May 26, 1970 L. McDONALD 3,514,037

PULSE JET AMPLIFIER

Filed Jan. 26, 1968 2 Sheets-Sheet 1

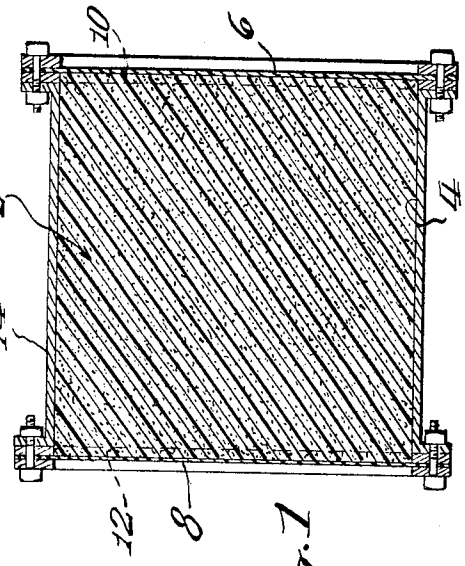


Fig. 1

Fig. 4

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Fig. 2

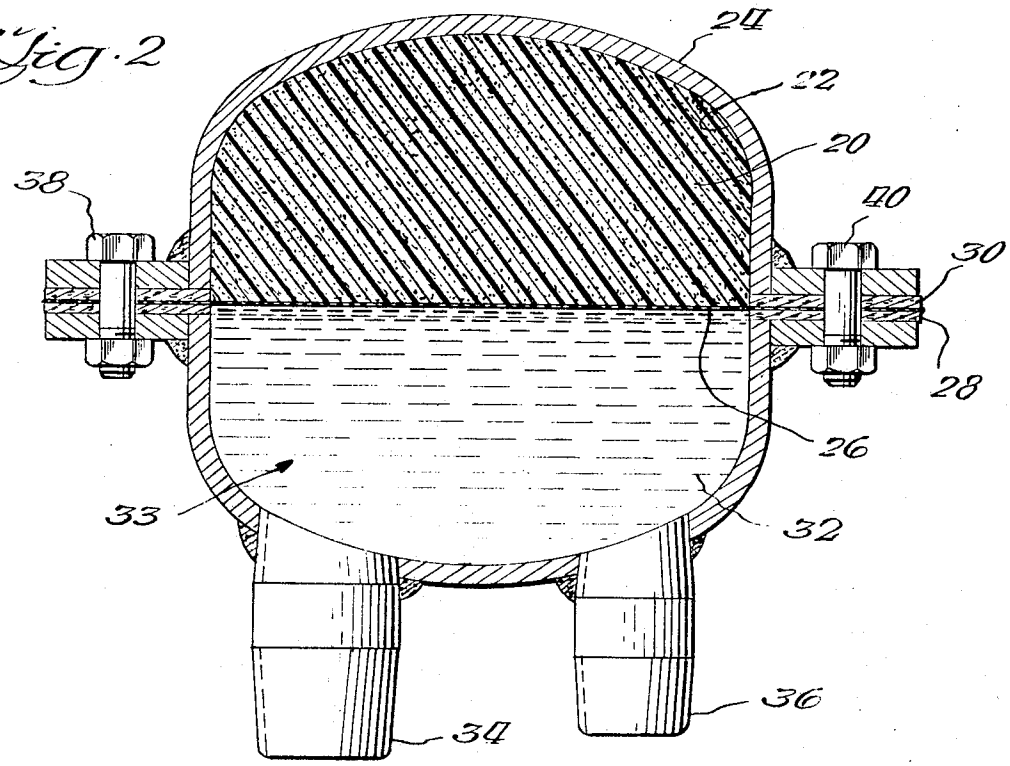
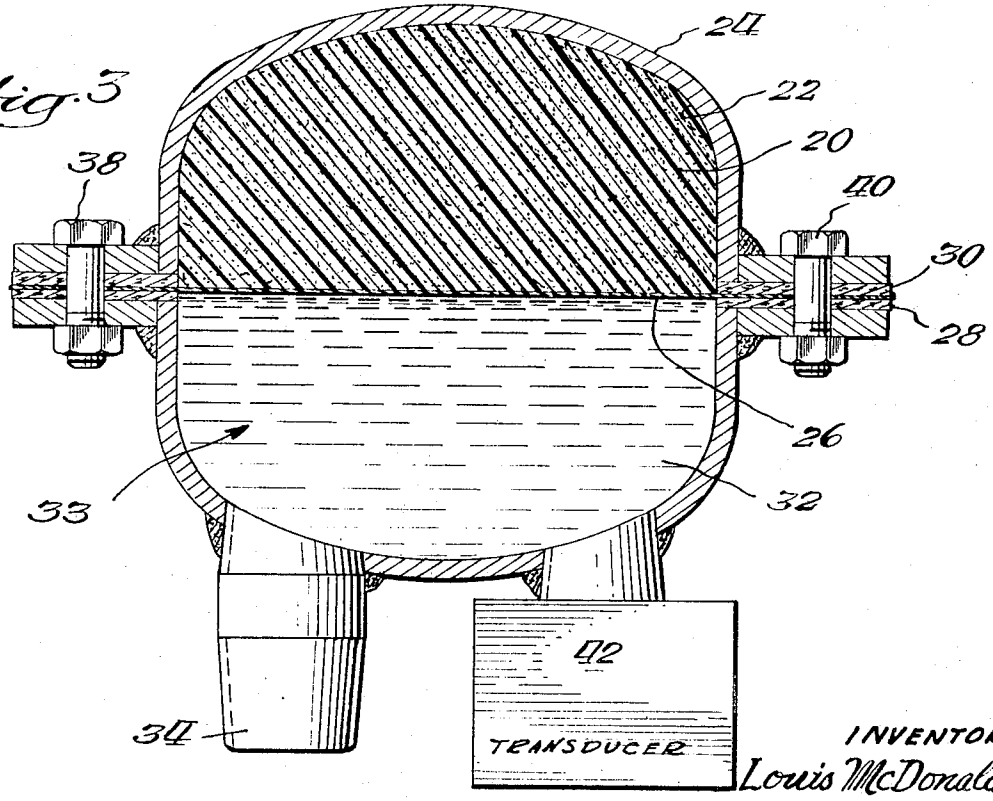


Fig. 3



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PULSE JET AMPLIFIER

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Int. Cl. B05f 1/08
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ABSTRACT OF THE DISCLOSURE

Device for amplifying fluid and other mechanical pulses of an essentially non-compressible nature at elevated pressure and without the addition of external energy. The device is characterized by a hollow chamber completely filled with a particular dilatant plastic characterized by elastic recovery from deformation under stress, said recovery being a function of the rate of application of the stress. Silicone putty is illustrative of the plastic. The device also includes means for transmitting the incoming pulses to the plastic and receiving an amplified pulse therefrom.

BACKGROUND OF THE INVENTION

This invention relates to the amplification of fluid and other machanical pulses of an essentially non-compressible nature at elevated pressure and without the addition of external energy. The device is particularly useful for amplifying hydraulic pulses in the order of 5–30 pulses per second and when incorporated into a hydraulic cleaning apparatus provides pulse amplification and increased effectiveness of the hydraulic fluid used for cleaning.

In a number of industrial operations, frequent cleaning of the equipment is carried out as required for efficiency and product quality. In many instances, the equipment is contaminated with various soils composed of minerals and solid organic matter together with various viscous fluids such as grease, fat and the like. The resultant soil is usually in the form of a plastic film.

Various techniques have been utilized in removing soils from the equipment surfaces. Commonly, a high pressure jet of cleaning fluid is directed against the soiled surface and acts to cause movement in the plastic film and removal of the soil.

In these cleaning operations, the use of a pulsating jet of fluid has been found to be more effective in the removal of soils than a steady high pressure stream. The pulsed stream, particularly when impinged on a thixotropic film, is thought to more readily overcome the yield stress of the soiled film than a steady stream. In addition, the pulsed stream also provides a higher level of turbulence once flow of the soiled film has been initiated and aids in the chemical action of the cleaning fluid on the soil and the desired suspension of the soiled particles in the fluid for removal.

Usually, pulses are generated from a reciprocating piston-operated pump, such as a positive displacement pump or other form of pulse generating means. For cleaning purposes, the pulse generating means provides a hydraulic fluid under predetermined velocity conditions which is also characterized by a pulse rate in the order of about 5–30 pulses per second and more advantageously about 10–20 pulses per second.

Since the effectiveness of the pulsed stream is related

to the amplitude of the pulses, it is important to develop increased pulse amplitudes in the hydraulic fluid under flow conditions. In addition, it is important to develop these amplitudes without a corresponding damaging effect on the pulse generating equipment. Generally, excessive discharge surges from a positive displacement pump result in a heavy knock, pounding or hydraulic ram effect on the discharge end and on the pumping system. Therefore, it is desirable to develop a pulse amplifying means for amplifying fluid and other hydraulic pulses.

SUMMARY

Briefly, the invention is directed to a device which amplifies fluid and other mechanical pulses of essentially non-compressible nature at elevated pressure and without the addition of internal energy. I have found that such amplification can be developed by a device which comprises a hollow chamber completely filled with a particular dilatant plastic characterized by elastic recovery from deformation under stress, the recovery being a function of the rate of application of the stress. Means are provided in association with the chamber for transmitting an incoming pulse under an elevated pressure to the plastic and receiving an amplified pulse therefrom. The chamber is otherwise essentially non-deformable by the plastic under conditions of the amplification. A preferred plastic is polymerized alkyl siloxane, otherwise commonly known as silicone putty.

While the device is particularly advantageous for cleaning operations involving pulse streams of cleaning fluid, it is also useful as a means of amplifying pulses and converting them from one form of energy to another. For example, fluid pulses may be amplified by the device and the amplified pulses may then be detected by separate transducer means associated with the generation of an electrical pulse. Other advantages of the device will become obvious from the detailed description below.

The drawings represent views illustrative of the device for amplifying pulses, and illustrative of the use of the device in a system for cleaning industrial equipment.

FIG. 1 is a sectional view of a pulse amplifier wherein a chamber is completely filled with the particular dilatant plastic and the remaining portion of the chamber is defined by two pulse activated means. In this embodiment the incoming signal and the amplified signal are each transmitted through a pulse activating means.

FIG. 2 is a second embodiment wherein a housing with a diaphragm defines the chamber which is completely filled with the dilatant plastic. In this embodiment the incoming signal and the amplified signal are both transmitted by a hydraulic fluid.

FIG. 3 is an embodiment similar to FIG. 2 except that the modified signal is changed to a mechanical pulse.

FIG. 4 is a schematic diagram of a system used for cleaning soil from the surfaces of industrial equipment which incorporates the amplifying device of the invention. A pulsed stream from a reciprocating pump is delivered to the pulse amplifier which then directs the amplified pulse to the soiled surface by means of a nozzle.

DETAILED DESCRIPTION OF THE INVENTION

As illustrated in FIG. 1, the device is useful for amplifying fluid and other mechanical pulses of an essentially non-compressible nature without requiring a separate energy source.

In the device a soft dilatant plastic **2** as illustrated by a silicone putty completely fills inner chamber **4**. Diaphragm means as illustrated by diaphragms **6** and **8** are connected to chamber **4** and positioned adjacent to plastic **2** to respectively transmit a pulse at an elevated pressure to plastic **2** and to receive the amplified pulse therefrom. Each diaphragm is resistant to deformation under conditions of amplification and serves as a medium for the pulse amplification. Gaskets **10** and **12** are provided to increase the sealing effect of plastic **2** within chamber **4**. The walls **14** of the chamber are also essentially non-deformable by the plastic under conditions of the amplification and advantageously are constructed of a metal with a high elastic limit. Usually, stainless steel type 304 or Monel K of a thickness of 0.0005–0.0015 inch, provide the desired results at pressures of 10–500 p.s.i.g. Gaskets **10** and **12** suitably are neoprene or other materials which provide a leak-tight seal between the diaphragm and chamber **4**.

In FIG. 2, the dilatant plastic such as silicone putty **20** completely fills void **22** of hollow body **24**. Hollow body **24** includes section **26** adjacent to plastic **20** which is constructed of a generally flat, metallic material to act as a diaphragm. Gaskets **28** and **30** are utilized to improve the sealing of plastic **20** with body **24**. Hollow body **24** also includes a second hollow chamber **32** adjacent diaphragm **26** and connected to hollow body **24**. Chamber **32** is constructed so as to be essentially non-deformable under conditions of pulse amplification and usually contains a hydraulic fluid **33** which acts as a medium for pulse transmission and reception. Inlet and outlet means illustrated by pipe **34** and pipe **36**, respectively are provided for introduction of the pulse and removal of the amplified pulse. Usually, the fluid is in motion at a predetermined velocity when the device is utilized for cleaning purposes. To illustrate representative dimensions of the device, chamber **32** is approximately 4 inches in diameter with pipe **34** about ¾ inch and pipe **36** about ½ inch.

Connecting means as illustrated by bolts **38** and **40** serve to connect body **24** to chamber **32** with diaphragm **26** separating the two chambers.

In FIG. 3, the elements of FIG. 2 are illustrated except that transducer **42** receives the amplified signal and converts it into an electrical signal which is then transmitted to an external receiving device (not illustrated). In this way the device may be utilized in a chemical process which does not permit the initial generation of electrical signals. The signal is converted by the device at a safe point to an electrical signal for transmission to desired indicator, controller for the like.

In FIG. 4, tank **44** serves to contain a supply of cleaning fluid which is fed by means of line **46** to pump **48**. Pump **48** is a positive displacement pump which serves as a pulse generator and cleaning fluid under flow conditions at an elevated pressure in the order of about 10–500 p.s.i.g. to line **50**. The surge pressure is indicated on gage **52** downstream from pump **48**.

Relief valve **56** serves to limit the pressure by returning a portion of the fluid to supply tank **44** by means of line **58** when the pressure exceeds a predetermined value. In normal operation line **60** delivers the fluid to pulse amplifier **62** which amplifies the pulse and feeds it by means of line **64**, gate valve **66** and hose **68** to gun means **70**. Gun means **70** is provided with valve **72** and with nozzle **74** for controlling the amount of fluid used in cleaning surface **76** of an item of industrial equipment.

Considering FIG. 2 for purposes of illustrating the operation of the device, the hydraulic pulse is fed at an elevated pressure into second chamber **32** filled with a hydraulic fluid. Pipe **34** serves as a means for introducing the pulse against diaphragm **26** and is adjacent to and associated with hollow body **24**. The pulse impinges against diaphragm **26** causing dilatant plastic **20** to initially compact and flow, then to act as a plastic solid and finally to release energy by expanding suddenly to provide amplification. Pipe **36** which is preferably smaller in diameter than inlet pipe **34** serves as a means for recovering the amplified pulse from diaphragm **26** and is also adjacent to and associated with hollow body **24**.

In FIG. 4, the device **62** is located advantageously near the discharge end of the apparatus in order to provide the amplified pulse near the point of use. In tests of device **62** in a system illustrated by FIG. 4 wherein the stream from nozzle **74** was directed against a spring scale, a scale deflection of about 0.75 lbs. was obtained indicating the relative amplitude of the pulse. The result was in contrast to a deflection of about 0.50 lbs. without device **62**. In addition, device **62** resulted in a deflection of 10 lbs. in the reading of gage **54** and a total load on the test scale of 4.5 lbs. compared to a reading of 75 lbs. and 4.0 lbs., respectively, for the apparatus without device **62**. This performance indicated that device **62** was also acting to dampen the pulses while at the same time providing an amplification of the pulse further indicating the remarkable performance of the device.

Tests were also carried out with both inlet and outlets of the same size and demonstrated that amplification occurred under these conditions.

The dilatant plastic is characterized by elastic recovery from deformation under stress, the recovery being a function of the rate of application of the stress. These characteristics are illustrated by silicone putty which is the preferred plastic although others developed with these characteristics can be used.

As indicated above, the device for amplifying pneumatic signals is useful in indicating and control systems in the chemical processing industry and also can be incorporated into apparatus used in cleaning soil from industrial equipment. The amplified pulse when delivered on to the surface not only acts to remove the soil but also aids in developing turbulence to carry the soil particles from the equipment.

I claim:

1. A device for amplifying fluid and other mechanical pulses of an essentially non-compressible nature at elevated pressure and without the addition of external energy, the device comprising a hollow chamber completely filled with a plastic characterized as dilatant with an elastic recovery from deformation under stress, said recovery being a function of the rate of application of said stress, and means in association with the chamber for transmitting an incoming pulse at an elevated pressure to the plastic and receiving an amplified pulse therefrom, the chamber being otherwise essentially non-deformable by the plastic under conditions of the amplification.

2. The device of claim **1** wherein the means for transmitting and receiving the incoming and outgoing pulses include diaphragm means connected to the chamber and positioned adjacent to the plastic, the diaphragm means being resistant to deformation under conditions of amplification and serving as a medium for the pulse amplification.

3. The device of claim **2** wherein the plastic is a silicone putty.

4. The device of claim **2** wherein the means for pulse transmission and reception includes a second hollow chamber containing a hydraulic fluid positioned adjacent to the diaphragm means and connected to the first chamber, the second chamber being essentially non-deformable under conditions of pulse amplification.

5. The device of claim **4** wherein the second hollow chamber includes an inlet and outlet means for introduction and removal of the pulse.

6. The device of claim **5** wherein the first chamber is rigid, the plastic is a silicone putty, and the inlet and

outlet means are means for introducing and removing hydraulic fluid under flow conditions from the second chamber.

7. The device of claim 6 wherein the outlet means is of smaller size than the inlet means.

8. A cleaning apparatus for removing soil from surfaces of industrial equipment and comprising means for generating pulses in a hydraulic fluid under flow conditions, the device of claim 1 as a pulse amplification means, means for directing the hydraulic fluid with amplified pulses against the soiled surfaces, and connecting means for transmission of the hydraulic fluid from the generating means to the amplifying means and from the amplifying means to the fluid directing means.

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