Dec. 28, 1937. W. J. HART 2,103,816

ELECTRICAL APPARATUS

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Fig. 1.

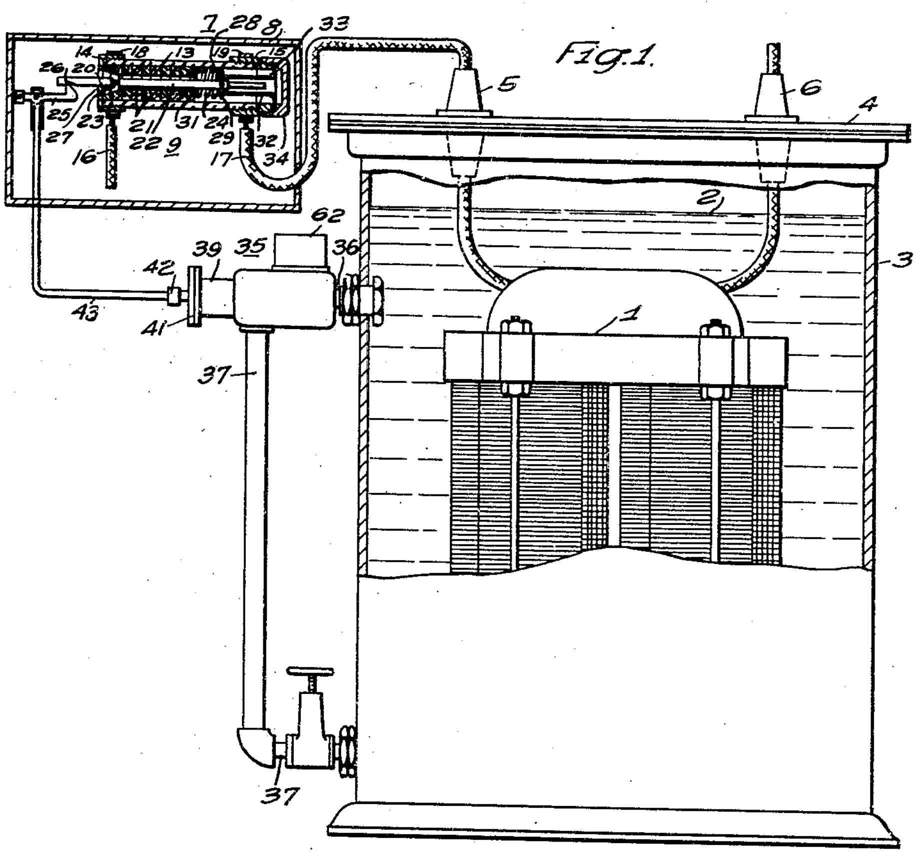

Fig. 2.

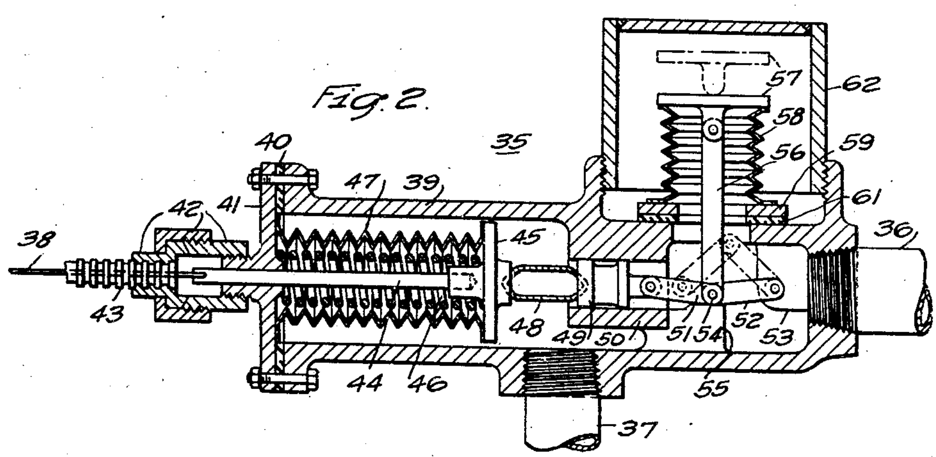

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Fig. 3.

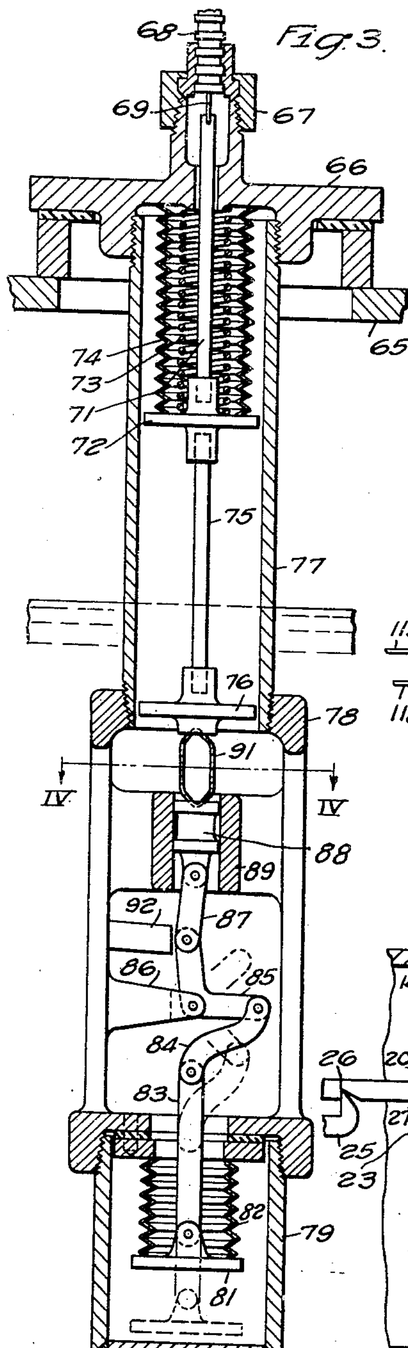

Fig. 4.

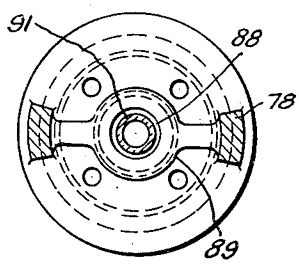

Fig. 8.

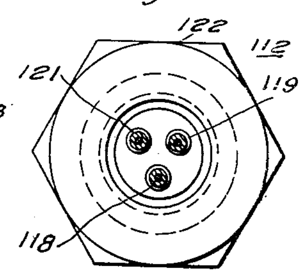

Fig. 7.

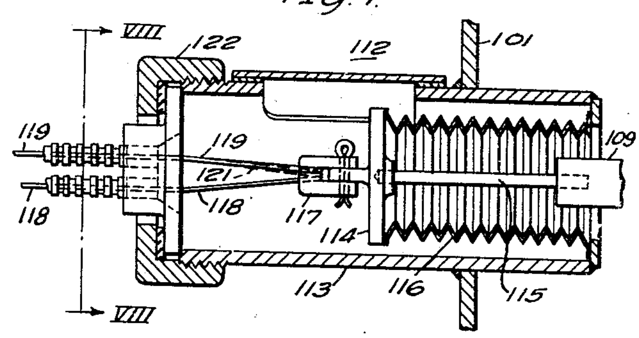

Fig. 12.

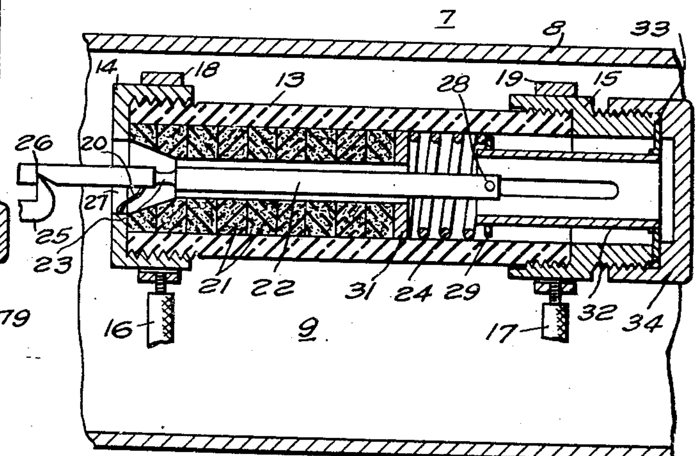

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Fig. 5.

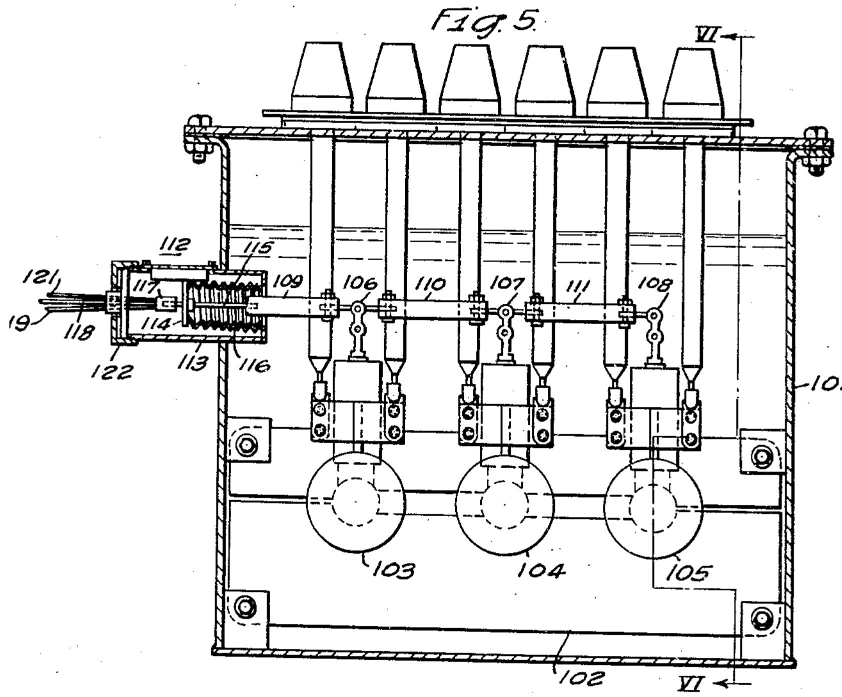
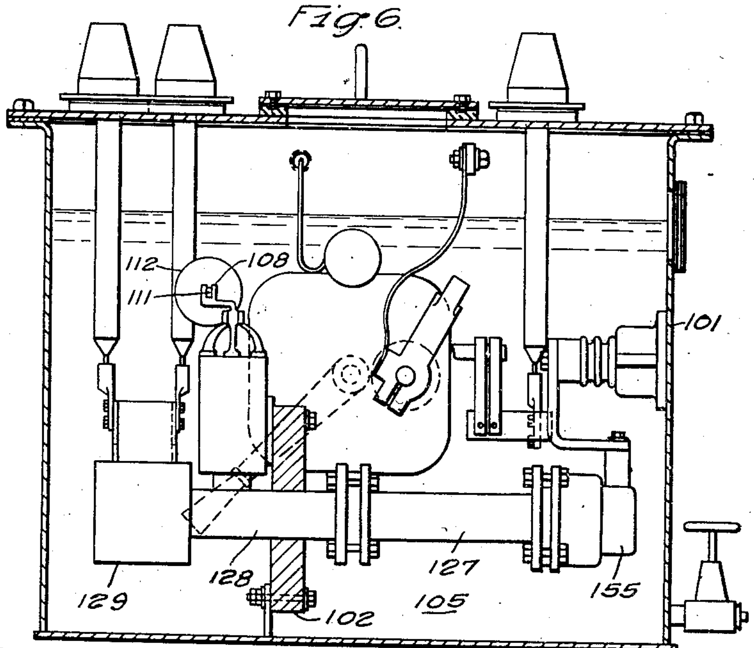


Fig. 6.



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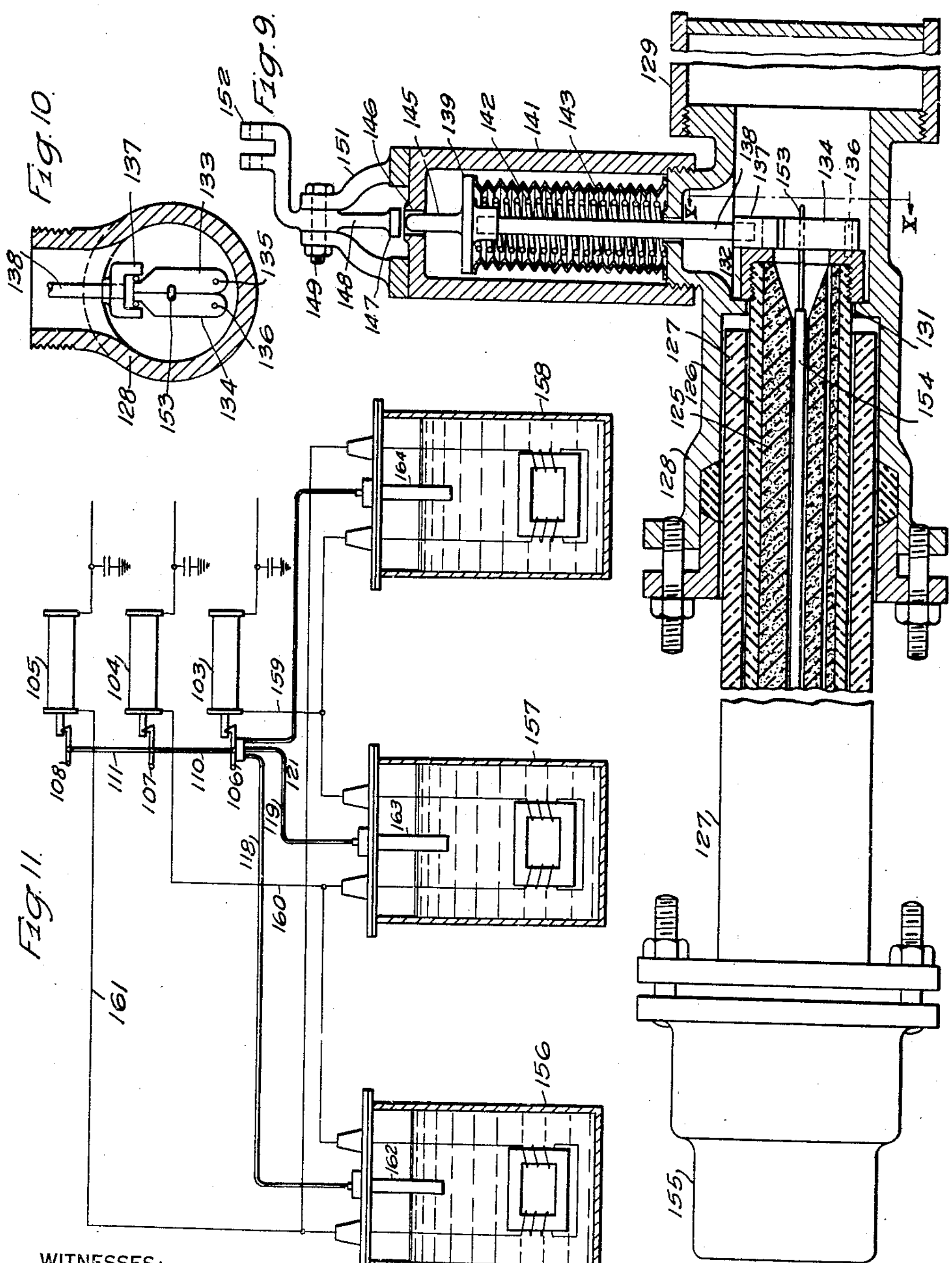
ELECTRICAL APPARATUS

Filed Oct. 31, 1933 4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,103,816

ELECTRICAL APPARATUS

William J. Hart, Sharon, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application October 31, 1933, Serial No. 696,049

6 Claims. (Cl. 200—81)

My invention relates to a protective device for electrical apparatus, such as oil immersed transformers, and particularly to means for interrupting a circuit through the apparatus upon the occurrence of predetermined conditions of the circuit or of the apparatus.

Such electrical apparatus is subject to different types of disturbances, one of which results in the flow of a heavy fault current through the circuit of the apparatus, another of which results in temperatures that are too high for the safe operation of the apparatus, such as may be produced by a continuing overload on the apparatus, and another of which causes a slow disintegration of the insulating material and the generation of gases from the decomposition products thereof, which may be explosive in character, and which tend to build up a pressure within the transformer casing that will eventually open up the gaskets under the transformer cover and permit the gas to fill the space above the transformer. This is particularly undesirable in certain locations, for example, particularly when the transformer is installed in a vault within a building where no proper facilities exist for ventilating the vault. It is possible under such circumstances for the vault to become filled with an explosive gas which, if ignited by a spark, may do considerable damage.

In the usual type of transformer the pressure developed from the sudden flow of heavy fault current may be so high as to force oil and gas out under the cover of the tank or even to open the welded tank seams. Such disturbances, however, usually originate as minor faults, or stewing arcs, between local parts of the apparatus and become progressively worse if not checked. Such an arc causes decomposition of the oil and solid insulation of the apparatus and results in explosive gaseous products that build up a gas pressure inside the tank which may finally become sufficient to force the gas past the gaskets or into the vault or chamber containing the transformer where a secondary explosion may occur. When, as a result of such stewing arc, enough oil is decomposed to uncover the transformer terminal board a heavy arc may occur between the terminals.

If the transformer is disconnected from its power circuit with the pressure when the transformer tank due to gases formed by a stewing arc has reached a value just below that which might force the gas past the gaskets, a secondary explosion in the vault containing the transformer, or the likelihood of a heavy arc between terminals as a result of uncovering the terminal board within the transformer may be prevented. The possibility of an arc inside the transformer casing and of the accompanying gas pressure becoming severe is reduced if the transformer is disconnected from its power circuit within a few cycles after the occurrence of a heavy fault current, which is quicker than it ordinarily would be disconnected if it were necessary to wait for a circuit breaker at a station or in the power feeder system to trip the circuit.

It is, therefore, desirable in electrical apparatus, such as transformers, that the apparatus be disconnected from the line upon the sudden flow of a heavy fault current such as may result from short circuited windings, upon the breakdown of the insulating material, such as may be caused by a continued or stewing arc between adjacent turns of the winding, or upon prolonged overloads resulting in excessive oil temperatures.

In accordance with my invention, I have provided a circuit interrupting mechanism for preventing explosions that occur as the result of short circuited windings, prolonged overloads, or stewing arcs in electrical apparatus and that will minimize or prevent explosions from gases given off as a result of a heavy arc fault occurring suddenly.

In the accompanying drawings:

Figure 1 is a view partly in elevation and partly in section of a transformer embodying apparatus containing the protective features of my invention;

Fig. 2 is an enlarged cross-sectional view of a detail of the embodiment of a pressure and temperature release device comprising a part of the apparatus illustrated in Fig. 1;

Fig. 3 is a cross-sectional view of one embodiment of the pressure and temperature release device comprising a part of my invention;

Fig. 4 is a cross-sectional view taken along the line IV—IV of Fig. 3;

Fig. 5 is a view partly in elevation and partly in cross-section of an auxiliary chamber or fuse box containing three circuit-interrupting devices for use with a three-phase circuit;

Fig. 6 is a cross-sectional view taken along the line VI—VI of Fig. 5;

Fig. 7 is an enlarged cross-sectional view of a detail of part of the tripping mechanism illustrated in Fig. 5;

Fig. 8 is an end view of the part of the apparatus shown in Fig. 7 taken along the line VIII—VIII;

Fig. 9 is a detail of the switch mechanism illustrated generally in Figs. 5 and 6;

Fig. 10 is a cross-sectional view taken along the line X—X of Fig. 9;

Fig. 11 is a schematic view showing the electrical and mechanical connections of the three circuit interrupting devices shown in Figs. 5 and 6 to three transformers of a bank; and

Fig. 12 is an enlarged cross-sectional view of the interrupting device shown in Fig. 1.

Referring to the drawings, and particularly to Figs. 1 and 2 thereof, a transformer 1 is shown immersed in oil or other suitable insulating and cooling medium 2 contained within a tank 3 upon which is mounted a cover 4. Terminal bushings 5 and 6 are illustrated mounted upon the cover of the tank and through which extend conductors that connect the transformer windings to an associated power circuit. The circuit from one of the terminals 5 is completed through a circuit interrupting device 7 comprising a conveniently located casing 8, and an explosion type fuse or switch 9 suitably mounted within the casing.

The circuit interrupting device indicated generally at 9 is illustrated as a boric acid type switch such as is covered generally in a copending application of Joseph Slepian, Serial No. 568,554, filed October 13, 1931, now Patent No. 2,077,276, patented April 13, 1937 and assigned to the same assignee as this application.

The circuit interrupter 9 as illustrated comprises a tubular enclosing casing 13 of fibre or other suitable insulating material that extends between metal terminal members 14 and 15 which electrically connect the circuit interrupting switch between cable conductors 16 and 17 through terminals 18 and 19 respectively. The casing member 13 is lined on the inside with solid blocks or washers of boric acid 21 having openings through the central portions thereof. A movable switch element or plunger rod 22, having a fusible portion 23 therein, extends through the opening in the boric acid blocks and is actuated by a biasing member 24 to move through the openings in the blocks and draw a circuit interrupting arc upon the fusing of the portion 23 thereof. The arc is thus drawn in contact with the walls of the boric acid blocks causing the boric acid to be decomposed and give off water vapor which flows longitudinally through the arc and out the end of the explosion chamber formed by the openings through the boric acid blocks.

The circuit closing, or movable plunger member 22, is normally held in its illustrated or circuit closing position by a latch 25 that engages a notch 26 at one end of the member 22. The terminal 14 is formed in the shape of a cap suitably secured to the tube 13 and provided with an opening 27 in the central portion thereof which provides for discharge of the arc gases from the explosion chamber. One end of the rod 22 is electrically connected to the terminal cap 14 by some suitable connecting means as, for example, a wire 20 fastened to the cap 14 and contacting with the rod 22. The mechanical strength of the connection between the wire 20 and the rod 22 is such that it will rupture when the rod is actuated toward the right by the spring 24. The other end of the rod 22 is connected through the pin 28 to an angle or collar 29. The compression spring 24 is positioned between the collar 29 and a washer 31 at the end of the series of boric acid blocks or discs 21. The collar 29 is electrically connected to the terminal 15 through a conductor 32 with which it slidably engages and through a disc 33 which is secured between the end of the terminal 15 and a cap 34.

A pressure and temperature actuated release device 35 is provided, the interior of which is connected by means of pipes 36 and 37 with the interior of the transformer casing below the level of the oil, thus permitting the oil to circulate through the release device. A wire-operating means 38 is provided operatively connecting the release device 35 to the latch 25 for tripping the same under certain predetermined conditions. The pressure release device is better shown in Fig. 2 and comprises a casing 39, the interior of which is connected by means of the pipes 36 and 37 to communicate with the transformer casing. An end plate or cap 41 is suitably attached to one end of the casing 39, a gasket 40 being provided to form a tight joint and is connected by glands or coupling members 42 to the outside of a metal casing 43 surrounding the operating wire 38. The end of the wire 38 connects with the end of a rod 44 that extends through an opening in the end plate 41 and terminates in a piston 45 that is biased by a compression spring 46 that extends from the piston 45 to the wall of the end plate 41 tending to force these two members apart. A sylphon bellows 47 extends between the end plate 41 and the piston 45 surrounding the spring 46 for the purpose of making an oil-tight joint between these members.

A quartz bulb 48, that is designed to rupture at a predetermined temperature, is positioned between the piston 45 and a piston 49 and acts as a compression member to prevent movement of the piston 45, in a direction away from the end plate 41 so long as the toggle or link mechanism to be described is in its illustrated position. The piston 49 is slidably mounted within a guide 50 that extends from one side-wall of the casing 39 and is connected by means of pivotally connected links 51 and 52 to an abutment 53. In the position illustrated in Fig. 2 the biasing action of the spring 46, tending to move the pistons 45 and 49 toward the right forces the ends of the links 51 and 52 that are pivotally connected at 54 downwardly against an abutment 55 that prevents further movement of the pistons. A rod 56 is pivotally connected to the links 51 and 52 at the point 54 and extends upwardly therefrom, the upper end being attached to a piston 57 from which a sylphon bellows 58 extends downwardly to a plate 59 that is suitably attached to the casing 39 and between which a gasket 61 is provided to form a tight joint. An opening in the plate 59, the gasket 61, and the wall of the casing 39 provides a passageway between the interior of the bellows 58 and the casing 39, permitting the oil within the casing to flow into the bellows. A casing 62 may be provided extending upwardly from the casing 39 and enclosing the sylphon bellows 58.

The purpose of the pressure release device is to operate to trip the circuit interrupting device 9 whenever the oil temperature within the transformer becomes excessive or whenever the pressure produced by gases given off by the oil and entrapped above the oil level in the transformer reaches a predetermined value. The actuating force of the mechanism is the spring 46 which, when released, forces the piston 45 away from the end wall 41 and pulls the wire 38 through the flexible cable 43, thus tripping the latch 25 and permitting the fuse mechanism to operate and interrupt the circuit through the transformer winding.

The oil from the transformer casing flows into the casing 39 through the pipe 36 and returns to the transformer casing through the pipe 37. It thus surrounds the quartz bulb 48 which is designed to burst at a predetermined temperature, allowing the compression spring to force the piston 45 toward the right and trip the boric acid fuse by means of the steel wire 38. This operation does not disturb the position of the pressure release element of the mechanism comprising the bellows 58, piston 49 and links 51 and 52.

When the internal pressure within the transformer tank exceeds the same minimum operating value permitted, this pressure, which also exists within the sylphon bellows 58, exerts a pressure on the piston 57 forcing it upwardly and moving the toggle mechanism comprising the links 51 and 52 away from the abutment 54, thus permitting the piston 49 to be moved by the pressure of the spring 46, the links and piston assuming the positions shown in dotted lines. In this operation of the mechanism the quartz bulb remains in its illustrated position between the pistons 45 and 49 and is moved bodily toward the right, as viewed in Fig. 2.

Referring to Figs. 3 and 4 of the drawings, an embodiment of the temperature and pressure release device is illustrated that is suitable for mounting on the cover of a transformer and that extends downwardly below the oil level. In Fig. 3 a portion 65 of the transformer cover is shown above which is mounted a base plate 66 supporting the release mechanism and which is connected by means of a nipple 67 to a flexible cable 68 through which an operating wire 69 extends for actuating the tripping mechanism of the circuit interrupting device. The wire 69 is connected by means of a rod 71 that extends through the base plate 66 to a piston 72 that is forced downwardly by a compression spring 73 extending between the piston 72 and the base plate 66 and which is surrounded by a sylphon bellows 74. A rod 75 extends downwardly from the piston 72 and carries a piston 76 on the lower end thereof. A supporting tube 77 is provided, the upper end of which is attached to the base plate 66 that extends downwardly about the pistons 72 and 76, and to the lower end of which is attached a supporting frame 78 for the temperature and pressure release responsive mechanism. To the lower end of the frame a casing 79 is attached surrounding and enclosing a piston 81 and pressure responsive sylphon bellows 82 connected therewith, the interior of which is filled with oil, and is responsive to the oil pressure. The piston 81 is attached, by means of links 83 and 84, to a bell crank lever 85 that is mounted upon a support 86 and connected by means of link 87 to a piston 88 that slides within the support 89 carried by the frame 78. A temperature responsive quartz bulb 91 is positioned between the pistons 76 and 88 for normally holding them apart against the pressure of the spring 73, and an abutment 92 is provided for preventing a counter-clockwise rotation of the bell crank lever 85 beyond the illustrated position thereof.

In the embodiment of the release mechanism illustrated in Fig. 3, whenever the internal pressure within the transformer exceeds the safe minimum amount, the pressure within the bellows 82 forces the piston 81 downwardly causing the bell crank lever 85 to rotate in a clockwise direction and the connecting link 87 to move accordingly, thus permitting the entire mechanism from the piston 81 to and including the rod 71 and the wire 69 to be moved downwardly and operate the fuse tripping mechanism.

Upon a predetermined temperature of the oil the bulb 91 will burst allowing the spring 73 to operate the pistons 72 and 76 downwardly and also to trip the fuse mechanism.

One temperature and pressure release device is required for each single-phase transformer to be protected and one for a three-phase transformer unit mounted in a single tank. Where a three-phase circuit is connected to three single-phase transformers operating as a bank, it is desirable to provide a pressure and temperature release device for each transformer, and three fuse mechanisms connected in circuit with the three transformers which may be mounted in an auxiliary fuse box compartment as illustrated in Figs. 5 and 6. A plurality of connections may be made, one to each over-temperature and over-pressure release device of the several transformers so that, upon the occurrence of abnormal conditions in any one of the three transformers, the several latching mechanisms of the fuses will be tripped, thus disconnecting the three transformers from the circuit upon a fault in any one of them.

Referring to Figs. 5 and 6, an auxiliary fuse box 101 is provided within which a support 102 is fastened for mounting the three circuit interrupting fuses 103, 104 and 105 that are respectively provided with latch operating mechanisms 106, 107 and 108 that may be connected together through connecting links 109, 110 and 111 to a common junction box 112 for the three fuse mechanisms shown in greater detail in Figs. 7 and 8.

Referring to Fig. 7, the junction box comprises a casing 113 mounted in the fuse box casing 101 and extending therethrough. A movable piston 114 is provided within the junction box casing and connected by means of a rod 115 to the link 109 which is operatively connected to the three fuse tripping mechanisms. A bellows 116 is provided between the piston 114 and the end of the junction box that is within the fuse box casing. A connecting lug 117 is suitably attached to the piston 114 and to which three wires 118, 119 and 121 are connected and extend through separate openings in an end cap 122 attached to the casing 113 of the junction box. The several wires 118, 119 and 121 extend through their respective flexible cables to the pressure and temperature release devices associated with the three transformers in the circuits of which the fuses 103, 104 and 105 are respectively connected.

The fuses illustrated in Figs. 5 and 6 and the tripping mechanism therefor may be similar to that illustrated in Figs. 9 and 10 which is for the same general purpose as the fuse 7 illustrated in Fig. 1. The fuse comprises a boric acid cartridge 125 within a fibre tube 126 mounted within an insulating container 127, one end of which extends within and is attached to a metallic casing 128, one end of which is connected to a casing 129 containing the condenser mechanism for the fuse, and also acts as a terminal for the device. A flange 131 extends inwardly from the central portion of the casing 128 and abuts against a metallic ferrule 132 that is screw-threadedly attached to the fibre tube 126 and is conductively connected to the casing 129 and to the latching mechanism comprising latches 133 and 134 pivotally mounted thereon at 135 and 136 respectively, the unpivoted or free ends of which are held in the closed position (illustrated in Fig. 10) by a bifurcated member 137 attached to the end of a rod 138 extending upwardly to a piston 139 within a casing 141 that is attached to and extends upwardly from the central portion of the casing 128. A spring 142, about which a sylphon bellows 143 is positioned, extends from the raised portion of the casing 128 to the piston 139 which is provided with a projection 145 that extends into an opening 146 in the upper end of the casing 141, and is normally prevented from moving through the opening by a shoe 147 attached to the end of a bell crank lever 148 that is pivotally mounted at 149 on a supporting bracket 151 extending upwardly from the casing 141. The upper end of the lever 148 is provided with a bifurcated member 152 for connection to the junction box 112 and to the operating wire of the pressure and temperature release mechanism.

In the closed or illustrated position of the latches 133, 134, a conical or wedge shaped terminal member 153, that may also be the fusible link of the device is held between the latches 133 and 134 and is operatively connected to the conducting rod or plunger 154. The connecting rod 154 is operatively connected to any suitable spring actuating mechanism for biasing it away from the latches through which it is connected to the terminal 129 of the fuse. The spring actuating mechanism will, in general, be similar to that illustrated in Fig. 1, the particular details thereof not being a part of this invention. One arrangement of such details is illustrated and described in an application by Herbert L. Rawlins, Serial No. 665,132 filed April 8, 1933, now Patent No. 1,976,634, patented October 9, 1934, and assigned to the same assignee as this application. The end of the tube 127 containing the fuse mechanism, that is remote from the latching and tripping mechanism, is provided with a ferrule 155 of electrically conducting terminal.

Fig. 11 illustrates schematically the arrangement of three transformers 156, 157 and 158, the illustrated circuits of which are shown connected in delta, from which extend circuit conductors 159, 160 and 161 that connect, respectively, to the fuses 103, 104 and 105 that are tripped by latching mechanisms 106, 107 and 108, respectively, that are connected to the common junction box into which extend the several operating wires 118, 119 and 121 that connect respectively to pressure and temperature release mechanisms 162, 163 and 164, that may be similar in construction to the mechanism illustrated in Figs. 3 and 4.

In the tripping mechanisms illustrated generally in Figs. 5, 6, 7, 8 and 11 and in detail in Figs. 9 and 10, when any one of the wires 118, 119 and 121 are actuated by the pressure and temperature release mechanism of the transformer to which the wire is connected the mechanism in the junction box illustrated in Figs. 5, 6 and 7 is actuated to rotate the lever 148 (Fig. 9) to remove the shoe 147 from the end of the projection 145, permitting this projection to be forced through the opening 146 by the spring 142, and thus moving the bifurcated member 137, that normally holds the latches 133 and 134 in their closed position, away from engagement with these latching members, thus permitting the connection rod 154 of each of the fuses 103, 104 and 105 to be operated to its open circuit position.

It will be apparent that other modifications of the structures shown and described and within the spirit of my invention will readily suggest themselves to those skilled in the art, and I do not wish to be limited otherwise than by the scope of the appended claims.

I claim as my invention:

1. In a protective system for electrical apparatus, a circuit interrupting device, the circuit interrupting device comprising a spring actuated plunger, a latch for holding the plunger in its circuit closing position, means responsive to a predetermined current flow through said plunger for releasing said plunger, means responsive to an unnormal temperature within said apparatus and to an unnormal pressure within said apparatus for independently tripping said latch to release said plunger.

2. In a circuit interrupting device, a circuit closing rod biased to a circuit opening position, a latch for holding said rod in its circuit closing position, said rod including a fusible link for interrupting the circuit therethrough upon the occurrence of a predetermined current flow, means independent of said fusible link for tripping said latch to permit the operation of said rod to its circuit opening position, a pressure device and a temperature responsive device for independently actuating said last named means.

3. In a protective system for electrical apparatus adapted to be connected in a circuit, a circuit interrupting device, means for normally holding said circuit interrupting device in a circuit closing position, a fuse connected in the circuit interrupting device responsive to a predetermined current flow for interrupting the circuit through said circuit interrupting device, and means responsive to an unnormal pressure and to an unnormal temperature for independently releasing said holding means to interrupt the circuit through said circuit interrupting device.

4. In a protective system for a transformer, in combination, a circuit closing member biased to a circuit opening position, a latch for holding the circuit closing member in its circuit closing position, means connected in the circuit closing member responsive to a predetermined current flow in the transformer for interrupting the circuit through the circuit closing member, and means independently responsive to predetermined pressures and predetermined temperatures within the transformer for releasing the latch to interrupt the circuit through the circuit closing member.

5. In a protective system for a transformer, in combination, a circuit closing member biased to a circuit opening position, a latch for holding the circuit closing member in its circuit closing position, means connected in the circuit closing member responsive to a predetermined current flow in the transformer for interrupting the circuit through the circuit closing member, and means cooperative with the circuit closing member for interrupting the circuit, the cooperative means being disposed to actuate the latch and being independently responsive to the temperatures and pressures within the transformer.

6. In a protective system for a transformer, in combination, a circuit closing member biased to a circuit opening position, means for holding the circuit closing member in its circuit closing position, means in the circuit closing member responsive to a predetermined current flow therethrough for interrupting the circuit, and means cooperative with the circuit closing member and being independently responsive to predetermined pressures and temperatures in the transformer for releasing the holding means to interrupt the circuit.

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