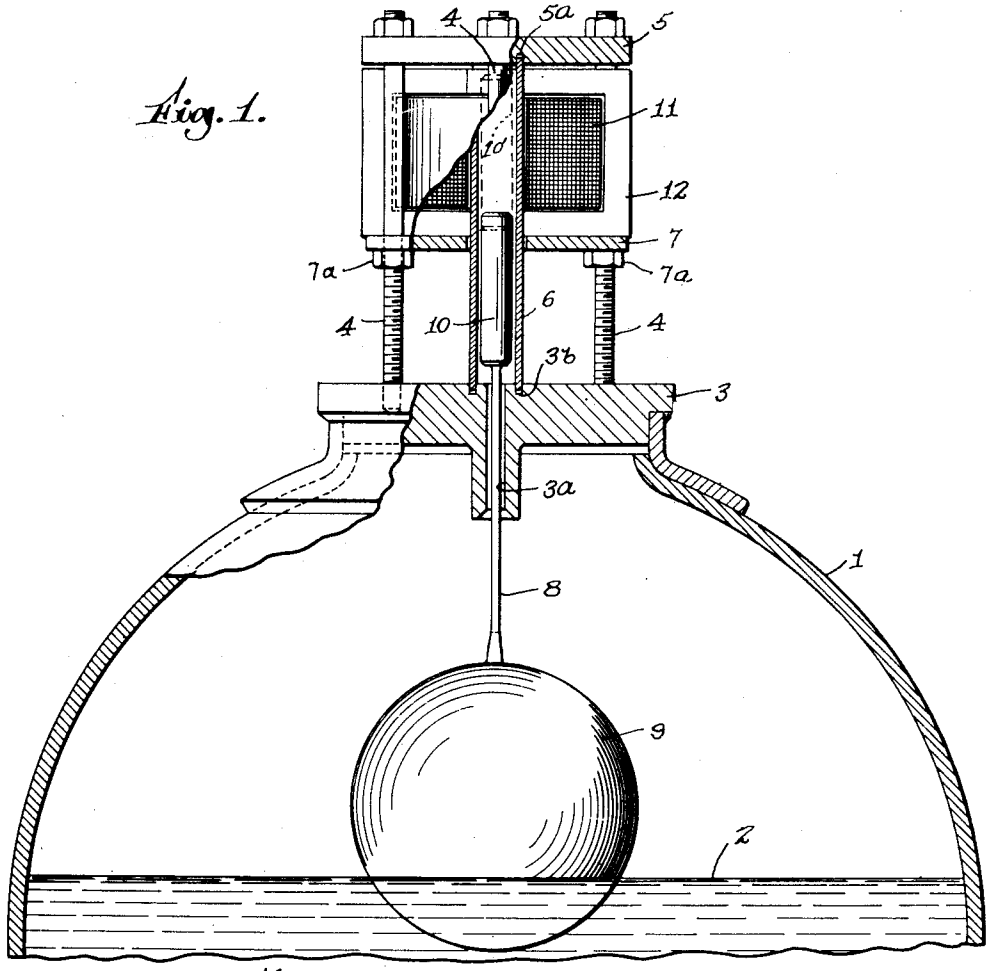
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ELECTRIC FLOAT CONTROL

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Fig. 1.



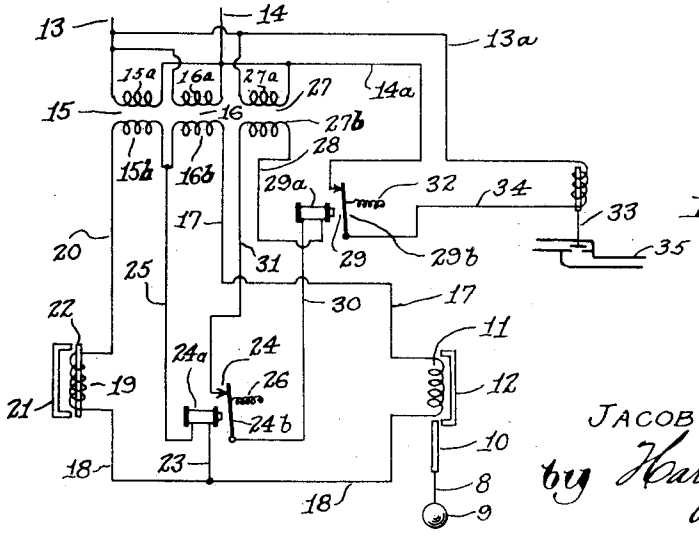


Fig. 2.

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Fig. 3.

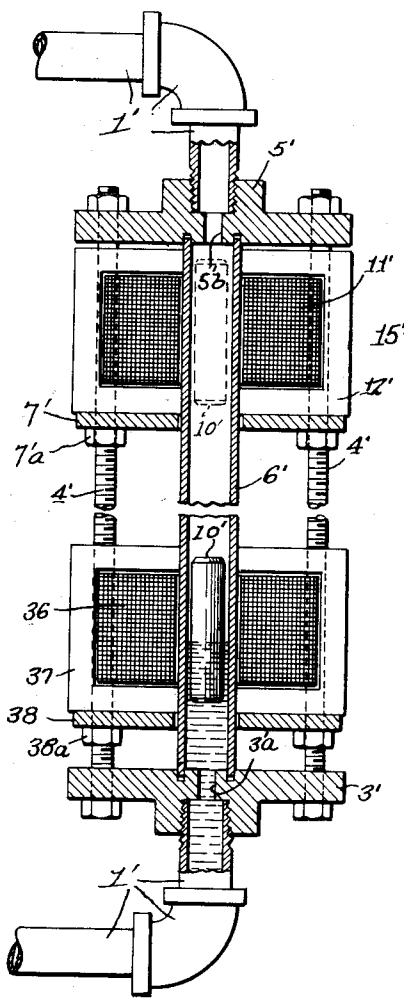
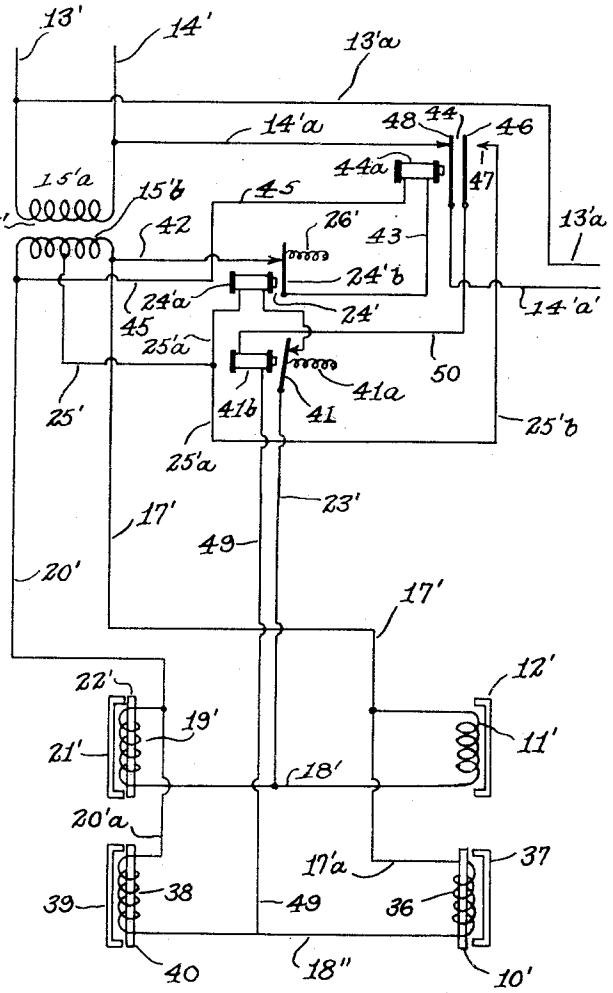


Fig. 4.



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ELECTRIC FLOAT CONTROL

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Application July 29, 1935, Serial No. 33,796

4 Claims. (Cl. 137—68)

This invention relates to improvements in electric float controls.

Float controls which have moving parts extending from inside to outside of a container have, so far as I am aware, required some sort of stuffing-box or packing, particularly if the parts are below the liquid level or if the container is at a pressure different from that of the atmosphere surrounding it. Where appreciable pressures are present the packing must be kept so tight as to interfere with a desirably free action of the control and even where such pressures are not experienced the packing required is not generally satisfactory. In the art of refrigeration, for example, especially where ammonia is used, the packing about movable parts must be carefully watched and great care exercised to see that it is kept tight. This, as before stated, makes the moving parts move stiffly and a desired sensitivity in the control is not enjoyed.

It is an object of this invention to provide a control having a float member within a container and actuated by changes of liquid level therein and having means outside the container which are actuated by the movement of said member although there is no physical or mechanical connection between them. Thus all stuffing-boxes and other forms of packing are eliminated. More specifically it is a feature of the invention to provide electric circuits whose characteristics are governed by the position of the float member to the end that different liquid levels effect different reactions in the circuits. Such a control is exceptionally sensitive.

The best modes in which I have contemplated applying the principles of my invention are shown in the accompanying drawings but these are to be taken as merely illustrative because it is intended that the patent shall cover by suitable expression in the appended claims whatever features of patentable novelty exist in the invention disclosed.

In the drawings:

Figure 1 is an elevation partly in section showing how the level actuated means may be attached to a container and be actuated by the main body of the liquid;

Figure 2 is a diagrammatic showing of the electrical circuits which may be associated with the level actuated means of Figure 1;

Figure 3 is another elevation, also partly in section, showing a modified form of float and means associated therewith; and

Figure 4 is a diagrammatic showing of the electrical circuits which are adapted to cooperate with the means shown in Figure 3.

Referring more particularly to the drawings, and especially to Figure 1, the wall 1 represents that of a container holding liquid 2 whose level is subject to change. Suitably attached to the container is what may be called a base plate 3, having a hole 3*a* therethrough leading to the interior of the container. Mounted on the base plate are supports 4, at the upper end of which is a top plate 5. Between the two plates is a tubular member 6, its ends being tightly sealed in circular grooves 3*b* and 5*a* of the respective plates. This member is made of non-magnetic material and preferably of material having low electric conductivity or high dielectric strength. It is arranged with respect to the hole 3*a* in the base plate so that a rod 8 may extend from a float 9 inside the container through the hole and to a metal cylinder 10 having high magnetic permeability. As the float moves upward and downward with changes of level of the liquid the member 10, hereinafter called an armature, moves correspondingly within the tubular member.

Surrounding the latter near its upper end is a coil of wire 11 connected to a source of alternating current. Outside of this coil are two U-shaped laminated magnetic bars 12 having high magnetic permeability and so disposed that their ends are separated by the tubular member. These bars together with the space through the middle portion of the coil (being the space containing the tubular member) constitute a path for the magnetic flux generated by the current flow in the coil. The latter and these bars, which serve as the fixed portion of the magnetic circuit and are hereinafter termed the fixed magnetic conductor, are adjustably mounted on the supports 4 by a plate 7 and nuts 7*a*. When the float is at a relatively low level so that the armature 10 is below the coil and the fixed magnetic conductor 12, the electrical characteristics of the coil are unaffected by the armature, but when the latter moves upward to the position indicated in dotted outline, its high magnetic permeability cooperating with the fixed magnetic conductor, appreciably affects the characteristics of the coil by changing the impedance. Thus it is that the moving parts within the space of the container (the interior of the tube 6 being treated as a part of such space) are able to affect an electrical agency outside of this space, which agency has no physical or mechanical connection with the moving parts inside the container.

To appreciate the effect of changing the char-

acteristics of the coil 11 reference is had to Figure 2 showing diagrammatically a preferred arrangement of circuits and electrical agencies. The wires 13, 14 of some suitable alternating current power line are separately connected to the primary windings 15a and 16a of a pair of duplicate transformers 15 and 16 respectively. The secondary windings 15b and 16b of these transformers are connected together and form part of a circuit which comprises a wire 17 connecting winding 16b with the coil 11 already described and shown in Figure 1. This coil is connected by wire 18 with an identically similar coil 19 and the latter is in turn connected by wire 20 with the secondary winding 15b of the transformer 15. Associated with coil 19 is a fixed magnetic conductor 21 which is a duplicate of conductor 12, and within coil 19 is a fixed armature 22 which is a duplicate of armature 10. It is clear that when armature 10 is in its upper position and occupies the same position relative to coil 11 and the fixed magnetic conductor 12 that the fixed armature 22 bears to coil 19 and conductor 21, the electrical characteristics of the two coils are the same. In other words, the value of the impedance of coil 11 is the same as the value of the impedance of coil 19.

Between the coils 11 and 19, the wire 18 is connected to another wire 23 which leads to the energizing coil 24a of a relay 24, from which another wire 25 is connected midway between the secondary windings 15b and 16b. Since these windings have the same impedance and electromotive force, and since the coils 11 and 19 have equal impedances when armature 10 occupies the same position with respect to coil 11 as the fixed armature 22 occupies with respect to coil 19, it follows that the current flow (alternating current flow) along wire 17, through coil 11 and wire 18, is the same as the flow through coil 19 and wire 20. Accordingly the voltage drop or difference in potential along wire 23, through coil 24a and wire 25 is zero, and hence no current will flow along these last mentioned elements.

If, however, the level of liquid falls and armature 10 is withdrawn from within coil 11, as shown in Figures 1 and 2, then the impedance of this coil is altered, being reduced because of the decrease in the inductive reactance of the coil. In other words, removal of the armature increases the reluctance to the flow of magnetic flux, thus decreasing the impedance of the coil. As a result more current can now flow along wire 17, through the coil 11 and along wire 18. Since the impedance of coil 19 has remained unchanged, substantially the same amount of current as before will flow through this coil and along wire 20, and the excess of current flow through coil 11 will now pass along wire 23, through the relay coil 24a and thence along wire 25 to the transformer.

The energization of the coil 24a by the flow of current just described effects movement of its armature 24b against the continuous tension of a spring 26. This relay 24 alone might be depended upon to control other agencies directly but is here shown as an intermediary element for closing an auxiliary circuit comprising the secondary winding 27b of another transformer 27, whose primary winding 27a is connected to branch wires 13a and 14a leading from the power mains. This secondary winding 27b is connected by a wire 28 to a coil 29a of a second relay 29, which in turn is connected by a wire 30 to the switch of relay 24. Wire 31 returns from this switch to the secondary winding 27b. Since an alternating current is always flowing through the primary winding 27a an induced current will flow along wire 28, through relay coil 29a, wire 30, and wire 31 whenever relay 24 is energized to close its switch.

This current flow energizes relay 29 and its armature 29b is moved against the force of spring 32 to close its switch. This is a part of a circuit comprising the wire 13a, some electrically actuated element 33, a wire 34 leading thence to the switch of relay 29, and the wire 14a. When this circuit is made by the closing of the relay switch the current flows through the element 33 and effects its operation as desired. As here shown, this element is a solenoid valve in a supply line 35 which may lead to container 1, but it is clear that this is merely representative of any other equivalent element such as a compressor, indicator, etc. Here, since this valve controls the supply line to the container and since float 9 therein was assumed to fall and thus withdraw armature 10 from within coil 11, it follows that valve 33 will be opened to permit flow of liquid to container 1 to restore its level. Upon such restoration to a point where armature 10 again effects the coil 11 so that it corresponds electrically with coil 19, the excess current flow along wire 23, through relay coil 24a and wire 25 will cease. Upon the consequent deenergization of relay 24, its controlled circuit will be broken and relay 29 in turn deenergized. Thus the electrical element 33 is affected in accordance with the change in level.

The principles of the invention thus far disclosed are likewise applied in the arrangements shown in Figures 3 and 4. Here the armature 10' is itself a float and moves within a tubular member 6' held between two plates 3' and 5' by supporting bolts 4'. Each plate (they preferably are duplicates) has a hole (3'a and 5'b) connecting the interior of the tube with pipe fittings 1' by which the interior of the tube may be placed in communication with a container much in the same manner as an ordinary gauge glass. Indeed, the tubular member 6' may be constructed of transparent material such as glass or quartz and perform the function of a gauge glass. The liquid in the container finds its level in the tube and changes in this level move the float or armature upward or downward.

Mounted on the supports 4' is a coil 11' and a relatively fixed magnetic conductor 12' similar to those first described. This is held in position by a plate 7' and nuts 7'a at any selected elevation. Below, on the supports 4' is another coil 36 and another relatively fixed magnetic conductor 37, these being likewise adjustably held by another plate 38 and nuts 38a. Thus there is provided separated electromagnetic fields which may be separately affected by the armature. As will presently appear, the amount or distance between these fields determines the delay or pause between one actuation and the other of a controlled electric element, such as the valve 33 shown in Figure 2.

Figure 4 shows diagrammatically the preferred arrangement of circuits to be associated with the coils 11' and 36. In this embodiment the wires 13' and 14' of the alternating current power line are connected to a transformer 15' having a single primary winding 15'a and a single secondary winding 15'b, although obviously the same arrangement of two transformers as is shown in

Figure 2 might be employed. Wire 17' leading from one end of the secondary winding connects with coil 11' and from this a wire 18' connects with a corresponding coil 19'. This has a fixed magnetic conductor 21' and a fixed armature 22' like conductor 12' and armature 10' respectively, so that when the latter is within coil 11', the value of the impedance of coil 11' and coil 19' will be the same. The latter coil is in turn connected by wire 20' with the other end of the secondary winding 15'b.

An extension 17'a of wire 17' also leads to coil 36 and another wire 18'' connects this coil to still another coil 38 having a fixed magnetic conductor 39 and a fixed armature 40 such that the value of the impedance of this coil 38 will be the same as that of the impedance of coil 36 when armature 10' is within the latter coil. Coil 38 is connected to wire 20' by the extension 20'a.

The central portion of the secondary winding 15'b is connected by a wire 25' and its branch 25'a with a coil 24'a of a relay 24'. This coil is also connected through the switch terminals of another relay 41, and by wire 23' with wire 18'. The switch terminals of relay 41 are normally maintained closed by a spring 41a and, assuming at the moment that this switch is closed, it is evident that the action of the coils 11' and 19' and the relay 24' are similar to those of coils 11 and 19 and relay 24 of Figure 2. When the armature 10' is withdrawn from coil 11', then current will flow along wire 23', coil 24'a and wire 25', (assuming the switch of relay 41 to be closed) and relay 24' will be energized to close its switch. The latter is part of a circuit comprising a wire 42 leading from wire 17', the switch of relay 24', a wire 43 leading thence to a coil 44a of a double switch relay 44, and wire 45 running back to the wire 20'. Accordingly, as the switch of relay 24' is closed, current will flow in the last mentioned circuit and energize the coil 44a. This will cause terminal 46 to disengage from another terminal 47 and move terminal 48 into contact with the terminal of wire 14'a. The main circuit is thus established along wires 13'a and 14'a (plus its extension 14'a' connected to terminal 48) through an electric element 33, (not shown in Figure 4) which may be a solenoid valve as indicated in Figure 2. This valve is held open while the armature 10' is out of coil 11' and within coil 36. While this condition prevails there will be equal current flow through coils 36 and 38 since the value of the impedance of each coil is the same. Consequently no flow will occur along a wire 49 which leads off from wire 18'' to the coil 41b of relay 41. This coil is also connected by wire 50 with the terminal 46, previously mentioned as being out of engagement with another terminal 47.

But now assume the liquid level changes so that armature 10' moves out of coil 36. This will affect the impedance of the coil and more current will flow along wire 17' (17'a) and the coil, and wire 18''. This would be expected to cause current flow along wire 49 but it will be recalled that terminals 46 and 47 are still disengaged. Accordingly no change takes place until armature 10' moves into coil 11' and so affects the impedance of that coil as to effect stoppage of current flow along wire 23'. When this occurs, the coil 24'a of relay 24' is deenergized and its switch opened under the pull of spring 26'. This, of course, breaks the circuit through coil 44a and thus allows terminal 48 to separate from wire 14'a thus opening the circuit controlling the electrical element 33. At the same time terminal 46 moves to engage terminal 47 and completes a circuit for current flow along wire 49, coil 41b, wire 50, and thence along a branch 25'b connecting terminal 47 with the wire 25'.

Completion of the last mentioned circuit and consequent flow of current through coil 41b causes the switch of relay 41 to open against the pull of spring 41a. This, of course, breaks the circuit between wire 18' and the transformer along wire 23' etc., although, as just described, there is at the moment no flow along wire 23' because armature 10' is within coil 11'. The purpose of thus opening the switch of relay 41 is to prevent any change in the position of the terminals of relay switch 44 until armature 10' is again moved within coil 36. That is to say, when the armature moves out of coil 11', a flow of current would occur along wire 23' if the switch of relay 41 were not open. Since it is held open by the current flow along wire 49, no current can flow along wire 23' until the armature moves into coil 36 and establishes conditions which stop the flow along wire 49. As this takes place, coil 41b is deenergized, the switch of relay 41 is closed and then current will flow along wire 23' to energize coil 24'a. As previously described, this brings about the opening of terminals 46, 47 and closure of terminal 48 with the wire 14'a, and the consequent actuation of the electrical element 33.

Thus the modification of the invention shown in Figures 3 and 4 enables a predetermined delay in the control of the element 33, and this delay may be determined by the relative positions of the coils 11' and 36 on the support rods 4'.

I claim:

1. Electric float control apparatus for restoring the level of liquid in a container comprising a transformer connected to a source of alternating current; a pair of circuits connected to the secondary winding of said transformer; a pair of coils in each of said pairs of circuits; one coil in each of said pairs of circuits having associated therewith a fixed magnetic conductor arranged externally of said coil and a fixed armature arranged internally of said coil; the other coil in each of said pairs of circuits having a corresponding fixed magnetic conductor arranged externally thereof; a fixed tubular member extending through each of the last mentioned coils, having an open connection with the container; an armature movable within said tubular member in response to changes of the liquid level in the container, and adapted when positioned in the path of magnetic flux of either of the last mentioned coils to increase the flow of said flux and thereby increase the impedance and correspondingly reduce the current flow through the coil surrounding said movable armature; a second pair of circuits, one of which is connected between one of the first mentioned pair of circuits and the secondary winding, and the other of which is connected between the other of the first mentioned pair of circuits and the secondary winding; and means associated with said second pair of circuits for controlling the admission of liquid to the container; the said apparatus being so organized that when the liquid is at a desired level the movable armature is positioned in the magnetic path of one of the last mentioned coils with respect to which it is movable whereby admission of liquid to the container is cut off, and when the liquid falls to a predetermined lower

level the movable armature is positioned in the magnetic path of the other of the last mentioned coils with respect to which it is movable whereby admission of liquid to the container occurs to restore the desired level; and said apparatus being further organized so that the control determined by the presence of the movable armature within the magnetic path of one of the coils with respect to which it is movable continues until the movable armature has moved within the magnetic path of the other of the coils with respect to which it is movable.

2. Electric float control apparatus for restoring the level of liquid in a container comprising a transformer connected to a source of alternating electric current; a connection between the secondary winding of said transformer and a coil; said coil; a connection between said coil and a relay; said relay; a connection between said relay and said secondary winding at a point remote from the first mentioned connection; means actuated by a predetermined current flow through said relay to effect admission of liquid to said container; a fixed magnetic conductor arranged externally of said coil having high magnetic permeability; a fixed tubular member, extending through said coil and in open connection with the container, having low magnetic permeability and a high electrical resistance whereby the flow of magnetic flux through the fixed magnetic conductor is retarded and the formation of eddy currents is rendered negligible; and an armature of high magnetic permeability movable in said tubular member in response to changes of liquid level in the container; the apparatus being so organized that when the liquid is at the desired level the armature is within the said coil and coacts with said fixed magnetic conductor to increase the flow of magnetic flux and the impedance of the coil with consequent reduction of the current flow whereby the current flow through said relay is below the said predetermined flow, and when the liquid level falls the armature is removed from said coil thereby effecting a decrease of flow of magnetic flux and the impedance of the coil with consequent increase of current flow to provide the predetermined flow through said relay.

3. Electric float control apparatus for restoring the level of liquid in a container comprising a transformer connected to a source of alternating electric current; a circuit connected to the secondary winding of said transformer; a coil in said circuit; a fixed magnetic conductor arranged externally of said coil having high magnetic permeability; a fixed tubular member extending through said coil and in open connection with the container, having low magnetic permeability and high electrical resistance whereby the flow of magnetic flux through the fixed magnetic conductor is retarded and the formation of eddy currents is rendered negligible; an armature of high magnetic permeability movable within said tubular member in response to changes of liquid level in the container; the said armature being positioned within said coil when the liquid is at the desired level to increase the flow of magnetic flux through the fixed magnetic conductor and the impedance of the coil with corresponding reduction of current flow in said circuit, and being withdrawn from said coil when the liquid falls below the desired level to effect reduction of flow of magnetic flux through the fixed magnetic conductor and the impedance of the coil with consequent increase of current flow in said circuit; and means associated with said circuit and responsive to changes in the current flow therethrough for controlling the admission of liquid to the container so that upon fall of the liquid level and consequent withdrawal of the armature from said coil said responsive means are actuated to admit liquid to the container and restore the level.

4. A circuit for electric float control apparatus having an armature member of high magnetic permeability movable, within a fixed tubular member of low magnetic permeability and high electrical resistance, in response to changes of level of a liquid; said circuit comprising a transformer connected to a source of alternating electric current; a lead from the secondary winding of said tranformer to a coil surrounding the said fixed tubular member and having a fixed magnetic conductor of high magnetic permeability arranged externally of the coil; a lead from said coil to another coil having electrical characteristics corresponding to the first mentioned coil with a fixed armature member within said other coil and a second fixed magnetic conductor arranged externally of said other coil both with electro-magnetic characteristics corresponding respectively to the movable armature member and to the first mentioned fixed magnetic conductor; a lead from said other coil to the said winding of the transformer; a lead from the lead intermediate of said coils to a relay; a lead from said relay to the secondary winding intermediately of the other said leads connected thereto; and means actuated by said relay for effecting a change in the level of the liquid; the de-energization of said relay being effected when the movable armature member is moved within the tubular member to a position with respect to the first mentioned coil corresponding to the position of the fixed armature member with respect to the second mentioned coil, and the energization of said relay being effected when the movable armature member is moved to without the magnetic field of the first mentioned coil.

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