

May 20, 1952

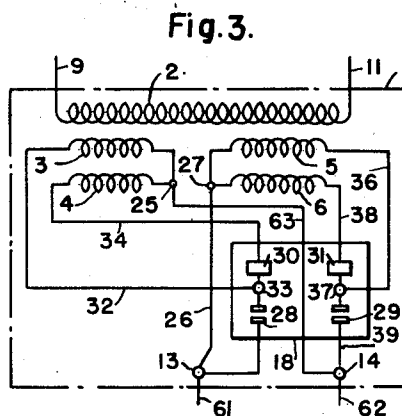
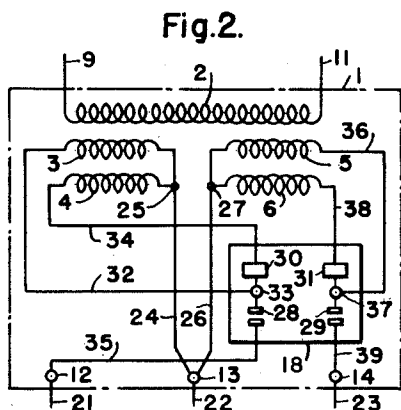
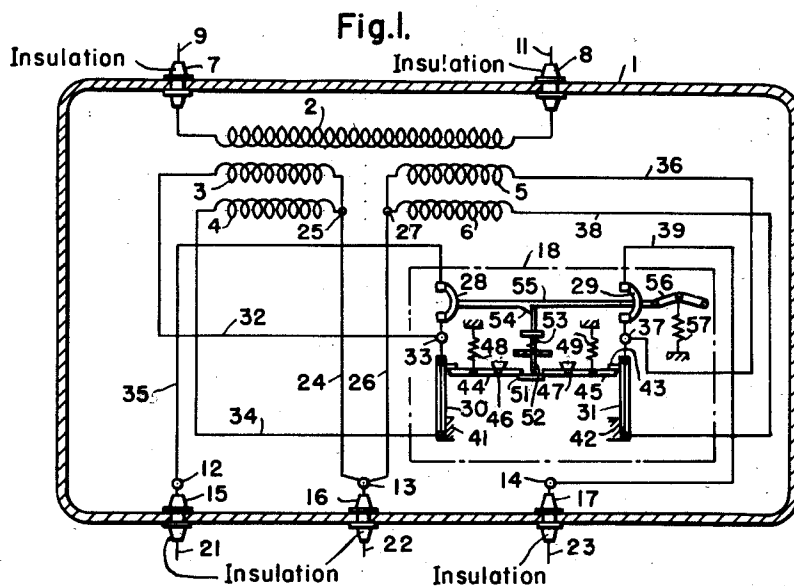
F. C. ROEDING ET AL.

2,597,185

SELF-PROTECTED DISTRIBUTION TRANSFORMER

Filed Jan. 10, 1950

3 Sheets-Sheet 1



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2,597,185

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3 Sheets-Sheet 2

Fig. 4.

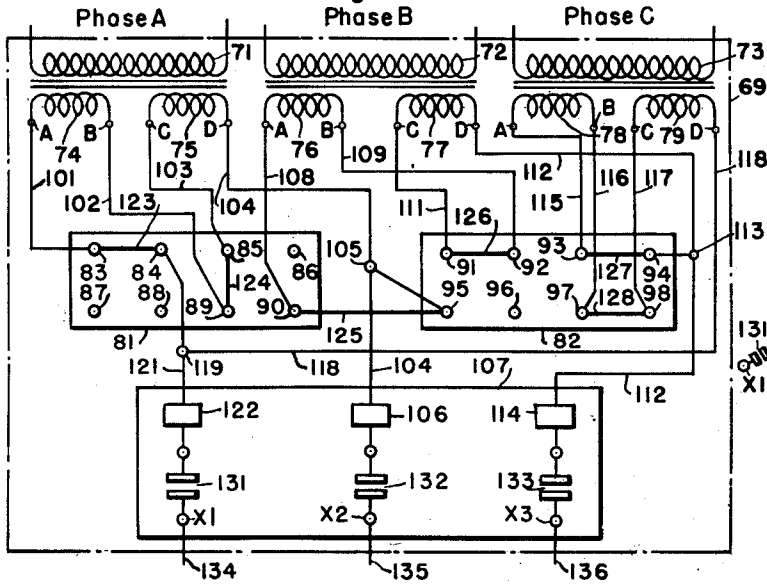


Fig. 5.

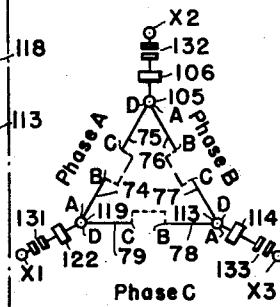


Fig. 6.

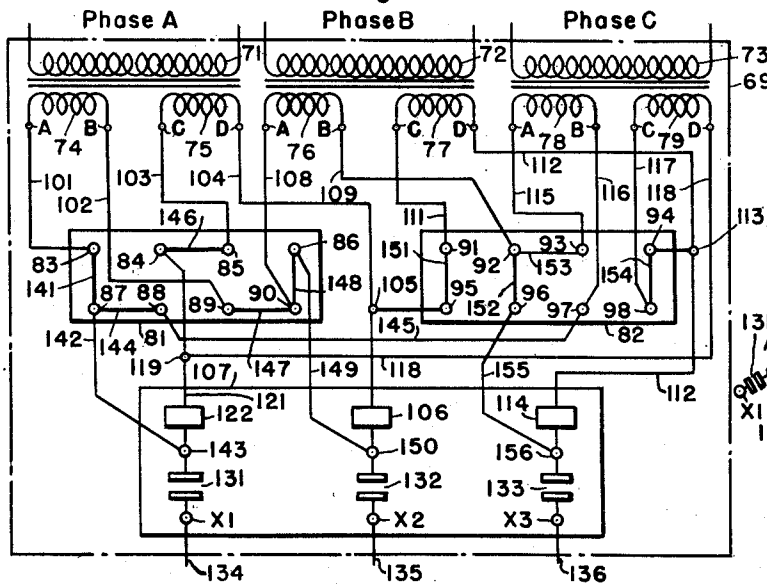
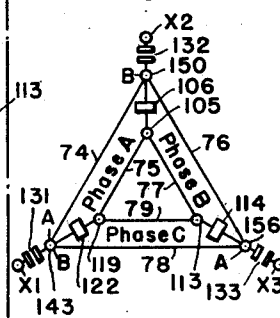


Fig. 7.



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2,597,185

SELF-PROTECTED DISTRIBUTION TRANSFORMER

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3 Sheets-Sheet 3

Fig. 8.

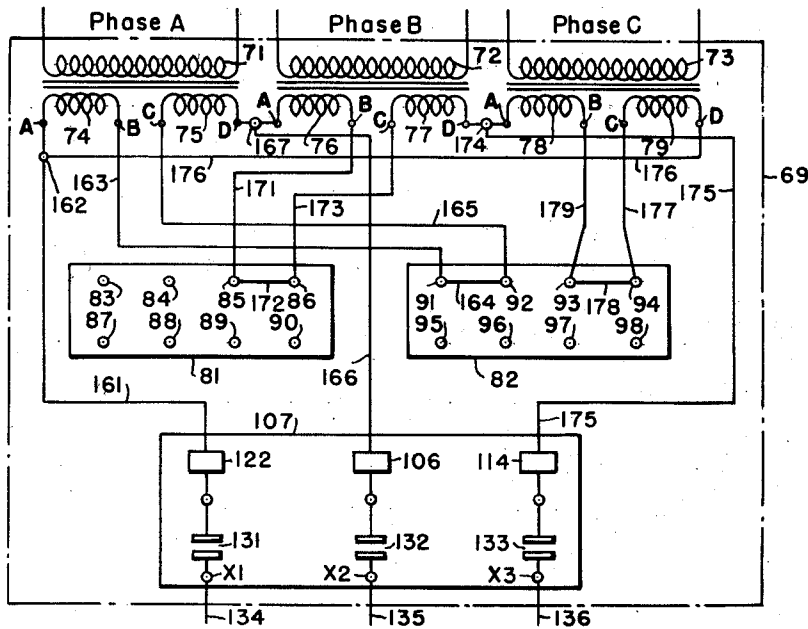


Fig. 9.

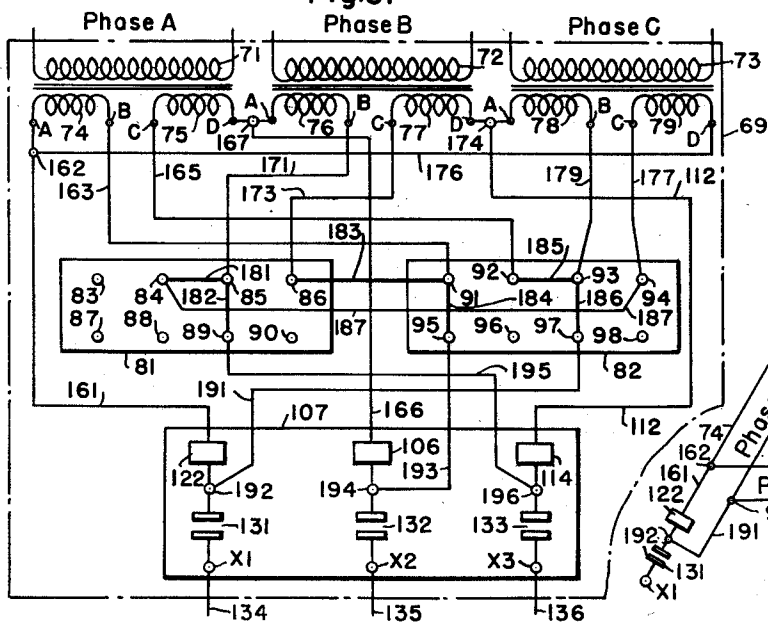
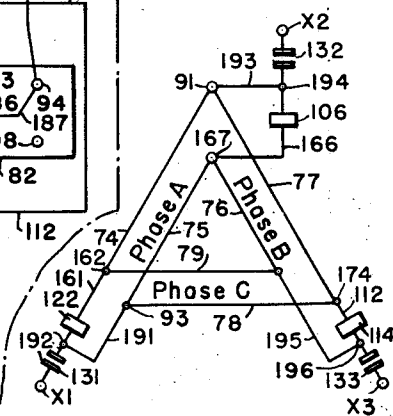


Fig. 10.



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2,597,185

SELF-PROTECTED DISTRIBUTION
TRANSFORMER

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Application January 10, 1950, Serial No. 137,702

11 Claims. (Cl. 175—294)

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Our invention relates to distribution trans-
formers and more particularly to means for pro-
tecting such transformers from damage caused
by too great overloads sustained for too long a
period of time.

In many distribution transformers connected
between a high voltage supply feeder circuit and
a low voltage distribution circuit, circuit breakers
are provided within the transformers for discon-
necting the transformer from the distribution
circuit upon predetermined load conditions on the
transformer. In transformers operating in a
cooling insulating liquid such as oil, a tempera-
ture-responsive element or a number of such ele-
ments may be employed for operating the cir-
cuit breaker to protect the transformer from
damage resulting from overheating caused by
overloading the transformer. Bimetal elements
may be used for this purpose and so located that
they are immersed in the insulating liquid and
heated both in accordance with the temperature
of the insulating liquid and in accordance with
the current flowing in the transformer secondary
circuit. The insulating liquid temperature is a
function of the heating of the transformer core
and coils over a considerable period of time and
the current flowing at any particular time is a
function of the heating of the transformer taking
place at this time. By properly coordinating the
relative effects of the long-time loads as indi-
cated by the liquid temperature and the short
time loads as indicated by instantaneous current
flowing in the secondary winding of the trans-
former, the temperature-responsive elements or
bimetals are made responsive to the copper tem-
perature of the transformer in a well-known
manner.

It is an object of the invention to provide a
self-protected transformer having a circuit
breaker for interrupting the secondary or dis-
tribution circuit therefrom, the circuit breaker
being actuated by thermally responsive means
heated in accordance with the heating of the
transformer structure and in which the second-
ary current is divided by the winding circuits of
the transformer in such a manner that a frac-
tion only of the total secondary current flows
through the thermally responsive elements, and
in which the contacts of the circuit breaker are
so located in the secondary circuit they will
interrupt the total current instead of only the
fraction flowing through the thermally responsive
element.

It is a further object of the invention to pro-
vide a self-protected transformer of the above-

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indicated character in which parallel circuit
paths including secondary winding coils are pro-
vided between transformer terminals in single
phase and three phase transformers in order to
reduce the current flowing in the bimetal or
equivalent thermal responsive elements for op-
erating the circuit breaker, thus reducing the
size of the bimetal element necessary for con-
trolling the circuit breaker and the number of
bimetal elements required to protect the trans-
former.

Other objects and advantages of the invention
will appear from the following description of
certain preferred embodiments thereof, reference
being made to the accompanying drawings in
which

Figure 1 is a diagrammatic view of circuits and
apparatus comprising a single phase transformer
unit organized in accordance with one embodi-
ment of the invention;

Fig. 2 is a somewhat more simplified view of
the subject matter shown in Fig. 1;

Fig. 3 is a diagrammatic view of circuits and
apparatus comprising a single phase transformer
arranged in accordance with another embodi-
ment of the invention in which the transformer
connections shown in Fig. 2 are rearranged for
operation on half voltage with all four secondary
winding coils connected in parallel circuit rela-
tion;

Fig. 4 is a diagrammatic view of circuits and
apparatus comprising a three phase transformer
having two secondary winding coils per phase
connected in series circuit relation;

Fig. 5 is a simplified diagram of the circuit
shown in Fig. 4;

Fig. 6 is a diagrammatic view of circuits and
apparatus generally similar to that shown in Fig.
4, except arranged for parallel connection of the
phase coils and comprises a three phase trans-
former having two secondary winding coils per
phase connected in two separate delta circuits
which are connected in parallel relation;

Fig. 7 is a simplified diagrammatic view of the
subject matter shown in Fig. 6;

Fig. 8 is a diagrammatic view of another modi-
fication of the invention as applied to a three
phase transformer having two secondary winding
coils per phase connected in series circuit rela-
tion;

Fig. 9 is a diagrammatic view of circuits and
apparatus modifying the circuits shown in Fig. 8
to provide a parallel delta relation in the sec-
ondary winding coil circuits; and

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Fig. 10 is a simplified diagrammatic view of the subject matter shown in Fig. 9.

Referring to the drawings and particularly to Figs. 1 and 2 thereof, a transformer is provided having a tank or casing 1 enclosing a primary winding 2 and a secondary winding shown as having four coils 3, 4, 5 and 6. The primary winding is connected through bushings 7 and 8 to a source of electrical energy represented by the supply conductors 9 and 11. The transformer is provided with a plurality of secondary winding transformer terminals 12, 13 and 14 from which conductors extend through insulating bushings 15, 16 and 17, respectively, to distribution circuit conductors 21, 22 and 23. A conductor 24 extends from the secondary winding terminal 13 to a junction point 25 that is connected to one end of each of the two secondary winding coils 3 and 4, and a similar conductor 26 extends from the terminal 13 to a junction point 27 connecting one end of the secondary winding coils 5 and 6 together. The terminal 13 is a neutral or ground terminal.

A circuit breaker shown generally at 18 is provided within the transformer casing having a two-pole switch represented by the circuit interrupting contact members 28 and 29 that are mechanically connected to operate together. Thermally responsive elements shown as bimetals 30 and 31 are provided for affecting the actuation of the circuit breaker.

A conductor 32 is shown for connecting the end of the secondary winding coils 3 remote from the junction point 25 to a junction point 33 between the switch contact members 28 and the bimetal 30 and the corresponding end of the secondary winding coil 4 is connected by means of conductor 34 to the bimetal 30 so that the current from this coil 4 will pass through the bimetal, the switch contact members 28 and conductor 35 to the terminal 12. The end of the winding coil 5 remote from the junction point 27 is connected by means of a conductor 36 to a junction point 37 between the bimetal 31 and the switch contact members 29. The corresponding end of the coil 6 is connected by a conductor 38 to the bimetal 31 and through the bimetal and the switch contact members 29 and conductor 39 to the terminal 14. The bimetal elements 30 and 31 are positioned in the transformer casing below the level of the cooling and insulating liquid and constitute thermally actuated load responsive elements for initiating the operation of the circuit breaker 18 to disconnect the transformer secondary winding from the distribution circuit conductors.

The bimetal elements 30 and 31 are mounted on suitable abutments 41 and 42, respectively, and are provided with latches 43 carried by the outer or moving ends thereof that are adapted to disengage tripping members 44 and 45 that are pivotally mounted on pins 46 and 47, respectively, and are biased by springs 48 and 49, respectively. The ends of the tripping members 44 and 45 that are remote from the latches 43 are positioned adjacent to an operating member 51 attached to a latch rod 52 that is normally biased by the spring 53 to its illustrated position to engage a projection 54 for maintaining the switch operating contact members 28 and 29 in circuit closing position. Upon movement of the bimetal member 30 sufficiently to the left as shown in Fig. 1 to release the latch 43, the tripping member 44 will operate under the force of the spring 48 to move the operating member

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51 and latch rod 52 downwardly to disengage the projection 54 causing the switch operating member 55 to be moved to the right as operated by a toggle mechanism 56 actuated by a spring 57 which moves the contact members 28 and 29 of the circuit breaker to their circuit interrupting positions. Likewise, movement of the bimetal element 31 to the right as shown in Fig. 1 sufficiently to unlatch the tripping member 45 causes a similar operation of the operating member 51 and latch rod 52 to cause movement of the circuit breaker to its circuit interrupting position.

The circuit breaker 18 is so mounted as to operate under the oil or cooling liquid in which the transformer is immersed so that the bimetal elements 30 and 31 are responsive both to the temperature of the transformer oil and also to the current flowing in the transformer secondary circuit. Either bimetal 30 or 31 is effective to trip the breaker which, when it operates, interrupts the current flow through both poles of the breaker to completely disconnect the secondary circuit from the distribution circuit supplied from the transformers.

The modification of the invention shown in Fig. 3 is generally similar to that shown in Figs. 1 and 2 except that no neutral conductor corresponding to the conductor 22 of Figs. 1 and 2 is provided as the transformer secondary winding terminals 13 and 14 are connected to two distribution circuit conductors 61 and 62, respectively. The junction point 25 is connected by conductor 63 to the terminal 14 and the remaining circuits are similar to those shown in Figs. 1 and 2. Thus, the right-hand ends of the four secondary winding coils 3, 4, 5 and 6 are all connected to the secondary winding terminal 14 and the left-hand ends of these four winding coils are all connected to the secondary winding terminal 13. Thus, the bimetal elements 30 and 31 each carry one-fourth of the total secondary winding current if we assume that each of the coils 3, 4, 5 and 6 carry the same current. In Fig. 3 as in Figs. 1 and 2, the bimetal 30 carries one-half of the current carried by the coils 3 and 4 and the bimetal 31 carries one-half of the current carried by the coils 5 and 6. In the structure shown in Figs. 1 and 2 this is one-half of the secondary current while in the arrangement shown in Fig. 3 it is one-fourth the secondary current.

Referring to Figs. 4, 5, 6 and 7, the invention is applied to a three phase transformer having three primary winding coils and six secondary winding coils. In the arrangement shown in Figs. 4 and 5, the two secondary winding coils of each phase are connected in series, the three phases being connected together in delta relation, while in the circuit connections shown in Figs. 6 and 7, the two secondary winding coils of each phase are connected in parallel circuit relation forming two parallel connected delta circuits, as shown in Fig. 7.

Referring to Fig. 4, the broken line 69 outlines the transformer casing containing the three primary windings 71, 72 and 73 associated respectively with phase A, phase B and phase C of the transformer. Secondary winding coils 74 and 75 are provided inductively related to the primary winding 71, secondary winding coils 76 and 77 are provided inductively related to the primary winding 72, and secondary winding coils 78 and 79 are provided inductively related to the primary winding 73. The letters A and B are used to indicate the terminals of the three secondary phase wind-

ing coils 74, 76 and 78 so as to more readily show the relation of the windings in the simplified circuit diagrams of Figs. 5, 7 and 10 and the letters C and D are used to designate that the terminals of the remaining three secondary winding coils 75, 77 and 79 for the same reason.

Two panel boards 81 and 82 are shown, the panel board 81 having eight studs, 83, 84, 85, 86, 87, 88, 89 and 90 and the terminal board 82 having studs 91 to 98, inclusive, for use in making the desired circuit connections for the secondary winding coils in the secondary circuit. As shown in Fig. 4, the terminal A of the coil 74 is connected by conductor 101 to the stud 83, the terminal B of the coil 74 is connected by conductor 102 to the stud 89, the terminal C of coil 75 is connected to the stud 85 by conductor 103, the terminal D of coil 75 is connected by conductor 104 to the stud 95 and also to a junction point 105 to the middle one of three bimetals 106 of a three-pole circuit breaker 107. The terminal A of the coil 76 is connected by conductor 108 to the stud 90 and the terminal B of coil 76 is connected by conductor 109 to the stud 92. The terminal C of the coil 77 is connected by conductor 111 to the stud 91 and the terminal D of the coil 77 is connected by conductor 112 and the junction point 113 to the stud 94, and to a bimetal 114 associated with one of the three poles of the circuit breaker 107. The terminal A of the coil 78 is connected by conductor 115 to the stud 93, and the terminal B of the coil 78 is connected by conductor 116 to the stud 97. The terminal C of coil 79 is connected by conductor 117 to the stud 98 and the terminal D of the coil 97 is connected by conductor 118 to a junction point 119 and by conductor 121 to the stud 84 and to the third bimetal 122 of the three-pole switch 107. As shown in Fig. 4, a jumper 123 connects the studs 83 and 84 of the terminal board 81, a jumper 124 connects the studs 85 and 89, a jumper 125 connects the stud 90 of the terminal board 81 to the stud 95 of the terminal board 82, a jumper 126 connects the studs 91 and 92, a jumper 127 connects the studs 93 and 94 and a jumper 128 connects the studs 97 and 98. The remaining studs are not connected in the circuit arrangement shown in Fig. 4. The three-pole circuit breaker 107 is provided with sets of switches 131, 132 and 133, one set for each pole of the circuit breaker. The three junction points 119, 105 and 113 referred to above are connected, respectively, through three bimetal elements 122, 106 and 114 and their associated pole switches 131, 132, and 133 to three transformer secondary terminals X1, X2 and X3 and from them respectively to three distribution circuit conductors 134, 135 and 136.

The circuit shown in Fig. 4 is more readily understandable by reference to Fig. 5 in which the elements of the secondary circuit are shown in a simplified diagram. It will be noted that the two secondary windings of each phase are connected in series and the three phases connected together in delta with the three pole circuit breaker having a pole connected between each point of the delta circuit and its associated secondary transformer terminal.

Referring to Fig. 6, the general arrangement of the transformer windings, the terminal boards 81 and 82 and the arrangement of the studs in the terminal boards, together with the connections of the several secondary winding coils to the studs correspond to the subject matter shown in Fig. 4. The several connecting jumpers 123, 124, 125, 126, 127 and 128 shown in Fig. 4 are not

used in Fig. 6, but other jumpers to be presently described are used. In Fig. 6, a jumper 141 is shown connecting the stud 83 to the stud 87 and a conductor 142 is shown connecting the stud 87 to a junction point 143 between the bimetal 122 and contact members of the switch 131 of the first one of the three poles of the breaker 107. A jumper 144 is connected between the studs 87 and 88 and a conductor 145 is shown connecting the stud 88 with the stud 97. A jumper 146 connects the studs 84 and 85. A jumper 147 connects the studs 89 and 90 and a jumper 148 connects the studs 90 and 86 and a conductor 149 connects the studs 86 to a junction point 150 between the bimetal 106 and the switch contact members 132 of the second pole of the circuit breaker 107.

A jumper 151 connects the studs 91 and 95, a jumper 152 connects the studs 92 and 96, a jumper 153 connects the studs 93 and 92, a jumper 154 connects the studs 94 and 98, a conductor 155 connects the stud 96 with a junction point 156 that is connected between the bimetal 114 and the contact members of the switch 133 of the third pole of the circuit breaker 107. The circuit resulting from the arrangement of the various circuit conducting members illustrated in Fig. 6 is more clearly shown in Fig. 7 and comprises two parallel connected delta circuits connected together at their respective corners with a bimetal between each of the two corresponding corners of the delta and switch contact members between the outer corners of the delta and the secondary terminals so that the current flowing through the three bimetal elements 122, 106 and 114 will be only the current flowing through the windings of the inner delta as shown in Fig. 7 or half of the total current of the two delta connected winding circuits, while the current interrupted by the three-pole switch 107 will be the entire current from the two parallel connected delta circuits of the secondary windings.

Referring to Figs. 8, 9 and 10, a three phase transformer is shown having three primary windings, six secondary winding coils, two terminal blocks, each having eight terminal studs, and a three-pole circuit breaker generally similar to those shown in Figs. 4 and 6. The particular circuit connections are, however, different from the previously described figures in a manner to be presently explained. The circuit connections shown in Fig. 8 result in a series delta relation of the secondary winding coils similar to that shown in Fig. 5 and the circuit connections shown in Fig. 9 comprise a double delta or two parallel delta circuits shown in a simplified diagram in Fig. 10.

In Fig. 8, the secondary circuit from the transformer secondary terminal X1 to the transformer secondary terminal X2 extends from the terminal X1 through the contact members of the circuit breaker 131 of the first pole of the three phase circuit breaker 107, through the bimetal 122, conductor 161 to the junction point 162 and from there to the terminal A of the secondary winding coil 74, through the coil 74 to the terminal B, through conductor 163 to the stud 91, through the jumper 164 to the stud 92 and conductor 165 to the terminal C of the secondary winding coil 75, through the coil 75 to the terminal D thereof and through conductor 166 including the junction point 167 to the bimetal 106, through the bimetal 106 and switch conductor members 132 of the second pole of the switch 107 to the transformer secondary terminal X2.

The circuit from the transformer secondary terminal X2 to the transformer secondary terminal X3 extends from the terminal X2 through the circuit breaker contact members 132 and the bimetal 166 of the second pole of the circuit breaker 107, through conductor 166 to the junction point 167 and to the terminal A of the secondary winding coil 76, through the coil 76 to the terminal B thereof, through conductor 171 to the stud 85 through jumper 172 to the stud 86, through conductor 173 to the terminal C of the secondary winding coil 77, through the coil 77 to the terminal D thereof to the junction point 174 and through conductor 175 to the bimetal 114 and switch contact members 133 of the third pole of the circuit breaker 107 to the secondary terminal X3.

The circuit from the transformer secondary terminal X3 to the transformer secondary terminal X1 may be traced from the terminal X1 through the switch contact members 131 and bimetal 122, conductor 161 to the junction point 162, conductor 176 to the terminal D of the secondary winding coil 78, through the coil 78 to the terminal C thereof through conductor 177 to the stud 94, through jumper 178 to the stud 93, through conductor 179 to the terminal B of the secondary winding coil 78 through the coil 78 to the terminal A thereof and to the junction point 174, through conductor 175, bimetal 114 and circuit contact members 133 to the secondary winding terminal X3. As will be seen by following the above traced circuits, the embodiment illustrated in Fig. 8 uses fewer jumpers on the terminal boards 81 and 82 than shown in Fig. 4, but arrives at the same general arrangement of the six secondary winding coils, namely, the two coils of each phase are in series circuit relation with each other forming a single delta connected secondary winding as shown in the simplified diagram in Fig. 5.

In the embodiment of the invention illustrated in Fig. 9, the connections of the terminals of the several secondary winding coils 74 to 79, inclusive, to the several studs on the terminal boards 81 and 82 are similar to the connections shown in Fig. 8 and the connections of the several junction points 162, 167 and 174 to the several poles of the three phase circuit breaker 107 and the transformer secondary winding terminals X1, X2 and X3 are also similar to the connections shown in Fig. 8. The same transformer unit may be connected as shown in Fig. 8 for series operation of the secondary phase winding coils or as shown in Fig. 9 for parallel operation of the secondary winding coils.

In Fig. 9, the circuits are changed from those shown in Fig. 8 by removing the three jumpers 172, 164 and 178 shown in Fig. 8 and adding jumpers 131, 132, 133, 134, 135, 136 and a conductor 137. In addition, a conductor 191 is connected between the junction point 192 that is between the bimetal 122 and the switch contact members 131 of the first pole of the three phase circuit breaker to the stud 97, a conductor 193 is connected between a junction point 194 that is between the bimetal 166 and the contact members of the switch 132 of the second pole of the three phase circuit breaker to the stud 95, and a conductor 195 is connected between a junction point 196 that is between the bimetal 114 and the contact members of the switch 133 of the third pole of the three phase circuit breaker to the stud 89.

The jumpers 181 to 186 and the conductor 187

are as shown in Fig. 9 connected as follows. The jumper 121 connects the stud 84 to the stud 85, the jumper 182 connects the stud 85 to the stud 89, the jumper 183 connects the stud 86 to the stud 91, the jumper 184 connects the stud 91 to the stud 95, the jumper 185 connects the stud 92 to the stud 93, the jumper 186 connects the stud 93 to the stud 97 and conductor 187 connects the stud 94 to the stud 84.

The circuit of Fig. 9 is more clearly shown in the simplified diagram of Fig. 10. It will be noticed by reference to Fig. 10, that any circuit from any transformer secondary terminal X1, X2 or X3 to any other one of the three terminals extends through two parallel branches between junction points inside the circuit breaker contact members and includes one of the three bimetals 166, 114 or 122 and two of the three circuit breaker pole switches 131, 132 and 133. For example, from the transformer secondary terminal X2 to the transformer secondary terminal X3, the circuit includes both pole switches 132 and 133. The circuits divide between the junction points 194 and 196, one circuit path including the conductor 193 to junction point 91, the secondary winding coil 77, junction point 174 conductor 112 and the bimetal 114 to the junction point 196, and the other parallel path between the junction points 194 and 196 including the bimetal 166, conductor 166 to the junction point 167, secondary winding coil 76 and conductor 195 to the junction point 196. Likewise, in tracing the circuit from the terminal conductor X2 to the terminal conductor X1, or from the terminal conductor X1 to the terminal conductor X3, the circuit in each case will pass through two poles of the three pole switch and through two parallel circuits including the two secondary winding coils of one phase of the three phase secondary of the transformer and including one of the bimetal elements.

There are certain advantages in the circuit arrangements shown in Figs. 9 and 10 over that shown in Figs. 6 and 7. The circuit arrangements shown in Figs. 6 and 7 work properly, providing the current divides properly between the two complete delta circuits shown. It will be noted, by reference to Fig. 7, however, that the outer delta does not include any bimetal elements. The bimetal elements of Fig. 7 are between the corners of the inner delta and the corners of the outer delta as shown in Fig. 7. If one of the circuits of the inner delta becomes interrupted for one reason or another, the entire current in that phase will necessarily flow through the coil connected in the outer delta of the diagram and will not include a bimetal element. This is impossible in the connection shown in Figs. 9 and 10, since each one of the two parallel paths per phase includes one thermal element which protects all six of the secondary winding coils independently of the difference of load between them.

It will be apparent from those skilled in the art that modifications may be made from the particular circuit arrangement shown within the scope of the invention and we do not wish to be otherwise limited than by the scope of the appended claims.

We claim as our invention:

1. In combination, a single phase electrical transformer comprising a casing, a primary winding and a secondary winding within the casing, the secondary winding comprising a pair of groups of secondary winding coils, a pair of

secondary winding transformer terminals, a pair of junction points connected to the pair of secondary winding transformer terminals, a two pole circuit breaker within the transformer casing, the two poles of said circuit breaker being connected respectively between one secondary winding terminal and its associated junction point, the secondary winding coils of each group being connected in a plurality of similar parallel-connected circuit paths between the pair of junction points, and temperature responsive means for operating the circuit breaker to interrupt the transformer secondary circuit comprising a pair of temperature responsive elements for tripping the circuit breaker, one temperature responsive element being associated with each junction point and responsive to the current flowing through one of the secondary winding coils only of the parallel-connected circuit paths connected to that junction point and responsive to a portion only of the current flowing through the junction point and the associated breaker pole to the associated secondary winding terminal.

2. In combination, a three phase electrical transformer comprising a casing, a primary winding and a secondary winding within the casing, the secondary winding comprising a plurality of groups of secondary winding coils, three secondary winding transformer terminals, three junction points, one connected to each secondary winding transformer terminal, a three-pole circuit breaker within the transformer casing, the three poles of said circuit breaker being connected respectively between one secondary winding terminal and its associated junction point, the secondary winding coils of each group being connected in a plurality of similar parallel-connected circuit paths between each pair of said three junction points, and temperature responsive means for operating the circuit breaker to interrupt the transformer secondary circuit comprising three temperature responsive elements for tripping the circuit breaker, one temperature responsive element being associated with each junction point and responsive to the current flowing through one of the secondary winding coils only of the parallel-connected circuit paths connected to that junction point and responsive to a portion only of the current flowing through the junction point and the associated breaker pole to the associated secondary winding terminal.

3. In combination, a three phase electrical transformer comprising a casing, a primary winding and a secondary winding within the casing, the secondary winding comprising a plurality of winding coils for each of the three phases of the transformer, the secondary winding coils being connected to provide a plurality of delta connected phase winding circuits providing junction points at the union between the adjacent coils in each delta connection, a three pole circuit breaker in said delta casing, three secondary transformer terminals, secondary circuit paths between corresponding junction points of the delta connected phase winding coils connecting the several delta connected groups of winding coils in parallel circuit relation, the circuit interrupting poles of the three pole circuit breaker being connected respectively between the three secondary transformer terminals and the secondary circuit paths connecting the several delta connected phase windings to the terminals, and three temperature responsive means each responsive to the current flowing in one of said

circuit paths between corresponding junction points of the several delta connected groups of secondary winding coils for operating the circuit breaker to interrupt the secondary circuit upon predetermined load conditions between any of the three secondary transformer junction points connected thereto.

4. In combination, a three phase electrical transformer comprising a casing, a primary winding and a secondary winding within the casing, the secondary winding comprising a plurality of winding coils for each phase of the transformer, three secondary winding transformer terminals, the secondary winding coils being connected in a plurality of delta connected groups, each group including three phase winding coils, the several groups of delta connected phase winding coils being connected together through circuit connections between corresponding junction points of the several delta connected groups, a three pole circuit breaker within the casing, the three poles of the breaker being connected respectively between the three circuit connections joining the groups of delta connected phase winding coils and the three secondary winding transformer terminals for interrupting the secondary circuit from the transformer, and three temperature responsive elements for operating the circuit breaker to interrupt the transformer secondary circuit, the three temperature responsive elements being connected respectively between the three transformer terminals and one delta connected group only of the several groups of delta connected secondary phase winding coils so as to be directly responsive to a portion only of the current flowing through the associated secondary winding terminal.

5. In a three-phase electrical transformer, a casing, a primary winding and a secondary winding within the casing, the secondary winding comprising a plurality of secondary winding coils for each phase, three secondary winding transformer terminals, phase winding coils associated with each of two phases of the transformer uniting to form a delta-connected group having junction points adjacent each one of the three secondary winding transformer terminals, additional phase winding coils associated respectively with each of the same two phases of the transformer uniting to form a similar delta-connected group having junction points adjacent each of the three secondary winding transformer terminals, corresponding junction points of the two deltas being connected to a corresponding common junction point, a three-pole circuit breaker in the transformer casing, each of the three poles of the circuit breaker being connected respectively between the three secondary winding transformer terminals and the adjacent common junction points associated therewith for interrupting the transformer secondary current between the secondary winding coils and the three phase secondary terminals, and three thermal elements each responsive to the current flowing between one of the secondary terminals and an associated junction point of one of the delta-connected groups only adjacent thereto for initiating the operation of the circuit breaker.

6. In combination, an electrical transformer comprising a casing, a primary winding and a secondary winding within the casing, the secondary winding comprising a plurality of groups of winding coils, each group comprising at least a pair of the winding coils connected in parallel

circuit relation and terminating in a junction point, a circuit breaker in the casing, a secondary circuit path from each of the junction points to a transformer terminal including circuit breaker contact members for interrupting the flow of current from the transformer, and temperature responsive means responsive to the current flowing in one of the winding coils of a group only disposed for operating the circuit breaker to interrupt the secondary circuit.

7. In combination, an electrical transformer comprising a casing, a primary winding and a secondary winding within the casing, the secondary winding comprising a plurality of groups of winding coils, each group comprising at least a pair of the winding coils connected in parallel circuit relation and terminating in a junction point, a circuit breaker in the casing, a secondary circuit path from each of the junction points to a transformer terminal including circuit breaker contact members for interrupting the flow of current from the transformer, and temperature responsive means connected in series circuit relation between one of the winding coils of a group and the junction point associated therewith and responsive to the current flowing in said one of the winding coils of the group only disposed to operate the circuit breaker to interrupt the secondary circuit.

8. In combination, an electrical transformer comprising a casing, a primary winding and a secondary winding within the casing, the secondary winding comprising a plurality of groups of winding coils, each group comprising at least a pair of the winding coils connected in parallel circuit relation and terminating in a junction point, a circuit breaker in the casing, a secondary circuit path from each of the junction points to a transformer terminal including circuit breaker contact members for interrupting the flow of current from the transformer, and a temperature responsive means for each of the groups of winding coils, each of the temperature responsive means being connected in series circuit relation between one of the winding coils and the junction point of the group with which it is associated to be responsive to the current flowing in said one of the winding coils of the associated group only for operating the circuit breaker to interrupt the secondary circuit.

9. In combination, an electrical transformer comprising a casing, a primary winding and a secondary winding within the casing, the secondary winding comprising a plurality of groups of winding coils, a plurality of secondary winding transformer terminals, each group of winding coils comprising at least a pair of the winding coils connected in parallel circuit relation and terminating in a junction point, a circuit breaker having a plurality of circuit interrupting poles disposed within the casing, the several poles of the circuit breaker being so disposed that each pole is connected between one of the secondary winding terminals and a junction point associated therewith for interrupting the flow of current from the transformer, and temperature responsive means comprising a plurality of temperature responsive elements each of which is operative to

trip the circuit breaker, one of the temperature responsive elements being connected in series circuit relation between one of the winding coils of a group and the junction point associated therewith to be responsive to the current flowing in said one of the winding coils of the group only and to a portion only of the current flowing through junction point and associated breaker pole.

10. In combination, a single phase electrical transformer comprising a casing, a primary winding and a secondary winding within the casing, the secondary winding comprising a plurality of groups of winding coils, each group comprising a plurality of the winding coils connected in parallel circuit relation and terminating in a junction point, a two-pole circuit breaker within the casing, a secondary transformer terminal for each of said junction points, a secondary circuit path from each of the junction points to the associated secondary transformer terminal and including one pole of the circuit breaker disposed for operation to interrupt the flow of current from the transformer, and temperature responsive means connected to be responsive to the current flowing in only one of the parallel-connected winding coils of a group disposed to operate the circuit breaker to interrupt the secondary circuit.

11. In combination, a single phase electrical transformer comprising a casing, a primary winding and a secondary winding within the casing, the secondary winding comprising a pair of groups of winding coils, each group comprising a plurality of the winding coils connected in parallel circuit relation and terminating in a junction point, a two-pole circuit breaker within the casing, a secondary transformer terminal for each of said junction points, a secondary circuit path from each of the junction points to the associated secondary transformer terminal and including one pole of the circuit breaker disposed for operation to interrupt the flow of current from the transformer, and temperature responsive means comprising a temperature responsive element for each group of the pair of groups of winding coils, each of the temperature responsive elements being connected in series circuit relation between one of the winding coils of the group associated therewith and the junction point of the group to be responsive to the current flowing in said one of the winding coils only to operate the circuit breaker to interrupt the secondary circuit.

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