United States Patent

[11] 3,633,461

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[33] **Japan**
[31] **43/28223**

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[54] **HYDRAULIC CIRCUITRY FOR THE HOIST RAM AND THE LIKE OF THE BUILDING MACHINERY**
10 Claims, 19 Drawing Figs.

[52] **U.S. Cl.** **91/436,** 91/446
[51] **Int. Cl.** **F15b 11/08,** F15b 13/042
[50] **Field of Search** 91/436, 446; 137/107, 546

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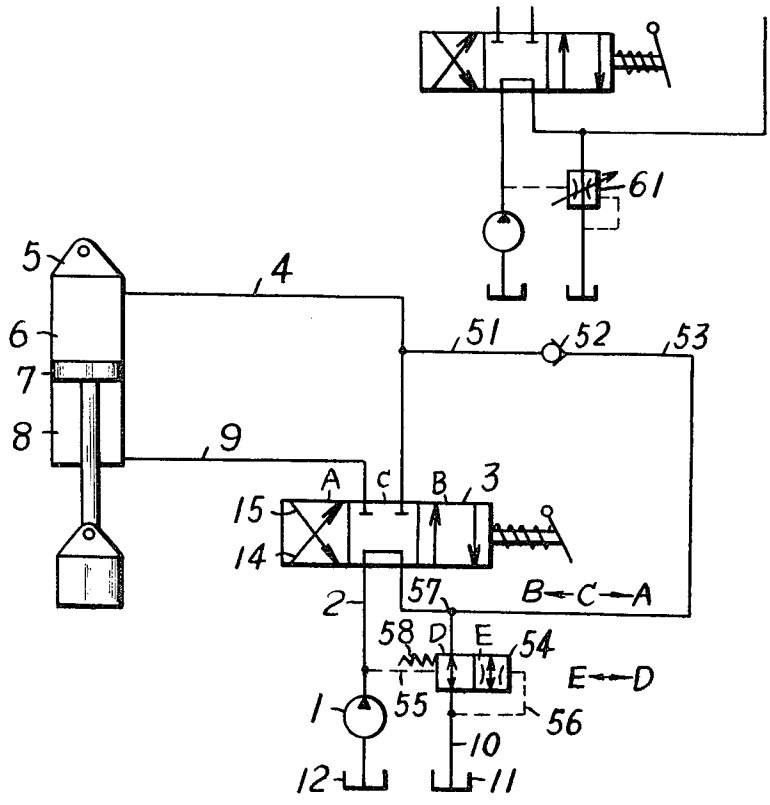
Primary Examiner—Paul E. Maslousky
Attorney—Steinberg & Blake

ABSTRACT: A hydraulic circuitry adapted to replenish oil under a positive pressure automatically into a cylinder for operating a blade of a bulldozer, when pressure in the cylinder is reduced, whereby the operation of the blade is made quick and easy.



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SHEET 1 OF 2

Fig. 1

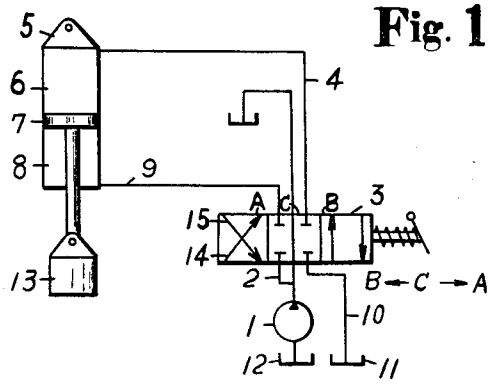


Fig. 3

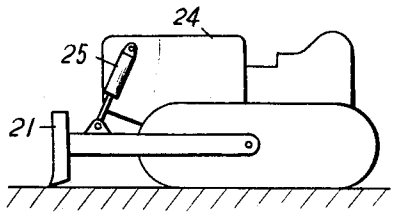


Fig. 4

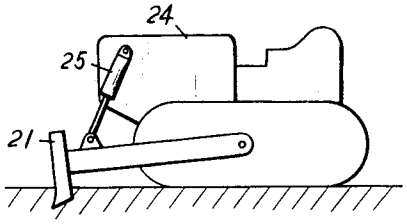


Fig. 2

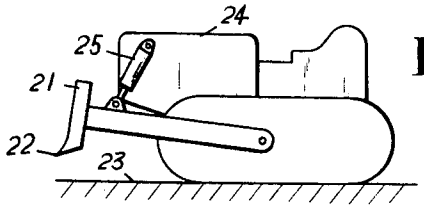


Fig. 6

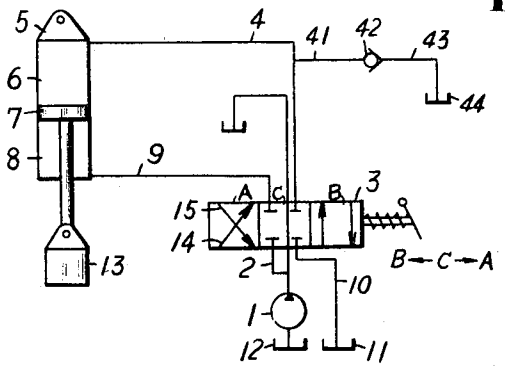


Fig. 5

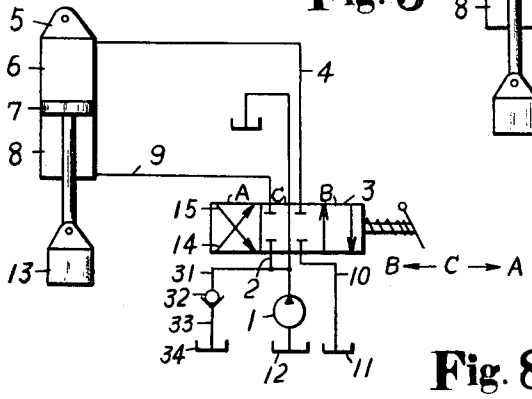


Fig. 8

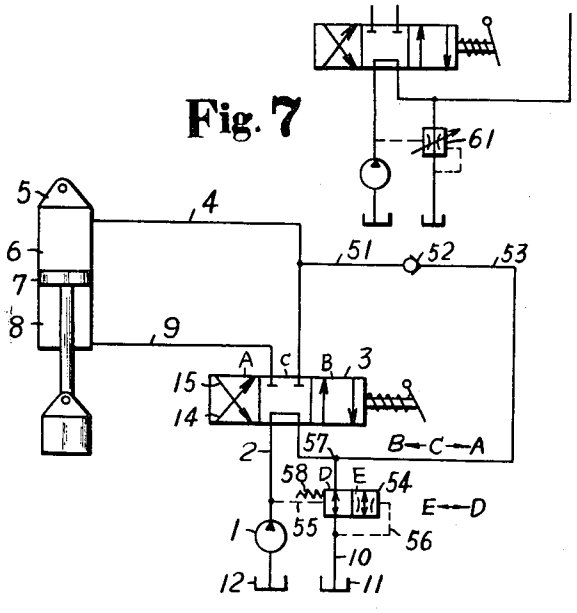
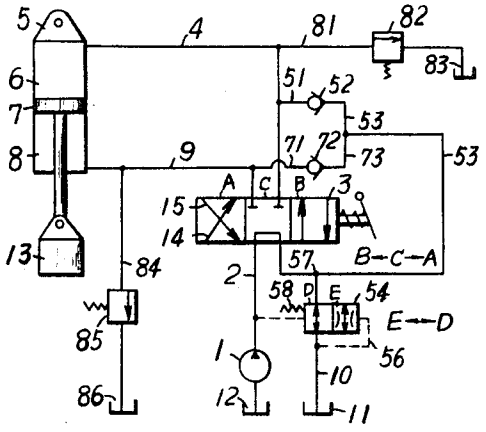


Fig. 9



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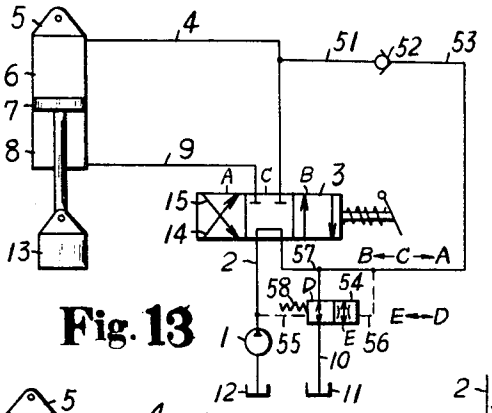


Fig. 13

Fig. 10

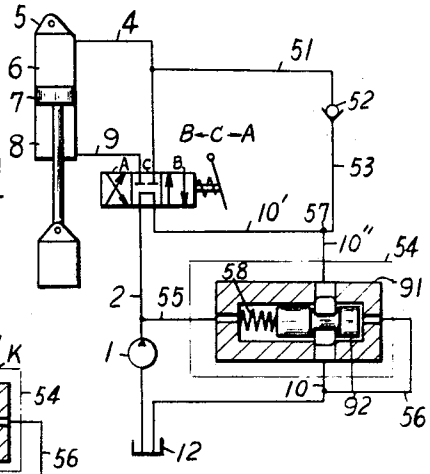


Fig. 11

Fig. 12

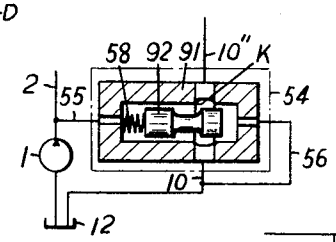


Fig. 14

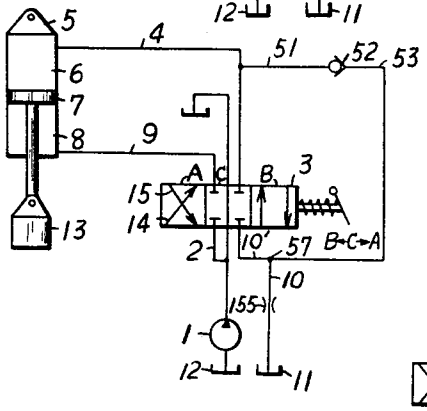


Fig. 15

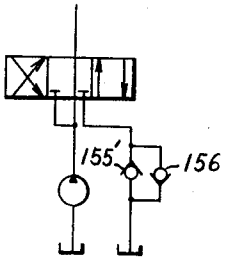
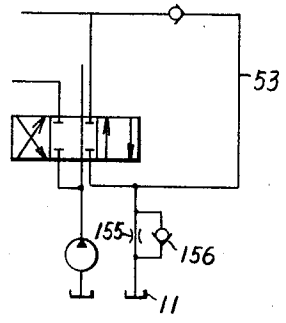


Fig. 16



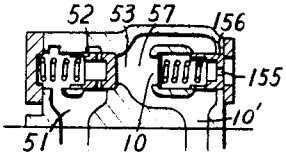


Fig. 17

Fig. 18

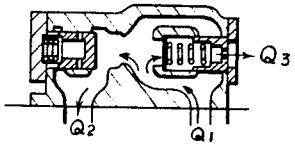
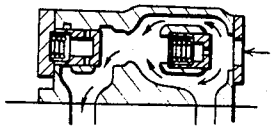
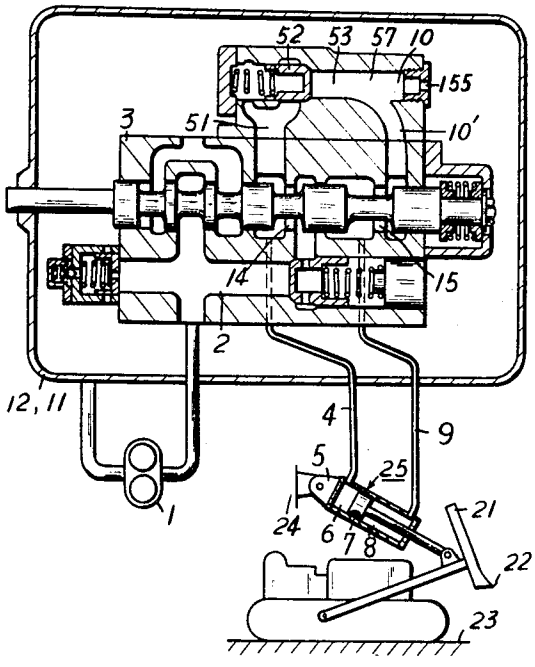


Fig. 19





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HYDRAULIC CIRCUITRY FOR THE HOIST RAM AND THE LIKE OF THE BUILDING MACHINERY

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to improvements in the building and earthwork machinery such as the bulldozer and the like, and particularly in the hydraulic circuitry for the hoist ram and the like for operating the blade of such machinery.

2. Description of the Prior Art

It is well known that the hoist ram provided in a bulldozer or the like is operated hydraulically. Such a hoist ram is provided with a hydraulic circuitry for energizing it. A basic circuitry of the class described is illustrated in FIG. 1, which comprises a hydraulic pump 1, a pressure-controlling valve 3 and the hoist ram 5. The hydraulic pump 1 is charged with oil from a reservoir 12, of which an output is introduced into the pressure-controlling valve 3 through a pipeline 2. The input into the pressure-controlling valve 3 may be, in general, changed over into three positions B, C and A therein. When the pressure-controlling valve 3 is in the position A, the pumped oil is introduced into an upper space 6 in the hoist ram 5 through a passage 14 provided in the pressure-controlling valve 3 and a pipeline 4 so as to pressure a piston 7 adapted to be slid vertically in a cylinder of the hoist ram 5 downward, and therefore, a quantity of oil contained in a lower space 8 under the piston 7 in the hoist ram 5 is returned to a reservoir 11 through a pipeline 9 and a passage 15 formed in the pressure-controlling valve 3. The reservoir 11 is adapted to be communicated with the reservoir 12. The pressure-controlling valve 3 may be changed over into either the positions B and C, but these positions are not particularly pertinent to this invention, and therefore, it is not necessary to describe them in detail.

Now in case the piston 7 is loaded by a load 13, the piston 7 tends to be lowered by gravity. When the pressure-controlling valve 3 is brought into the position A from either the position C or the position B, and therefore, the lower space 8 under the piston 7 is brought into communication with the reservoir 11 through the pipeline 9, the passage 15, and the pipeline 10, the oil contained in the lower space 8 tends to be exhausted out of the lower space 8 by being pushed by the loaded piston 7 regardless of the output of the hydraulic pump 1.

In this case, if the output of the hydraulic pump 1 is relatively small in quantity and the piston 7 is lowered relatively speedy, a negative pressure occurs in the upper space 6 in the hoist ram 5. The negative pressure will diminish to cavitation at a value in pressure. The negative pressure occurs in the upper space 6 of the hoist ram 5 when

$$Q<\pi/4{,}000\times D^2\times 60V$$

in which Q represents the output of the hydraulic pump 1 in liters per minute, D represents the inner diameter of the hoist ram 5 in centimeters, and V represents the lowering speed of the piston 7 in centimeters per second. When the negative pressure diminishes to a limit (which is, in general, about 0.3 to 0.4 kg./cm.^{2}), cavitation is generated. When the pressure-controlling valve 3 is changed over into either the position C or the position B when the cavitation exists in the upper space 6, the cavitation remains as it is. When the pressure-controlling valve 3 is not operated in position A, the cavitation will disappear within a specified period.

In the state shown in FIG. 2, a cutting edge 22 of a blade 21 of a bulldozer is raised above the ground surface 23. The blade 21 is supported by a pair of push arms adapted to be driven by a pair of hoist rams 25 so as to raise and lower the blade 21. When the blade 21 is being lowered to be brought into contact with the ground surface 23 as shown in FIG. 2, the blade 21 corresponds to the load 13 in FIG. 1, and therefore, when the blade 21 is lowered quickly and the upper space, which corresponds to the upper space 6 in FIG. 1, upon the piston of the hoist ram 25 is not so quickly charged with oil, cavitation is generated similarly to the case described referring to FIG. 1. Now, for an earthmoving job, it is necessary to thrust the cutting edge 22 into the ground 23 as shown in FIG. 4. In this

case, it is necessary to charge the upper space in the hoist ram 25 with oil under pressure for lowering the piston. However, when the cavitation is left as it generated, it is at first required to make the cavitation be eliminated by a high pressure or else to await natural disappearance of the cavitation, and therefore, a delay in time in thrusting the cutting edge 25 into the soil 23 is unavoidable. Thus it is necessary to hold the blade 21 once in the state as shown in FIG. 3, contacting the cutting edge 22 with the surface of the ground 23 for a while (about several seconds) and then to lower the blade 21 again into the soil 23 for lowering the blade 21 from the state of FIG. 2 to the state of FIG. 4.

However, in the practical work, such a manner of operation as above is very disadvantageous so that such hydraulic circuitries as shown in FIGS. 5 and 6 have been proposed. In accordance with the prior art as shown in FIG. 5, a pipeline 33 including a check valve 32 is additionally provided between a reservoir 34 and the pressure-controlling valve 3, which serves to charge oil into wherever cavitation exists. In case the cavitation is generated wherever between the hydraulic pump 1 and the controlling valve 3 and between the passage 14 in the controlling valve 3 and the upper space 6 of the hoist ram 5 and the pressure-controlling valve is positioned A, the oil is sucked from the reservoir 34 to the cavitation for making it disappeared. However, if the pressure-controlling valve 3 is promptly returned from the position A to the position C and the cavitation has been generated in the upper space 6 of the hoist ram 5 or the pipeline 4, it is impossible to replenish the cavitation with oil from the reservoir 34 through the additional pipeline 33 up to a quantity sufficient for making the cavitation disappear due to the quick return of the pressure-controlling valve 3 from the position A to the position C, and therefore, it is not possible to operate the pressure-controlling valve 3 early enough and, in addition, the operation requires a great amount of skill.

FIG. 6 shows an alternative prior art, in accordance with which an additional pipeline 41 is joined with the pipeline 4 between the pressure-controlling valve 3 and the upper space 6 of the hoist ram 5, and communicated with a reservoir 44 through a check valve 42 and a pipeline 43, so that the upper space 6 is replenished with oil supplied from the reservoir 44 when cavitation occurs in the upper space 6 or the pipeline 4. In this construction, it is possible to replenish oil from the reservoir 44 even if the pressure-controlling valve 3 is shifted to the position C, and therefore, it is considered that this construction is superior to that shown in FIG. 5. However, the replenishment is not positive or is made by virtue of suction only.

SUMMARY OF THE INVENTION

Briefly stated in accordance with one aspect of this invention, there is provided, in a hydraulic system comprising a hydraulic hoist ram having a piston to be loaded in a single direction, and a hydraulic pump for supplying a liquid medium to the ram for driving the piston, the ram and the pump being connected with a pair of pipelines for transferring the pumped liquid medium alternatively, and a pressure-controlling valve being provided between the pair of pipelines and the hydraulic pump for the alternation, an additional pipeline adapted to supply a space upon the piston opposite to the load with the liquid medium under a positive pressure automatically, when a pressure subjected to the liquid medium within the space is reduced.

In accordance with this invention, the positive pressure is supplied to the fluid of the additional pipeline from the other space, which is being compressed under the piston in the hoist ram. The additional pipeline is inserted between the space upon the piston of the hoist ram and the inlet of the reservoir for returning the liquid medium from the other space to the reservoir during the pressure-controlling valve is positioned A. The additional pipeline is provided with a check valve for passing the liquid medium only toward the space upon the

piston. The inlet is provided with a means for passing a greater quantity of the liquid medium toward the additional pipeline than toward the reservoir.

A principal object of this invention is to provide an easily operable bulldozer or the like.

Another object of this invention is to provide a bulldozer or the like, of which a blade may be inserted into soil without a delay in time after the same has been lowered onto the soil.

By virtue of the arrangements in accordance with this invention, any occurrence of cavitation is substantially avoided and, even if the same occurs, disappearance thereof is made immediately and automatically, so as to achieve the above objects without any care and skill in operation.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be better understood and other objects and additional advantages of the invention will become apparent upon perusal of the following description taken in connection with the drawings, in which:

FIG. **1** is a diagram of a basic hydraulic circuitry in accordance with the prior art;

FIGS. **2**, **3** and **4** are schematic views of a bulldozer, of which a blade is held above the ground surface, has been brought in contact with the surface, and has been inserted into the soil, respectively;

FIGS. **5** and **6** are diagrams of hydraulic circuitries of the class described, improved in the prior art, respectively;

FIG. **7** is a diagram of a hydraulic circuitry embodying this invention;

FIG. **8** is a partly removed diagram of the second embodiment in accordance with this invention;

FIG. **9** is a diagram of the third embodiment in accordance with this invention;

FIG. **10** is a diagram of the fourth embodiment in accordance with this invention;

FIG. **11** is a similar view to FIG. **7** but a throttle valve provided in the circuitry is shown as an axially sectional view in an inactive position;

FIG. **12** is a partly removed diagram similar to FIG. **11** but the throttle valve is in an active position;

FIG. **13** is a diagram of the fifth embodiment in accordance with this invention;

FIG. **14** is a partly removed diagram of the sixth embodiment in accordance with this invention;

FIG. **15** is a partly removed diagram of the seventh embodiment in accordance with this invention;

FIG. **16** is an axially sectional view of another throttle valve provided in the circuitry shown in FIG. **13**; and

FIGS. **17**, **18** and **19** show three positions of still another throttle valve provided in the circuitry shown in FIG. **14**, for explaining the operation thereof.

Similar numerals refer to similar parts throughout the several views.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring more particularly to the drawings, the preferred embodiments of this invention will now be described; however, this description will be understood to be illustrative of the invention and not as limiting it to the particular arrangements as shown and described. In the first embodiment of this invention, there is an additional pipeline **51**. Whereas the additional pipeline **41** is inserted between the upper space **6** of the hoist ram **5** and the reservoir **44** as shown in FIG. **6** in accordance with the prior art, the additional pipeline **51** in this embodiment is inserted between the upper space **6** of the hoist ram **5** and the pipeline **10** for returning the exhausted oil to the reservoir **11**. The additional pipeline **51** includes a check valve **52** for passing oil only toward the upper space **6** similarly to the circuitry shown in FIG. **6**. The pipeline **10** includes a specified throttle valve **54** between a junction **57**, where the additional pipeline **53** extended from the pipeline **51** is joined with the pipeline **10**, and the reservoir **11**, as shown in FIG. **7**.

The throttle valve **54** may be shifted between two positions D and E, which tends to be positioned D normally by the action of a spring **58**. An auxiliary pipeline **55** connects the throttle valve **54** with the pipeline **2** so as to sense the pressure in the pipeline **2** communicating with the upper space **6** through the pipeline **4** and the passage **14** during the pressure-controlling valve **3** is positioned A. When the pressure in the pipeline **2** becomes negative, the throttle valve **54** is adapted to be shifted to the position E against the action of the spring **58** so as to throttle the pipeline **10**, and therefore, oil compressed in the lower space **8** of the hoist ram **5** and returned to the reservoir **11** through the pipeline **9** and the passage **15** is rather directed to the pipeline **53** than to the reservoir **11**. Thus by virtue of not only suction in the upper space **6** but also compression in the lower space **8**, cavitation is avoided or made promptly to disappear. The throttle valve **54** will be concretely described hereinafter referring to FIGS. **11** and **12**. Otherwise constructed variable throttle valve **61** may be substituted for the valve **54** as shown in FIG. **8**, if it is sensible to the negative pressure in the upper space and pipelines communicated therewith.

Referring now to FIG. **9**, the third embodiment of this invention comprises a relief pipeline **81** communicating the upper space **6** with a reservoir **83** through a relief valve **82**, another relief pipeline **84** communicating the lower space **8** with a reservoir **86** through another relief valve **85**, and a still additional pipeline **71** communicating the pipeline **9** with the extension **53** of the additional pipeline **51** through a check valve **72**, in addition to the hydraulic circuitry of the first embodiment shown in FIG. **7**.

When the pressure-controlling valve **3** is positioned A and the piston **7** is lowered slowly, pressure in the upper space **6** and therefore in the pipeline **2** is elevated, whereby the throttle valve **54** is positioned D so as to return the oil returning from the lower space **8** through the pipeline **9**, the passage **15** and the pipeline **10** including the throttle valve **54**. While the returning oil acts on to the check vales **52** and **72** through the extension **53** in this case, these check valves **52** and **72** do not open due to difference in pressure, the pipelines **51** and **71** being not under negative pressure, so that the returning oil is directed entirely to the reservoir **11**. Meantime, if the piston **7** is lowered rapidly so that pressure in the upper space **6** and therefore in the pipeline **2** becomes negative, the throttle valve **54** is shifted by virtue and action of the negative pressure in the pipeline **2** against the action of the spring **58** toward the position E so as to throttle the flow of the returning oil. The returning oil directed to the reservoir **11** is thus directed to the pipeline **53** under pressure subjected in the lower space **8** and negative pressure generated in the upper space **6**. The oil is thus passed through a branched extension **53'** the check valve **52** and the additional pipeline **51** and directed to the upper space **6** of the hoist ram **5**, acting for preventing the upper space **6** from occurrence of cavitation.

When the pressure-controlling valve **3** is shifted suddenly from the position A to the position while the piston **7** is being lowered rapidly, it is natural that pressure in the lower space **8** and the pipeline **9** is suddenly elevated. Such a sudden elevation in pressure is, of course, disadvantageous, which is absorbed by the provision of the another relief valve **85** to an extent. At the same time, the upper space **6** and the pipeline **4** become negative in pressure due to the interruption from the hydraulic pump **1**. In this case, the fluid of the pipeline **2**, normally pressured, is directed to the pipeline **4** through the junction **57**, the extension **53**, the check valve **52** and the additional pipeline **51** so as to overcome the negative pressure in the upper space **6**. In addition, oil contained in the reservoir **11** is sucked toward the junction **57** so as to replenish the fluid of the pipeline **2** by virtue of the position D of the throttle valve **54**.

When the piston **7** is suddenly externally pushed upwards, a sudden elevation in pressure in the upper space **6** is absorbed to an extent by passing the oil through the relief valve **82**. At the same time, the lower space **8** becomes in the state of a

negative pressure, which is overcome by a flow through the check valve **72**.

There is a pilot pipeline **56** for driving the throttle valve **54** together with the auxiliary pipeline **55** and the spring **58**, which is derived from the reservoir **11** in the third embodiment of this invention shown in FIG. **9**. Meantime, the pilot pipeline **56** in the fourth embodiment of this invention shown in FIG. **10** is derived from the extension **53** of the additional pipeline **51** instead of the reservoir **11**.

In this embodiment, similarly to the preceding embodiment, when the upper space **6** is under a negative pressure and after the negative pressure has been overcome as far as possible by the appropriated returning oil, the negative pressure in the upper space **6** is further eliminated by directing the output of the hydraulic pump **1** through the extension **53**, the check valve **52** and the additional pipeline **51** if the hydraulic valve **3** is shifted from the position A to the position C so as to substantially equalize the pressure in the pipeline **4** with the additional pipeline **53**. Under these circumstances, the pressure in the additional pipeline **53** becomes lower than the pressure in the pipeline **2**, and therefore, in the auxiliary pipeline **55**, whereby the throttle valve **54** is returned to the position D so that the output of the hydraulic pump **1** is returned to the reservoir **11** substantially without resistance.

The first, third and fourth embodiments of this invention include a specified throttle valve **54**, which will now be described concretely referring to FIGS. **11** and **12**. The throttle valve **54** comprises a valve body **91**, a spool **92**, and a spring **58**. The pipeline **10** is divided into three parts, **10'** arranged between the pressure-controlling valve **3** and the junction **57**, **10''** arranged between the junction **57** and the throttle valve **54**, and **10** arranged between the throttle valve **54** and the reservoir **12** for facilitating explanation. The returning oil is passed from the pipeline **10''** to the pipeline **10** through the throttle valve **54** without any resistance by the spool **92** when the throttle valve has position D or the spool **92** is positioned right in the drawings by the action of the spring **58**. When the pressure in the pipeline **2**, and therefore in the auxiliary pipeline **55** becomes negative due to a sudden lowering of the piston **7** and other causes, the spring **58** is overcome by the negative pressure so as to shift the spool **92** leftwards as shown in FIG. **12**, whereby the flow through the throttle valve **54** is throttled at K. By virtue of this throttling, pressure in the extension **53** is elevated so as to open the check valve **52** for passing the returning oil to the upper space **6** through the check valve **52**, the additional pipeline **51** and the pipeline **4**.

The fifth embodiment as shown in FIG. **13** is quite similar to the first or the second embodiment as shown in FIGS. **7** and **8**, but the throttle valve **155** of the fifth embodiment is appreciably different from the throttle valve **54** and the variable throttle valve **61**. The throttle valve **155** is a fixed throttle valve but is adapted to be replaceable manually. The throttle **155** comprises a disc having a perforation. By virtue of the reduced area of the perforation, a negative pressure in the upper space **6** of the hoist ram **5** is effectively made to disappear and cavitation is avoided so that the blade **21** or the load **13** may be lowered rapidly and the pressure-controlling valve **3** may be handled with less care. However, such requirement is not constant in magnitude in accordance with circumstances. The time required for lowering the blade **21**, and therefore, the piston **7** varies depending upon the kind of work. In order to meet such a requirement, the throttle valve **155** in this embodiment is adapted to be replaced by a similar one but having another perforation of a different size.

In the sixth embodiment shown in FIG. **14**, there is a check valve **156** arranged in parallel with the fixed throttle valve **155**. The check valve **156** is effective to suck the oil contained in the reservoir **11** toward the extension **53**, when the extension **53** is under a negative pressure.

In the seventh embodiment shown in FIG. **15**, the throttle valve **155** in the sixth embodiment is replaced by another check valve **155'**. It is necessary that the check valve **155'** is arranged for flowing toward the reservoir **11** while the check valve **156** is arranged for flowing toward the extension **53** and the flow of the check valve **155'** is smaller than the flow of the check valve **156**. This arrangement is similarly effective to that of the sixth embodiment.

The fixed throttle valve **155** provided in the fifth embodiment and other essential parts of the hydraulic circuitry are concretely illustrated in FIG. **16**, in which the pressure-controlling valve **3** is positioned at A.

The essential parts of the sixth embodiment of this invention as shown in FIG. **14** is concretely illustrated in FIG. **17**, which acts as shown in FIG. **18** when the returning oil compressed in the lower space **8** in the hoist ram **5** is directed toward the upper space **6** through the extension **53**, the check valve **52** and the additional pipeline **51**. An output Q_1 of the lower space **8** is divided into a drain or return Q_3 directed to the reservoir **11** and a flow Q_2 of through the extension **53** at the junction **57**, when the piston **7** is lowered. After the piston **7** has been lowered, the oil contained in the reservoir **11** is sucked to the extension **53** as shown in FIG. **19**.

While particular embodiments of this invention have been illustrated and described, modifications thereof will readily occur to those skilled in the art. It should be understood therefore that the invention is not limited to the particular arrangements and constructions disclosed but that the appended claims are intended to cover all modifications which do not depart from the true spirit and scope of the invention.

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

1. In a hydraulic system comprising

hydraulic ram means having a piston to be loaded in a single direction,

hydraulic pump means communicating with said ram means for supplying a liquid medium to said ram means for driving said piston thereof,

a pair of pipelines for transferring said pumped liquid medium alternatively to a pair of spaces on opposed sides of said piston, respectively,

a controlling valve means for interchanging said pair of pipelines with each other so as to direct said liquid medium to either of said pair of spaces,

reservoir means from which liquid medium is supplied to said pump means and to which liquid medium is returned from said ram means,

a return pipeline extending between said controlling valve means and said reservoir means,

and means comprising an additional pipeline for supplying one of said pair of spaces with said liquid medium under a positive pressure automatically, when a pressure subjected to said liquid medium within said one of said pair of spaces is reduced, said additional pipeline being connected between that one of said pair of pipelines which is connected with said one space and said return pipeline, and said additional pipeline carrying a check valve for directing liquid medium only to said one space while said return pipeline carries a throttle valve means for directing liquid medium under pressure through said additional pipeline and check valve to said one space when the pressure therein is reduced.

2. The combination of claim **1** and wherein said additional pipeline is adapted to supply one of said pair of spaces opposite to said load with fluid comprising a part of said liquid medium being returned from the other of said pair of spaces under a positive pressure.

3. The combination of claim **2** and wherein said positive pressure applied to said fluid is derived from the last-named positive pressure.

4. The combination of claim **2** and wherein said throttle valve means is controlled by a pressure applied to an output of said hydraulic pump.

5. The combination of claim **2** and wherein said throttle valve has an aperture of predetermined size.

6. The combination of claim **2** and wherein a second check valve shorts said throttle valve means for passing said liquid medium toward said additional pipeline.

7. The combination of claim 2 and wherein a pair of relief pipe lines for said pair of spaces is provided for expelling excessive pressures through relief valves, respectively.

8. The combination of claim 6 and wherein said throttle valve means and said second check valve shorting the latter form a single unit wherein said throttle valve means is fully operative when said second check valve shorting the same is closed while said throttle valve means is not fully operative when said second check valve shorting the same is open.

9. The combination of claim 8 and wherein said throttle valve means and second check valve shorting the same form a single unit including a valve which in its closed position has a throttling aperture to form said throttle means while said valve is displaced to an open position for acting as said second check valve shorting said throttle valve means while rendering said throttle valve means not fully operative.

10. The combination of claim 9 and wherein said first-named check valve in said additional pipeline is situated downstream of said throttle valve means and said second check valve to receive liquid medium from said second check valve when the latter is displaced to an open position and said throttling valve means is not fully operative.

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