Nov. 12, 1957 C. J. COBERLY 2,812,662

PRESSURE PULSATION INDICATOR

Filed June 3, 1950 2 Sheets-Sheet 1

Fig. 1.

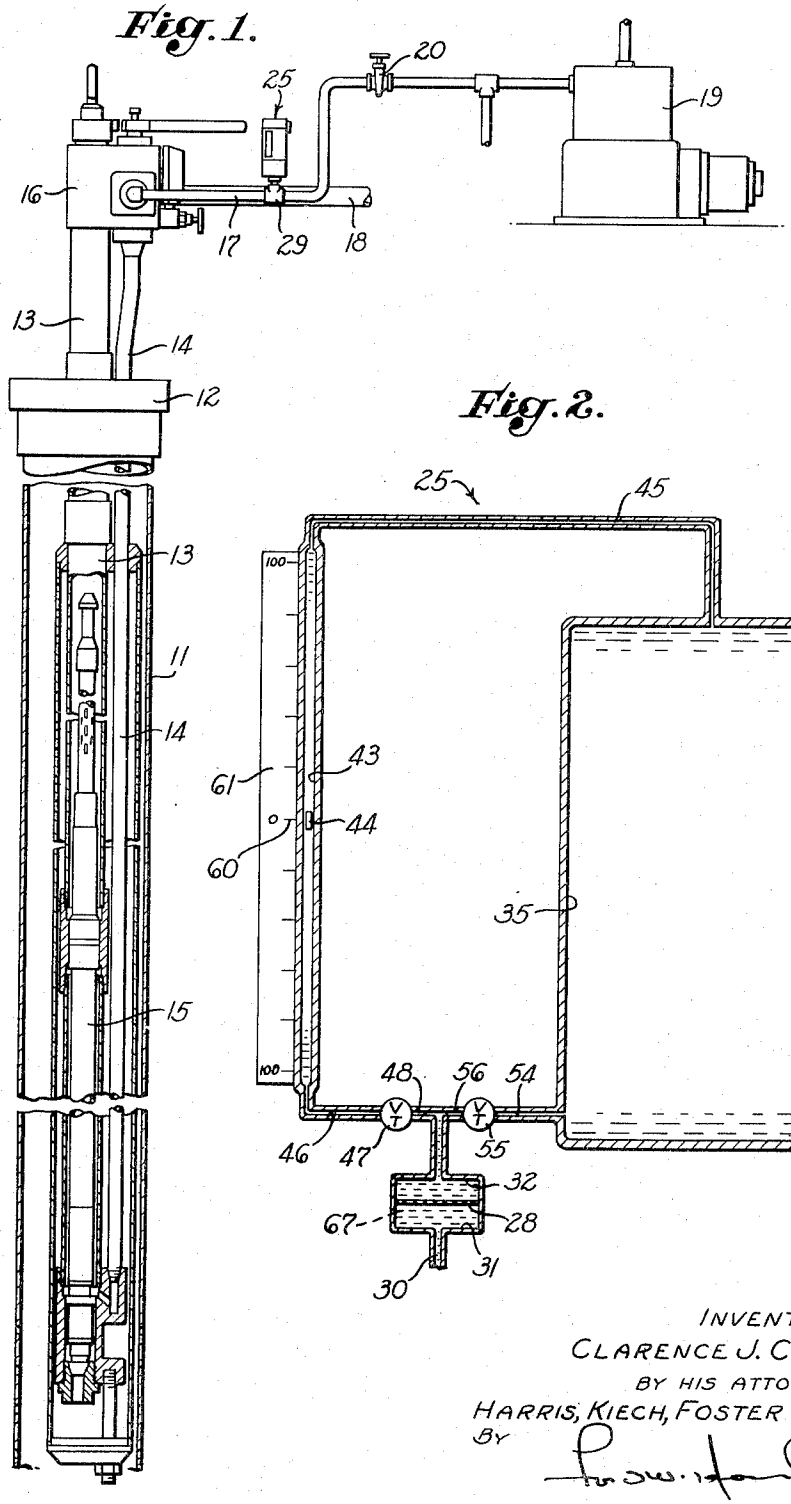


Fig. 2.

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Filed June 3, 1950 2 Sheets-Sheet 2

Fig. 3.

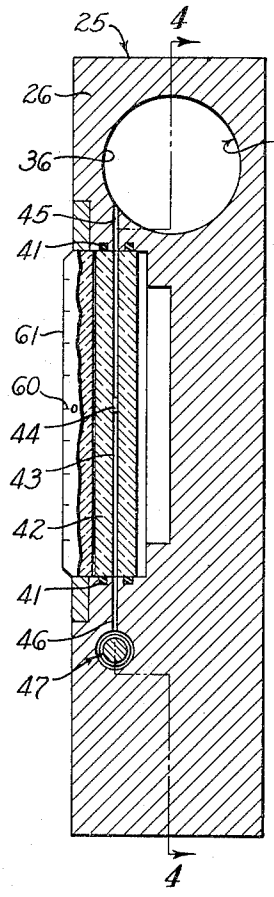


Fig. 5.

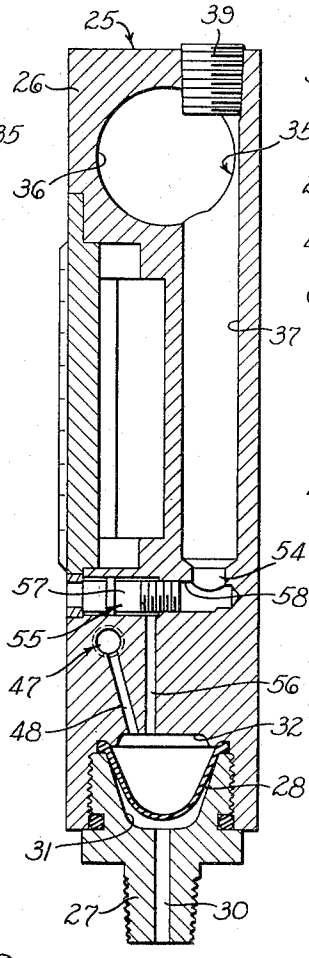


Fig. 4.

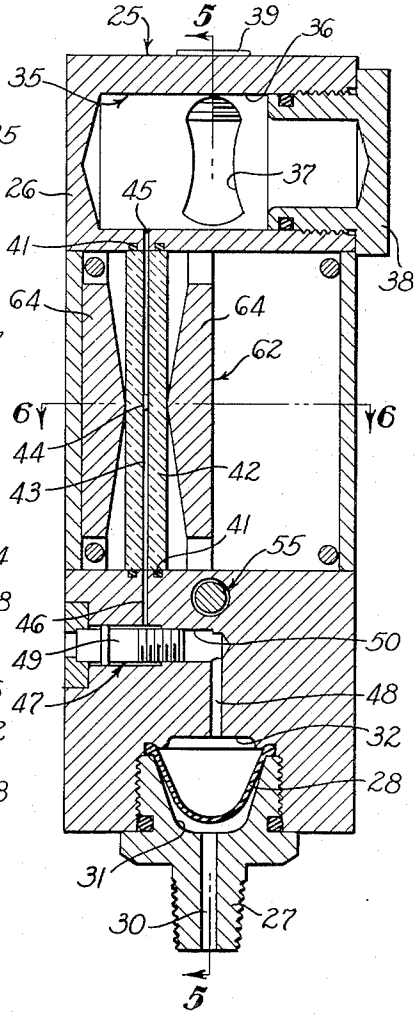
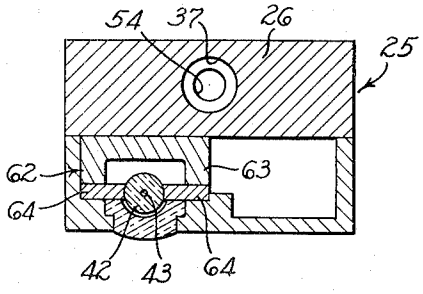


Fig. 6.



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PRESSURE PULSATION INDICATOR

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Application June 3, 1950, Serial No. 166,008

9 Claims. (Cl. 73—388)

The present invention relates in general to devices for measuring fluid pressures, and more particularly, to devices for indicating the amplitudes and directions of fluid pressure pulsations.

Although not limited thereto, the invention finds particular utility in oil well pumping systems wherein fluid-operated pumps of the reciprocating type are employed for pumping oil and other fluids from wells. In fluid-operated pumping systems of this character, an operating fluid, such as oil, is delivered to the fluid-operated pump under pressure by way of a supply line which extends from a source of pressurized operating fluid at the surface of the ground downwardly in the well to the pump. Such a fluid-operated pump includes a motor piston which is reciprocated in its cylinder by an alternating fluid pressure differential applied thereto, and includes a valve for so regulating the delivery of the operating fluid to the motor cylinder and the exhaust of spent operating fluid therefrom as to reverse the fluid pressure differential each time the motor piston reaches the ends of its stroke. In such a fluid-operated pump, the delivery of the operating fluid to the motor cylinder from the supply line is interrupted momentarily each time the motor piston reaches the ends of its stroke with the result that the fluid pressure in the supply line increases momentarily, assuming that the rate of delivery of the operating fluid under pressure to the supply line is substantially constant, which is usually the case.

The magnitude of such pressure pulsations in the supply line of a fluid-operated pumping system is significant for various reasons. For example, the magnitudes of the pressure pulsations provide an indication of the condition of the pump and also the pumping conditions in the well. Since the pressure of the operating fluid employed in such a fluid-operated pumping system may be of the order of magnitude of, for example, two thousand pounds per square inch, it will be apparent that any device for indicating or measuring the absolute pressure in the supply line will not provide readily perceptible indications of such pressure pulsations, which may be of the order of magnitude of from twenty-five to fifty pounds per square inch, for example, relative to the normal pressure of the operating fluid.

In view of the foregoing, a primary object of the invention is to provide a pressure pulsation indicator which is capable of producing amplified and therefore readily perceptible indications or measurements of such pressure pulsations relative to an average or reference pressure, the average pressure depending upon the pump design and the fluid level of the well on which the indicator is employed.

Another object is to provide a pulsation indicator which may be used over a wide range of average or reference pressures and which will have a sensitivity which is substantially independent of the reference pressure.

Liquids, such as the oils customarily employed in fluid-operated pumping systems, are normally regarded as substantially incompressible. However, such liquids

do vary in volume with variations in pressure, the compressibility of the oils normally employed in fluid-operated pumping systems being in the neighborhood of one percent at the operating pressures normally employed, e. g., two thousand pounds per square inch.

With the foregoing in mind, a basic object of the invention is to provide a pressure pulsation indicator which utilizes the compressibility of a liquid to provide indications or measurements of varations in pressure from a reference pressure.

Another object is to provide pressure pulsation indicators capable of indicating or measuring the amplitudes and directions of pressure variations from a reference pressure.

In general, the invention contemplates a pressure pulsation indicator which includes a chamber containing a liquid and which includes a cylinder communicating at one end with the chamber and having a volume which is small compared to the volume of the chamber, the cylinder containing a piston one end of which is exposed to the liquid in the chamber and the other end of which is exposed to the fluid pressure pulsations to be measured so that the fluid pressure pulsations result in movement of the piston in its cylinder to vary the volume of the liquid in the chamber inversely with the fluid pressure variations, an important object of the invention being to provide a device of this character.

Another object is to provide a pressure pulsation indicator having means for indicating the amplitude and direction of movement of the piston in response to variations in the volume of the liquid resulting from the fluid pressure variations. A related object is to provide an indicator wherein the means for indicating movement of the piston comprises a scale parallel to the axis of the cylinder, the cylinder preferably being transparent so that the position of the piston relative thereto may be observed visually.

Another object is to provide such an indicator wherein the piston is movable in both directions in its cylinder relative to a zero position intermediate the ends of the cylinder so as to indicate both positive and negative variations in fluid pressure from the reference pressure, i. e., to indicate both increases and decreases in the fluid pressure relative to the reference pressure.

Another object is to provide a magnetizable piston and magnetic means for biasing the piston toward its zero position intermediate the ends of the cylinder.

A further object of the invention is to provide such a pressure pulsation indicator for measuring both the amplitude and directions of fluid pressure pulsations which includes means for varying the sensitivity of response of the indicator to fluid pressure variations.

A further object is to provide a means for controlling the sensitivity of the indicator consisting of an adjustable hydraulic resistance in series with the cylinder so that the pulsations of the piston may be damped to any desired extent.

The foregoing objects and advantages of the present invention, together with other objects and advantages thereof which will become apparent, may be attained with the exemplary embodiments of the invention which are illustrated in the accompanying drawings and which are described in detail hereinafter. Referring to the drawings:

Fig. 1 is a utility view of a fluid-operated pumping system incorporating a pressure pulsation indicator which embodies the invention;

Fig. 2 is a diagrammatic view of a pulsation amplitude and direction indicator of the invention;

Fig. 3 is a sectional view of a possible structural embodiment of the pulsation amplitude and direction indicator illustrated diagrammatically in Fig 2;

Fig. 4 is a sectional view taken along the broken line 4—4 of Fig. 3; and

Figs. 5 and 6 are sectional views taken along the broken lines 5—5 and 6—6, respectively, of Fig. 4.

Referring particularly to Fig. 1, the numeral **11** designates a casing which is set in an oil well and which is perforated adjacent its lower end to admit oil from a surrounding oil producing formation thereinto. Suspended in the casing **11** from a casing head **12** are supply and production tubings **13** and **14**, respectively, a fluid-operated pump **15** of the reciprocating type being disposed in the supply tubing **13** and being operable by a fluid under pressure in the supply tubing to pump oil from the well into the production tubing **14**, which conveys the oil upwardly to the surface. Connected to the upper ends of the supply and production tubings **13** and **14** is a tubing head **16** having valve means, not shown, therein for connecting a supply pipe **17** to the supply tubing **13** and for connecting the production tubing **14** to a production pipe **18**, the latter leading to a suitable point of disposal for the oil pumped from the well. The supply pipe **17** is connected at its inlet end to a source of operating fluid under pressure, such as a conventional triplex pump **19** adapted to deliver the operating fluid under pressure at a substantially constant rate. Thus, the supply pipe **17** and the supply tubing **13** comprise a supply line for delivering the operating fluid under pressure to the fluid-operated pump **15** in the well to operate it, the rate of delivery of the operating fluid to the pump **15** being controlled by a valve **20** in the supply pipe **17**. As hereinbefore discussed, the pressure of the fluid in the supply line pulsates, i. e., the pressure of the fluid in the supply line increases momentarily above its normal value at the ends of the stroke of the motor piston, not shown, of the fluid-operated pump **15**. The numeral **25** designates a pressure pulsation indicator of the invention which is installed in the supply pipe **17** to measure the amplitude and direction of the pressure pulsations therein, and which is illustrated diagrammatically in Fig. 2, and structurally in Figs. 3 to 6.

Referring particularly to Figs. 3 to 6, the pulsation amplitude and direction indicator **25** comprises a housing **26** having threaded into the lower end thereof a fitting **27** which retains a diaphragm **28**, the fitting **27** being threadable into an element, such as the fitting **29** in the supply pipe **17**, containing a fluid, variations in the pressure of which are to be measured by the indicator **25**, the fitting **27** is provided with a passage **30** therethrough for applying the pressure of the fluid, variations in the pressure of which are to be measured, to the diaphragm **28**. As will be apparent, the fitting **27** and the diaphragm **28** cooperate to provide a chamber **31** therebetween with which the passage **30** communicates, and the housing **26** and the diaphragm cooperate to provide a chamber **32** therebetween.

The housing **26** is provided with a chamber **35** therein which is defined by intersecting bores **36** and **37** respectively closed by threaded plugs **38** and **39**. Carried by the housing **26** and sealed at its ends with respect thereto by annular sealing elements **41** is a transparent tube **42** which comprises a cylinder **43** for a piston **44**, the latter being visible through the transparent tube **42**. In effect, the tube **42** approaches being a capillary tube, the volume of the cylinder **43** being small as compared to the volume of the chamber **35**, as will be discussed in more detail hereinafter. The cylinder **43**, which is substantially vertical in the particular construction illustrated, communicates at its upper end with the chamber **35** through a passage **45** and communicates at its lower end with the chamber **32** adjacent the diaphragm **28** through a passage **46**, a throttle valve **47** and a passage **48**. The throttle valve **47** comprises a valve element **49** threaded into a bore **50** with which the passages **46** and **48** communicate, communication between the passages **46** and **48**, which are spaced apart axially of the bore **50**, being provided by an axially varying clearance between the threads on the valve element **49** and the threads in the bore **50**. Thus, by varying the position of the valve element **49** in the bore **50**, the restriction to flow offered by the throttle valve **47** may be varied to vary the sensitivity of response of the pulsation amplitude and direction indicator to fluid pressure variations, as will be discussed in more detail hereinafter.

The chamber **35** also communicates with the chamber **32** through a passage **54**, a throttle valve **55** and a passage **56**, the throttle valve **55** comprising a valve element **57** threaded into a bore **58** with which the passages **54** and **56** communicate. The latter are spaced apart axially of the bore **58** so that communication therebetween is provided by an axially varying clearance between the threads on the valve element **57** and those in the bore **58**, the position of the valve element **57** in the bore **58** determining the restriction to flow between the chambers **32** and **35** which is offered by the throttle valve **55**. As will become apparent, the throttle valve **55** provides an adjustable means for automatically compensating for any drift of the mean fluid pressure, variations in which are being measured by the indicator **25**.

In order to permit employing the indicator **25** for indicating both positive and negative variations in pressure from a reference pressure, i. e., both increases and decreases in pressure relative to a reference pressure, the piston **44** is designed to move in both directions in its cylinder **43** from an intermediate position substantially midway between the ends of its cylinder. Such intermediate position is designated by a zero indicium **60** on a scale **61** parallel to the axis of the cylinder **43**, the piston being visible through the transparent cylinder so that its position relative to the scale **61** may be observed visually. Since, as hereinbefore indicated, the axis of the cylinder **43** is substantially vertical, means **62** is provided for biasing the piston **44** toward its zero position, the biasing means comprising, in the particular construction illustrated, a channel-shaped magnet **63**, Fig. 6, having pole pieces **64**, Fig. 4, which converge from the ends of the cylinder **43** toward the zero position of the piston. Thus, the magnetic field produced has its maximum intensity at the zero position of the piston **44** and, if the piston is made of a magnetizable material, it constantly seeks its zero position.

Prior to operation, the various chambers, passages, and the like defined by the housing **26** and the diaphragm **28**, i. e., the chambers **32** and **35**, the cylinder **43** and the connecting passages, are filled with a compressible liquid such as oil. Preferably, a clear oil or other liquid is used in the instrument in order to permit visual observation of the position of the piston **44** relative to the scale **61**, the liquid in the instrument being separated from the fluid, variations in the pressure of which are to be measured, by the diaphragm **28**. As will be apparent, the indicator **25** may be filled with the desired liquid readily by removing the plug **39** and opening the throttle valves **47** and **55**. In order to avoid the effects of the higher compressibility of air or other gases, it is essential that substantially all air be bled from the indicator in filling it with the desired liquid, and that the liquid itself be substantially free from air or gas inclusions. After the indicator has been filled with the desired liquid and sealed by reinserting the plug **39**, it may be employed to measure both the amplitude and direction of pressure pulsations by threading the fitting **27** into an element, such as the fitting **29** in the supply pipe **17**, containing the fluid variations in the pressure of which are to be measured.

Considering the operation of the indicator **25** and referring particularly to Fig. 2, assume that the pressure of a fluid **67** in the chamber **31** below the diaphragm **28** increases from atmosphere to a mean or normal value, hereinafter termed an average or reference value, such as, for example, two thousand pounds per square inch. The reference pressure is communicated to the liquid in

the indicator 25 by the diaphragm with the result that the liquid in the indicator is correspondingly compressed, flexing of the diaphragm compensating for such compression of the liquid. As diagrammatically illustrated in Fig. 2, the chamber 35 accommodates substantially all of the liquid in the indicator 25. Consequently, as the pressure increases to the reference pressure, the piston 44 moves upwardly toward the upper end of the cylinder 43 as the liquid in the cylinder thereabove is displaced into the chamber 35, some displacement into the chamber 35 also taking place through the throttle valve 55. When the piston 44 reaches the upper end of the cylinder 43, any additional displacement of the liquid in the chamber 35 necessary to attain the reference pressure in the liquid takes place either through the throttle valve 55, or takes place past the piston in the form of leakage. Once the pressure of the liquid in the indicator 25 has attained the reference pressure, the piston 44 tends to drop by gravity toward the lower end of the cylinder 43 by virtue of a slight leakage therepast, but is maintained in its zero position opposite the zero indicium 60 on the scale 61 by the magnetic biasing means 62.

With the foregoing conditions obtaining, assume that pressure pulsations occur in the test fluid, i. e., the fluid variations in the pressure of which are to be measured, which test fluid may, for example, be the operating fluid delivered to the fluid-operated pump 15 through the supply line 17, 13. Such pressure pulsations in the test fluid are communicated to the liquid in the indicator 25 by the diaphragm 28 and result in movement of the piston 44 either upwardly or downwardly from its zero position in the cylinder 43, depending on whether the pressure pulsations represent increases or decreases relative to the reference pressure. If a particular pressure pulsation represents an increase relative to the reference pressure, the piston 44 moves upwardly to compress the liquid in the chamber 35 and, if such pressure pulsation represents a decrease relative to the reference pressure, the liquid in the chamber 35 expands to move the piston downwardly. As will be apparent, it is necessary that the throttle valve 55 be so adjusted relative to the throttle valve 47 that the resistance to flow offered by the latter is less than that offered by the former. As will also be apparent, by varying the restriction offered by the throttle valve 47 relative to that offered by the throttle valve 55, the sensitivity of the response of the pison 44 to variations from the reference pressure may be varied. In other words, the movement of the piston from its zero position resulting from a given variation from the reference pressure may be varied. Thus, the movement of the piston 44 for a given pulsation in pressure from the reference pressure may be adjusted to match the calibration of the scale 61 so that the amplitude of the pressure pulsation may be observed visually by noting the position of the piston relative to the indicia on the scale. The sensitivity of response may also be adjusted by varying the restriction to flow offered by the throttle valve 55 relative to that offered by the throttle valve 47.

It will be noted that the presence of the throttle valve 55 provides a means for automatically adjusting the indicator 25 to compensate for any drift in the reference pressure, i. e., any gradual variation in the mean pressure of the test fluid. For example, assume that, over a period of time, the pressure of the test fluid 67 increases gradually. Such gradual increase in pressure is equalized above and below the piston 44 through the throttle valve 55 so that the piston continues to indicate only the amplitude and direction of pressure pulsations with no change in the calibration of the indicator, which is an important feature of the invention. The throttle valve 55 operates in a similar manner to compensate for any drift of the reference pressure downwardly from the original value.

Considering the matter of the relative volumes of the chamber 35 and the cylinder 43, it will be noted that the smaller the volume of the cylinder 43 relative to that of the chamber 25, the greater the sensitivity of the indicator 25. For example, it might be desirable to provide relative volumes for the chamber 35 and cylinder 43 such that the piston moves upwardly or downwardly a distance of one inch for a positive or negative pressure pulsation, respectively, of one hundred pounds per square inch for particular settings of the throttle valves 47 and 55. Thus, it will be seen that a pressure pulsation of twenty-five pounds per square inch would produce a piston movement of one-quarter inch, which is readily perceptible. A piston movement of one inch for a pressure pulsation of one hundred pounds per square inch may be attained by employing approximately two cubic inches of a liquid which is reduced in volume by one percent from its volume at atmospheric pressure upon application of a pressure of two thousand pounds per square inch thereto, and by employing a cylinder 43 having a diameter of 0.0356 inch. It will be understood, of course, that these values are intended as illustrative only and that there is no intention of limiting the invention thereto.

It is important to note that the sensitivity described above is substantially independent of the reference pressure, i. e., the movement of the piston of ¼" for a 25 p. s. i. pressure pulsation is the same at a reference pressure of 500 p. s. i. as it is at 4000 p. s. i. The only variation in sensitivity is due to a very slight variation of the compressibility factor of the oil in the chamber 35 with pressure. With most fluids the compressibility is less at high pressure than at low pressure. If this factor is assumed to be 1.00 at 500 p. s. i. then it would be only approximately 2% higher, or 1.02, at 5000 p. s. i. For practical purposes, therefore, as a surge indicator the sensitivity of this device is independent of pressure.

Although I have disclosed exemplary embodiments of my invention herein and have indicated possible applications thereof it will be understood that the invention might be susceptible of other embodiments and other applications without departing from the spirit of the invention.

I claim as my invention:

1. In a device for measuring variations in fluid pressure, the combination of: a rigid chamber filled with a liquid; a rigid, liquid-filled cylinder communicating at one end with said chamber and having a volume which is small compared to the volume of said chamber; a piston movable in both directions in said cylinder with respect to a position intermediate the ends of said cylinder, and having two opposed end surfaces one of which is exposed to the pressure of said liquid in said chamber, said piston making a loose fit in said cylinder so as to provide restricted fluid communication between said end surfaces of said piston; means, including rigid, liquid-filled passage means communicating with the other end of said cylinder, for exposing the other end surface of said piston to a fluid pressure variation to be measured, whereby the fluid pressure variation results in movement of said piston to vary the volume of said liquid in said chamber inversely with the fluid pressure variation; means for indicating movement of said piston; and bidirectional biasing means for biasing said piston toward said position intermediate the ends of said cylinder in both directions.

2. In a device for measuring variations in fluid pressure, the combination of: a rigid chamber filled with a liquid; a rigid, liquid-filled cylinder communicating at one end with said chamber and having a volume which is small compared to the volume of said chamber; a magnetizable piston movable in both directions in said cylinder with respect to a position intermediate the ends of said cylinder, and having two opposed end surfaces one of which is exposed to the pressure of said liquid in said chamber; means, including rigid, liquid-filled passage means communicating with the other end of said cylinder, for exposing the other end surface of said piston to a fluid pressure variation to be measured, whereby the fluid pressure variation results in movement of said piston to vary the volume of said liquid in said chamber inversely

with the fluid pressure variation; means for indicating movement of said piston; and magnetic means for biasing said piston toward said position intermediate the ends of said cylinder.

3. A device as defined in claim 2 wherein said magnetic means includes a magnet having poles which converge axially of said cylinder toward said position intermediate the ends thereof.

4. In a device for measuring variations in fluid pressure, the combination of: a rigid chamber filled with a liquid; a rigid, liquid-filled cylinder communicating at one end with said chamber and having a volume which is small compared to the volume of said chamber; a piston movable in both directions in said cylinder with respect to a position intermediate the ends of said cylinder, and having two opposed end surfaces one of which is exposed to the pressure of said liquid in said chamber; means, including rigid, liquid-filled passage means communicating with the other end of said cylinder, for exposing the other end of said piston to a fluid pressure variation to be measured, whereby the fluid pressure variation results in movement of said piston to vary the volume of said liquid in said chamber inversely with the fluid pressure variation; means for indicating movement of said piston; throttle valve means in said passage means for varying the restriction to fluid flow therethrough to vary the sensitivity of said device; a rigid, liquid-filled passage communicating at one end with said chamaber and at its other end with said passage means; and by-pass valve means in said passage, said by-pass valve means and said throttle valve means being in parallel relative to each other.

5. In a device for measuring variations in fluid pressure, the combination of: a rigid chamber filled with a liquid; a rigid, liquid-filled cylinder communicating at one end with said chamber and having a volume which is small compared to the volume of said chamber; a piston movable in both directions in said cylinder with respect to a position intermediate the ends of said cylinder, and having two opposed end surfaces one of which is exposed to the pressure of said liquid in said chamber; means, including rigid, liquid-filled passage means communicating with the other end of said cylinder, for exposing the other end surface of said piston to a fluid pressure variation to be measured, whereby the fluid pressure variation results in movement of said piston to vary the volume of said liquid in said chamber inversely with the fluid pressure variation; means for indicating movement of said piston; a rigid, liquid-filled passage communicating at one end with said passage means and at its other end with said chamber; and by-pass valve means in said passage.

6. In a device for measuring variations in fluid pressure, the combination of: a rigid chamber filled with a liquid; a rigid, liquid-filled cylinder communicating at one end with said chamber and having a volume which is small compared to the volume of said chamber; a piston movable in both directions in said cylinder with respect to a position intermediate the ends of said cylinder, and having two opposed end surfaces one of which is exposed to the pressure of said liquid in said chamber; means, including rigid, liquid-filled passage means communicating with the other end of said cylinder, for exposing the other end surface of said piston to a fluid pressure variation to be measured, whereby the fluid pressure variation results in movement of said piston to vary the volume of said liquid in said chamber inversely with the fluid pressure variation; means for indicating movement of said piston; diaphragm means traversing said passage means; a rigid, liquid-filled passage communicating at one end with said chamber and at its other end with said passage means; and by-pass valve means in said passage.

7. In a device for measuring variations in fluid pressure the combination of: a rigid chamber filled with a liquid; a rigid, liquid-filled cylinder communicating at one end with said chamber and having a volume which is small compared to the volume of said chamber; a piston movable in said cylinder and having two opposed end surfaces one of which is exposed to the pressure of said liquid in said chamber; rigid, liquid-filled passage means adapted to be connected to the source of fluid pressure, variations in which are to be measured, said passage means having a first branch communicating with the other end of said cylinder for exposing the other end surface of said piston to the fluid pressure, variations in which are to be measured, and having a second branch communicating with said chamber; a first flow restricting means in said first branch; and a second flow restricting means in said second branch, said second restricting means having a greater resistance to flow therethrough than said first restricting means.

8. A device as defined in claim 7 wherein said first and second restricting means are variable.

9. A device as defined in claim 8 including means for biasing said piston toward an intermediate position in said cylinder.

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