damping piston 48 then moves upwards for a short time under the action of any excessively high pressure so that an injurious excessive increase in the oil pressure is avoided.

The parts of the drop hammer described above are by themselves sufficient to permit very simple control of the hammer merely by means of the lever 56, and in particular, to enable the force of the blow delivered by the top 3 to be regulated in an extremely simple manner. The apparatus described herein makes possible a further change in the force of the blow delivered by the top.

Let it be assumed that the non-return air flow controlling valve 81 is held closed or locked. If the manually operable air flow controlling valve 73 is closed,
the air space above the piston is under approximately atmospheric pressure. If the piston is driven upwards hydraulically in the manner described above, the air in the space above the piston is compressed. On the one hand this causes the upward movement of the piston to be braked towards the end of its stroke, and on the other hand the compressed air represents a reservoir of energy which during the downward movement of the piston restores the work absorbed during the upward movement of the piston, and thereby addi-
tionally accelerates the descending piston. Such arrange-
ments are known in drop hammers. The present inven-
tion aims at making the manner of operation of the energy reservoir variable, in order in this way to obtain a more or less rapid succession of blows as required. This can be achieved if the parts shown in dot-dash lines are present in an apparatus that does not have the parts shown in full lines above the partition wall.

If, when the piston is down, compressed air is admitted to the space from the container by actuation of the valve, then after the valve has been closed again the subsequent hammering blow should be substantially harder than before, since the descending piston and tup will then descend at a much greater speed than that of free fall, since a strong air pressure will be additionally exerted on the top of piston 8 until it reaches its lowest position i. e. until the blow is delivered. The strength of the blow can be reduced again by letting some of the air out of the space above the piston.

Since the manner of operation described above necessarily required a charged compressed air container, the construction of the hammer shown in full lines is preferred. For this purpose, the adjustable stop which can be termed a valve blocking or locking means which closes the non-return air flow controlling valve 81 closed is moved to a position permitting upward move-
ment of valve 81. In addition, the valve 73 is closed. If the piston 8 is now made to slide upwards and downwards several times, the component parts above the partition 71 causes the piston to operate as a pump. During the downward movement of the piston, air is sucked in from the outside through the non-
return valve 84. This quantity of air is driven through the non-return air flow controlling valve 81 into the pressure chamber 75 when the piston moves upwards. The manometer or pressure gauge 74 indicates the pressure in the pressure chamber 75. Any excessive pressure which might become dangerous to the drop hammer escapes through the safety valve 76. If it is now desired to operate the hammer, this can be done either with the manually operable valve 73 open or with said valve closed. The available compression space comprised by the total volume of the space 70 and chamber 75 can thus be divided as desired. There are then two possible ways of operating the hammer. If it is operated using the pressure space 70, strong compression of air takes place in the space 70 at the end of the upward potential movement. The energy of this air, however, is not so great as the potential energy of the combined volume of space 70 and chamber 75. If the hammer is operated using both space 70 and chamber 75 in communication with one another, a very strong pressure is exerted on the top of piston 8 even at the end of the downward move-
ment of the tup. In this connection, the quantity of air in the space above the piston is so greatly increased as to have a pressure greater than atmospheric pressure, for instance, 3.5 or more atmospheres, when the piston is down.

1. A hydraulically actuated drop hammer, including a vertically disposed cylinder, a piston movable in the cylinder, a tup carried by the piston, an anvil beneath the tup for supporting a workpiece during a hammering operation, means operable to establish a flow of liquid under pressure into the lower portion of the cylinder to raise the piston and thus the tup including control means operable beneath the piston whereby the piston and tup descend during a hammering operation and the piston displaces the liquid from the cylinder, so that gaseous medium in the cylinder above the piston being compressed during the raising of the piston and expanding as the piston descends, compressed gaseous medium containing means operably associated with the cylinder above the upper limit of piston travel for receiving a supply of gaseous medium under such pressure as to be greater than atmo-
spheric pressure even when the piston is in its lowermost position, and controllable flow-control means for controlling communication between said containing means and cylinder for controllably increasing the pressure of gaseous medium acting on the piston during its descent.

2. A drop hammer as claimed in claim 1 in which said compressed gaseous medium containing means and said flow-control means operable to increase the pres-
sure of gas in the cylinder on the descending piston include a conduit means communicating with the cylin-
der above the upper limit of piston travel, valve means associated with the conduit means for controlling fluid flow therethrough and a compressed air containing means having said supply of medium under pressure therein in communication with the conduit means whereby actua-
ation of the valve means admits compressed air into the cylinder above the piston.

3. A drop hammer as claimed in claim 1 in which said compressed gaseous medium containing means and said flow control means comprise a chamber within the cylinder, a partition above the upper limit of piston travel separating said chamber from the space above the piston, means by which said chamber can be sup-
plied with air under pressure, conduit means through the partition, and a selectively operable valve in said conduit means for controllably permitting air under pres-
sure to flow from the chamber into the space above the piston as desired.

4. A hydraulically actuated drop hammer as claimed in claim 1 in which said compressed gaseous medium containing means comprises a compressed air container separate from the cylinder, a conduit means extending from said compressed gas container to and communicating with the cylin-
der above the upper limit of piston travel and said flow-
control means comprising a manually operable valve in said conduit means between the container and the cylinder and operable to control communication therebetween whereby the opening of said valve admits compressed air directly into the cylinder above the piston to augment the force of the descent thereof.

5. A hydraulically actuated drop hammer including a vertically disposed cylinder, a piston movable in the cylinder, a tup carried by the piston, means operable to establish a flow of liquid under pressure into the lower portion of the cylinder to raise the piston and thus the tup including control means operable to rapidly exhaust liquid from the cylinder beneath the piston whereby the tup descends during a hammering operation, a partition means transversely of the cylinder above the upper limit of piston travel and defining a gaseous medium containing chamber above the upper limit of piston travel and conduit means through the partition, controllable valve means in the conduit means for controlling communication between the chamber and the cylinder at a location that is subjacent the partition and also above the upper limit of piston travel for communicating with the con-
ditions of the piston with said valve means closed will comprress and supply the chamber with a quantity of compressed gaseous medium under such pressure as to
be greater than atmospheric pressure when the piston is in its lowermost position and upon such actuation of said valve means to open position a controllable flow of compressed medium will be established through the first-mentioned conduit means and into the cylinder above the piston to controllably augment the gravitational descent of the piston during hammering.

6. A hydraulically actuated drop hammer including a vertically disposed cylinder, a piston movable in the cylinder, a tup carried by the piston, an anvil beneath the cylinder for carrying a workpiece to be impacted upon by the tup, means operable to establish a flow of liquid under pressure into the lower portion of the cylinder to raise the piston and thus the tup including control means operable to permit exhaust of liquid from the cylinder so that the piston and thereby the tup falls to impact a workpiece, said piston in falling displacing the liquid from beneath the piston, a partition extending transversely across the cylinder above the upper limit of the piston travel, a chamber means above said partition, a conduit means for providing communication between the chamber means and the cylinder space above the piston, a selectively operable valve means operably associated with said conduit means for controlling communication between the chamber means and said space, additional conduit means also communicating between the chamber and the cylinder at a location beneath the partition but above the upper limit of piston travel, a non-return valve operably associated with said additional conduit means and constructed and arranged to permit air to flow from beneath the partition, through said additional conduit means and into said chamber in response to upward movement of the piston and with said selectively operable valve means in a position to prevent communication between said cylinder and chamber and said non-return valve means preventing reverse flow of air from the chamber into the cylinder beneath the partition, said additional conduit means also having a port opening to atmosphere, said port being located between said cylinder and said first-mentioned non-return valve, a second non-return valve operably associated with said port and constructed and arranged to permit air to enter said additional conduit means through said port and to flow toward the cylinder when the piston descends to prevent the escape of air from said additional conduit means whereby plural reciprocations of said piston with said selectively operable valve means in a position to prevent communication between said chamber means and said space will charge said chamber with a supply of air under such pressure as to be greater than atmospheric pressure even when the piston is in its lowermost position whereby subsequent actuation of said selectively operable valve means to open position will controllably supply compressed air into the cylinder beneath the partition to substantially augment the gravity fall of the piston and tup to increase the energy of the blow struck by the tup and movable means operably associated with said additional conduit means and said first-mentioned non-return valve means and constructed and arranged for selectively preventing or permitting opening movement of said first-mentioned non-return valve.

7. A hydraulically actuated drop hammer as claimed in claim 5 and a safety valve means operably associated with said chamber to permit escape of air from the chamber if the pressure in the chamber exceeds a predetermined maximum.

8. The combination with a hydraulically actuated drop hammer of the type including a vertically disposed cylinder and a tup carrying piston reciprocable in the cylinder and means for alternately admitting liquid under pressure into the cylinder beneath the piston to raise the tup and to exhaust liquid from the cylinder so as to permit the piston and tup to fall so that the piston will displace the liquid in falling, a container means and associated conduit means in communication with the cylinder above the upper limit of piston travel said container means receiving a supply of air under such pressure as to be greater than atmospheric pressure when the piston is in its lowermost position and selectively operable valve means operably associated with said conduit means for controllably establishing a direct flow of air under pressure said container means and into the cylinder in contact with said piston to increase the rate of fall of the piston.

9. The combination as claimed in claim 8 in which said cylinder is elongated, a partition extending transversely across the cylinder above the upper limit of piston travel and defining a chamber in the cylinder above the piston, said chamber constituting said container means, said associated conduit means and said valve means being incorporated in said partition, additional conduit means in communication between the cylinder immediately subjacent the partition and the chamber and non-return valve means operably associated with said additional conduit means and constructed and arranged to permit plural reciprocations of the piston to establish a supply of compressed air in the chamber with said first-mentioned valve means closed.

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