June 15, 1965 B. I. SPRAYBERRY ETAL 3,188,975

HYDRAULIC PULSATION ABSORPTION SYSTEM

Filed March 25, 1963 2 Sheets-Sheet 1

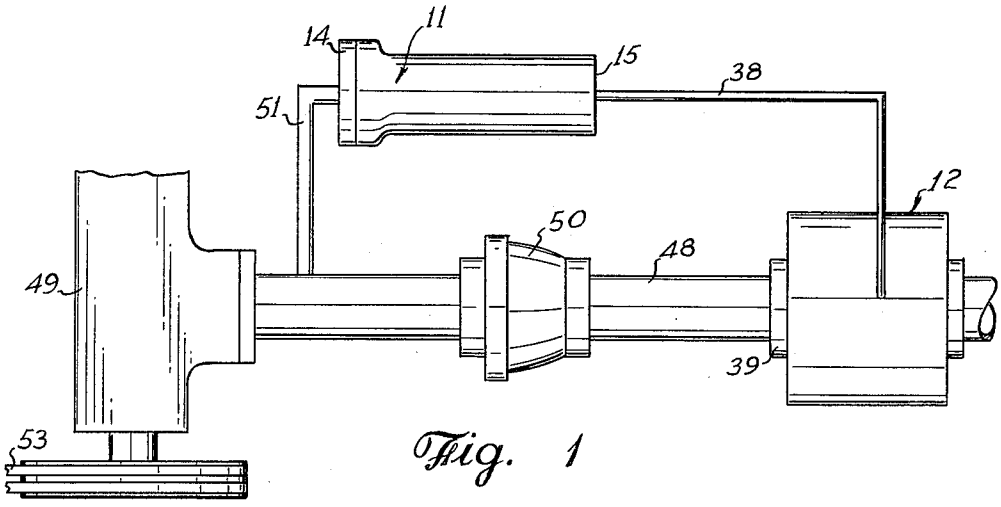


Fig. 1

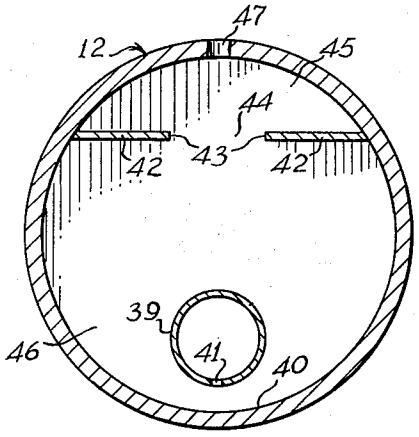


Fig. 2

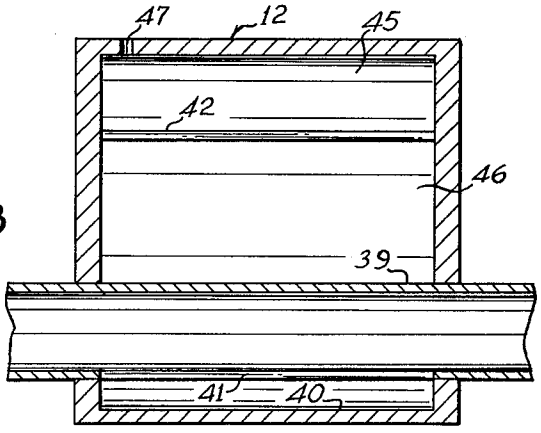


Fig. 3

INVENTORS:
BRYCE I. SPRAYBERRY
CHARLES W. BROWN
BY
Newton, Hopkins & Jones
ATTORNEYS

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Fig. 4

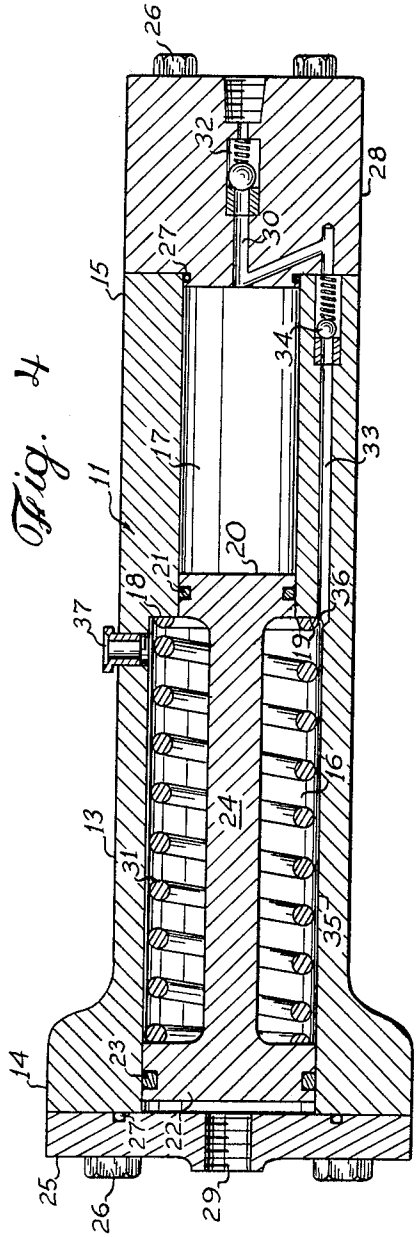
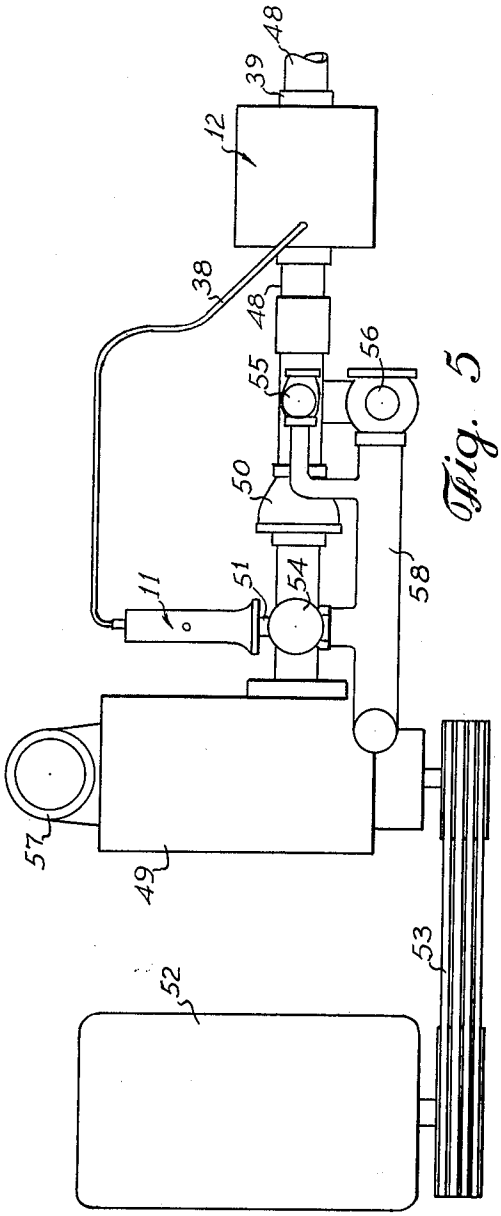


Fig. 5



INVENTORS:
BRYCE I. SPRAYBERRY
CHARLES W. BROWN
BY
Newton, Hopkins & Jones
ATTORNEYS

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HYDRAULIC PULSATION ABSORPTION SYSTEM

Bryce I. Sprayberry, Atlanta, and Charles W. Brown, Decatur, Ga., assignors to Southeastern Elevator Company, a Division of Turnbull Elevator, Inc., Atlanta, Ga., a corporation of Georgia

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This invention relates to a system for absorbing the pulsations and variations in pressure which generally characterize the flow of liquids, and more particularly to a system for absorbing and eliminating the objectionable pulsations, pressure variations and vibrations which a pump, such as a positive displacement pump, causes in a closed hydraulic system, such as a hydraulic elevator.

The flow of liquids in pipes resulting from the action of hydraulic pumps is generally characterized by some pulsations and variations in velocity and pressure because a steady uniform flow of liquids is extremely difficult to achieve. It is practically impossible to achieve when the flow of the liquid is first initiated. The hydraulic systems used with hydraulically operated elevators are particularly subject to pulsations and variations in velocity and pressure. This is because the flow of liquid must be frequently started and stopped as the elevator is moved from one position to another, because the positive displacement pumps customarily used inherently cause pulsations and variations in the pressure and velocity of liquids, and because the closed system is of relatively short length.

This invention eliminates pulsations and variations in the pressure and velocity of a liquid even in the closed hydraulic system of a hydraulically operated elevator. Thus, it eliminates the objectionable pulsations and vibrations which have previously been associated with hydraulic elevators.

The invention achieves this improvement in closed hydraulic systems by creating an air cushion each time operating pressure is developed in the closed hydraulic system. This air cushion is created by an air pump whose operation is responsive to changes in hydraulic pressure in the hydraulic system. The liquid in the hydraulic system is exposed directly to the air cushion without interfering air bags, diaphragms or other material separation, as the liquid flows in the system through a baffled muffler containing both the air cushion and a low velocity liquid. In this muffler, objectionable pulsations and pressure variations in the liquid are absorbed.

These and other features and advantages of the invention will be more clearly understood from the following detailed description and accompanying drawings, in which like characters designate corresponding parts in all figures, and in which:

FIG. 1 is a schematic presentation of a hydraulic system having the pulsation absorption device associated with it.

FIG. 2 is a section view of the muffler of the pulsation absorption device taken in a plane perpendicular to the centerline of the pipe section extending through the muffler.

FIG. 3 is a section view of the muffler of the pulsation absorption device taken in a vertical plane containing the centerline of the pipe section extending through the muffler.

FIG. 4 is a section view of the air pump of the pulsation absorption device taken in a vertical plane containing the centerline of the air pump.

FIG. 5 is a schematic presentation of the hydraulic system for a hydraulically operated elevator and shows the pulsation absorption device as part of a hydraulic system of this type.

These figures and the following detailed description

disclose a preferred specific embodiment of the invention, but the invention is not limited to the details disclosed since it may be embodied in other equivalent forms.

The invention is best understood by considering the pulsation absorption system as comprisesd of an air pump 11 and a muffler 12. The air pump 11 is a hollow cylindrical shell 13 open at both ends. Its inside diameter at one end 14 and for a portion of its length extending from this end 14 is greater than its inside diameter at its other end 15 and for the rest of its length extending to end 15. The portion of the cylindrical shell 13 having the larger inside diameter is the hydraulic liquid chamber 16, and the portion of the cylindrical shell 13 having the smaller inside diameter is the air chamber 17. A circular shoulder 18 is formed within the cylindrical shell 13 where the hydraulic liquid chamber 16 joins the air chamber 17. The surface 19 of the shoulder 18 is perpendicular to the centerline of the cylindrical shell 13 and the width of the surface 19 is the difference between the inside diameter of the hydraulic liquid chamber 16 and the inside diameter of the air chamber 17.

An air piston 20 is slidably positioned within the air chamber 17. The outside diameter of the air piston 20 is substantially the same as the inside diameter of the air chamber 17, and the cylindrical surface of the air piston 20 has a sealing ring 21 or other sealing means embedded in it to prevent the passage of air around the air piston 20 as it slidably moves within the air chamber 17.

A liquid piston 22 is slidably positioned within the hydraulic liquid chamber 16. The outside diameter of the liquid piston 22 is substantially the same as the inside diameter of the hydraulic liquid chamber 16 and cylindrical surface of the liquid piston 22 has a sealing ring 23 or other sealing means embedded in it to prevent the passage of liquid around the liquid piston 22 as it slidably moves within the hydraulic liquid chamber 16.

A piston rod 24 joins the air piston 20 and liquid piston 22. The length of the piston rod 24 is selected so that when the liquid piston 22 is at the end 14 of the cylindrical shell 13, the air piston 20 is at the shoulder 18 within the cylindrical shell 13. As the liquid piston 22 moves within the hydraulic liquid chamber 16 from end 14 toward the shoulder 18, the air piston 20 moves within the air chamber 17 from the shoulder 18 toward the end 15 of the cylindrical shell 13.

The end 14 of the cylindrical shell 13 is closed by a liquid cap 25 which is attached to the end 14 by bolts 26. A seal such as an O-ring 27 is placed between the liquid cap 25 and the end 14 of the cylindrical shell 13, to prevent the escape of liquid. The end 15 of the cylindrical shell 13 is closed by an air cap 28 which is attached to the end 15 by bolts 26. An O-ring 27 or other sealing means is used between the air cap 28 and the end 15 of the cylindrical shell 13 to prevent the escape of air.

The liquid cap 25 has a liquid inlet hole 29 extending through it to provide access to the sealed hydraulic liquid chamber 16 and the air cap 28 has an air passage 30 extending through it to provide access to the sealed air chamber 17. A return spring 31 is positioned within the hydraulic liquid chamber 16 surrounding the piston rod 24 and with one end engaging the shoulder 18 and the other end engaging the liquid piston 22.

When liquid under pressure greater than the pressure exerted by the return spring 31 is introduced into the hydraulic liquid chamber 16 through liquid inlet hole 29, the liquid forces the liquid piston 22 toward the shoulder 18 and compresses the return spring 31. When the liquid pressure is reduced below that pressure necessary to compress the return spring 31, the return spring 31 expands and forces the liquid piston 22 toward the liquid cap 25 and the liquid out of the hydraulic liquid chamber 16

through the liquid inlet hole 29. Thus, the motion of the liquid piston 22 and of the piston rod 24 is a function of the increase or decrease in the liquid pressure introduced through the liquid inlet hole 29.

The motion of the piston rod 24 in response to the motion of the liquid piston 22 in the hydraulic liquid chamber 16 results in a corresponding motion of the air piston 20 in the air chamber 17. The air passage 30 contains a check valve 32 of conventional type which permits air to pass through the air passage 30 from the air chamber 17, but will not permit air to pass through the air passage 30 into the air chamber. As a result, the motion of the air piston 20 toward the end 15 of the cylindrical shell 13 as the liquid piston 22 moves toward the shoulder 18 under liquid pressure will cause air to be expelled under pressure from the air chamber 17 through the air passage 30, but the motion of the air piston 20 toward the shoulder 18 as the liquid piston 22 moves toward the liquid cap 25 under return spring 31 pressure will not cause air to enter the air chamber 17 through the air passage 30.

Air enters the air chamber 17 only through an air inlet channel 33 which extends within the wall of the air chamber 17 and the air cap 28 from the hydraulic liquid chamber 16 to the air chamber 17. The air inlet channel 33 has a check valve 34 of conventional type positioned within it which permits air to pass through the air inlet channel 33 from the hydraulic liquid chamber 16 to the air chamber 17, but will not permit air to pass through the air inlet channel 33 from the air chamber 17 to the hydraulic liquid chamber 16.

The air inlet channel 33 opens into the bottom 35 of the hydraulic liquid chamber 16 at a point between the shoulder 18 and the position of the liquid piston 22 when its motion toward the shoulder 18 is stopped by the air piston 20 engaging the air cap 28. This location of the inlet opening 36 of the air inlet channel 33 insures that the liquid piston 22 will not close the inlet opening 36. The location also insures a constant supply of air for the air inlet channel 33 since the space in the cylindrical shell 13 between the liquid piston 22 and the air piston 20 is in direct communication with the atmosphere through an air port 37. The air port 37 is also located in that length of the hydraulic liquid chamber 16 which is not traversed by the liquid piston 22 as it moves toward and away from the shoulder 18.

The drawing of air into the air chamber 17 through the air port 37, a portion of the hydraulic liquid chamber 16 and the air inlet channel 33 and the location of the inlet opening 36 in bottom 35 of the hydraulic liquid chamber 16 makes the air pump 11 self-cleaning and, if a lubricating liquid is used, self-lubricating. In spite of the sealing ring 23, a small amount of liquid will pass around the liquid piston 22 when liquid pressure is applied to the liquid piston 22 and will pool in the bottom 35 of the hydraulic liquid chamber 16. If this pooled liquid is of a lubricating type, it will aid in lubricating the motion of the liquid piston 22 in the hydraulic liquid chamber 16. However, when a vacuum is created in the air chamber 17 by the motion of air piston 20 toward the shoulder 18, the majority of this pooled liquid is drawn into the inlet opening 36 ahead of or with the air in the hydraulic liquid chamber 16.

This drawing of the pooled liquid in the bottom 35 of the hydraulic liquid chamber 16 into the inlet opening 36, the air inlet channel 33 and the air chamber 17 prevents excessive liquid from accumulating in the bottom 35 of the hydraulic liquid chamber 16. Within the air chamber 17, the liquid drawn into air chamber 17 will, if of a lubricating type, serve to lubricate the motion of the air piston 20 in the air chamber 17 and is expelled from the air pump 11 with air each time the air piston 20 is forced toward the air cap 28. Thus, liquid will not accumulate in the air pump 11 and the air pump 11 can be continuously lubricated.

The arrangement of the air passage 30, the air inlet channel 33 and the check valves 32 and 34 causes air to be expelled from the air chamber 17 through the air passage 30 as the liquid piston 22, piston rod 24 and air piston 20 are forced toward the end 15 of the cylindrical shell 13 by liquid pressure and to be drawn into the air chamber 17, through the air inlet channel 33 as the liquid piston 22, piston rod 24 and air piston 20 are driven toward end 14 of the cylindrical shell 13 by return spring 31 pressure. Thus, each time liquid pressure is applied to the air pump 11, the air pump 11 expells a quantity of air under pressure through the air passage 30.

The air expelled from the air pump 11 through the air passage 30 is led by suitable tubing 38 of known type to the muffler 12 of the pulsation absorption system. The muffler 12 is cylindrical in cross-section or of some other suitable shape and closed at both ends. A pipe section 39 extends through the muffler 12. Within the muffler 12, the pipe section 39 is positioned between the bottom 40 of muffler 12 and the centerline of the muffler 12 and with its centerline parallel to the centerline of the muffler 12 in a vertical plane containing both its centerline and the centerline of the muffler 12.

A slot 41 passing completely through the wall of the pipe section 39 extends the length of the pipe section 39 within the muffler 12. This slot 41 is in that portion of the pipe section 39 nearest the bottom 40 of the muffler 12 and is in the same vertical plane as the centerline of the muffler 12 and the centerline of the pipe section 39.

Two baffle plates 42 are positioned in the muffler 12 above the pipe section 39 and the centerline of the muffler 12. These baffle plates 42 are in the same horizontal plane and extend the length of the muffler 12 from the opposite sides of the muffler 12. The extending edges 43 of the baffle plates 42 and the ends of the muffler 12 define a rectangular opening 44 between the portion of the muffler 12 above the horizontal plane in which the baffle plates 42 lie and the rest of the muffler 12. The portion of the muffler 12 above the baffle plates 42 is the air cavity 45 and the rest of the muffler 12 is the liquid cavity 46. The air from the air pump 11 enters the muffler 12 through an air inlet hole 47 which opens into the air cavity 45.

In operation with a typical hydraulic system as shown in FIGURE 1, the pulsation absorption system is associated with a closed hydraulic system by connecting the liquid inlet hole 29 of the air pump 11 to the hydraulic line 48 at a point between a hydraulic pump 49 driven by a belt 53 and a hydraulic check valve 50 and by placing the pipe section 39 in the hydraulic line 48 as a section of the hydraulic line 48 at a point more remote from the hydraulic pump 49 than the check valve 50. The hydraulic pump 49, the check valve 50, and the line 51 joining the liquid inlet hole 29 to the hydraulic line 48 are of known type.

Initially, the closed hydraulic system is filled with liquid under zero hydraulic pressure when the hydraulic pump 49 is not operating. With zero hydraulic pressure on this portion of a hydraulic system, the liquid piston 22 of the air pump 11 is held adjacent to the liquid cap 25, the air chamber 17 is filled with air, and the muffler 12 contains liquid up to the level of the baffle plates 42.

Hydraulic pressure is increased in the hydraulic system and movement of a ram such as that used with a hydraulic elevator is achieved by driving the hydraulic pump 49 with a belt 53 and adding additional liquid to the hydraulic system from a reservoir. When operation of the hydraulic pump 49 is initiated, the hydraulic pressure first begins to develop in the hydraulic line between the hydraulic pump 49 and the check valve 50. As the hydraulic pressure increases, the additional liquid begins to pass through the check valve 50 and into the hydraulic line 48 beyond the check valve 50. The result of this initial flow of liquid through the check valve 50 is to increase the hydraulic pressure on the liquid in the pipe section 39 and cause additional liquid to pass through the

slot 41 into the muffler 12 and raise the level of the liquid in the muffler 12.

However, the increasing hydraulic pressure is being applied to the liquid piston 22 through the line 51 and as the hydraulic pressure increases, it reaches a pressure sufficient to collapse return spring 31 and operate the air pump 11. This forces air into the air cavity 45 of the muffler 12 and places air in the muffler 12 above the liquid. The liquid will continue to rise in the muffler 12 and compress the air until the air pressure equals the hydraulic pressure. When the desired static or operating hydraulic pressure is established throughout the system, the air in the muffler 12 will be trapped in the muffler 12 and will be exerting a pressure on the liquid equal to the hydraulic pressure. If the hydraulic pressure between the check valve 50 and the pump 49 is subsequently reduced to zero, the return spring 31 will force the liquid piston 22 toward the liquid cap 25 and drive the liquid from the air pump 11. With the next application of hydraulic pressure to the hydraulic system, the air pump 11 will again operate. Excess air does not accumulate in the muffler 12 because of repeated operation of the air pump 11 since the flow of liquid through the muffler 12 each time hydraulic pressure is developed between the pump 49 and the check valve 50 absorbs the excess air.

The quantity of air injected by the air pump 11 into the air cavity 45 each time the air pump 11 operates is fixed by the size of the air chamber 17 and the amount of air absorbed by the liquid becomes relatively constant after the hydraulic system has been operated several times. Thus, after several operations of the hydraulic system, the injected air and unabsorbed air trapped in the muffler 12 with each application of hydraulic pressure to the hydraulic system become relatively constant in quantity. For a fixed operating hydraulic pressure, this quantity of air will occupy the same space in the muffler 12 each time the operating hydraulic pressure is applied to the hydraulic system.

The baffle plates 42 are positioned within the muffler 12 so that the space above them is substantially equal to space occupied by the injected air and unabsorbed air when the liquid in muffler 12 is under operating hydraulic pressure. Thus, when the hydraulic system is under operating pressure, the liquid cavity 46 of the muffler 12 is filled with liquid and the air cavity 45 is filled with air. The air and the liquid in the muffler 12 are in contact through the rectangular opening 44.

The air trapped in the air cavity 45 has greater compressibility than the liquid in the hydraulic system, and its resiliency in combination with the low velocity liquid in the liquid cavity 46 results in a pulsation absorption system which effectively absorbs pulsations and pressure variations in the hydraulic liquid as it passes through the pipe section 39. The pulsation absorption system has proved particularly effective in connection with hydraulically operated elevator systems such as that schematically shown in FIG. 5.

The elevator system is operated by oil pressure and has a motor 52, an oil pump 49 driven by a belt 53, a control valve 54, an oil check valve 50, a leveling valve 55, a lowering valve 56 and controls of conventional known type and arranged in the usual manner. The pump 49 draws oil from a reservoir through its suction intake 57 and the hydraulic line 48 leads to the ram by which the elevator car is moved. The air pump 11 is connected to the control valve 54 and the muffler 12 is positioned in the hydraulic line 48. The elevator is operated in the usual manner and the closing of the control valve 54 applies hydraulic pressure to the air pump 11 at the same time it applies hydraulic pressure to the hydraulic line 48 and starts upward elevator motion. The resulting air cushion in the muffler 12 absorbs pulsations and pressure variations and prevents undesirable vibration of the elevator car as it moves upward.

When the elevator car stops after it has moved upward, the elevator car is maintained in position by the closed oil check valve 50 and closed lowering valve 56. The motor 52 is stopped and the hydraulic pressure on the oil pump 49 side of the oil check valve 50 drops to zero. This permits the air pump 11 to return to position for pumping additional air into the muffler 12. The elevator car is lowered by opening the lowering valve 56 and releasing oil through it into the reservoir through pipe 58. The released oil carries absorbed air with it to the reservoir and the muffler 12 is now ready to receive an additional quantity of air with the next application of hydraulic pressure from the pump 49.

If the elevator car moves upward several times before being lowered, the air pump 11 will operate each time the elevator car moves upward from one floor to another. However, this does not result in an excessive amount of air in the air cavity 45 of the muffler 12 since the additional oil passes through the pipe section 39 with each additional floor travelled by the elevator car absorbs most of the excess air as the elevator moves upward and carries it back to the reservoir when the elevator car is completely lowered. Moreover, the fact that the oil in the muffler 12 is always under the pressure exerted by the weight of the elevator car and ram and that the unabsorbed air in the muffler 12 is always under some hydraulic pressure does not alter the general operation of the pulsation absorption device 10 described above. The air pump 11 operates with the hydraulic pressure of the hydraulic system and will force air into the air cavity 45 of the muffler 12 even if oil in the muffler 12 is under hydraulic pressure.

It will be obvious to those skilled in the art that many variations may be made in the embodiments here chosen for the purpose of illustrating the present invention without departing from the scope thereof as defined by the appended claims.

What is claimed as invention is:

1. A pulsation absorption system for absorbing pulsations of hydraulic pressure in a hydraulic line with a particular hydraulic pressure, said pulsation absorption device comprising, in combination, a closed cylindrical shell having two ends, a bottom, a centerline, and a top through which an air inlet hole passes; a pipe section extending through the cylindrical shell between the centerline of the cylindrical shell and the bottom of the cylindrical shell, said pipe section having its centerline parallel to and in the same vertical plane as the centerline of the cylindrical shell, having its ends extending outside the cylindrical shell and inserted into the hydraulic line, and having a slot extending through that portion of its length within the cylindrical shell and along that side nearest the bottom of the cylindrical shell; two baffle plates positioned within the cylindrical shell above the centerline of the cylindrical shell, the said two baffle plates extending from opposite sides of the cylindrical shell, lying in the same horizontal plane, and defining with the two ends of the cylindrical shell a rectangular opening and with the two ends and the top of the cylindrical shell a volume; and means responsive to the particular hydraulic pressure in the hydraulic line for injecting through the air inlet hole that volume of air necessary to fill the volume defined by the two baffle plates and the two ends and the top of the cylindrical shell each time the particular hydraulic pressure is developed within the hydraulic line.

2. A muffler for absorbing pulsations of hydraulic pressure in a hydraulic line with an air cushion, said muffler comprising, in combination, a closed cylindrical shell having two ends, a bottom, a centerline, and a top through which an air inlet hole passes; a pipe section extending through the cylindrical shell between the centerline of the cylindrical shell and the bottom of the cylindrical shell, said pipe section having its centerline parallel to and in the same vertical plane as the centerline of the cylindrical shell, having its ends extending outside the cylindrical shell and adapted for insertion of the pipe

section into the hydraulic line, and having a slot extending through that portion of its length within the cylindrical shell and along that side nearest the bottom of the cylindrical shell; two baffle plates positioned within the cylindrical shell above the centerline of the cylindrical shell, the said two baffle plates extending from opposite sides of the cylindrical shell, lying in the same horizontal plane, and defining with the two ends of the cylindrical shell a rectangular opening and with the two ends and the top of the cylindrical shell a volume; and means for injecting a quantity of air through the air inlet hole substantially equal to the volume defined by the two baffle plates and the two ends and the top of the cylindrical shell.

3. A muffler for absorbing pulsations of hydraulic pressure in a hydraulic line with an air cushion of a fixed volume, said muffler comprising, in combination, a closed cylindrical shell having two ends, a bottom, a centerline, and a top; a pipe section extending through the cylindrical shell between the centerline of the cylindrical shell and the bottom of the cylindrical shell, said pipe section having its centerline parallel to and in the same vertical plane as the centerline of the cylindrical shell, having its ends extending outside the cylindrical shell and adapted for insertion of the pipe section into the hydraulic line, and having a slot extending through that portion of its length within the cylindrical shell and along that side nearest the bottom of the cylindrical shell; and two baffle plates positioned within the cylindrical shell above the centerline of the cylindrical shell, the said two baffle plates extending from opposite sides of the cylindrical shell, lying in the same horizontal plane, and defining with the two ends of the cylindrical shell a rectangular opening and with the two ends and the top of the cylindrical shell a volume equal to the fixed volume of the air cushion.

4. A muffler for absorbing pulsations of hydraulic pressure in a hydraulic line with a volume of air, said muffler comprising, in combination, a shell having two ends and a top; a section of the hydraulic line extending through the shell and having a slot extending through a portion of its length within the shell; means for introducing the volume of air into the shell; and two baffle plates positioned within the shell and enclosing with the two ends and the top of the shell the volume of air.

5. A muffler for absorbing pulsations of hydraulic pressure in a hydraulic line with air, said muffler comprising, in combination, a cylindrical shell having two ends and a top through which an air inlet hole passes; a pipe section extending through the cylindrical shell, said pipe section having its ends extending outside the cylindrical shell and adapted for insertion of the pipe section into the hydraulic line and having a slot extending through a portion of its length within the cylindrical shell; two baffle plates positioned within the cylindrical shell, the said two baffle plates extending from opposite sides of the cylindrical shell and defining with the two ends and the top of the cylindrical shell a volume; and means for injecting air through the air inlet hole into the volume defined by the two baffle plates and the two ends and the top of the cylindrical shell.

6. A self-lubricating pump for ejecting a fixed quantity of air in response to the hydraulic pressure of a liquid in a hydraulic line greater than a particular hydraulic pressure comprising, in combination, a cylindrical horizontally extending shell having a first end, a second end, a centerline extending between the first end and the second end, a cylindrical liquid chamber extending into the cylindrical shell from the first end of the cylindrical shell with its centerline coinciding with the centerline of the cylindrical shell, an air port extending through the cylindrical shell into that portion of the liquid chamber most remote from the first end of the cylindrical shell, a cylindrical air chamber extending through the cylindrical shell between the second end of the cylindrical shell and the liquid chamber with its centerline coinciding with the centerline of the liquid chamber and the centerline of the cylindrical shell, said liquid chamber and said air chamber having different diameters so as to form a shoulder within the cylindrical shell where the air chamber joins the liquid chamber; an air channel defined by said shell and extending between the lower-most portion of the liquid chamber adjacent said shoulder and the air chamber; a liquid piston slidably positioned within the liquid chamber; an air piston slidably positioned within the air chamber; a piston rod extending within the cylindrical shell between the liquid piston and the air piston with its centerline coinciding with the centerline of the cylindrical shell; a spring positioned around the piston rod and extending between the liquid piston and the shoulder within the cylindrical shell, said spring exerting pressure on the liquid piston equal to the particular hydraulic pressure; a liquid cap fixedly attached to the first end of the cylindrical shell across the liquid chamber, said liquid cap having a liquid inlet hole extending through it and into the liquid chamber; an air cap fixedly attached to the second end of the cylindrical shell across the air chamber, said air cap having an air passage extending through it and into the air chamber; a first check valve located within the air channel and positioned to permit the passage of air only from the liquid chamber to the air chamber; a second check valve located within the air passage and positioned to permit the passage of air only from the air chamber; and means for placing the liquid inlet hole in communication with the liquid in the hydraulic line.

7. A self-lubricating pump for ejecting a fixed quantity of air in response to the particular hydraulic pressure of a liquid in a hydraulic line comprising, in combination, a horizontal cylindrical shell having a first end, a second end, a cylindrical liquid chamber extending into the cylindrical shell from the first end of the cylindrical shell, an air port extending through the cylindrical shell into that portion of the liquid chamber most remote from the first end of the cylindrical shell, an air chamber extending through the cylindrical shell between the second end of the cylindrical shell and the liquid chamber and having an air channel extending between it and the lowermost portion of the liquid chamber most remote said first end through the cylindrical shell; a liquid piston slidably positioned within the liquid chamber; an air piston slidably positioned within the air chamber; a piston rod extending between the liquid piston and the air piston; a spring positioned around the piston rod and exerting pressure on the liquid piston equal to the particular hydraulic pressure; a liquid cap fixedly attached to the first end of the cylindrical shell across the liquid chamber said liquid cap having a liquid inlet hole extending through it into the liquid chamber; an air cap fixedly attached to the second end of the cylindrical shell across the air chamber, said air cap having an air passage extending through it into the air chamber; a first check valve located within the air channel and positioned to permit the passage of air only from the liquid chamber to the air chamber; a second check valve located within the air passage and positioned to permit the passage of air only from the air chamber; and means for placing the liquid inlet hole in communication with the liquid in the hydraulic line.

8. A self-lubricating pump for ejecting a fixed quantity of air in response to the particular hydraulic pressure of a liquid in a hydraulic line comprising, in combination, a horizontally positioned cylindrical shell having a cylindrical liquid chamber with an air port and a liquid inlet hole extending into it through the cylindrical shell, a cylindrical air chamber with an air passage extending into it through the cylindrical shell, and an air channel extending between the bottom portion of the liquid chamber adjacent said air chamber and the air chamber; a first piston positioned in the liquid chamber for slidable motion with reference to the liquid inlet hole; a second

piston positioned in the air chamber for slidable motion with reference to the air passage; a piston rod extending between the first piston and the second piston; a spring engaging the first piston and urging the first piston toward the liquid inlet hole with a force equal to the particular hydraulic pressure; a first check valve located within the air channel and positioned to permit the passage of air only from the liquid chamber to the air chamber; a second check valve located within the air passage and positioned to permit the passage of air only from the air chamber; and means for placing the liquid inlet hole in communication with the liquid in the hydraulic line.

9. A self-lubricating pump for ejecting a fixed quantity of air in response to a particular hydraulic pressure of a liquid in a hydraulic line comprising, in combination, a closed horizontally positioned cylindrical shell having a hollow cylindrical chamber within it, a liquid inlet hole passing through its first end into the cylindrical chamber, an air passage passing through its second end into the cylindrical chamber, and an air port passing through it intermediate its first end and second end and into the cylindrical chamber; a first piston positioned within the cylindrical chamber for slidable motion toward and away from the first end of the cylindrical shell; a second piston positioned within the cylindrical chamber for slidable motion toward and away from the second end of the cylindrical shell; a piston rod extending between the first piston and the second piston; a spring positioned within the cylindrical chamber and having one end fixed and the other end engaging the first piston and urging the first piston toward the first end of the cylindrical shell with a pressure equal to the particular hydraulic pressure; and means for introducing liquid pooled between said first piston and said second piston into said air chamber for lubrication.

10. A self-lubricating pump for ejecting a fixed quantity of air in response to particular hydraulic pressure of a liquid in a hydraulic line comprising, in combination, a closed shell having a hollow chamber within it, a liquid inlet hole passing through its first end into the chamber, an air passage passing through its second end into the chamber; a first piston positioned within the chamber for slidable motion toward and away from the first end of the shell; a second piston positioned within the chamber for slidable motion toward and away from the second end of the shell; a piston rod extending between the first piston and the second piston; means for urging the first piston toward the first end of the shell with a pressure equal to the particular hydraulic pressure; and means for introducing liquid pooled in said chamber between said first and second pistons into said chamber adjacent said second end.

11. A pulsation absorption system for absorbing pulsations of hydraulic pressure in a hydraulic line having a particular hydraulic pressure, said pulsation absorption system comprising, in combination, a cylindrical shell having two ends, a bottom, a centerline, and a top through which an air inlet hole passes; a pipe section extending through the cylindrical shell between the centerline of the cylindrical shell, said pipe section having its centerline parallel to and in the same vertical plane as the centerline of the cylindrical shell, having its ends extending outside the cylindrical shell and inserted into the hydraulic line, and having a slot extending through that portion of its length within the cylindrical shell and along that side nearest the bottom of the cylindrical shell; two baffle plates positioned within the cylindrical shell above the centerline of the cylindrical shell, said two baffle plates extending from opposite sides of the cylindrical shell, lying in the same horizontal plane, and defining with the two ends of the cylindrical shell a rectangular opening and with the two ends and the top of the cylindrical shell a first volume; a tube having a hollow chamber within it, a first end, a second end, a liquid inlet hole passing through its first end from the hollow chamber, and an air passage passing through its second end from the hollow chamber; a first piston positioned within the said hollow chamber for slidable motion toward and away from the said first end of the tube; a second piston positioned within the hollow chamber for slidable motion toward and away from the said second end of the tube, said second piston defining when most remote from the second end of the said tube a cavity within the hollow chamber which has a volume substantially equal to the said first volume; means for causing air to enter the said cavity; a piston rod fixedly extending between the first piston and the second piston; means for urging the first piston toward the first end of the tube with a pressure slightly less than the particular hydraulic pressure; means for operatively connecting the liquid inlet hole with the hydraulic line; and means for operatively connecting the air passage to the said inlet hole.

12. A pulsation absorption system for absorbing pulsations of hydraulic pressure in a hydraulic line containing a liquid at a particular pressure, said pulsation absorption system comprising, in combination, a cylindrical shell having two ends and a top through which an air inlet hole passes; a pipe section extending through the cylindrical shell, said pipe section being inserted into the hydraulic line and having a slot extending in that portion of its length within the cylindrical shell through which the said liquid enters the cylindrical shell; two baffle plates positioned within the cylindrical shell above the pipe section, said baffle plates defining with the two ends of the cylindrical shell an opening and with the two ends and the top of the cylindrical shell a first volume; a gas substantially filling the said first volume; a tube having a hollow chamber within it, a liquid inlet hole extending from the hollow chamber, and an air passage extending from the hollow chamber; a first piston positioned within the said hollow chamber for slidable motion toward and away from the liquid inlet hole; a second piston positioned within the hollow chamber for slidable motion toward and away from the air passage, said second piston defining when most remote from the air passage a cavity within the hollow chamber which has a volume equal to the volume of the gas in the said first volume absorbed by the liquid in the cylindrical shell; means for releasing a gas into the said cavity; a piston rod extending between the first piston and the second piston; means for urging the first piston toward the liquid inlet hole with a pressure slightly less than the particular hydraulic pressure; means for operatively connecting the liquid inlet hole with the hydraulic line; and means for operatively connecting the air passage to the air inlet hole.

13. A pulsation absorption system for absorbing pulsations of hydraulic pressure in a hydraulic line containing a liquid at a particular hydraulic pressure, said pulsation absorption system comprising, in combination, a cylindrical shell having an air inlet hole extending through it; a pipe section in the cylindrical shell, said pipe section being in the hydraulic line and having a slot extending through it to permit the said liquid to enter the cylindrical shell; baffle plates positioned within the cylindrical shell to define an opening and a first volume; a gas substantially filling the said first volume and engaging the liquid in the cylindrical shell through the said opening; a tube having a hollow chamber within it, a liquid inlet hole extending from the hollow chamber, and an air passage extending from the hollow chamber; a first piston positioned within the said hollow chamber for slidable motion toward and away from the liquid inlet hole; a second piston positioned within the hollow chamber for slidable motion toward and away from the air passage, said second piston defining when most remote from the air passage a cavity within the hollow chamber which has a volume substantially equal to the volume of the said gas absorbed by

the liquid in the cylindrical shell; means for releasing a gas into the said cavity; a piston rod extending between the first piston and the second piston; means for urging the first piston toward the liquid inlet hole with a pressure slightly less than the particular hydraulic pressure; means for operatively connecting the liquid inlet hole with the hydraulic line; and means for operatively connecting the air passage to the air inlet hole.

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LAURENCE V. EFNER, *Primary Examiner.*

ROBERT M. WALKER, *Examiner.*