

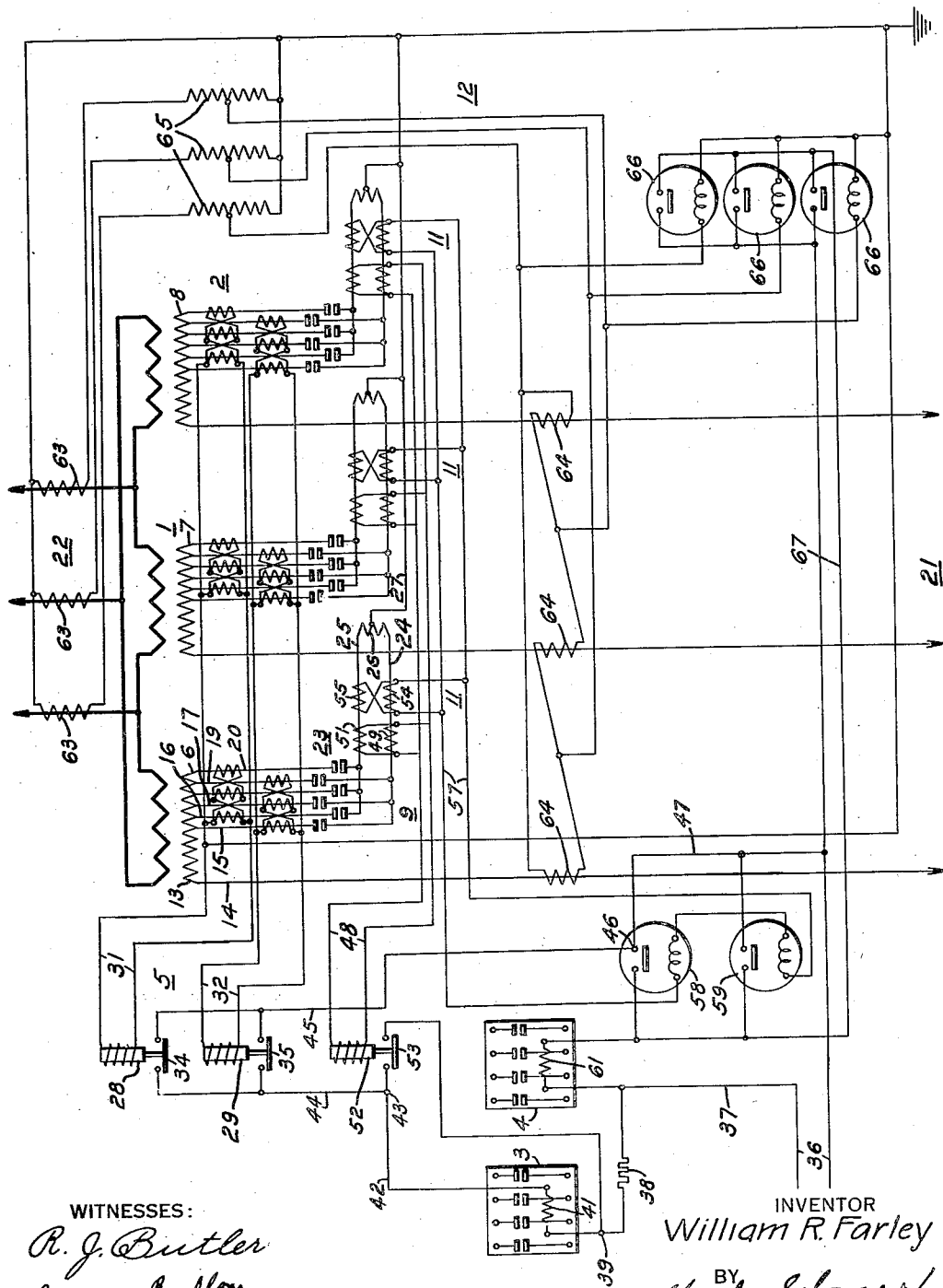
Sept. 24, 1929.

W. R. FARLEY

1,729,099

PROTECTIVE SYSTEM FOR TRANSFORMERS

Filed March 2, 1927



WITNESSES:

R. J. Butler
Leslie G. Rudlong

INVENTOR

William R. Farley

BY

Wesley G. Carr
ATTORNEY

UNITED STATES PATENT OFFICE

WILLIAM RICHARDSON FARLEY, OF WILKINSBURG, PENNSYLVANIA, ASSIGNOR TO
WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF
PENNSYLVANIA

PROTECTIVE SYSTEM FOR TRANSFORMERS

Application filed March 2, 1927. Serial No. 172,036.

My invention relates to transformer tap-changing systems and more particularly to electrical protective systems therefor.

One object of my invention is to provide a transformer tap-changing system that shall have a relay protective system for disconnecting the transformers from external circuits in the event of faulty operation of the transformer tap-changing mechanism.

Another object of my invention is to provide a protective system for transformer tap-changing equipment that shall distinguish a short-circuit between tap connections from a short-circuit existing in a circuit external to the tap-changing mechanism.

Another object of my invention is to provide an electrical protective system for transformer tap-changing devices that shall depend for its operation upon the vectorial sum of the currents delivered from a plurality of groups of balanced current transformers.

In transformer tap-changing mechanisms, a short-circuit occurring between tap connections is liable to become many times more severe than is a short-circuit occurring in a circuit external to the transformer since there is no line impedance introduced in the first case to reduce the value of the current.

In operation, there are occasions when it is not desirable to disconnect a bank of transformers from their external circuits when the external circuits are short-circuited and accordingly it is necessary to provide such transformer tap-changing apparatus with relay protective systems that shall be able to distinguish between a short-circuit condition between the tap connections and a short-circuit condition in an external circuit.

Accordingly, I have provided a relay system embodying a number of sub-sections, one of which is a quick-acting relay section that is responsive to conditions of current unbalance between the tap connections of a transformer; another sub-section is responsive to conditions in the external circuit for rendering the quick-acting relay inoperative or neutralized if the short-circuit condition effects both the tap connections and the external circuit; another sub-section provides protection for the bank of transformers in accordance

with the duration and intensity of the condition of current unbalance by utilizing the vectorial sum of the currents delivered to a circuit by a plurality of groups of balanced current transformers; and another sub-section provides differential protection between the incoming and outgoing lines to the transformer bank.

In the accompanying drawing, the single figure is a diagrammatical view of circuits and apparatus embodying my invention.

My invention comprises, in general, a transformer bank 1 that is protected by a relay system 2 comprising a plurality of contactors 3 and 4 that are disposed in the tripping circuits of suitable circuit interrupters, (not shown) and are controlled by a sub-section 5 of the relay system 2 that is responsive to conditions of unbalance in tap-changing mechanisms 6, 7 and 8 of the transformer bank 1; a sub-section 9 that is responsive to conditions of unbalance in the tap-changing mechanism 6, 7 and 8 and neutralizes the effect of the sub-section 5 under the conditions hereinafter more fully described; a sub-section 11 that is responsive to the duration and intensity of a condition of unbalance in the outgoing circuits of the tap-changing mechanisms 6, 7 and 8; and a sub-section 12 that is responsive to a predetermined difference between the in-put to the transformer bank 1 and the out-put therefrom.

The individual transformers connected in the transformer bank 1 may be of any suitable type and may be connected in delta or star relation, as desired, and each comprises a suitable system of mechanical and electrical connections constituting tap-changing mechanisms 6, 7 or 8. Since the mechanisms 6, 7 and 8 are identical, the details of mechanism 6 only will be described. Mechanism 6 comprises a secondary winding 13 that is divided into sub-sections by conductors 14, 15, 16, 17, 18, 19 and 20. The several conductors 14 constitute the line conductors for the outgoing circuit 21 that co-operates with a supply circuit 22. Each of the conductors 15 to 20, inclusive, is provided with a contractor 23 that is actuated by suitable mechanism not shown.

Suitable mechanism for controlling the operation of the contactors 23 is described in the application of Dann et al., Serial #101,246, filed April 12, 1926, which has been assigned to the Westinghouse Electric and Manufacturing Company.

The conductors 15, 17 and 19 are connected, through their respective contactors 23, to a conductor 24, while the conductors 16, 18 and 20 are connected, through their contactors 23, to a conductor 25. The conductors 24 and 25 are connected, through an auto-transformer 26, to a conductor 27 that constitutes a neutral connection for the several transformer windings 13.

The sub-section 5 of the relay protective system 2 comprises a pair of relays 28 and 29. The relay 28 is connected by a circuit 31 to suitable current transformers, energized from the tap conductors 16, 18 and 20 and the relay 29 is connected by circuit 32, to suitable current transformers energized from the tap conductors 15, 17 and 19.

While the several current transformers connected to the relays 28 and 29, respectively are shown as being connected in parallel circuit with respect to each other it is obvious that separate relays 28 and 29 may be provided for each of the several phases of the transformer bank.

The settings of the relays 28 and 29 are so calibrated that the relays are not operated by the normal load current traversing the tap conductors 15 to 20, inclusive. However, upon the occurrence of a condition of unbalance between the tap conductors 15 to 20, inclusive, of any winding 13, the associated relay 28 or 29 is actuated. The actuation of the relays 28 and 29 affords protection of the tap-changing mechanisms 6, 7 and 8 under conditions of short circuit between the tap connections or conductors 15 to 20, inclusive. A short circuit between any of these conductors is much more violent than is a short circuit in the external circuit 21 for the reason that there is no line impedance to reduce the short-circuit currents.

Contact members 34 and 35 of the relays 28 and 29 are connected in parallel circuit to each other and in series relation with a supply circuit 36 through the operating coil 41 of the contactor 3 by a circuit that extends from a conductor 37 of the circuit 36 through a resistor 38, a terminal 39, the operating coil 41 of the contactor 3 and conductor 42, terminal 43 and conductor 44, contact members 34 and 35 in parallel circuit, conductor 45 and a terminal 46 to a conductor 47 of the circuit 36. Accordingly, upon the energization of either of the relays 28 to 29 the contactor 3 is energized to close the tripping circuit of suitable circuit interrupters associated with the transformer bank 1.

The sub-section 9 of the relay system 2 comprises a relay 52 that is connected by means of a circuit 48 to be energized from cooperating pairs of current transformers 49 and 51. One current transformer 49 is connected to each of the conductors 24, and an associated current transformer 51 is connected to each of the conductors 25. The cooperating pairs of current transformers 49 and 51, for each of the transformer tap-changing mechanisms 6, 7 and 8, are calibrated to energize the relay 52 whenever an excessive amount of current traverses their associated conductors 24 and 25 respectively. The magnitude of such current may be made to correspond to a short-circuit current in the outgoing circuit 21.

The energization of the relay 52 causes its contact 53 to complete a circuit between the terminals 39 and 43 that shunt-circuits the operating coil 41 of the contactor 3, thereby rendering the latter inoperative. Accordingly, when a condition of current unbalance occurs between any of the tap connections 15 to 20, inclusive, and an excessive current traverses either of the conductors 24 and 25 of any one of the tap-changing mechanisms 6, 7 and/or 8, the relays 28 and 29 are energized to close their contacts 34 and 35 to energize the contactor 3; but the energization of the relay 52 shunt-circuits the contactor 3 and thereby neutralizes the effect of the relays 28 and 29 upon it.

Therefore the sub-section 5 of the relay system 2 is responsive to conditions of short circuit between the tap-connections 15 to 20, inclusive, and the sub-section 9 of the relay 2 is responsive to short-circuit currents in the outgoing circuit 21, which may or may not be of the same magnitude as those energizing the subsection 5 and the sub-section 9, when actuated, neutralizes the effect of the sub-section 5. Accordingly, the relay system 2 distinguishes between conditions of short circuit between tap connections in the tap-changing mechanisms and short-circuit conditions in external circuits.

The sub-section 11 of the protective system 2 comprises a current transformer 54 connected to each of the conductors 24 and a current transformer 55 connected to each of the conductors 25, the current transformers 54 and 55 being connected in opposition to each other, and a circuit 57 that connects them to a pair of relays 58 and 59. The relays 58 and 59 are connected in series relation and have different time and current settings, as is more fully described in the application of Fraley and Rogers, Serial No. 102,205, filed April 15, 1926 and which is assigned to the Westinghouse Electric & Manufacturing Company.

Upon the energization of either of the relays 58 and 59 a circuit is completed between the conductor 47 through the operating coil

61 of the contactor 4 to the conductor 37 of the supply circuit 36.

Since the several groups of associated current transformers 54 and 55 are connected in opposition to each other the resultant current delivered by each group to the circuit 11 should be of the same magnitude as that delivered by any other group, providing the tap-changing mechanisms 6, 7 and 8 are in step. Since the currents delivered by the groups of current transformers 54 and 55 to the circuit 11 are in phase with the currents traversing the several conductors 14 constituting the outgoing circuit 21, it follows that the normal vectorial sum of such currents in the circuit 11, and, therefore, traversing the relays 58 and 59, is zero. Accordingly the energization of either relay 58 or relay 59 indicates that at least one of the tap-changing mechanisms 6, 7 and/or 8 is out of step. The energization of either relay 58 or relay 59 results in the energization of the contactors 4, and the subsequent tripping of the circuit interrupters connecting the transformer bank 1 to any desired circuits.

The subsection 12 of the relay protective system 2 comprises a plurality of current transformers 63 that are connected to the conductors of the incoming circuit 21 and a plurality of current transformers 64 that are connected to the conductors of the outgoing circuit 21 through a balancing transformer system 65 that is operated conjointly with the operation of the contactors 23 for changing the current ratios of the system whenever the tap-changing mechanisms 6, 7 and 8 are operated. The details of the systems 65 are shown and described in the application of H. A. Travers, Serial No. 116,314, filed June 16, 1926, which has been assigned to the Westinghouse Electric & Manufacturing Company.

Should an unbalance exist between the current transformers 63 and 64 attached to any one of the phases of the transformer bank 1 the corresponding relay 66 would be energized to complete a circuit 67 to be connected in parallel to the relays 58 and 59 for operating the contactor 4 to disconnect the transformer bank 1.

Assuming the transformer bank 1 to be in operation under normal current conditions and a short circuit to occur between the conductors 14 to 20, inclusive, of any one of the tap-changing mechanisms 6, 7 and/or 8, the corresponding relay 28 or 29, or both, are immediately energized to energize the contactor 3 and thereby to de-energize the transformer bank 1. Since the short-circuit currents between the tap-changing mechanisms are very heavy, it is necessary that the transformer bank 1 be de-energized immediately upon the occurrence of such excessive currents. However, should the short-circuit

currents also traverse either or both of the conductors 24 and 25, the sub-section 9 of the relay protective system 2 would be energized to render the relays 28 and 29 of the sub-section 5 inoperative, so far as the contactor 3 is concerned, that is, by shunt-circuiting the latter.

Should the current traversing the conductors 24 and 25 become unbalanced, or should one of the tap-changing mechanisms 6, 7 and/or 8 get out of step, the sub-section 11 of the relay protective system 2 would cause the energization of the contactor 4 by means of the relays 58 and 59. Accordingly, the sub-section 11 of the relay system 2 provides for protection of the transformer bank 1 against conditions of current unbalance between the several conductors 24 and 25 and out-of-step operation of the mechanisms 6, 7 and 8.

The sub-section 12 of the protective system 2 differentiates between the amount of incoming and outgoing current to and from the transformer bank 1.

Accordingly, it will be seen that I have devised a protective system for a transformer tap-changing device that is operative to distinguish between short-circuit conditions between the tap connections of the transformer tap-changing mechanisms from short-circuit conditions exterior to the transformer tap-changing mechanisms, and that also protects the transformer bank against conditions of overload and unbalance as well as out-of-step operation.

It is to be understood that such changes in the circuits, connections, arrangement and design of the component parts of my invention may be made and shall fall within the scope of the appended claims.

I claim as my invention:

1. The combination with a transformer having a plurality of tap connections and an external circuit, of a protective relay system for distinguishing between conditions of an external short circuit and short circuits between tap connections.

2. The combination with a transformer having a plurality of tap connections and an external circuit, of a relay protective system comprising a quick-acting relay responsive to conditions of short circuit between the tap connections and a relay mechanism responsive to short circuit conditions in the external circuit for neutralizing the effect of the quick-acting relay.

3. In combination, a plurality of transformers each having tap-changing circuits and mechanism associated therewith, a group of balanced current transformers responsive to a condition of unbalance between certain of the tap-changing circuits for each transformer, and a relay controlled in accordance with the vectorial sum of the currents deliv-

ered by the several groups of balanced current transformers.

4. The combination with a transformer having a plurality of tap connections and an external circuit, circuit interrupters associated with said transformer, of a protective relay system that comprises a section having relays for actuating said circuit interrupters and responsive to conditions of unbalance between the tap connections and a second section having relays for neutralizing the effect of the first section, the relays of said second section being responsive to the current in the external circuit.

15 In testimony whereof, I have hereunto subscribed my name this 21st day of February, 1927.

WILLIAM R. FARLEY.

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