Sept. 29, 1942. R. A. WITTMANN 2,296,969

LIQUID RESPONSIVE SYSTEM

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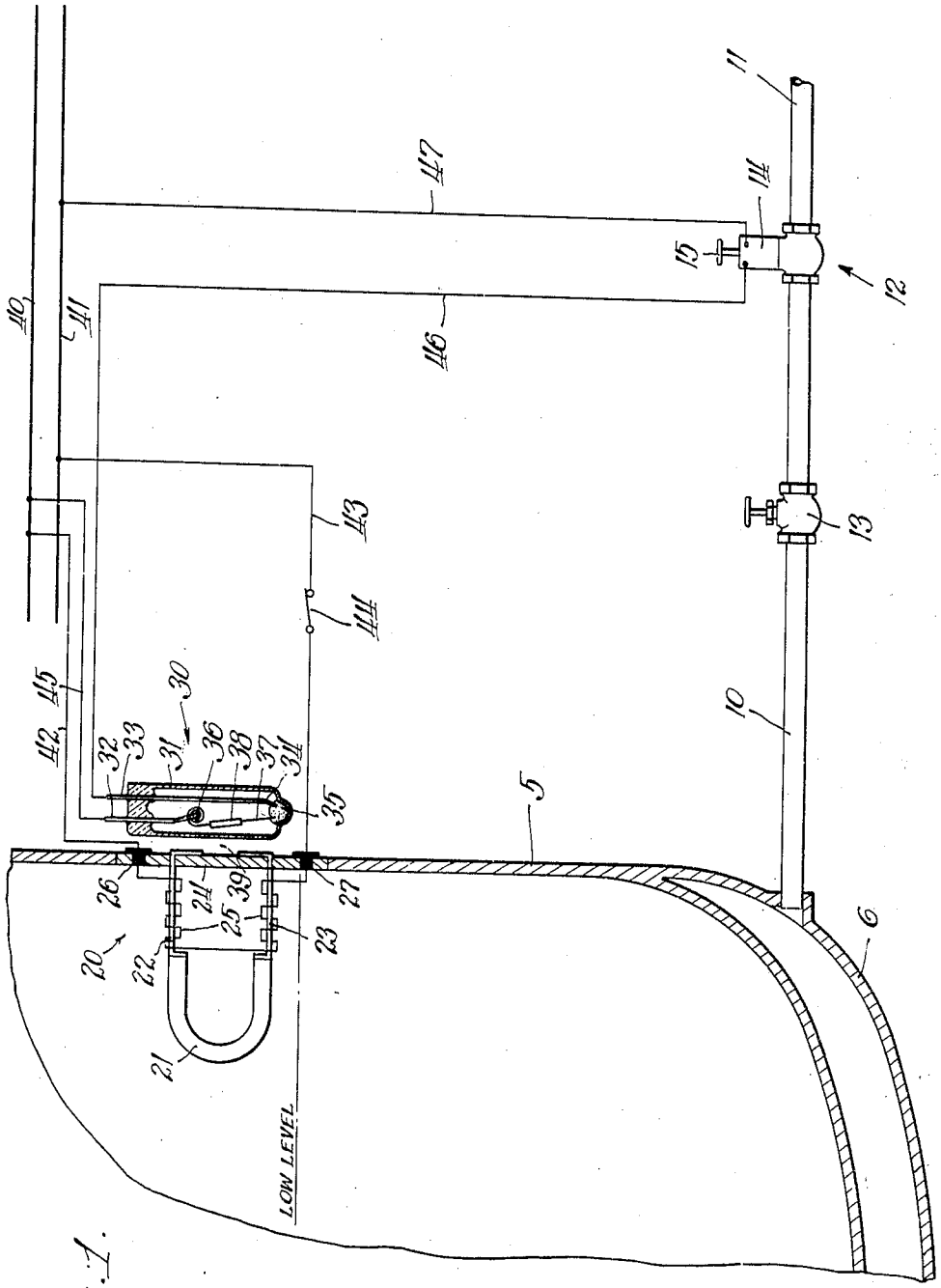


Fig. 1.

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Fig. 2.

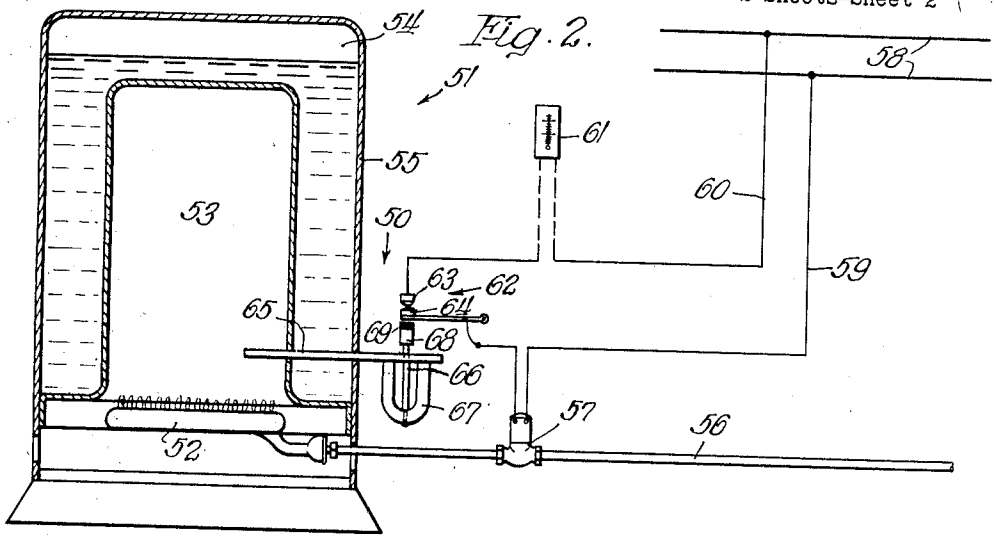


Fig. 3.

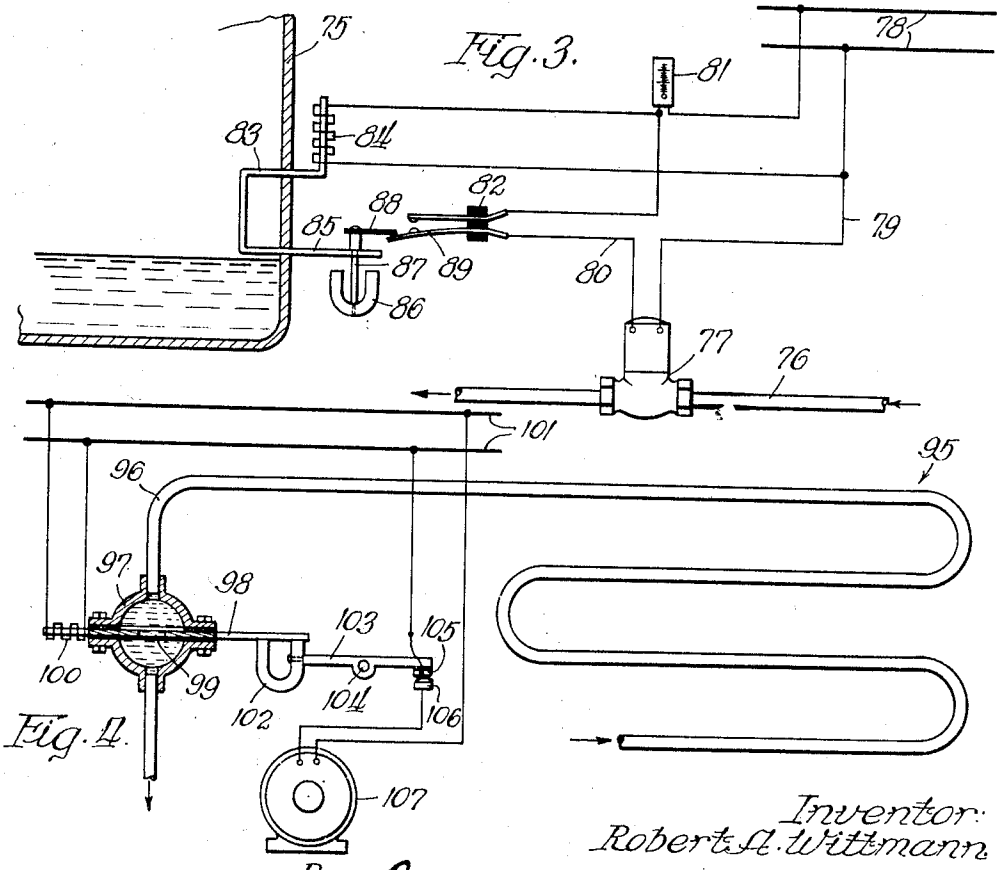


Fig. 4.

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LIQUID RESPONSIVE SYSTEM

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14 Claims. (Cl. 200—88)

My invention relates, generally, to systems responsive to the absence and presence of liquids, and it has particular relation to such systems in which Curie point metal is the responsive element.

My invention can be used in conjunction with boilers, autoclaves, pressure and vacuum kettles, evaporators, stills, condensers, cooling and heating coils, and similar devices where a check on the absence or presence of liquid is required. Because of its freedom from moving parts exposed to the liquids in which it may be disposed for operation, it is a marked improvement over similar systems used heretofore. Since it can be made resistant to or protected from corrosive liquids and vapors it has a wide application in the chemical and related industries. Also it can be designed to operate under substantially all temperatures encountered in practice.

Accordingly, one object of my invention is to provide a system responsive to the absence and presence of liquids wherein there are no moving parts exposed to the liquids and hence eliminating frequent safety inspections.

Another object of my invention is to provide a system responsive to the absence and presence of liquids which will operate satisfactorily for long periods under both continuous and intermittent operating conditions.

Another object of my invention is to provide a system responsive to the absence and presence of liquid which can be readily installed in new or existing equipment.

Other objects of my invention will, in part, be obvious and in part appear hereinafter.

Accordingly, my invention is disclosed in the embodiments shown in the accompanying drawings, and it comprises the features of construction, combination of parts, and arrangement of elements which will be exemplified in the constructions hereinafter set forth and the scope of the application of which will be indicated in the appended claims.

For a more complete understanding of the nature and scope of my invention, reference may be had to the following detailed description, taken in conjunction with the accompanying drawings in which:

Figure 1 illustrates diagrammatically one embodiment of my liquid responsive system applied to a steam jacketed kettle;

Figure 2 illustrates diagrammatically another embodiment of my liquid responsive system applied to a boiler;

Figure 3 illustrates diagrammatically another embodiment of my liquid responsive system applied to a boiler; and

Figure 4 illustrates diagrammatically still another embodiment of my liquid responsive system applied to what may be either a cooling or heating coil.

Referring to Figure 1 of the drawings, it will be observed that the reference character 5 designates a kettle the bottom portion of which is surrounded by a steam jacket 6. For example, this might be a kettle in which a liquid is evaporated to remove a desired amount of water. The steam jacket 6 may be supplied with steam through the pipe 10 from a steam main through a shut-off valve shown, generally, at 12. For accurate control of the steam supply, a needle valve 13 may be provided in the pipe. The shut-off valve 12 is provided with an electric motor 14 for closing it. A hand wheel 15 is provided to manually open and close the valve 12. The manner in which the motor 14 is operated will be described in detail hereinafter.

With a view to limiting the level to which a liquid in the kettle 5 can be evaporated, a liquid level responsive system shown, generally, at 20 is provided. The liquid level responsive system 20 comprises a permanent horseshoe magnet 21 with two pole extension members 22 and 23 extending from the poles thereof. If desired, the permanent horseshoe magnet 21 can be replaced by some other shaped permanent magnet or by an electromagnet. A non-magnetic plate 24 may be inserted into the side wall of the kettle 5 with the pole extension members 22 and 23 passing therethrough as shown. Electrically insulated, liquid and vapor-proofed, heating coils 25 are wrapped around the pole extension members 22 and 23 as shown, and connected in series circuit relationship with the terminal leads extending through insulating bushings 26 and 27. A magnetically operated switch shown, generally, at 30 is disposed adjacent to the ends of the pole extension members 22 and 23 as shown.

The details of construction of the magnetic control switch 30 may be varied and I shall describe one form that operates very satisfactorily. The magnetic control switch 30 comprises a glass container 31 with a pair of sealed inleads 32 and 33. The inlead 33 continues as a conductor 34 to the bottom of the glass container 31, where, in a suitably formed depression of the container 31, there is deposited a pool of mercury 35 in which the conductor 34 is at all times immersed. The inlead 32 is connected to a coil spring conductor 36 which normally holds the lower contact end

37 in the pool of mercury 35. This coil spring conductor 36 carries a magnetic armature 38 which, when attracted towards the adjacent wall of the container 31, causes the lower contact end 37 to leave the mercury pool 35 and thereby break electrical contact with it to open the circuit between the inleads 32 and 33. The magnetic control switch 30 is so positioned that the magnetic armature 38 is opposite the air gap 39 between the ends of the pole extension members 22 and 23.

With a view to furnishing a source of electrical energy for operating the motor 14 and the heating coils 25, a pair of energized conductors 40 and 41 are provided. For example, this source may be the ordinary 110 volt alternating current source. The terminal ends of the heating coils 25 may be connected by the conductors 42 and 43 to the energized conductors 40 and 41. A switch 44 is provided in the conductor 43 for controlling the energization of the heating coils 25 as desired. The inlead 32 of control switch 30 can be connected to the energized conductor 40 by the conductor 45. Inlead 33 is connected by means of conductor 46 to one terminal of the motor 14. The other terminal of the motor 14 is connected to the energized conductor 41 by the conductor 47. It will be seen that the control switch 30 is in series circuit relationship with the motor 14.

The pole extension members 22 and 23 are of Curie point metal which, when below their Curie point, are ferromagnetic and, when above it, are nonmagnetic. Since there is a large variety of Curie point metals with different Curie points or transition temperatures, it is possible to make a selection for different operating conditions as desired. When the heating coils 25 are energized they will heat the pole extension members 22 and 23. However, when the pole extension members 22 and 23 are surrounded by liquid, the heat will be transferred away to such an extent that they will not rise above their Curie point and become nonmagnetic. If however the pole extension members 22 and 23 are not surrounded by a liquid medium, but instead a gaseous medium, the heat from the heating coils 25 will not be dissipated so rapidly and the pole extension members 22 and 23 will become nonmagnetic.

It will be seen that when the pole extension members 22 and 23 are below their Curie point and therefore ferromagnetic nearly all of the flux from the permanent horseshoe magnet 21 will flow across the air gap 39 between the ends of the pole extension members 22 and 23. The flux density will then be sufficient to attract the magnetic armature 38 against the force of the coil spring conductor 36 and cause the lower contact end 37 to leave the mercury pool 35, thereby opening the circuit between the inleads 32 and 33. However, when the pole extension members 22 and 23 are heated above their Curie point and are therefore nonmagnetic, the flux density in the air gap 39 will decrease to such an extent that the magnetic armature 38 will no longer be attracted to an extent sufficient to maintain the control switch 30 in the open positon.

In operation, assume that the kettle 5 is filled with a definite quantity of a liquid to be evaporated to a certain degree and that the quantity is such that when it is evaporated down to the level of the permanent magnet 21, the desired quantity of water will have been removed. After the batch has been put into the kettle 5, the shut-off valve 12 is opened and the needle valve 13 is adjusted allowing steam to pass through to the steam jacket 6. Also, the switch 44 is closed to complete the circuit through the heating coils 25. The liquid surrounding the heating coils 25 will conduct the heat away at such a rate that the pole extension members 22 and 23 of the Curie point metal will not be heated above their Curie point and therefore the control switch 30 will be in the open position. After a time the liquid level in the kettle 5 will gradually fall partially or wholly below the permanent magnet 21 as illustrated. When this occurs, the pole extension members 22 and 23 will no longer be surrounded by liquid but they will be surrounded by the gases above the liuid. As the heat from the heating coils 25 cannot now be so rapidly dissipated, the pole extension members 22 and 23 will be heated above their Curie point and become nonmagnetic. When this happens the flux density in the air gap 39 will decrease causing the control switch 30 to close. Upon closing of the control switch 30, the circuit to the motor 14 will be completed. The motor 14 on energization operates the shut-off valve 12 to the closed position, thereby shutting off the steam supply to the steam jacket 6. The operator may now draw off the concentrated batch and refill the kettle 5. The foregoing cycle of operation can then be repeated. The responsive switches herein disclosed may optionally be normally open or normally closed with appropriate closed or open circuits, respectively, accordingly. It is well known that before a liquid can go into vapor, the temperature must first be raised to the boiling point, and then the so called latent heat of vaporization must be supplied to it. In the case of water, the latent heat of vaporization is a very large quantity. In brief, with a high specific heat to begin with, and with a large latent heat of vaporization required to vaporize the liquid after it reaches the boiling point, a body of liquid is capable of receiving a large amount of heat, and of keeping its temperature at no higher than the boiling point even though considerable amounts of heat be conducted to it.

In the present case, thermal contact of the Curie point material with the liquid keeps said material from increasing its temperature above the boiling point of the liquid, no matter how much heat is supplied to the body by the electric heaters 25 or 84 or 100, in Figure 1 or 3 or 4, or the gas heater 52 in Figure 2. The Curie point of the magnetic element is selected to lie above the boiling point of the liquid. Hence the present device cannot operate so long as liquid remains in thermal contact with the body of Curie point material. That means that the present device provides a sensitive and stable means for detecting liquid level, or the presence of liquid in a given position, which is peculiarly reliable and durable.

If desired, my liquid level responsive system can be disposed entirely within the kettle 5 and the magnetic control switch 30 can be replaced by some other type of magnetic switch. When entirely disposed in the kettle 5, the liquid level responsive system can be adjustably suspended so that the steam can be shut off at any desired level. In some cases it may be desirable to dispose the liquid level responsive system in a liquid well fittted on the side of the kettle 5.

Also, if desired, only one of the pole extension members 22 or 23 can be wrapped with a heating coil 25. In evaporating some liquids it may be necessary to make certain that they are not overheated. In order to take care of this requirement the pole extension members 22 and 23 may

be selected so that they will become nonmagnetic below this maximum allowable temperature so that the heat supply may be shut off even though the liquid is not evaporated to the desired extent. Such an installation will respond to either of the aforesaid conditions, namely, it will respond to dropping of the liquid level below the selected minimum height, or the liquid leaving the locus of thermal contact between the liquid and the element; and, second, it will respond if the liquid is heated to a temperature in excess of a certain fixed value even if the level of the liquid be above the selected minimum, or be in position to make the aforesaid thermal contact.

It will be seen that there are many other applications of my liquid level responsive system illustrated in Figure 1. For example, it may be used equally well to operate shut-off valves in steam, hot oil or gas mains. Another important application is its use in maintaining a definite liquid level. In this case the magnetic control switch can be connected in series with the motor of an electric pump which supplies liquid to a tank. When the liquid surrounds the heating coils **25**, the heat will be dissipated and the magnetic control switch will be opened, thereby shutting off the motor which operates the pump. If, however, the liquid level should fall below the pole extension members, the heat from the heating coils **25** will not be dissipated to the former extent and the magnetic control switch will be closed thereby starting the electric motor which drives the pump supplying liquid to the tank. The pump will continue to operate until the liquid again surrounds the pole extension members and the heat of the heating coils **25** is once more dissipated allowing the magnetic control switch to open and to stop the electric motor. Also, the permanent magnet **21** may be located in a tank at the lower water level point and the magnetic control switch **30** may be connected to an alarm in such manner that, once the liquid falls below this lower limit, the magnetic control switch **30** will close, thereby causing the alarm to be sounded.

Referring now to Figure 2 of the drawings, another construction of a liquid level responsive system shown, generally, at **50**, is applied to a boiler shown, generally, at **51**, for operation therewith. The boiler **51** may be heated by a gas burner **52** positioned at the bottom of the combustion chamber **53**. The combustion chamber **53** is formed by the boiler top **54** and the water leg **55**. Gas is supplied to the bas burner **52** through a supply line **56** containing a solenoid operated valve **51**. Electric current for opening the solenoid valve **57** is supplied thereto from a pair of energized conductors **58** through conductors **59** and **60**. The conductor **60** contains in series circuit relation a thermostat **61** and a switch shown, generally, at **62**. The switch **62** consists of a stationary contact **63** and a movable contact **64**.

The liquid level responsive system **50** has as its responsive element a bar of Curie point metal **65** extending through the water leg **55** into the combustion chamber **53**. The bar **65** is positioned at the lowest safe operating water level of the boiler **51**. A rod **66** is adapted to move up and down in a hole provided therefor in the outer end of the bar **65**. The rod **66** carries from its lower end a permanent horseshoe magnet **67**. An extension **68** of the rod **66** is provided as support means therefor having a diameter greater than that of the hole through which the rod **66** is suspended. The extension **68** is provided with a cap of insulation **69**. As shown the cap **69** will bear against the movable contact **64** when the magnet **67** is attracted to the underside of the bar **65** and the switch **62** will be closed thereby. When the magnet **67** is not attracted it will drop and the switch **62** will be opened.

In normal operation the water leg **55** is filled with water about the bar of Curie point metal **65**. The end of the bar **65** within the combustion chamber **53** is heated by the burner **52** and the heat is conducted therethrough to its outer end under which the magnet **67** is suspended. So long as the bar **65** is surrounded by water in the leg **55** sufficient heat will be dissipated therefrom so that the outer end will remain below its Curie point and thus will be ferromagnetic. When the outer end is below its Curie point and ferromagnetic the magnet **67** will be attracted to it and the switch **62** will be closed. If now the thermostat **61** is calling for heat the circuit to the solenoid valve **57** will be completed and the valve will be opened allowing gas to flow to the burner **52**. Now if the water in the water leg **55** falls below the bar **65** heat will not be dissipated from it sufficiently and the outer end will rise above its Curie point and become non-magnetic allowing the magnet **67** to drop and thereby opening the switch **62** and shutting off the solenoid valve **57**. Thus it will be impossible for gas to be supplied to the burner **52** unless the water in the water leg **55** is at a level above that of the bar of Curie point metal **65**. It will be understood that the boiler **52** might be heated by oil or coal and the liquid level responsive system **50** could be adapted to close the oil supply valve or stop a stoker if a low water level should occur.

With a view to providing a liquid level responsive system in which the responsive element is a body of Curie point metal, which is electrically heated and which will only be heated when heat is being supplied to the installation to be protected, I have provided the system illustrated in Figure 3 of the drawings. In this figure a section of a boiler **75** may be provided which is heated by suitable means such as a gas burner. Gas may be supplied to a gas burner through the supply line **76** containing a solenoid operated valve **77**. Electric current may be supplied for operating the solenoid valve **77** from a pair of energized conductors **78** through conductors **79** and **80**. The conductor **80** has in series circuit relation therewith a thermostat **81** and a switch **82**. A member **83** of Curie point metal is provided as the responsive element being disposed partly within and partly outside the boiler **75**. One section of the member **83** is heated by an electric resistance coil **84** which may be supplied with electric energy from the energized conductors **78** and is in series circuit relation with the thermostat **81**. A horizontal section **85** of the member **83** is provided adjacent to and below the switch **82**, beneath which a permanent magnet **86** carried on a rod **87** is supported. The permanent magnet **86** operates just as the permanent magnet **67**, Figure 2, operates. The rod **87** carries a member **85** of insulating material which is adapted to move the movable contact **89** of the switch **82** to the open position.

In operation gas can be supplied to the burner heating the boiler **75** only when the thermostat **81** calls for heat and thus opens the solenoid valve **77**. The heating coil **84** also can be supplied with current only when the thermostat calls for heat. Thus it is seen that current is supplied to my liquid level responsive system only when

its safety protection is desired. If when the thermostat 81 is calling for heat and when the burner is heating the boiler 75, the water level should drop so that the Curie point member 83 is no longer surrounded by water, the heat supplied to the Curie point member 83 by the heating coil 84 will not be dissipated sufficiently and the horizontal section 85 thereof will be heated above its Curie point and will become non-magnetic. Upon this occurrence the permanent magnet 86 will no longer be attracted to the underside of the horizontal section 85 and it will drop causing the switch 82 to be opened as shown in the drawing. When the switch 82 is opened the circuit to the solenoid valve 77 will be broken and the gas supply to the gas burner will be shut off, preventing damage to the boiler 75 due to low water level therein. It will thus be seen that a very reliable and economical safety system is effected.

Failure of the cooling water supply to cooling coils employed in various installations may easily result in serious damage. Thus in the case where large transformers are kept from overheating by cooling coils therein the failure of the cooling water supply in such instances may cause the destruction of the transformer. In order to provide against such and similar destruction I have provided a system responsive to the presence and absence of liquid as shown in Figure 4 of the drawings. A cooling coil shown, generally, at 95 may be taken as representative of one that might be used in a transformer, condenser or other installation. In the outlet pipe 96 of the cooling coil 95 a pipe fitting 97 is interposed through which a member 98 of Curie point metal extends. A hole 99 in the member 98 allows cooling water to flow therethrough. The projection of the member 98 extending to the left of the pipe fitting 97 is heated by an electric heating coil 100 which is supplied with current from a pair of energized conductors 101. Sufficient heat is supplied by the heating coil 100 so that the projection of the member 98 extending to the right of the pipe fitting 97 is heated above its Curie point and becomes non-magnetic when cooling water is not flowing through the pipe fitting 97 and conducting heat away from the member 98. When cooling water is flowing, unless its temperature be above the safe operating limit, the member 98 is cooled sufficiently so that the projection on the right is below its Curie point and is thus ferromagnetic. A permanent magnet 102 carried by an arm 103 pivoted at 104 is positioned to be attracted to the underside of the member 98. The arm 103 carries at its other end a contact 105 adapted to close with another stationary contact 106 when the magnet 102 is attracted to the member 98. The closing of contacts 105 and 106 may be arranged to complete a circuit from the energized conductors 101 to an electric operating device 107. In the case where the cooling coil 95 is used in connection with a transformer this electric operating device 107 might be adapted to operate a switch permitting the transformer to be put in or out of service. Thus in operation assume that the cooling coil 95 is disposed in a transformer and that the proper supply of cooling water is flowing thereto. In this condition the right hand projection of the Curie point member 98 will be cooled below its Curie point and the magnet 102 will be attracted to it closing the contacts 105 and 106 and thereby allowing the electric operating device 107 to put the transformer in service. Now if the cooling water supply should fail for some reason the member 98 will become heated above its Curie point and become non-magnetic allowing the magnet 102 to drop and thus opening the circuit to the electric operating device 107, thereby causing the transformer to be taken out of service and preventing damage thereto.

The Curie point metal may be selected to respond at such a value that if the liquid itself becomes too warm, the control circuit will be switched, without reference to the separate heat input means 100. Or the Curie point metal may be responsive to the combined effect of the electrical heat input and the temperature of the cooling or condensing medium.

The level control herein disclosed may be employed for high level as well as for low level by causing the liquid at high level to effect an abstraction of heat to produce a response of the switch.

In the disclosure herein where the heat of electric current flow is relied upon the heater may burn out.

The circuit may optionally be arranged to rely upon the current carrying properties of the heater wire to maintain the system in operation. That is to say, the heater wire may serve as a fuse to shut off the current from the rest of the system. Alternatively, a relay in circuit with the heater may operate upon the current supply or it may control one or more circuits to take the system out of operation or perform any other safety or emergency operation such as shutting down the system or a part of the same. Thus, for example, it may cut out the burner or the motor or the like.

It will be understood that wherever permanent horseshoe magnets have been used they may be replaced by electro-magnets and permanent magnets in other shapes.

Since certain further changes can be made in the foregoing construction, and different embodiments of the invention may be made without departing from the scope thereof, it is intended that all matter shown in the accompanying drawings or described hereinbefore shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. In a system responsive to the presence and absence of liquid independently of the temperature of the liquid, in combination, a responsive element of Curie point metal, means independent of said liquid for heating said responsive element above its Curie point to render the element non-magnetic, a container for liquid associated with said element and adapted to bring liquid into thermal contact therewith, thermal contact of liquid in said container with the element serving to dissipate the heat of said heater and to cool the element below its Curie point whereby it becomes magnetic, a source of flux interacting with said responsive element, and means external to the container controlled by interaction of said responsive element and said source of flux.

2. In a system responsive to the presence and absence of liquid independently of the temperature of the liquid, in combination, a responsive element of Curie point metal, means adapted to contain liquid in which the element is adapted to be immersed, means independent of the liquid for heating said responsive element above its Curie point when it is not sufficiently cooled by being immersed in said liquid, a source of flux interacting with said responsive element as a function of its magnetic condition, and means

external to the liquid containing means, said last named means being controlled by the interaction of said source of flux and said responsive element.

3. In a liquid level responsive system, in combination, a source of flux, spaced apart extension means including a responsive element of Curie point metal extending from the opposite magnetic poles of said source of flux, means for heating said responsive element above its Curie point to render the element non-magnetic, a liquid container adapted to contain liquid the level of which may fluctuate above and below a predetermined level, said element being subject to thermal contact with the liquid when the level of the liquid rises to or above said predetermined level for cooling said element below the Curie point whereby it becomes magnetic, and a magnetic switch disposed adjacent to the ends of said spaced extension means away from the opposite magnetic poles of said source of flux and adapted to be operated when said responsive element is not immersed in liquid.

4. In a liquid level responsive system, in combination, a source of flux, spaced apart responsive elements of Curie point metal extending from the opposite magnetic poles of said source of flux, heating elements disposed to heat said spaced apart responsive elements to raise them above the Curie point, whereby the said elements become substantially non-magnetic, a container for liquid, the level of which liquid varies in respect to a predetermined level, said liquid upon attaining said predetermined level coming in thermal contact with said elements and cooling the same below the Curie point whereby they become magnetic, a circuit means connecting said heating elements and a current source, and a magnetic switch disposed adjacent to the ends of said spaced apart responsive elements away from the opposite magnetic poles of said source of magnetic flux and adapted to be operated when said spaced apart responsive elements are not cooled by said liquid.

5. In a liquid level responsive system, in combination, a permanent horseshoe magnet, spaced apart responsive elements of Curie point metal extending from the opposite magnetic poles of said horseshoe magnet, a container for liquid, the level of which varies in respect to a predetermined level, said liquid upon attaining said predetermined level coming in thermal contact with said elements and cooling the same below the Curie point whereby they become magnetic, heating coils surrounding said responsive elements for heating them above their Curie point when not cooled by said liquid, circuit means for interconnecting said heating coils and a current source, and a magnetic switch disposed adjacent to the air gap between the ends of said responsive elements having spring conductor carrying a magnetic armature. The spring of said conductor holding its lower contact end immersed in a pool of mercury when said magnetic armature is not sufficiently attracted by the flux in said air gap.

6. In a liquid level responsive system, in combination, a responsive element of Curie point metal, said element comprising a plurality of sections, means for heating said responsive element, a magnet adapted to be attracted to said responsive element when it is at a temperature below its Curie point, and switch means operated by said magnet, one section of said responsive element being exposed to said heating means, means for immersing another section of said element in liquid, and another section of said element attracting said magnet when said last named section is at a temperature below its Curie point.

7. In a liquid level responsive system, in combination, a responsive element of Curie point metal, means for heating said responsive element, a magnet adapted to be attracted to said responsive element when it is ferromagnetic, said switch means operated by said magnet, said element comprising a plurality of sections, a heating coil for heating one section of said responsive element, means for immersing another section thereof in liquid, and another section thereof attracting said magnet when ferromagnetic, electric current being supplied to said heating coil only when the liquid level responsive system is in operation.

8. In a system responsive to the presence and absence of fluid flow, in combination, a responsive element of Curie point metal comprising a plurality of sections, one section of which is positioned in a path of fluid flow, means for continuously heating another section of said responsive element, magnet means adapted to be attracted to another section of said responsive element when said last named section is at a temperature below its Curie point due to the presence of fluid in thermal contact with said first named section, and switch means operated by said magnet means.

9. A device responsive to the presence of a body of liquid independently of the temperature of the liquid, comprising a body of Curie point material the Curie point of which lies above the boiling point of the liquid, heating means independent of the liquid in thermal conductive relation to at least a part of said body to heat said body when the body is out of thermal contact with the liquid to a temperature above the Curie point which will render a selected part of the same non-magnetic, and liquid containing means in which a body of liquid may be brought into thermal contact with said body to abstract sufficient heat from the body to bring said selected part below the Curie point and to render the same magnetic, and control means responsive to the magnetic or non-magnetic condition of said selected part of the body.

10. A device sensitive to contact with a liquid comprising heating means, a vessel adapted to contain a liquid, a body of Curie point material in thermal contact with the heating means and adapted to be contacted with liquid when the same occupies a predetermined position in said vessel, the heating means being adapted to raise the temperature of the Curie point material to the Curie point to render the same non-magnetic when said material is out of thermal contact with the liquid, thermal contact of the liquid dissipating the heat added by said heating means to the extent of cooling a selected part of the same below the Curie point and thereby rendering the same magnetic, and control means including an electric switch responsive to the magnetic or nonmagnetic condition of said selected part of the body.

11. In combination, a permanent magnet, a body of Curie point material, means including a switch responsive to extension of the field of the magnet through the body of Curie point material when the same is diamagnetic, heating means for heating the Curie point material when the same is out of thermal contact with a body of liquid to the Curie point whereupon it becomes

paramagnetic, and means adapted to contain liquid which when in thermal contact with the body conducts away heat fast enough to keep the body below the Curie point.

12. Means responsive to the presence or absence of liquid in a predetermined space comprising in combination a body of Curie point material having a Curie point lying above the boiling point of the liquid, means adapted to confine liquid in thermal contact with a portion of said body for the purpose of limiting the temperature of said portion to a value below the Curie point of the material, means independent of the liquid for continuously adding heat to said body, said means being capable in the absence of heat removal by said liquid of raising the temperature of said body above the Curie point, a control element, and magnetic means cooperating with said body and being movable when said body reaches said Curie point, for operating said control element.

13. In combination, a body of Curie point material, means for adding heat to said body to raise it to its Curie point, means for providing liquid contact with said body which liquid is adapted to carry heat away from said body so long as the liquid is in thermal contact with the body to keep said body below the Curie point, a source of magnetic flux interacting with said body in one manner when the body is below its Curie point, and in a different manner when the body is at or above the Curie point, and means controlled by the interaction of said body and said source of flux.

14. In combination, a vessel in which liquid is adapted to be contained above a certain level, a body of Curie point material in thermal contact with liquid above said level, the Curie point of said material being above the boiling point of said liquid, heating means in thermal conductive relation to said body, for supplying heat to the body at a rate faster than said body can dissipate the same in the absence of thermal contact with said liquid, a source of magnetic flux interacting with said body, and means controlled by interaction of said body and said source of flux.

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