Dec. 22, 1959 J. H. BORDEN 2,918,091

HYDRAULIC DAMPENERS

Filed Jan. 15, 1958 2 Sheets-Sheet 1

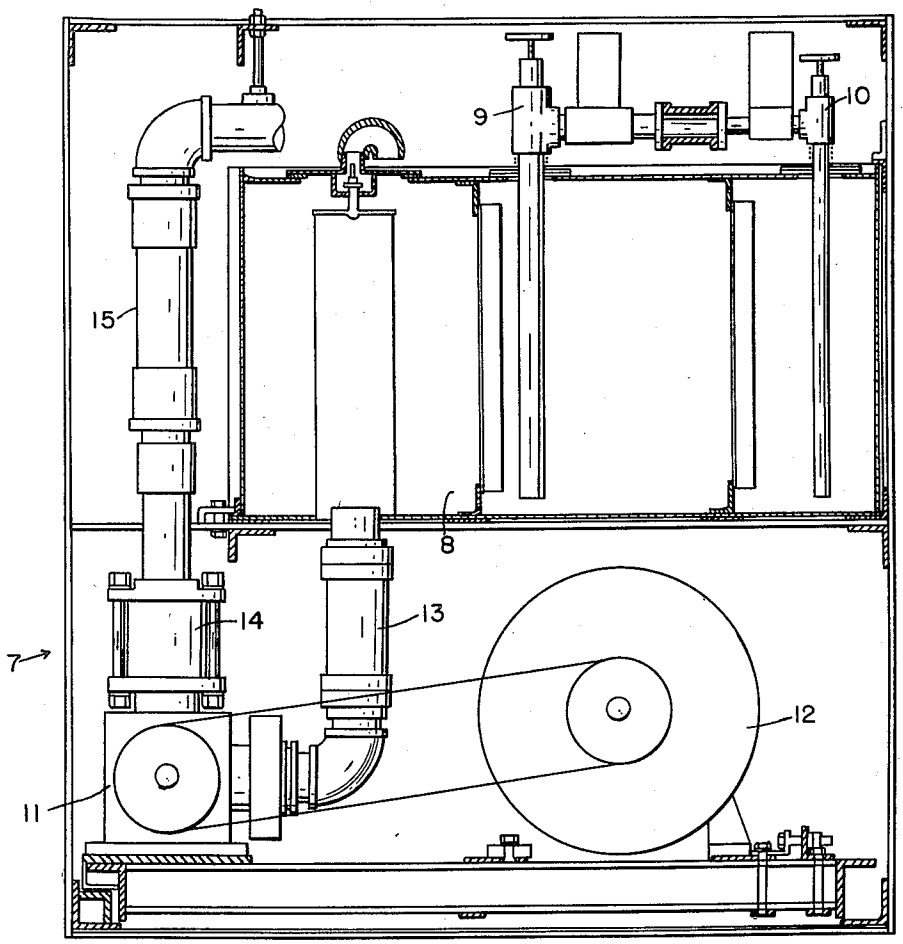


Fig - I

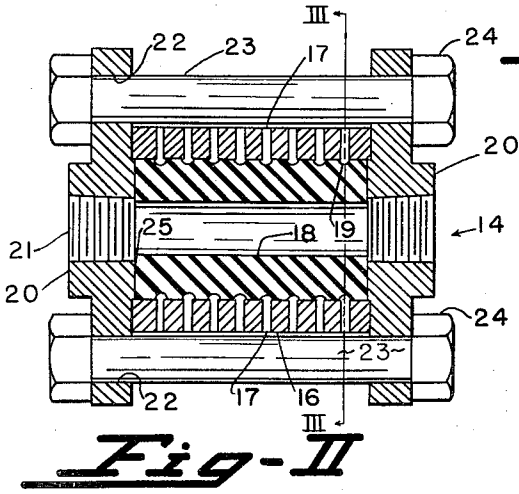


Fig - II

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HYDRAULIC DAMPENERS

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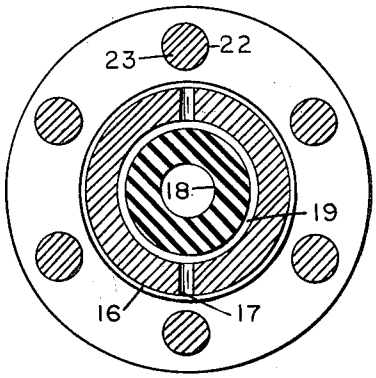


Fig III

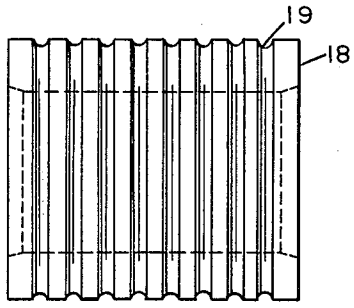


Fig IV

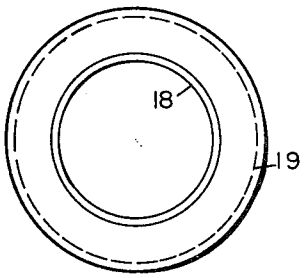


Fig V

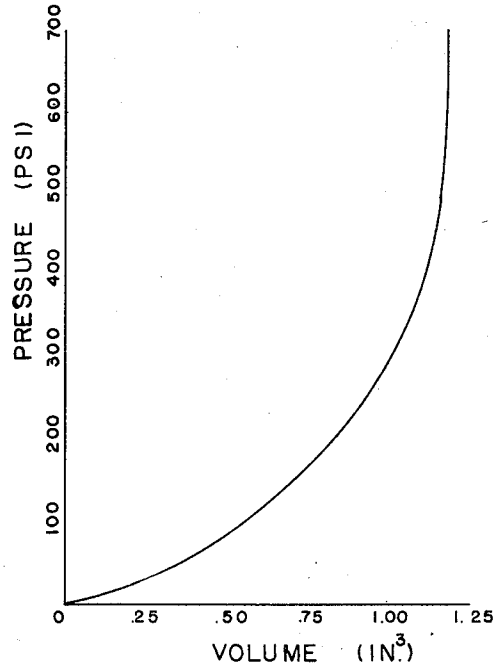


Fig VI

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2,918,091

HYDRAULIC DAMPENERS

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Application January 15, 1958, Serial No. 709,052

6 Claims. (Cl. 138—30)

This invention relates to hydraulic dampeners and more particularly to dampeners adapted to be placed directly in a high pressure hydraulic line between a pressure source and a pressure load wherein detrimental pressure pulsations are encountered.

Hydraulic elevator systems are typical of the source-load combinations giving rise to pressure pulsations which the present invention alleviates and essentially eliminates.

The type of hydraulic elevator system to which this invention appertains comprises a cylinder with an axially movable piston therein, the piston being mechanically connected to an elevator car, a pump, and appropriate piping and valving to supply oil or other liquid under pressure to the cylinder on one side of the piston for lifting the elevator car, and to release the liquid from the cylinder for permitting the car to descend.

The weight of the elevator car which is borne by the piston keeps the liquid in the cylinder and piping under constant pressure. This invention recognizes that a confined body of liquid under pressure, when subjected to pumping by positive displacement pumps, behaves in a manner that is different from the manner in which unconfined bodies of liquid behave when subjected to such pumping. This invention recognizes that each stroke of a positive displacement pump working against the head of the confined body of liquid supporting an elevator car sets up a pressure wave which may be quite disproportionate to the modicum of liquid that is added to the confined body of liquid, and that the pressure waves thus generated are different from and have effects that transcend the effects of back and forth bodily movements of unconfined fluids, being somewhat analogous in this respect to shock waves.

Pressure waves generated in the substantially in compressible confined liquid speed through the liquid to the piston, piston rod and other connections to the elevator car and cause throbbing or vibration which is liable to be unpleasant to persons riding the car and is liable to be highly deleterious to commodities being carried thereby.

It is the practice in this art to minimize what have been regarded as pulsations in hydraulic elevator systems by reverting to the use of types of pumps that set up impulses which are less pronounced than the impulses set up by pumps having reciprocating plungers, but all types of positive displacement pumps create pressure waves in confined liquid which are transmitted through the incompressible liquid to the piston and result in vibration of the elevator car.

Various expedients have been employed which have imperfect damping effects upon this harmful vibration. Among such expedients are "domes" containing air (with or without flexible cellular substances such, for example, as sponge rubber) or elastic diaphragms or stretchable sections of hose. The effects of all such expedients are generally unsatisfactory and most of them are troublesome and subject to the development of leaks and to rapid deterioration.

I have discovered means for avoiding significant or perceptible propagation of pressure waves set up by pumps working against the "heads" encountered in hydraulic elevator systems. This dampening means is leak proof and gives promise of indefinite endurance.

It is an object of this invention to provide a device which when installed in a hydraulic line leading from a pump to a cylinder and lifting piston of a hydraulic elevator system curtails pressure waves that emanate from the pump, and passes the energy of such waves along as an even flow of power.

It is a further object to provide a device which will smooth out such waves without constricting the flow of, or causing turbulence in, liquid moving therethrough.

It is a further object to provide such a device which can readily be installed by persons having ordinary skill in the art whether or not such persons understand the theory of operation of the device.

A further object is to provide such a device which when installed is leak proof and which may be expected to function indefinitely without repair or replacement.

And still a further object is to provide a device of this character which is simple in structure and low in cost and which, when installed, occupies little space.

Other objects and advantages of the invention will be apparent upon perusal of the following description as illustrated by the accompanying drawings, in which:

Fig. I is a schematic layout of a sub-assembly of a hydraulic elevator system incorporating the invention;

Fig. II is an axial sectional view of a pressure wave neutralizing unit embodying the invention;

Fig. III is a sectional view taken substantially on the line III—III of Fig. II;

Fig. IV is a side elevational view on an enlarged scale of an element of the pulsation neutralizing unit shown in Figs. II and III;

Fig. V is an end view of the element illustrated in Fig. IV; and

Fig. VI is a graph showing increases in volumetric capacity of the unit illustrated in Figs. II and III, and changes in pressure required to cause such increases in volume plotted are coordinate axes of abscissas and ordinates.

These drawings and the following description illustrate and describe a preferred form of the invention but are not intended to limit its scope.

As described herein and illustrated in the accompanying drawings the invention is incorporated in a hydraulic elevator system sub-assemblage on a frame **7**. The sub-assemblage can be fabricated in lots at a factory and carried in stock. The sub-assemblage includes the frame **7**, an oil reservoir **8**, with starter and relief valves **9** and **10**, a positive displacement pump **11**, a driving motor **12**, a conduit **13** leading from the reservoir **8** to the pump **11**, a pressure wave neutralizing unit **14** and piping **15** leading from the pressure wave neutralizing unit to a hydraulic cylinder, not shown, containing a lifting piston, not shown.

The positive displacement pump **11** may be of any desired type but preferably is of the type that is commonly known as a gear pump. The pump when driven by the motor **12** takes oil or another suitable liquid from the reservoir **8** and forces it through the unit **14** and piping **15** to a hydraulic cylinder which contains a lifting piston that is mechanically connected to an elevator car to be lifted. The reservoir **8**, valves **9** and **10**, positive displacement pump **11**, motor **12**, and conduit **13** are not separately new. These parts are therefore described and illustrated only in such detail as to make clear their cooperative relationship in the new sub-assemblage. The hydraulic lifting piston, the elevator car and the connections between the plunger and elevator

ear may be of any preferred existing type and they therefore are not shown in the drawings or described in this specification.

The pressure wave neutralizing unit **14** includes a rigid casing that constitutes a section of the piping leading from the pump to the cylinder that contains the lifting piston. The casing is lined with a liner of resilient material which is resistant to deterioration by and impervious to the liquid in the system, the physical characteristics of which, and the conditioning of which, when assembled in the casing, are such that it is capable of substantially neutralizing or eliminating pressure waves which have been propagated from the pump to the vicinity of the liner, and thus is capable of curtailing the propagation so that the pressure waves have substantially no impact upon the cylinder or lifting piston. The exact character of the liner material and the liner construction are susceptible of variation to obtain optimum results in various uses of the dampener. Elevator systems often employ an oil derived from petroleum and operate with maximum pressures in the range of 200 to 300 pounds per square inch. In such systems. I have found it advantageous to employ a nonporous, volumetrically incompressible, resilient material which is resistant to deterioration by petroleum oils and is essentially impervious thereto. Neoprene is particularly advantageous in this application.

The casing of the unit **14** is a tube **16**, preferably of seamless steel. Extending along opposite sides of the tube **16** are rows of perforations **17**. Within the tube **16** is a generally cylindrical resilient liner **18**. Around the exterior of the liner **18** is a series of circumferential grooves **19** each of which, when the liner and tube are assembled, will register with two perforations **17**, through opposite sides of the tube **16**.

Fitted upon each end of the tube-liner assembly **16—18** is a clamping end cap **20** having a threaded central opening **21** adapted to receive a threaded pipe end and having a plurality of bolt holes **22** through which pass clamping bolts **23**. The cylindrical liner **18** when not under axial pressure may be slightly longer than the tube **16** so that when clamping nuts **24** are turned up to force the end caps **20** into tight engagement with the ends of the seamless steel tube **16** bosses **25** telescope into the tube to force the ends of the liner **18** toward each other, whereby the liner is subjected to columnar stress. The ends of the liner **18** and the clamping faces of the clamping caps **20** and bosses **25** are planar and smooth so that the joints between the liner and the clamping caps are oil tight even when the oil within the system is under low pressure.

The columnar stress of the liner maintains the seal of the dampener to the system when the liquid pressure is relieved, and conditions the unit **14** for neutralizing pressure waves, propagated from the pump **11** into the noncompressible liquid that passes through the unit. The resilience of the liner **18** smooths the pressure within the system by yielding in response to a pressure surge or impact to store energy during the rising portion of a pressure wave cycle and by releasing energy to the liquid as the pressure wave subsides and the liner tends to return to its original configuration. Since the liner material is essentially volumetrically incompressible, it yields by displacement into its peripheral grooves **19**. This mode of operation is desirable since it has been found that compressible materials tend to admit the incompressible liquid into their voids and thereby become incompressible when those voids are filled. Thus, under high pressure utilization the present construction avoids the deterioration incidental to the gradual elimination of the cushioning voids of conventional dampeners and air domes resulting from the diffusion of the liquid into those voids and the entraining of the gas in the voids into the liquid system.

In order to avoid the compression of gas between the reinforcing outer shell or casing **16** and the liner **18** as the liner material is displaced to fill the peripheral grooves **19** and to avoid the accumulation of any liquid which may escape from the system and enter these grooves thereby filling them, the grooves are vented to the atmosphere through the perforations in the sides of tube **16**. These perforations register with grooves **19** when caps **20** are clamped in position. The grooves also appear to counteract any tendency of the liner to collapse or buckle when clamped between the clamping end caps, and appear to improve the functioning of the liner in curtailing propagation of pressure waves through the liquid in the system. The thick, rigidly confined, precompressed liner has the right properties and the right formation and the right conditioning to eliminate pressure waves from liquid that it confines under pressure.

The dimensions of the tube **16**, the perforations **17**, the liner **18**, and the grooves **19** are not extremely critical. Generally the reinforcing outer casing should be designed with an adequate safety factor in the light of the maximum pressures attainable in the liquid. The thickness of the walls of the liner **18** and the available volume for distortion of the liner within the casing **16** are dictated by the volumetric changes of a pulsation creating the pressure wave, the pressure levels and the hardness and resilience of the liner material. Thus the additional volume of the grooves available when the liquid is at working pressure should be of the order of the volume of liquid injected into the system in one cycle of a pump operation creating a pressure pulsation in the system. If a relatively stiff material is employed, the liner walls can be thinner than with a pliant material. A stiff material will sustain larger grooves than a pliant material; hence, where a given volume is to be available, a pliant material may be employed with a large number of grooves of small cross section while stiff material might require only a few grooves of large cross section.

Fig. VI illustrates the change in volume as a function of applied pressure for a dampener of the type illustrated in Figs. I through V for an elevator system operating with a maximum pressure in the range of 200 to 300 p.s.i. In this range it will be noted that the curve is relatively flat and that a large volume change is absorbed by the unit for a relatively small change in pressure. The curve shown was derived from a unit of 60 durometer neoprene having an axial length of 2½ inches, an outside diameter of 3⅛ inches, an inside diameter of 1⅝ inches and 5 circumferential grooves on ½ inch centers and having a semicircular cross section of ¼ inch diameter. Such a unit is compressed axially by about 1/16 of an inch to effect an end seal to the dampener caps when the liquid pressure is relieved.

The form of device described herein and illustrated in the accompanying drawings is to be regarded as exemplary only and it is to be understood that the invention encompasses modifications within the spirit and scope of the subjoined claims.

Having described the invention, I claim:

1. Means for curtailing the propagation of pressure waves through liquid traveling under pressure in a hydraulic elevator system comprising, in combination, a rigid metallic tube having planar ends and a plurality of longitudinally extending rows of perforations along its sides, a thick generally cylindrical liner within said tube, said liner being molded of neoprene artificial resin of approximately 60 durometer hardness, said liner when unstressed being slightly longer than said tube and having planar ends and a plurality of circumferential grooves around its exterior, a pair of clamping end caps adapted to engage the ends of said liner and adapted when drawn toward each other to subject said liner to columnar stress within said tube, the grooves of said liner when it is so stressed within said tube registering with and cooperating with said perforations to vent air from between said tube and said liner, a plurality of clamping

bolts passing through openings in said clamping end caps for drawing said clamping end caps toward each other, and means for directing such liquid to travel axially through said liner.

2. Means for curtailing the propagation of pressure waves through liquid traveling under pressure in a hydraulic elevator system comprising, in combination, a rigid metallic tube having a plurality of perforations along its sides, a thick generally cylindrical liner within said tube, said liner being of liquid impervious, resilient material which is resistant to the liquid of the hydraulic system, said liner when unstressed being slightly longer than said tube and having a plurality of circumferential grooves around its exterior, a pair of clamping end caps adapted to engage the ends of said liner and adapted when drawn toward each other to subject said liner to columnar stress within said tube, the grooves of said liner when it is so stressed within said tube coperating with said perforations to vent air from between said tube and said liner, a plurality of clamping bolts drawing said clamping end caps toward each other, and means whereby such liquid is directed to traveling axially through said liner.

3. Means for curtailing the propagation of pressure waves through liquids traveling under pressure in a hydraulic elevator system comprising, in combination, a rigid metallic tube having perforations along its sides, a thick generally cylindrical liner within said tube, said liner being of artificial resin of approximately 60 durometer hardness, said liner having planar ends and a plurality of circumferential grooves around its exterior, a pair of clamping end caps adapted to engage the ends of said liner and adapted when drawn toward each other to subject said liner to columnar stress within said tube, the grooves of said liner when it is so compressed within said tube registering with and cooperating with said perforations to vent air from between said tube and said liner, and a plurality of clamping bolts passing through openings in said clamping end caps for drawing said clamping end caps toward each other.

4. Means for curtailing the propagation of pressure waves through liquid traveling under pressure employed in a hydraulic elevator system comprising, in combination, a rigid metallic tube having a plurality of perforations through its sides, a thick generally cylindrical liner within said tube, said liner being molded of neoprene, said liner when unstressed being slightly longer than said

tube and having a plurality of depressions around its exterior, means for subjecting said liner to columnar stress within said tube, the depressions of said liner when it is so subjected to columnar stress within said tube registering with and cooperating with said perforations to vent air from between said tube and said liner, and means whereby such liquid is directed to travel axially through said liner.

5. Means for curtailing the propagation of pressure waves through liquid traveling under pressure in a hydraulic elevator system comprising, in combination, a rigid metallic tube having perforations along its sides, a thick generally cylindrical liner within said tube, said liner being of artificial resin, said liner having a plurality of circumferential grooves around its exterior, a pair of clamping end caps adapted to engage the ends of said liner and adapted when drawn toward each other to subject said liner to axial pressure within said tube, the grooves of said liner when it is so compressed within said tube cooperating with said perforations to vent air from between said tube and said liner, a plurality of clamping bolts drawing said clamping end caps toward each other, and means whereby such liquid is directed to travel axially through said liner.

6. Means for curtailing the propagation of pressure waves through liquids traveling under pressure in a hydraulic elevator system comprising, a rigid metallic tube having perforations along its sides, a thick generally cylindrical liner within and having a major portion of its outer surface conform to the inner surface of said tube, said liner being of liquid impervious material which is resistant to the liquid of the hydraulic system and having indentations in its outer walls, and means subjecting said liner to compressive columnar stresses within said tube, said indentations being in registry with said perforations when said liner is so stressed.

References Cited in the file of this patent

UNITED STATES PATENTS

435,927	Ginty	Sept. 9, 1890
1,106,572	Loepsinger	Aug. 11, 1914
2,359,112	Hymans	Sept. 26, 1944
2,755,820	Taylor	July 24, 1956
2,808,070	Malsbary	Oct. 1, 1957

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,918,091 December 22, 1959

Joseph H. Borden

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 42, for "plotted are" read -- plotted re --.

Signed and sealed this 5th day of July 1960.

(SEAL)
Attest:
KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents