(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 702 387 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
20.03.1996 Bulletin 1996/12

(51) Int. Cl.[6]: **H01H 71/10**

(21) Application number: **95114334.6**

(22) Date of filing: **12.09.1995**

(84) Designated Contracting States:
DE FR GB IT

(30) Priority: **16.09.1994 US 308029**

(71) Applicant: **EATON CORPORATION**
Cleveland, Ohio 44114-2584 (US)

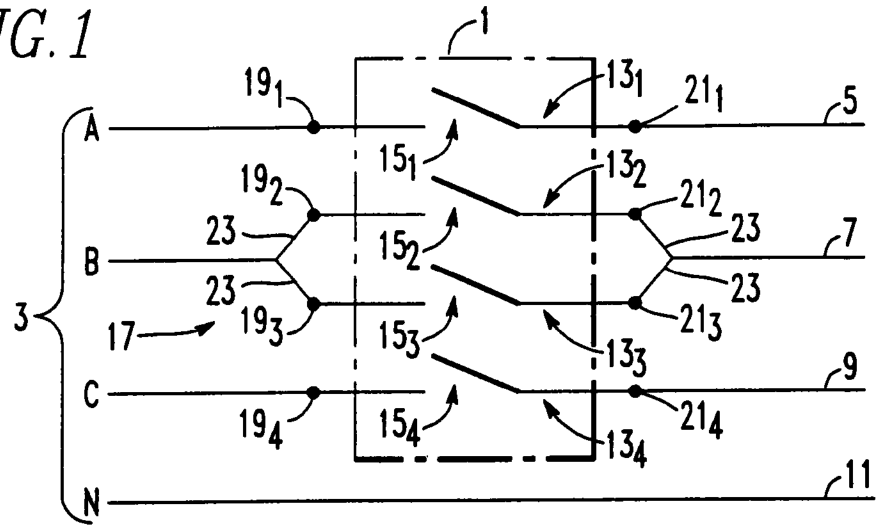
(72) Inventor: **Eberts, William George**
Corapaolis, Pennsylvania 15108 (US)

(74) Representative: **Wagner, Karl H.**
WAGNER & GEYER
Patentanwälte
Gewürzmühlstrasse 5
D-80538 München (DE)

(54) Multipole circuit breaker with reduced operating temperature

(57) At least one inner pole (13_2) of a multipole circuit breaker (1) is connected in parallel with another pole (13_1) to reduce the current through the inner pole, and therefore, lower the operating temperature of the circuit breaker. In circuit breakers having electronic trip units (41), the current transformers (43) providing sensed currents for the poles (13) connected in parallel are connected to the trip unit (41) in parallel. In circuit breakers having thermal-magnetic trip devices (27), the current/time characteristics of the thermal-magnetic devices associated with the poles (13) connected in parallel are set so that they collectively substantially match the current/time characteristics of the other poles. A four pole breaker (1) can be connected in a three conductor distribution system (3) by connecting the two center poles ($13_{2,3}$) in parallel to one conductor (7), and connecting each of the other two poles ($13_{1,4}$) to a different one of the remaining conductors (5,9). One inner pole and the adjacent outer pole can be connected in parallel to one conductor in a two conductor distribution system, with the other inner and outer poles connected in parallel to the other conductor. In the two conductor system, the four pole breaker can be replaced by a three pole breaker having the center pole and one outer pole connected alone in parallel to one conductor and the other outer pole connected to the second conductor.

FIG. 1



EP 0 702 387 A1

Printed by Rank Xerox (UK) Business Services
2.9.13/3.4

Description

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to circuit breakers and in particular to multipole circuit breakers having at least some of the poles connected in parallel to reduce the operating temperature of the breaker.

Background of Information

Multipole circuit breakers are used to provide protection in multi-phase electrical systems. For instance, three pole circuit breakers are used to separately interrupt current in the three phases of a three-phase electrical system. Often, four pole circuit breakers are used to interrupt current in all four conductors of a three-phase electrical system having a ground or neutral conductor in addition to the three-phase conductors.

Users and manufacturers of circuit breakers are always interested in the possibility of being able to increase the current rating of a particular size circuit breaker, or to reduce the size, and therefore the cost, of the circuit breaker, while maintaining a given current rating. One of the factors affecting the current carrying capacity of circuit breakers is the operating temperature reached. The current flowing through the circuit breaker with the contacts closed produces joule heating which raises the operating temperature.

Restrictions have been placed upon the maximum temperature a circuit breaker can reach in operation, stated in terms of a maximum allowable temperature increase over ambient conditions. Typically, the poles of a multipole circuit breaker are mounted side-by-side in a housing so that there are inner poles and outer poles. For example, in a three pole circuit breaker the center pole is an inner pole flanked by two outer poles. In the case of a four pole circuit breaker there are two inner poles and two outer poles. Even in the case of balanced currents, the inner poles run hotter than the outer poles as they are sandwiched between the outer poles which are also generating heat. Thus, the inner poles become the limiting factor on the thermal rating of the circuit breaker. Of course, the circuit breaker can be made to run cooler by making the current carrying parts larger. However, often the dimensions of the circuit breaker are dictated by standardized dimensions of the panel boards in which the circuit breakers are typically mounted.

There is a need therefore, for an improved multipole circuit breaker with increased current carrying capability but which maintains the operating temperature within established limits. There is a need for such an improved multipole circuit breaker having either an electronic trip unit or a thermal-magnetic trip function. There is an additional need for such an improved multipole circuit breaker which requires minimum structural changes to handle.

SUMMARY OF THE INVENTION

These needs and others are satisfied by the invention which is directed to a multipole circuit breaker in which at least one set of at least two poles are connected in parallel to one of the conductors of an electric power distribution system. More particularly, the multipole circuit breaker includes at least three poles mounted side-by-side in a housing to form at least one inner pole and at least two outer poles, with the at least one set of at least two poles including an inner pole and an outer pole. With this arrangement, the current through the inner pole which is connected in parallel with an outer pole is ideally reduced by half. Clearly, this reduces the number of conductors in which the circuit breaker can interrupt current. However, a standard four pole circuit breaker can be used with a three-phase system, or a three pole circuit breaker can be used in a single phase (two conductor) system in accordance with the invention. In the case of a four pole circuit breaker used with a three-phase system, the two inner poles are connected in parallel to one conductor and the two outer poles are connected separately to the other two conductors. Such an arrangement can be used with a four wire system where, as is typical in the United States, the neutral or ground fourth conductor is not switched. In the case of the three pole circuit breaker, the center pole and one of the outer poles are connected in parallel to one conductor in the electrical distribution system and the other outer pole is connected to the other conductor.

The invention can be used with circuit breakers having an electronic trip unit, or a thermal-magnetic trip. In the case of the multipole circuit breaker with an electronic trip unit, the current sensors for the two parallel connected poles are connected in parallel to the electronic trip unit. Thus, the electronic trip unit sees the sum of the currents for the poles connected in parallel, the same total current it would see if a single pole were used.

In the case of the multipole circuit breaker with a thermal-magnetic trip, the current/time characteristic for the thermal-magnetic device on the poles connected in parallel are selected so that they collectively substantially match the current/time characteristics of the thermal-magnetic devices on the other poles connected singly to a conductor in the electric power distribution system.

More particularly, the invention is directed to:

a multipole circuit breaker for interrupting current in a given number of separate conductors in an electric power distribution system, said circuit breakers comprising:

a plurality of poles, wherein said plurality is greater than said given number, each said pole having separable contacts for interrupting current therethrough;

common means for opening and closing said separable contacts of said plurality of poles substantially together; and

connecting means connecting said poles to said conductors with at least one set of at least two of said plurality of poles connected in parallel to one of said given number of conductors.

BRIEF DESCRIPTION OF THE DRAWINGS

A full understanding of the invention can be gained from the following description of the preferred embodiments when read in conjunction with the accompanying drawings in which:

Figure 1 is a schematic circuit diagram of one embodiment of a four pole circuit breaker in accordance with the invention.

Figure 2 is a schematic circuit diagram of another embodiment of a four pole circuit breaker in accordance with the invention.

Figure 3 is a schematic diagram of the multipole circuit breaker of Figure 1 incorporating an electronic trip unit.

Figure 5 is a schematic diagram of the multipole circuit breaker of Figure 2 incorporating a thermal-magnetic trip function.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Figure 1, a circuit breaker 1 is connected in a four wire electrical distribution system 3 having three-phase conductors 5, 7 and 9 for phases A. B and C, and a fourth conductor 11 for the neutral N. The circuit breaker 1 has four poles 13_1 *to* 13_4 each having separable contacts 15_1 *to* 15_4. Connections 17 connect the four pole circuit breaker 1 for interruption of current in the three-phase conductors 5, 7, and 9 of the electric distribution system 3. These connections 17 include line side terminals 19_1 *to* 19_4 and loadside terminals 21_1 *to* 21_4. The lineside terminal 19_1 and loadside terminal 21_1 of the first pole 13_1 of the circuit breaker 1 are connected to the conductor 5 of the electrical system 3. Similarly, the lineside terminal 19_4 and loadside terminal 21_4 of the fourth pole 13_4 are connected directly to the conductor 9. For the two inner poles, 13_2 *and* 13_3 the connections 17 further include connection or jumper bars 23 connecting the lineside terminals 19_2 *and* 19_3 to the lineside of conductor 7 and connecting the loadside terminals 21_2 *and* 21_3 to the loadside conductor 7. Thus, the inner poles 13_2 *and* 13_3 are connected in parallel in the conductor 7 while the outer poles 13_1 *and* 13_4 are connected separately in the conductors 5 and 9 respectively. Thus, the poles 13_2 *and* 13_3 form at least one set of at least two of a plurality of poles of the circuit breaker 1 which are connected in parallel to one of a given number of conductors (3) in the electrical system 3. It will be noted that the fourth, neutral conductor 11 is not switched by the circuit breaker 1.

Figure 2 illustrates another embodiment of the invention in which the multipole circuit breaker 1' is connected in an electrical system 3' having a line conductor L 25 and a neutral (N) conductor 27. Elements similar to those in the circuit breaker 1 of Figure 1 are given like reference characters primed. In this embodiment, connections 17' include connector bars 23' the connecting the lineside terminals $19'_1$ of the first pole $13'_1$ and the lineside terminal $19'_2$ of the second pole $13'_2$ to the lineside of the line conductor 25. Additional connector bars 23' connect the loadside terminals $21'_1$ *and* $21'_2$ of these poles to the loadside of the conductor 25. In like manner, the third and fourth poles $13'_3$ *and* $13'_4$ are connected by connecting bars 23' to the lineside and loadside of the neutral conductor 27. Thus, one inner pole $13'_2$ is connected in parallel with an adjacent one of the outer poles $13'_1$ in the conductor 25, while the other inner pole $13'_3$ is connected in parallel with the adjacent other outer pole $13'_4$ in the other conductor 27.

Yet another embodiment of the invention is illustrated in Figure 3, again where elements like those in Figures 1 and 2 have the same reference numerals but are double primed. In this case, the multipole circuit breaker 1" is a three pole circuit breaker having $13''_1$ *to* $13''_3$ connected in an electrical distribution system having two conductors, a line (L) conductor 29 and a neutral (N) conductor 31. The inner (or center) pole $13''_2$ is connected in parallel with one of the outer poles $13''_1$ in the conductor 29 by the connecting bars 23". The other outer pole $13''_3$ is connected in the other conductor 31.

Figure 4 illustrates schematically the structure of the circuit breaker 1 of Figure 1. This four pole circuit breaker 1 has a housing 33 made of an electrically insulative material. The housing 33 has partitions 35 forming four compartments 37_1 *to* 37_4. The four poles 13_1 *to* 13_4 are mounted in the compartments 37_1 *to* 37_4 respectively side-by-side so that the poles 13_2 *and* 13_3 are inner poles which are flanked by the outer poles 13_1 *and* 13_4. The separable contacts 15_1 *to* 15_4 associated respectively with each of the poles are operated together by a common operator 39 which includes an electronic trip unit 41. The common operator 39 also includes sensors for sensing current in the respective poles in the form of current transformers 43_1 to 43_4. Input leads 45_1 *to* 45_4 provide the current sensed by the current transformers 43_1 *to* 43_4 to the electronic trip unit 41. The leads 45_2 *and* 45_3 connect the current transformers 43_2 *and* 43_3 to the electronic trip unit in parallel, while the leads 45_1 *and* 45_4 connect the associated current transformers 43_1 *and* 43_4 to the electronic trip unit separately. As is well known, the electronic trip unit 41 monitors the sensed current provided by the current transformers 43 and trips the circuit breaker to open the separable contacts 15 in response to selected current/time characteristics. Typically, the phase currents are auctioneered with the electronic trip unit responding to the phase current of greatest magnitude. Connecting poles 13_2 *and* 13_3 in parallel splits the current of the phase to which they are connected to. However, also connecting the current transformers 43_2 *and* 43_3 in parallel adds the split currents together so that the electronic trip unit sees the current for that phase the same as it would had all the current passed through a single pole of the circuit breaker in the conventional manner. Thus, no adjustment need be made to the trip unit.

Without the parallel pole connection shown in Figure 4, it can be appreciated that the inner poles 13_2 *and* 13_3 of a four pole circuit breaker will run hotter than the outer poles 13_1 *and* 13_4 if comparable currents are run through the inner poles and the outer poles. Splitting the current of one phase between the two inner poles 13_2 *and* 13_3 not only reduces the temperature of these inner poles but also reduces the temperature of the outer poles since the heat radiated from the inner poles through the adjoining partitions 35 to the outer poles is reduced. Tests on a four pole circuit breaker arranged in the three pole application as shown in Figure 4 showed a drop in center pole temperature of 30° C and a reduction in the outer pole temperature of 14° C. Whereas the center pole had been running at least 10° C hotter than the outer poles, with the invention as shown in Figure 4 the center poles ran 5° C cooler than the outer poles.

Figure 5 illustrates schematically the structure of the circuit breaker 1' shown in Figure 2. Again the circuit breaker 1' has an electrically insulating housing 33' which is divided by partitions 35' into four compartments $37'_1$ *to* $37'_4$ in which the poles $13'_1$ *to* $13'_4$ are mounted side-by-side. The common operator 39' in the circuit breaker 1' includes thermal-magnetic devices 47_1 *to* 47_4 in each of the respective poles $13'_1$ *to* $13'_4$. As is well known, the thermal-magnetic device 47 includes a bimetal which responds to persistent overcurrents to rotate a trip bar 49 which in turn operates a spring operated mechanism 51 which trips the contacts $15'_1$ *to* $15'_4$ open. Higher overcurrents through the thermal-magnetic device 47 generates a magnetic field which actuates an armature within the thermal-magnetic device 47 to rotate the trip bar 49 and open the contacts 15. The thermal-magnetic devices 47 respond to a selected current/time characteristic which generates the thermal and magnetic trips. In the embodiment of Figure 5 in which the four pole circuit breaker 1' is connected in a two line electrical distribution system 3' the poles $13'_1$ *and* $13'_2$ are connected in parallel while the poles $13'_3$ *and* $13'_4$ are also connected in parallel. With this arrangement, the currents through each of the poles is ideally reduced in half so that the current/time characteristics of all of the poles can be set the same. However, the circuit breaker 1' could also be configured for use in a three conductor system as is the case with the circuit breaker 1 in Figure 4. In that case, the two inner poles $13'_2$ *and* $13'_3$ would be connected in parallel and the two outer poles $13'_1$ *and* $13'_4$ would be connected separately to the second and third conductors of the electrical distribution system. In that arrangement, the current/time characteristics of the thermal-magnetic devices 47_2 *and* 47_3 would be selected such that collectively they would match the current/time characteristics of the thermal-magnetic devices 47_1 *and* 47_4. This could be accomplished by selecting the current/time characteristics of the thermal-magnetic devices 47_2 *and* 47_3 so that they respond to half the current of the devices 47_1 *and* 47_4 in the same amount of time.

The connecting bars 23 connecting the appropriate poles in parallel have been shown external to the circuit breaker housing 33. Alternatively, such connections could be made inside the circuit breaker housing. However, the external arrangement shown is preferred because it provides for better cooling and does not require changed in the structure of the circuit breaker. In fact, in the case of a multipole circuit breaker with an electronic trip unit, the only change required to the conventional circuit breaker is the connection in parallel of the current transformers associated with the parallel connected poles. The absence of the fourth current input does not affect the operation of the electronic trip unit. However, if desired, the four pole trip unit could be replaced with the three pole electronic trip unit in the case of the configuration shown in Figure 4, or with a two pole electronic trip unit in the case of the configuration shown in Figure 2.

While specific embodiments of the invention have been described in detail, it will be appreciated by those skilled in the art that various modifications and alternatives to those details could be developed in light of the overall teachings of the disclosure. Accordingly, the particular arrangements disclosed are meant to be illustrative only and not limiting as to the scope of invention which is to be given the full breadth of the claims appended and any and all equivalents thereof.

Claims

1. A multipole circuit breaker (1) for interrupting current in a given number of separate conductors (5,7,9), in an electric power distribution system (3), said circuit breakers comprising:

   a plurality of poles (13), wherein said plurality is greater than said given number, each said pole having separable contacts (15) for interrupting current therethrough;

   common means (39) for opening and closing said separable contacts (15) of said plurality of poles (13) substantially together; and

   connecting means (17) connecting said poles (13) to said conductors (5,7,9) with at least one set of at least two of said plurality of poles (13) connected in parallel to one of said given number of conductors (5,7,9).

2. The multipole circuit breaker (1) of Claim 1 wherein said common means (39) comprises sensing means (43) associated with each pole (13) for sensing current flowing through said pole with said separable contacts (15) closed, electronic trip means (41) responsive to current sensed by said sensing means (43) for tripping said separable contacts (15) open in response to selected current/time characteristics of said current sensed, and input means (45_2, 45_3) inputting current sensed by said sensing means (43_2, 43_3) associated with each pole (13_2, 13_3) of

said at least one set of at least two poles (13) into said electronic trip means (41) in parallel.

3. The multipole circuit breaker (1) of Claim 2 wherein said sensing, means (43) comprise current transformers (43_{1-4}) associated with each pole (13_{1-4}).

4. The multipole circuit breaker (1) of Claim 1 wherein said common means (39) comprises a trip device (49) for opening said separable contacts (15) when actuated, and thermal-magnetic means (47) associated with each pole (13) for actuating said trip device (49) in response to selected current/time characteristics of current through the associated pole (13), said current/time characteristic of said poles (13) connected in parallel being selected to collectively substantially match the current/time characteristics of the thermal-magnetic means (27) associated with the other poles (13).

5. The multipole circuit breaker (1) of Claim 1 adapted for use with an electric power distribution system (3) having said given number of conductors (5,7,9) equal to three, wherein said multipole circuit beaker (1) has a housing (33) and said plurality of said poles comprises four poles (13_{1-4}) arranged in said housing (33) side-by-side to form two center poles (13_2, 13_3) and two outer poles (13_1, 13_4), and wherein said connecting means (17) comprises means (23) connecting said two center poles (13_2, 13_3) in parallel to one (7) of said three conductors (5,7,9) and separately connecting each of the outer poles (13_1, 13_4) to one other conductor (5,9).

6. The multipole circuit breaker (1) of Claim 5 wherein said common means (39) comprises a current transformer (43) associated with each pole (13), electronic trip means (41) responsive to current sensed by said current transformers (43) for tripping said separable contacts (15) open in response to selected current/time characteristics of said current sensed, and input means ($45_{2,3}$) inputting current sensed by the current transformers (43_2, 43_3) associated with said center poles (13_2, 13_2) into said electronic trip unit (41) in parallel and inputting current sensed by the current transformers (43_1, 43_4) associated with said outer poles (13_1, 13_4) into said electronic trip unit (41) separately.

7. The multipole circuit breaker (1) of Claim 5 wherein said common means (39) comprises a trip device (49) for opening said separable contacts (15) when actuated, and thermal-magnetic means (27) associated with each pole (13) for actuating said trip device (49) in response to said selected current/time characteristics of current through the associated pole (13), the current/time characteristics of said center poles (13_2, 13_3) connected in parallel being selected to collectively substantially match the current/time characteristics of the thermal-magnetic means (27) associated with the other poles (13_1, 13_4).

8. The multipole circuit breaker (1) of Claim 1 adapted for use with an electric power distribution system (3) having two conductors (25, 27), wherein said circuit breaker has a housing (33) and said plurality of said poles (13) comprises four poles (13_1, 13_4) arranged in said housing (33) side-by-side to form two center poles (13_2, 13_3) and two outer poles (13_1, 13_4) each adjacent one of said center poles, and wherein said connecting means (23) comprises means (23') connecting one center pole (13_2) and one outer pole (13_1) adjacent to said one center pole (13_2) in parallel to one conductor (25), and connecting the other center pole (13_3) and the other outer pole (13_4) adjacent to said other center pole (13_3) in parallel to the other conductor (27).

9. The multipole circuit breaker (1) of Claim 8 wherein said common means (39) comprises a current transformer (43) associated with each pole (13), electronic trip means (41) responsive to said current sensed by said current transformers (43) for tripping said separable contacts (15) open in response to selected current/time characteristics of said current sensed, and input means (45_2, 45_1) inputting current sensed by said current transformer (43_2) associated with said one center pole (13_2) and current sensed by said current transformer (43_1) associated with the adjacent one outer pole (13_1) in parallel into said electronic trip unit (41), and inputting current sensed by said current transformer (43_3) associated with the other center pole (13_3) and current sensed by the current transformer (43_4) associated with the adjacent other outer pole (13_4) in parallel into said electronic trip unit (41) separately from the sensed current in said one center pole (13_2) and said one outer pole (13_1).

10. The multipole circuit breaker (1) of Claim 1 adapted for use with an electric power distribution system (3) having said given number of conductors (29, 31) equal to two, wherein said circuit breaker (1) has a housing (33) and said plurality of said poles (13) comprises three poles (13_{1-3}) arranged in said housing (33) side-by-side to form an inner, center pole (13_2) and two outer poles (13_1, 13_3), and wherein said connecting means (23) comprises means (23) connecting said inner, center pole (13_2) and one outer pole (13) in parallel to one conductor (29) and connecting the other outer pole (13_3) to the other conductor (31).

11. The multipole circuit breaker (1) of Claim 10 wherein said common means (39) comprises a current transformer (43) associated with each pole (13), electronic trip means (41) responsive to current sensed by said current transformers (43) for tripping said

separable contacts (15) open in response to selected current/time characteristics of said current sensed, and input means ($45_{2,1,3}$), inputting current sensed by said current transformers ($43_{2,1}$) associated with said center pole (13_2) and said one outer pole (13_1) into said electronic trip unit (41) in parallel, and inputting current sensed by said current transformer (43_3) associated with said other outer pole (13_3) into said electronics trip unit (41) separately.

12. The multipole circuit breaker (1) of Claim 10 wherein said common means (39) comprises a trip device (49) for opening said separable contacts (15) when actuated, and thermal-magnetic means (27) associated with each pole (13) for actuating said trip device (49) in response to selected current/time characteristics of current through the associated pole (13), said current/time characteristics of said thermal-magnetic means ($27_{2,1,3}$) associated with said center pole (13_2) and said one outer pole (13_1) collectively substantially matching the current/time characteristic of said other outer pole (13_3).

13. The multipole circuit breaker (1) of Claim 1 wherein said connecting means (23) further comprises means (23') connecting an additional set of at least two poles (13) in parallel to a conductor (5,7,9).

14. The multipole circuit breaker (1) of Claim 1 wherein said plurality of poles (13) comprises at least three poles which are mounted side-by-side in a housing (33) to form at least one inner pole (13_2) and at least two outer poles ($13_{1,3}$), and wherein said at least one set of at least two poles (13) includes at least one inner pole (13_2).

FIG. 1

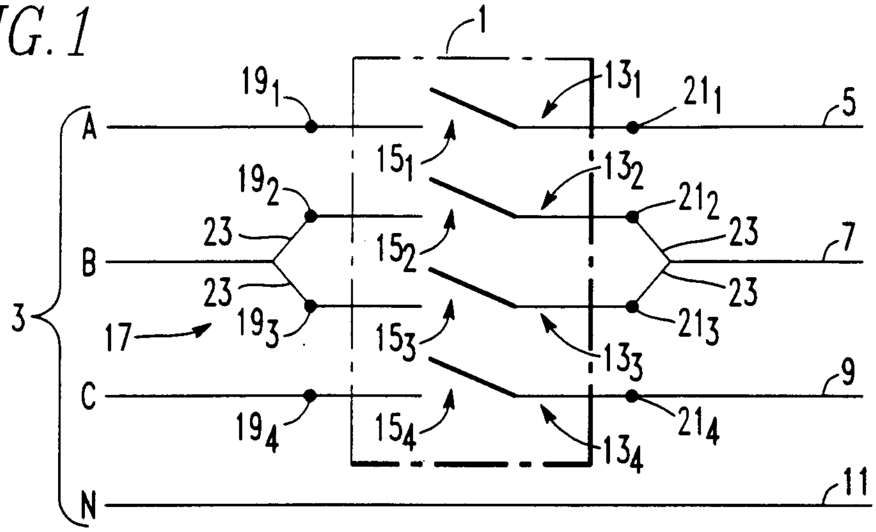


FIG. 2

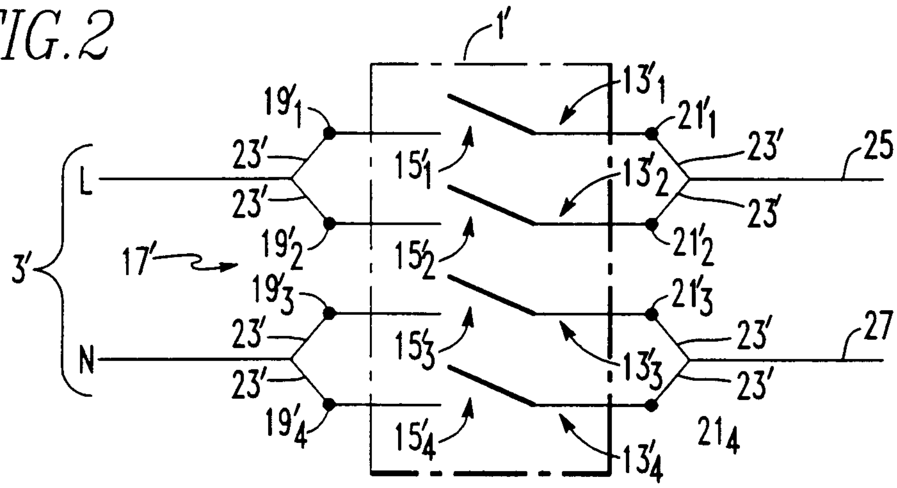
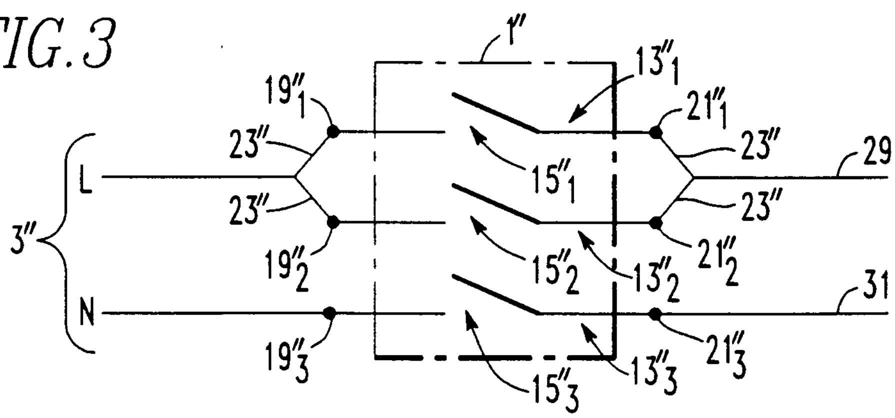
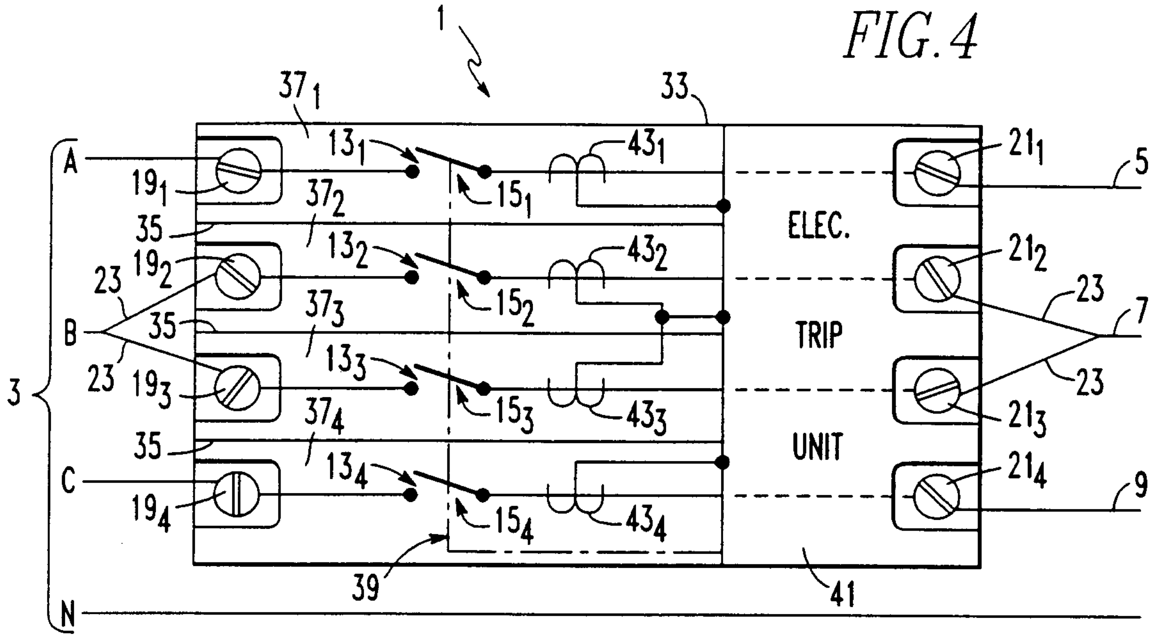


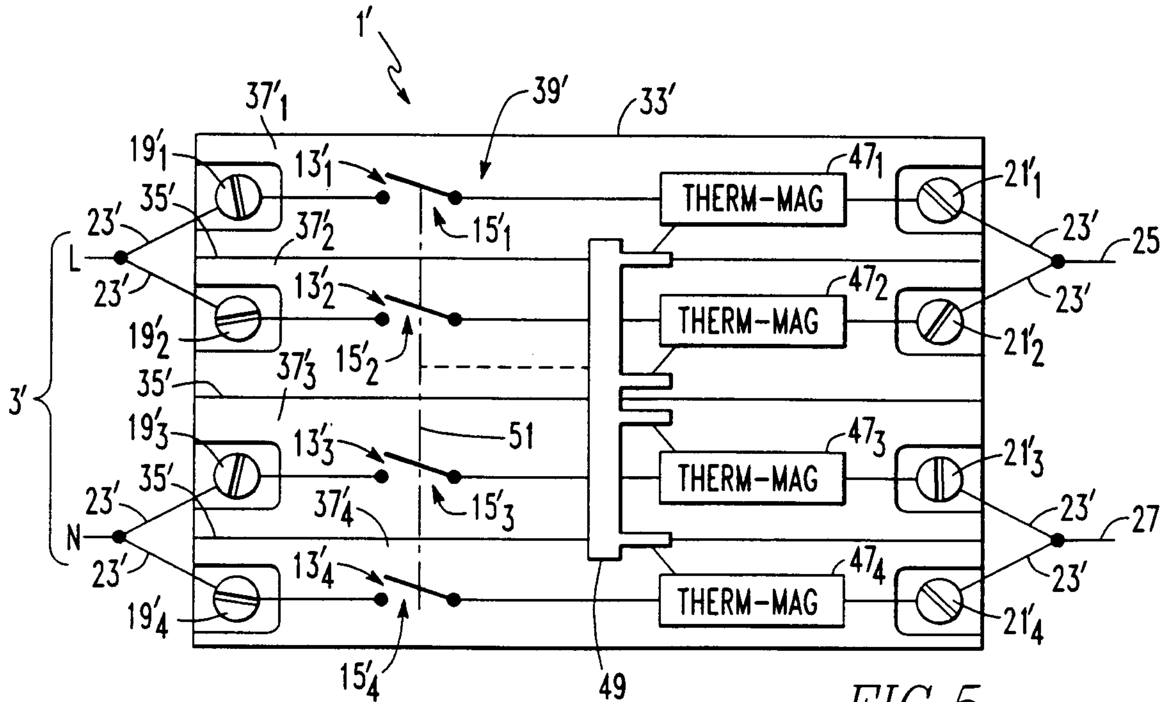
FIG. 3





ELEC.
TRIP
UNIT
A
B
C
N

FIG. 4



THERM-MAG
THERM-MAG
THERM-MAG
THERM-MAG
L
N

FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 11 4334

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP-A-0 117 094 (HEINEMANN ELECTRIC CO.) * abstract; figures 1-3 *	1,2	H01H71/10
A	DE-A-35 15 158 (LINDNER GMBH) * abstract; figures 2,3 *	1,2	
P,A	EP-A-0 670 585 (H. KOPP AG) * page 1, line 1 - line 34 * * page 4, line 13 - line 42; figures 3-5 *	1,2	
A	DE-B-21 01 060 (LICENTIA PATENT-VERWALTUNGS-GMBH) * the whole document *		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	19 December 1995	Ruppert, W

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document