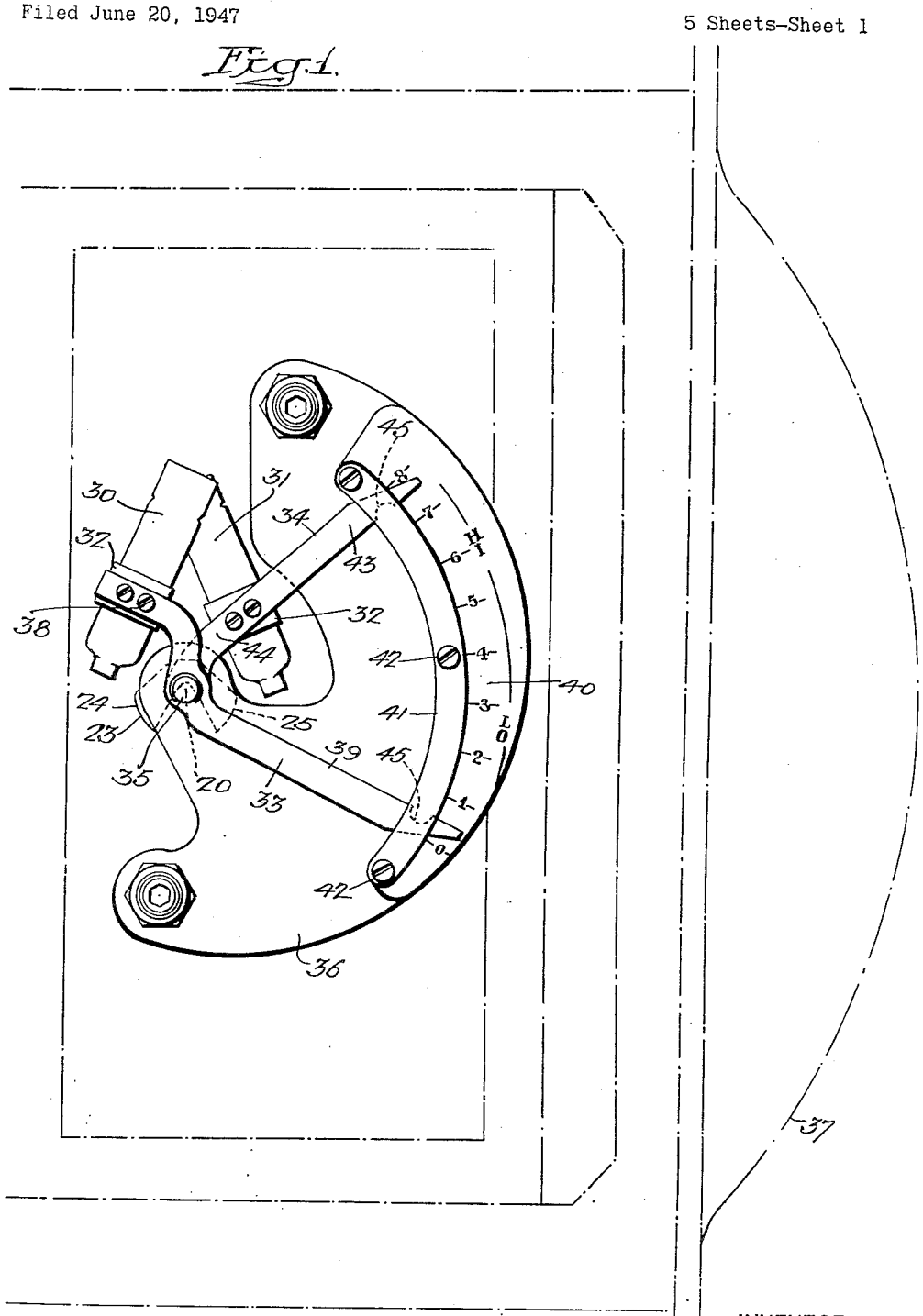
Dec. 11, 1951 D. R. YARNALL ET AL 2,578,276

CIRCUIT CLOSER FOR HIGH-LOW ALARMS

Filed June 20, 1947 5 Sheets-Sheet 1

Fig. 1.



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Fig. 3.

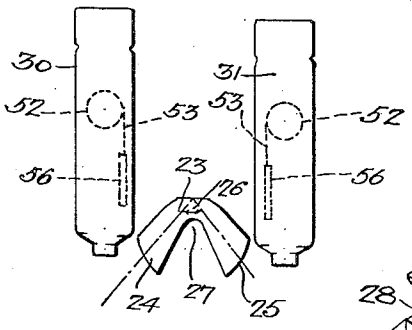


Fig. 4.

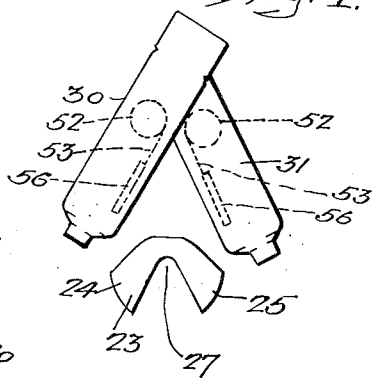


Fig. 5.

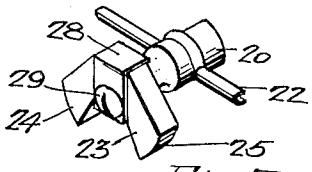


Fig. 2.

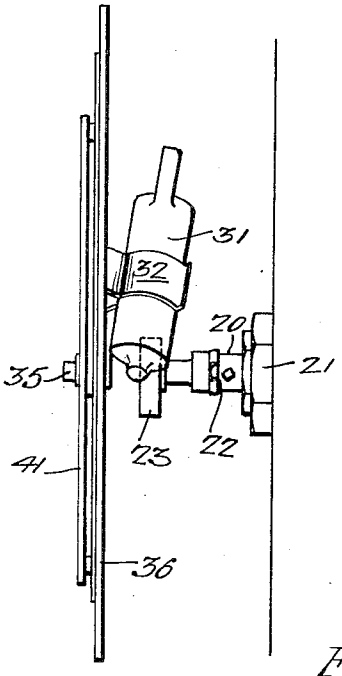


Fig. 7.

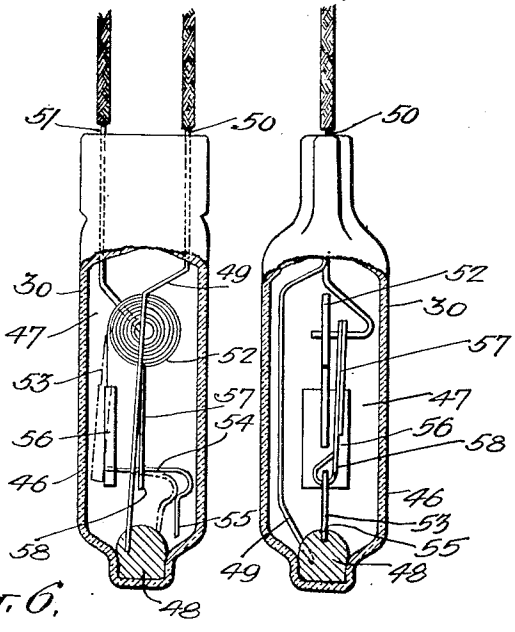
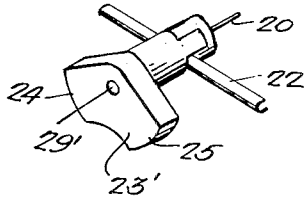


Fig. 8.

Fig. 6.



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CIRCUIT CLOSER FOR HIGH-LOW ALARMS

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Fig. 13.

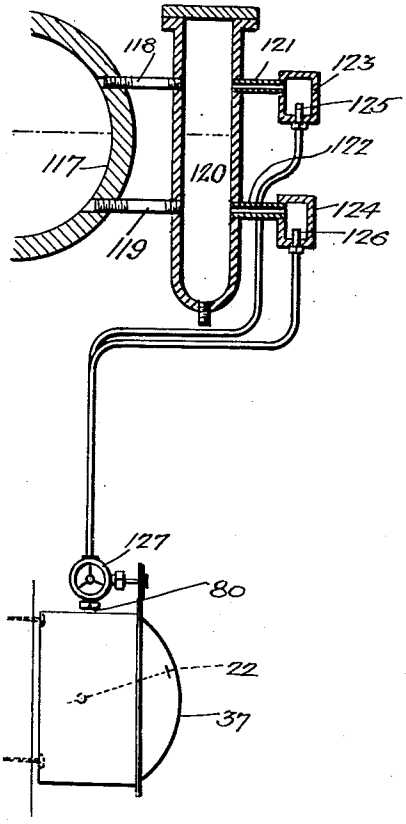


Fig. 9.

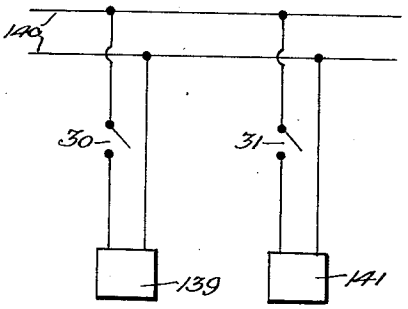
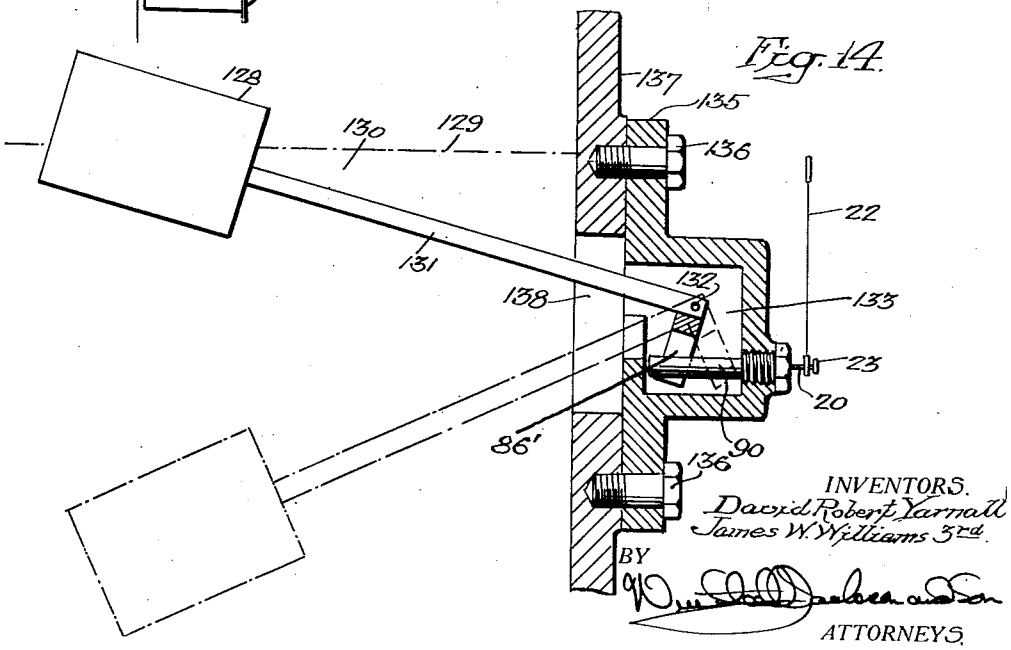


Fig. 14.



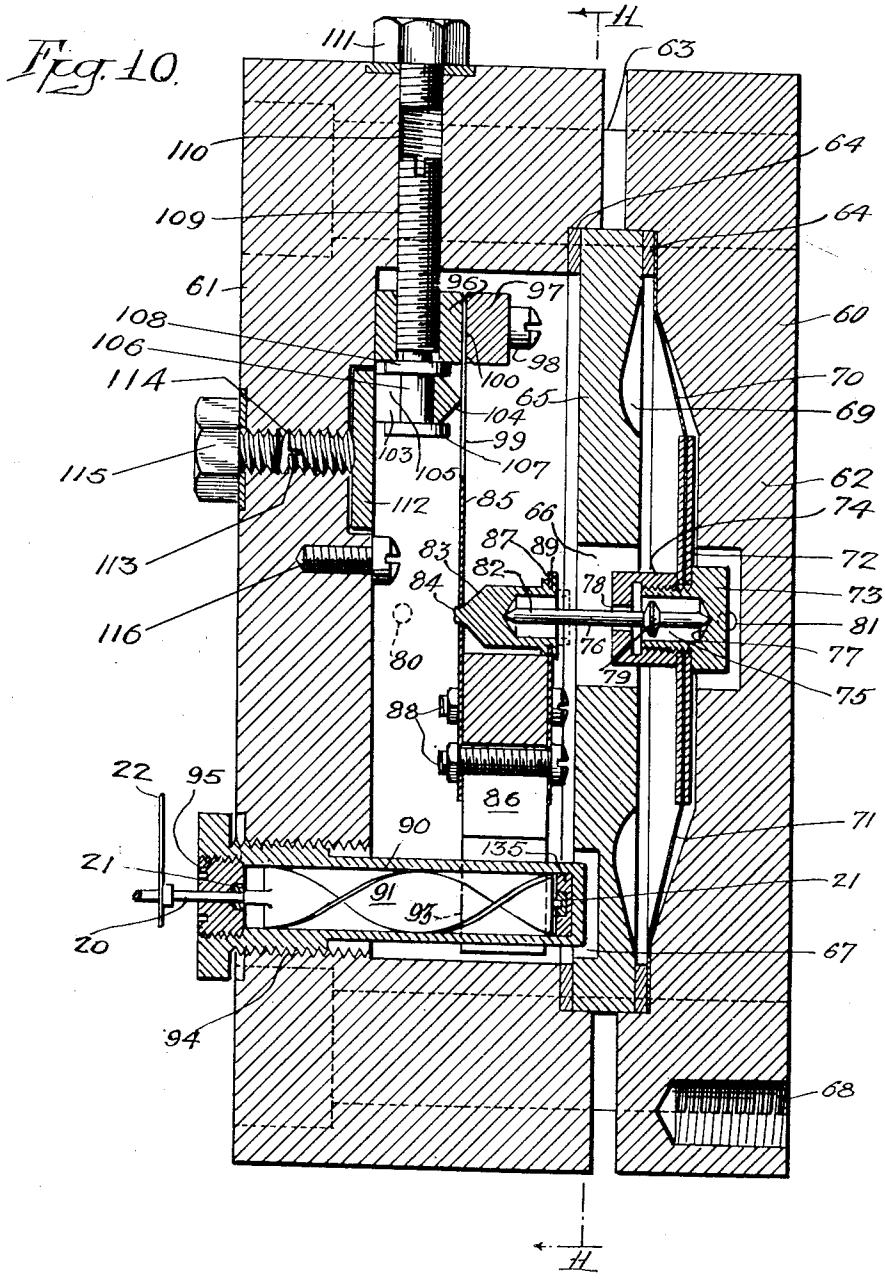
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CIRCUIT CLOSER FOR HIGH-LOW ALARMS

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Fig. 10.



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CIRCUIT CLOSER FOR HIGH-LOW ALARMS

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Fig. 11.

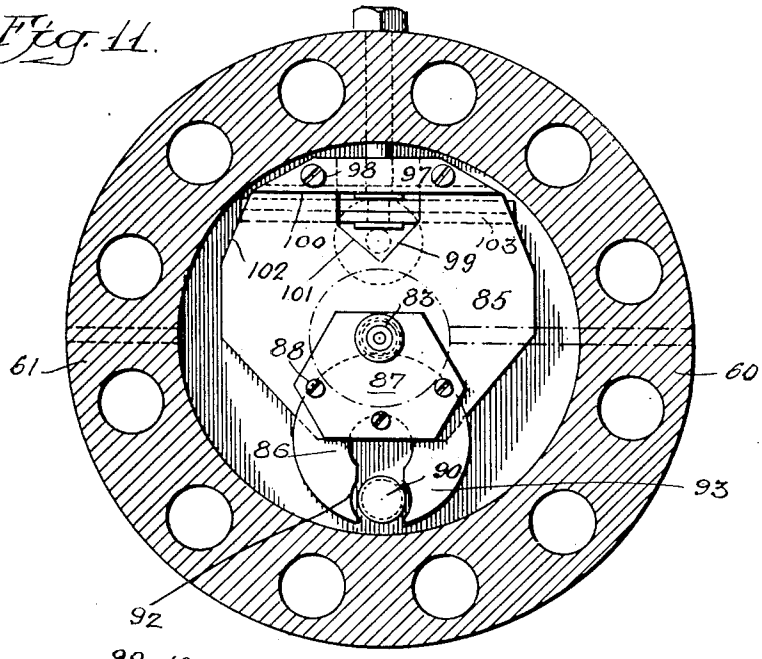


Fig. 12.

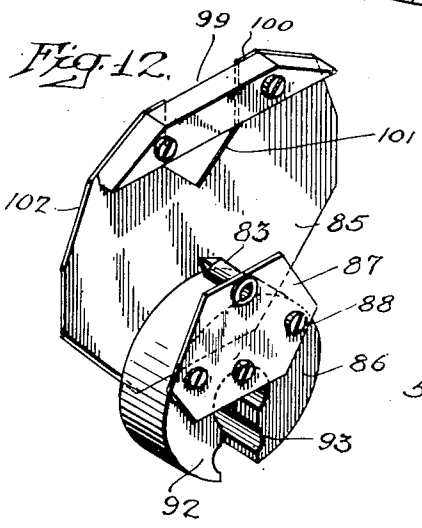


Fig. 7a

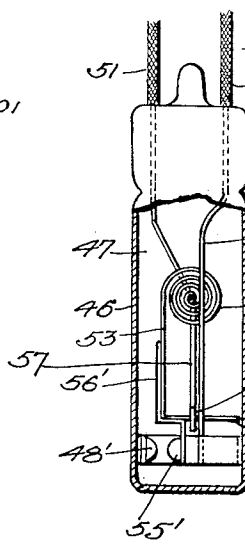
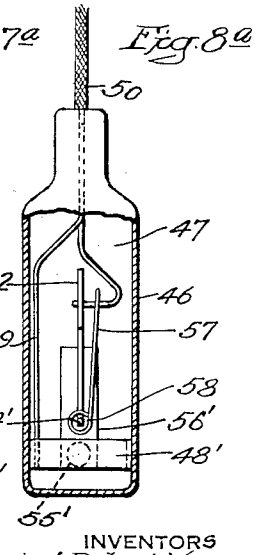


Fig. 8a



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2,578,276

UNITED STATES PATENT OFFICE

2,578,276

CIRCUIT CLOSER FOR HIGH-LOW ALARMS

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Application June 20, 1947, Serial No. 755,980

2 Claims. (Cl. 200—87)

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Our invention relates to high-low alarms of the type used on boilers and the like, to circuit closers therefor, and to processes of circuit closing.

A purpose of our invention is to reduce the reaction on a primary indicator shaft of a high-low alarm carrying a circuit closing magnet due to operation of a sensitive magnetic switch.

A further purpose is to build up the closing force exerted by the magnet on the magnetic switch very gradually, obtaining smooth operation and gradual development of a slight reaction on the primary indicator.

A further purpose is to close a sensitive magnetic switch by a bar magnet, one pole of which is maintained remote from the switch and the other pole of which is swung close to the switch, so that the percentage change in reluctance of the magnetic path with unit movement of the proximate pole will be slight.

A further purpose is to extend the bar magnet transverse to the axis of the supporting primary indicator shaft, preferably equally in opposite directions to balance the magnet, and preferably also to curve the poles about the axis.

A further purpose is to employ wide bar magnet poles, extending preferably over more than 30 degrees of arc and preferably less than 90 degrees of arc, the most desirable span being approximately 45 degrees of arc, so that the effect of the magnetic field will be gradually applied.

A further purpose is to support magnetic sensitive switches, preferably two in number, on adjustment arms individual to each switch, and preferably pivoted on an adjustment pivot in prolongation of the primary indicator axis, so that the switches can be swung around the arcuate path of movement of the poles.

Further purposes appear in the specification and in the claims.

In the drawings we have chosen to illustrate a few only of the embodiments in which our invention may appear, choosing the forms shown from the standpoints of convenience in illustration, clarity in explanation and satisfactory operation.

Figure 1 is a front elevation of the circuit closer of our invention.

Figure 2 is a side elevation of the circuit closer.

Figures 3 and 4 are detail diagrammatic front elevations showing the switches in different adjustment positions.

Figure 5 is a perspective of the primary indicator shaft and circuit closing magnet.

Figure 6 is a perspective similar to Figure 5 showing a variation in the magnet.

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Figure 7 is a front elevation partly in central longitudinal section, of one form of sensitive magnetic switch.

Figure 8 is a right side elevation of Figure 7 partly in central longitudinal section.

Figures 7ª and 8ª are views corresponding to Figures 7 and 8 respectively showing a variant form of magnetic switch.

Figure 9 is a diagram of the alarm circuits.

Figure 10 is a central vertical section through one form of primary indicator.

Figure 11 is a section on the line 11—11 of Figure 10 to reduced scale.

Figure 12 is a detail perspective of the horseshoe magnet and support for the primary indicator.

Figure 13 is a diagrammatic view, partly in section, showing the high-low alarm applied to a boiler.

Figure 14 is a diagrammatic central vertical section of a variant primary indicator.

Like numerals refer to like parts throughout.

In the operation of boilers and other pressure vessels, it is common to employ so-called high-low alarms to warn the operator of emergency conditions regarding liquid level. Many of the most satisfactory primary indicators which move a shaft at a point of indication in response to liquid level or the like are capable of exerting very little force on the primary indicator shaft without loss in precision or reliability of the indication. This is true for example of the magnetizable spiral as described and claimed in the United States patent applications of Walter J. Kinderman, Serial No. 517,242, filed January 6, 1944, now Patent No. 2,509,644, May 30, 1950, for Differential Pressure Gauge, and Serial No. 713,035, filed November 29, 1946, for Meter. The usual circuit closing switches for high-low alarms are, therefore, not well suited for operation by the most effective primary indicators.

We have investigated the possibility of employing sensitive magnetic switches for circuit closing, using the well-known horseshoe magnets. We find that these switches closed in this way are not satisfactory, as they impose a substantial reaction on the primary indicator.

In the course of our investigation of the problem we have discovered that it is possible to avoid substantial reaction on the primary indicator and eliminate abruptness in action by redesigning the mechanism.

We find that it is very important to employ a bar magnet, in which the poles are diverging and remote, rather than a horseshoe magnet, in operating on the magnetic type switches. One pole

only of the bar magnet, mounted on the primary indicator shaft, is brought close to a magnetic switch while the other pole is remote so that the change in the reluctance of the magnetic path due to the presence of the armature of the magnetic switch is gradual, and, for a given unit of magnetic motion, represents only a fraction of the change which occurs in a horseshoe magnet, with its short return path. Thus the reaction on the shaft of the primary indicator is much reduced, and the indicator does not jump or deflect when the switch closes.

By balancing the bar magnet about the axis, difficulty through unbalance is avoided. Wide poles extending over from 30 to 90 degrees of arc, further reduce the abruptness of the response as the switch closes. The poles are desirably curved on a radius corresponding to the radius of movement, so as to minimize unevenness of the field. The switches are also desirably made arcuately adjustable about the shaft axis.

As shown in Figures 1, 2, 5 and 6, a primary indicator shaft **20** in bearings **21** responds to high and low liquid level as later explained. The shaft supports an indicator pointer **22** and on one end, transverse to the axis, supports a bar magnet **23** of any suitable permanent magnet alloy. The bar magnet has diverging poles **24**, **25** preferably curved as shown on an arc about the shaft axis, and suitably flat in the axial direction. The poles extend for a substantial distance around the circumference, preferably from 30 to 90 degrees of arc, and most desirably about 45 degrees.

It will be understood that the bar magnet is preferably not straight, but the midlines of the poles make an angle **26** which is between 45 and 315 degrees, and preferably of the order of 90 to 120 degrees. In the preferred form (Figures 1 to 5 inclusive) there is thus a recess **27** at one side in line with the axis, and the magnet is mounted on the shaft **20** by a U-clip **28** and a screw **29** passing through holes in the arms of the clip into the end of the shaft. In the alternate form of Figure 6, the bar magnet **23'** is bored at **29'** to receive the screw **29**.

Arranged at adjustable positions around the magnet **23** are sensitive magnetic switches **30** and **31**, desirably of the hermetically sealed type, held by clips **32** on arms **33** and **34** pivoted at **35** on the axis of shaft **20** in prolongation of the shaft. The adjustment pivot is supported on a base plate **36** mounted on the housing **37**. On arm **33** the clip **32** is mounted on a portion **38** beyond the pivot **35** from an adjustment extension **39** which rides over a scale **40** under a clamp guide **41** and is limited in travel by screws **42**. On arm **34** the adjustment extension **43** under guide **41** is on the same side of the pivot as the clip-supporting portion **44**. Adjustment extensions **39** and **43** are recessed at **45** and permit movement half-way up or down on scale **40**.

By swinging the adjustment extensions to different positions, the switches **30** and **31** respectively operating on low and high liquid level, are moved to positions corresponding to different liquid levels, as shown in Figures 3 and 4. Figure 3 corresponds to a relatively low high-level alarm position and a relatively high low-level alarm position, while Figure 4 corresponds to a relatively high high-level alarm position and a relatively low low-level alarm position. Of course the arms **33** and **34** can be adjusted independently when screws **42** are loosened, and will stay in adjusted position due to the clamping action of bar **41** when screws **42** are tightened.

Figures 7 and 8 show the construction of the magnetic mercury switches, which represent one of the types of sensitive magnetic switches well suited to the present invention. These comprise casings **46** of glass or other insulation sealed and containing inert gas on the interior at **47**. A cavity at the bottom holds a mercury pool **48**, connected by a lead **49** to a terminal **50** passing through the casing. The opposite terminal **51**, passing through the casing, supports an electrically conducting spiral spring **52** at its center from the outer end of which extends downward a movable contact **53**, offset at **54**, and having a contact end **55** which in open position (solid lines in Figure 7) is above and to one side of the mercury pool **48** and in closed position (dot-and-dash lines in Figure 7) enters the mercury pool **48**. A magnetically susceptible armature **56** on the movable contact **53** near the side wall of the casing, moves between the positions shown in Figure 7 to close the switch (dot-and-dash position) against the action of the spring. A support **57** on the terminal **51** carries an eye **58** which guides the offset portion **54** of the movable contact **53**.

Figures 7[a] and 8[a] show a hermetically sealed inert gas filled sensitive magnetic switch, which employs a fixed solid metallic contact **48'** connected to the terminal similarly to the connection of the mercury pool in Figures 7 and 8, and cooperating with a relatively movable solid metallic contact **55'** supported on the spiral spring **52** already described. A magnetizable armature **56'** is positioned on the movable element. An extension **54'** from the movable element is guided in motion by the eye **58**, already described.

It will thus be evident that as the magnet pole approaches the armature **56** of one of the switches, force is gradually built up by the magnet on the armature against the spring, until the switch closes.

The operation of the primary indicator is not itself part of the present invention, but may conform to Walter J. Kinderman United States patent applications Serial No. 517,242, filed January 6, 1944, supra for Differential Pressure Gauge, and Serial No. 713,035, filed November 29, 1946, supra for Meter. In these devices angular motion from a primary indicator shaft is transmitted without substantial frictional loss from a closed space in response to pressure differential or the like within the space.

A housing **60** of the indicator, as best seen in Figures 10 and 11, comprises a body **61** and a cover **62** united by bolts **63** and sealed by annular packing **64** on opposite sides of a diaphragm support **65** apertured at **66**. The diaphragm support is recessed at **67** on the side toward the body **61** in order to permit a well, later to be described, to fit into the recess. The housing is mounted in any suitable position, such as vertical, by a bolt entering a threaded opening **68**. On the side toward the cover, the diaphragm support is recessed at **69** to permit collapse into this space of an annular transversely free flexible diaphragm portion **70** of a diaphragm **71**. The diaphragm is held at its upper edge by the packing **64** which protects against leakage between the support and the cover. At the center the diaphragm is stiffened by diaphragm plates **72** which are united by threaded members **73**, **74** recessed at **75** to receive a thrust pin **76** engaging in a conical socket **77** and extending through an

opening 78 in the threaded member 74. The pin 76 carries a collar 79 to prevent accidental removal of its end from the space 75.

The diaphragm 71 is subjected to differential pressures on opposite sides through nipples 80 and 81. The pressure upon the inner face at 81 is a standard pressure in liquid level devices, which should be equal to or greater than the pressure obtained due to the highest level of liquid indicated.

At the opposite end the thrust pin 76 engages within a cavity 82 of a thimble 83 which is mounted as by peening at 84 on a leaf spring 85. The spring provides a convenient support for an indicator horseshoe magnet 86, and retards the movement of the magnet. The horseshoe magnet 86 is conveniently mounted on the spring by extending a plate 87 over the magnet and thimble and bolting through the plate, magnet and spring at 88. The thimble may conveniently be peened over at 89 to unite to the plate.

The motion of the magnet is transmitted to the primary indicator shaft 20 through a pressure wall or well 90 of suitable nonmagnetic material, which surrounds a magnetically susceptible rotatable armature 91 of spiral formation which is external of the housing 60 in the sense that it is not subjected to the pressure of the housing. The magnetic transmission is based upon the change of reluctance of the magnetic path with movement of the magnet at right angles to its flux along the axis of the armature, accompanied by rotary reaction of the armature to the magnet movement to reestablish the reluctance of the magnetic circuit at a balance position.

The magnet 86 is preferably a permanent magnet of highly magnetic alloy having curved poles 92, 93 which effectively surrounds the well 90, with suitable clearance to permit movement longitudinally of the well.

Both the permanent magnet 23 and the permanent magnet 86 may suitably be made of Alnico (24 to 30% nickel, 9 to 13% aluminum, balance iron) as well known in the art.

The well is threaded at 94 into the housing and internally threaded at 95 to receive the mounting of one bearing 21, the opposite bearing 21 being in the end of the well.

The armature 91, like the armature 56, may preferably be of soft iron or long carbon steel, such as Swedish iron or "core" iron. Silicon bronze is satisfactory for the well. The relation of the spiral pitch to the magnet thickness should be relatively high. A 4 to 1 ratio gives good results, and a 3 to 1 ratio is acceptable.

Provision is made for adjustment of the fulcrum of spring 85. Movement of the fulcrum edge normal to the plane of the spring controls the zero setting, while movement of the fulcrum edge along the surface of the spring parallel to the spring length changes the unsupported spring length and, therefore, changes the deflection characteristics. This is equivalent to calibration for range of liquid level travel.

The spring is desirably supported at its rear end between a transverse block 96 and its cap 97, both held together by bolts 98. If the supporting spring were of the same thickness and width throughout its length, the possible adjustment in range of movement due to fulcrum adjustment would be relatively small. To increase the effect of change in fulcrum, the spring can be varied in thickness or, as is more convenient in production, can be varied in width where it

is bent. The spring is accordingly made wide and is slotted at 99 adjacent the supporting end 100, and the walls adjacent the bifurcation are tapered oppositely at 101. The outer walls are tapered inwardly and upwardly toward the upper end at 102.

Although the spring is at all times supported by the block and the cap, the effective length of the spring is determined by an adjustable fulcrum in the form of a bar 103 having a knife edge 104 extending across the spring. The bar 103 is movable transversely of the length of the knife edge. The bar 103 is slotted transversely at 105 from the back so as to permit it to be slid from the left in Figure 10 upon a barrel 106 of a spool 107 having flanges 108. The spool is rigid with a screw 109 threaded into the housing 60 and into the block 96. The screw is accessible for turning through an opening 110 closed by a closure bolt 111. A disc 112 on the screw 113 mounted in the housing behind bar 103 moves the bar to the left or right in Figure 10 and correspondingly moves the fulcrum. Access to the screw 113 is provided through an opening 114 closed by a closure bolt 115. Since the setting of the zero point of the indicator is dependent upon the position of the magnet to the right or left in Figure 10, the zero point can be adjusted by advancing or retracting the disc 112. A set screw 116 prevents lowering of the bar 103 beyond the limit of adjustment.

In operation, the device of Figures 10 to 12 is controlled by motion of the diaphragm under differential pressure which causes the pin 76 to move the horseshoe magnet 86 against the retardation of the spring 85. Movement of the horseshoe magnet surrounding the well causes the armature 91 to rotate and thus turn the primary indicator shaft 20.

In Figure 13 the mechanism is shown applied to a steam drum and water column by which water level differences are indicated by difference in pressure on the indicator. The steam drum (boiler) 117 is connected by pipes 118, 119, one reliably above and one below the water level, with the water column 120 from which pipes 121, 122, again one reliably above and one reliably below the water level, connect with pressure pots 123, 124. From these pressure pots pipes 125, 126 lead through valves 127 to opposite sides of the diaphragm 71 as shown in Figure 10.

In this form the pipe connection 126 carrying varying pressure communicates with the nipple 80 at the left hand side of Figure 10. The pipe 125 communicates with the nipple 81 on the opposite side of the diaphragm in Figure 10. As the variant water level communicating with the lower pressure pot 124 drops, the pressure difference with respect to the constant level in pressure pot 123 increases and the magnet is shifted along the well toward the pointer, that is, outward along the armature, so as to give progressively lower indication for variant water level.

In Figure 14 the invention is applied to a plain float 128 within a boiler or other chamber under pressure but with indication outside. The float follows the level 129 of the liquid 130. The float arm or rod 131 is rigidly fastened to a magnet 86′ so that each forms one arm of a crank pivoted at 132. The magnet thus swings angularly to the same extent as the float arm or rod. The compartment 133 is formed conveniently by a fitting 134 attached by flanges 135 and

bolts 136 to a side of the boiler 137. The compartment communicates with the boiler through a casing opening 138. The magnet can be of the same character as magnet 86 except that for a considerable angle of swing of the magnet the poles desirably are opposite parallel surfaces. The well 90 and the armature 91 may be as in Figures 10 and 11.

It will be evident that the advantages of the invention in minimizing reaction on the primary indicator shaft from the magnetic mercury switches and obtaining smooth action, can be obtained with any of a wide variety of alarm circuits. For example, in Figure 9 we illustrate a low level alarm 139 such as an electric bell or lamp, in circuit with switch 30 across electric power lines 140. Similarly a high level alarm 141 is in circuit with a switch 31 across the lines 140. Other suitable alarm circuits may be used.

In view of our invention and disclosure variations and modifications to meet individual whim or particular need will doubtless become evident to others skilled in the art, to obtain all or part of the benefits of our invention without copying the structure shown, and we, therefore, claim all such insofar as they fall within the reasonable spirit and scope of our claims.

Having thus described our invention what we claim as new and desire to secure by Letters Patent is:

1. In a liquid indicator, a primary indicator including a shaft turning in response to high and low quantities to be indicated, a single divergent U-shaped permanent magnet positioned centrally on the shaft with the plane of the U transverse to the shaft, an adjustment pivot in prolongation of the axis of the shaft, an adjustment arm on the adjustment pivot having a plurality of angular adjustment positions, a switch mounted on the adjustment arm remote from the pivot and having a relatively fixed contact element, a swingable contact element adapted to contact the relatively fixed contact element when the switch is closed, having a spring urging the contact elements into open position and having a magnetizable armature on the movable contact element located at one side of the shaft generally in prolongation of a radius of the orbit of turning of the magnet, the armature being swingable about a point located on a line generally transverse to the said radius at a position remote from the radius, and the armature adapted to be magnetically influenced to move the movable contact for closing the switch, the switch in closed position having one magnet pole adjacent the armature and the other magnet pole remote therefrom and the magnet pole adjacent the armature being the only magnet pole adjacent thereto.

2. In a liquid indicator, a primary indicator including a shaft turning in response to high and low quantities to be indicated, a single divergent U-shaped permanent magnet centrally positioned on the shaft with the plane of the U transverse to the shaft, the magnet having radially outwardly directed arcuate poles each covering 30° to 90° of the arc of turning of the magnet, an adjustment pivot in prolongation of the axis of the shaft, a pair of adjustment arms on the adjustment pivot extending in divergent directions, switches each mounted on one of the adjustment arms remote from the pivot and each having a relatively fixed contact element, a movable contact element adapted to contact the relatively fixed contact element when the switch is closed, a spring urging the contact elements into open position, and a magnetizable armature on the movable contact element located at one side of the shaft generally in prolongation of a radius of turning of the magnet and swingable about a point located on a line generally transverse to said radius and remote therefrom, the armature being adapted to be magnetically influenced to move the movable contact element of the switch to close the switch, each switch in closed position having one pole adjacent the armature and the other pole remote from the armature of the switch when closed and the pole adjacent the armature of the closed switch being the only magnet pole adjacent such armature.

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