

Dec. 18, 1951

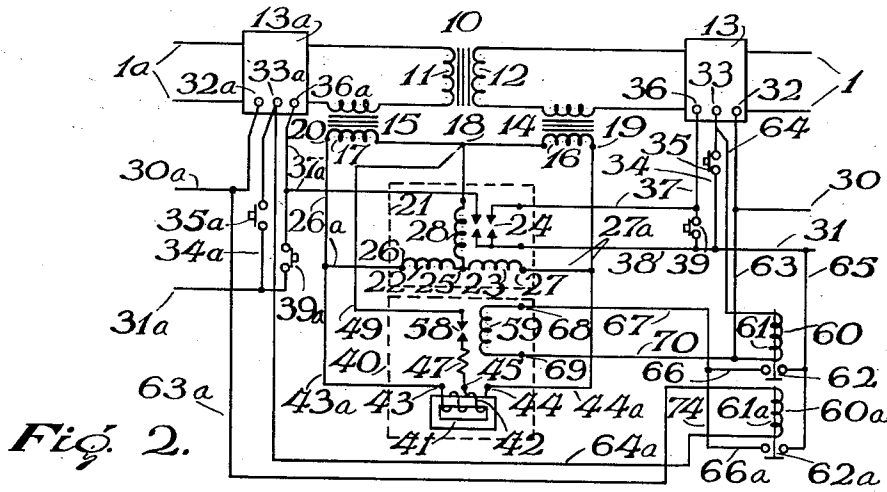
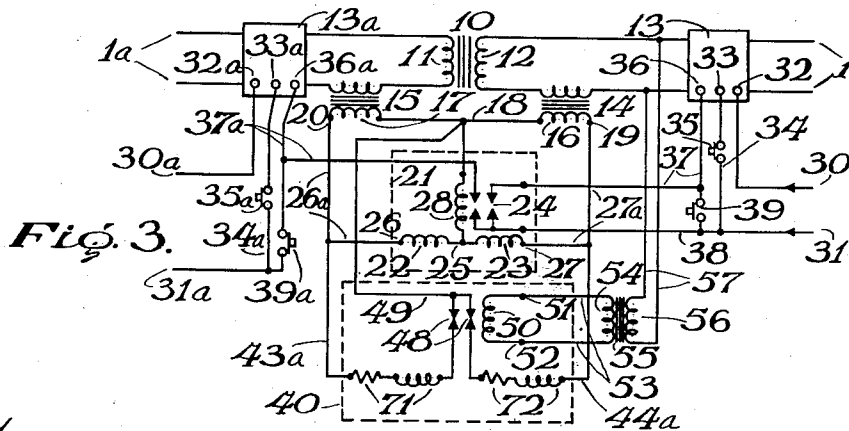
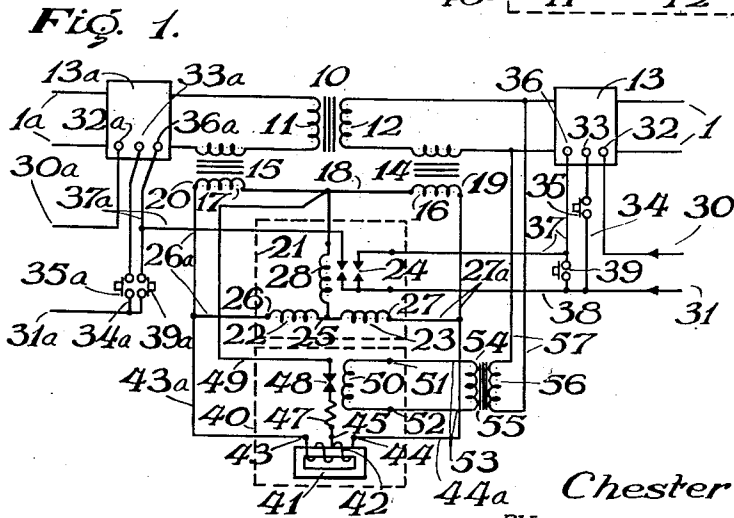
C. L. HEADLEY

2,579,042

DIFFERENTIAL RELAY SENSITIVITY ADJUSTER

Filed July 14, 1950

2 SHEETS—SHEET 1



INVENTOR

Chester L. Headley

BY

Cameron, Kerkam, & Sutton
ATTORNEYS

Dec. 18, 1951

C. L. HEADLEY

2,579,042

DIFFERENTIAL RELAY SENSITIVITY ADJUSTER

Filed July 14, 1950

2 SHEETS—SHEET 2

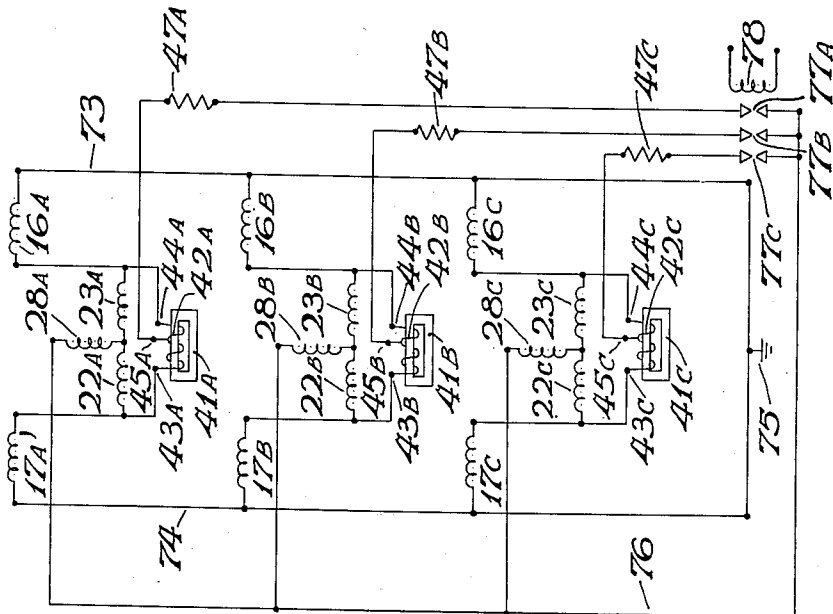


Fig. 4

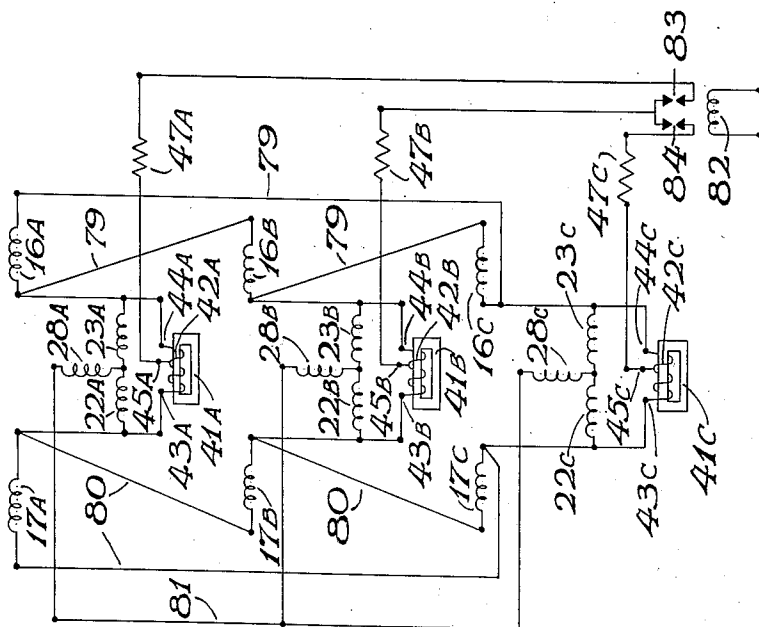


Fig. 5

INVENTOR
 Chester L. Headley
 BY
 Cameron, Kerkam, & Sutton
 ATTORNEYS

UNITED STATES PATENT OFFICE

2,579,042

DIFFERENTIAL RELAY SENSITIVITY
ADJUSTER

Chester L. Headley, Baltimore, Md., assignor to
Consolidated Gas Electric Light and Power
Company of Baltimore, Baltimore, Md., a cor-
poration of Maryland

Application July 14, 1950, Serial No. 173,847

24 Claims. (Cl. 175-294)

1

This invention relates to means for automatically changing the sensitivity of a differential protective relay of the type having restraint windings symmetrically connected with respect to an operating winding. Such relays are used to protect electrical apparatus such as power transformers and the invention will be described hereinafter with reference to the use where energy may flow to the transformer from either side. It is to be understood that relays embodying the invention can be used in any transformer protective scheme.

It has been observed that when a transformer is connected to a power supply there may be an inrush of current of great magnitude that lasts for a fraction of a second and then subsides to the normal load value. When the sensitivity adjustment of differential relay protective means associated with the transformer is suitable to protect the transformer under normal operating conditions, the relay may respond to the inrush current with the result that a false tripping occurs, disconnecting the transformer from the supply circuit. One method of overcoming this difficulty is to increase the current setting at which the differential relay operates to such a value that inrush current will not cause tripping, but the setting is then excessive for overload currents to be expected, and hence some protection is sacrificed. Accordingly it has been proposed to provide means for automatically decreasing the sensitivity of the differential relay for the short time during which the inrush current flows and then restoring normal sensitivity to the relay for subsequent operation.

One of the objects of the present invention is to provide improved means for automatically reducing the sensitivity of the differential relay upon energization of the transformer and for a short time immediately thereafter during which magnetizing inrush current may flow.

Another object is to provide improved means of the above type that are applied symmetrically with respect to the relay and that produce uniform desensitization regardless of which side of the transformer is first energized.

Another object is to provide improved means of the type characterized in the preceding objects that can be applied readily to an existing differential relay and does not have to be built into the relay at the time of its manufacture.

2

A further object is to provide improved means as characterized above and such that faults occurring during the inrush period when the relay is desensitized can still cause the relay to operate.

A still further object is to provide improved means as characterized above that are simple in construction and operation, relatively inexpensive, and yet rugged and efficient in service.

Several embodiments of the invention are illustrated schematically in the accompanying drawings, but it is to be expressly understood that said drawings are for purposes of illustration only and are not to be construed as a definition of the limits of the invention, reference being had to the appended claims for this purpose.

In the drawings,

Fig. 1 illustrates a single-phase arrangement embodying the invention;

Fig. 2 shows another single-phase arrangement embodying the invention;

Fig. 3 shows a further single-phase arrangement utilizing linear impedance in the desensitizing circuits;

Fig. 4 illustrates a three-phase application of the invention; and

Fig. 5 illustrates another three-phase system embodying the invention.

In Fig. 1 the transformer to be protected is indicated at 10 and is provided with windings 11 and 12 which may supply energy in either direction between two supply circuits 1 and 1a. Circuit breakers 13 and 13a control the energization of transformer 10. Current transformers 14, 15 are associated with the circuits connected to windings 12 and 11, respectively, and have secondary windings 16, 17, respectively, that are connected in series by wire 18; the other terminals of these windings being indicated at 19 and 20, respectively. The differential relay for the protection of transformer 10 against abnormal conditions is shown schematically within the rectangle 21 and includes restraining windings 22, 23 which oppose closing of suitable relay contacts 24. The restraining windings 22, 23 are connected in series by a wire 25. The terminal 26 of restraining winding 22 is connected to the terminal 20 of current transformer 15 by wires 26a; and the terminal 27 of restraining winding 23 is connected to the terminal 19 of current transformer 14 by wires 27a. The differential

relay 21 includes an operating winding 28, one terminal of which is connected to the wire 25 (which is common to restraining windings 22, 23) and the other terminal of which is connected to the wire 18 (which is common to current transformer windings 16, 17). The differential relay contacts 24 are normally open, but are closed when the effect of current flow through the operating winding 28 overbalances the effect of the current flowing in restraining windings 22, 23. Upon closure of the contacts 24 circuit breakers 13 and 13a are operated to disconnect transformer 10 from the system as described below.

Circuit breakers 13 and 13a may be operated by control power separate from the supply circuits 1, 1a, being for example connected by conductors 30, 31 and 30a, 31a to the same source of control power which may, in many cases, be a direct current source. The conductors 30, 30a are connected to corresponding circuit breaker terminals 32, 32a and the conductors 31, 31a are connected to corresponding circuit breaker terminals 33, 33a by wires 34, 34a. Any suitable circuit closing means, as push buttons 35 and 35a, may be used in series with wires 34 and 34a. When moved to closed position button 35 energizes terminals 32, 33 of circuit breaker 13 to effect closure thereof and when push button 35a is closed terminals 32a and 33a of circuit breaker 13a are energized to effect closure of breaker 13a. Tripping of circuit breaker 13 by differential relay 21 is accomplished upon energizing a circuit which includes wire 30, terminal 32 and a terminal 36, of circuit breaker 13, wires 37, differential relay contacts 24, and wires 38, 31. Tripping of circuit breaker 13a by the differential relay takes place upon energizing a similar circuit 30a, 32a, 36a, 37a, relay contacts 24, and wires 32 and 31. Relay contacts 24 close under fault conditions existing between the current transformers 14 and 15 that result in net current through the operating winding 28 sufficient to operate the differential relay 21. Push buttons 39 and 39a may be provided as indicated in Fig. 1 to permit manual tripping of circuit breakers 13 and 13a to open position.

The apparatus thus far described comprises differential relay protection means for transformers which are in common use and to which the present invention can be applied in the following manner. As indicated above, the present invention provides means for decreasing the sensitivity of differential relay 21 for a short period following closure of either circuit breaker 13 or 13a. These means are shown schematically in Fig. 1 within the rectangle 40 and include a reactor 41 and a reactor winding 42 having terminals 43, 44 and a center tap terminal 45. Terminal 43 is connected to terminal 26 of relay 21 by wires 43a and 26a; and terminal 44 is connected to terminal 27 of relay 21 by wires 44a and 27a. Center tap 45 is connected to wire 18 by a circuit which includes a resistor 47, normally closed relay contacts 48, and a wire 49, said contacts 48 being associated with a relay winding 50 and this relay being of any suitable type having delayed operation so as to cause contacts 48 to open after a predetermined time interval following energization of electro-magnet winding 50. The terminals 51, 52 of the relay winding 50 are connected by wires 53 to the secondary winding 54 of a potential transformer 55, the primary winding 56 of which is connected by wires 57 to the transformer 10 so that the trans-

former 55 is energized when the transformer 10 is energized.

To illustrate the operation of the present invention as shown in Fig. 1, it is assumed that circuit breakers 13 and 13a are open, and transformer 10 is therefore deenergized. Under this condition, differential relay contacts 24 are open and contacts 48 of sensitivity adjuster 40 are closed. Potential transformer 55 is deenergized, as is relay winding 50. In order to energize transformer 10, push button 35 or 35a is closed manually to effect closure of circuit breaker 13 or 13a. Upon closure of either circuit breaker potential transformer 55 is energized thereby energizing relay winding 50 to cause the then closed relay contacts 48 to separate after a predetermined time delay. This time delay period is adjusted to such duration as to permit the inrush current transient that may occur in transformer 10 to subside, whereupon opening of contacts 48 restores normal sensitivity to differential relay 21.

Should an inrush current transient occur upon closure of circuit breaker 13 or 13a a current of large magnitude may be produced in current transformer secondary windings 16 or 17. For purposes of illustration, assume circuit breaker 13 to be closed before breaker 13a, then current will flow in part through the circuit including terminal 19, wires 27a and 44a, terminal 44, the portion of winding 42 to center tap 45, resistor 47, contacts 48, wires 49 and 18, to the other side of secondary winding 16. Another portion of the current flows in the circuit which includes terminal 19, wire 27a, restraining windings 22, 23, wires 26a and 43a, terminal 43, the portion of winding 42 to center tap 45, resistor 47, contacts 48, wires 49 and 18, to the other side of transformer winding 16. These paths will carry a large portion of the current produced in winding 16 for the reason that restraining windings 22, 23 are of relatively low impedance as compared to operating winding 28, and also because of the low impedance of reactor winding 42 between terminals 43, 44. The low reactor impedance results from the flow of current in opposite directions through the two portions 43, 45 and 44, 45 of reactor winding 42, the magnetizing effect of the current in portion 43, 45, largely neutralizing the magnetizing effect of current in the portion 44, 45, thereby neutralizing the reactance of winding 42. The effect of the current flow through restraining coils 22, 23 is to raise the setting at which differential relay contacts 24 close. There is another current path which includes terminal 19, wire 27a, restraining coil 23, wire 25, operating coil 28, and wire 18 to the other side of current transformer secondary 16. In this circuit the current flow through operating winding 28 lowers the setting of differential relay 21, but the magnitude of this current is relatively small due to the high impedance of operating coil 28 in comparison with the impedance of the circuit including restraining coil 22, reactor winding 43, 45, and resistor 47.

When contacts 48 open the impedance of reactor winding 42 between terminals 43, 44 rises to a relatively high value due to the elimination of currents in opposite directions through windings 43, 45 and 44, 45, which, as indicated above, neutralize the reactance of winding 42. The current flowing in the circuit including wire 44a, winding 42 and wire 43a which is in parallel with restraining windings 22 and 23 is negligible in comparison with the current through these wind-

ings flowing under normal operating conditions. Hence, normal sensitivity is restored when contacts 48 open.

If a fault of sufficient magnitude develops during the short period that contacts 48 of sensitivity adjuster 40 are closed, differential relay 21 will operate and clear transformer 10 from the system by opening circuit breakers 13 and 13a. However, if the fault is not severe enough to cause the relay to operate (at reduced sensitivity), the transformer will be cleared at the moment relay contacts 48 open and normal sensitivity is restored.

It will be understood that the relay 48, 50 of Fig. 1, in which the contacts 48 are normally closed but are opened and thereafter held open by the relay winding 50, can be replaced by a relay of known type having normally open contacts which are closed immediately upon energization of the relay winding but open again after a predetermined time period. In this case the relay winding need not be continuously energized, and hence can be operated if desired by the control power used to operate the circuit breaker 13 (or 13a) as above described. Fig. 2 shows an apparatus embodying these modifications. The differential relay 21 and the sensitivity adjuster 40 are the same as those shown in Fig. 1 and the parts are correspondingly numbered except for the relay contacts 58 and the relay winding 59 which replace the relay 48, 50 of Fig. 1 and are of the alternative type mentioned above.

The relay winding 59 is energized by control power immediately upon closing either push button 35 or 35a to close the circuit breaker 13 or 13a. To this end two relays 60 and 60a are provided having operating windings 61 and 61a and associated relay contacts 62 and 62a. One end of each of the operating windings 61 and 61a is connected by a wire 63 or 63a with the control power supply line 30 or 30a, and the other end of each operating winding is connected by a wire 64 or 64a to the terminal 33 or 33a of the circuit breaker 13 or 13a. One contact of each relay is connected by a wire 65 to the control power supply line 31, and the other relay contacts are connected by wires 66 and 66a to a common wire 67 leading to one terminal 68 of the relay winding 59. The other terminal 69 of the winding 59 is connected by a wire 70 with the wire 63 leading to the control power supply line 30.

Closure of push button 35 to close the circuit breaker 13 energizes winding 61 of relay 60 by a circuit which includes wires 31, 34, push button 35, wire 64, winding 61 and wire 63 to wire 30. Energizing of relay winding 61 causes contacts 62 to close and energize time-delay relay winding 59 through a circuit including wires 31 and 65, relay contacts 62, wires 66 and 67, terminal 68, relay winding 59, terminal 69 and wires 70 and 63 to wire 30. Closing of push button 35a causes operation of relay 60a and energization of winding 59 in a similar manner. Relay 58, 59 closes immediately upon energization and then opens relay contacts 58 after a time delay. The operation of the sensitivity adjuster 40 is the same as described in connection with Fig. 1.

In the arrangements indicated in Figs. 1 and 2, non-linear impedances 43, 45 and 44, 45 are arranged symmetrically with respect to relay terminals 26, 27, but where desired these non-linear impedances may be replaced by linear impedances as illustrated in Fig. 3 in which like

reference numerals are employed to designate elements previously described. Instead of the reactor winding 43, 45 of Fig. 1, a linear impedance 71 is connected between restraint winding terminal 26 and the terminal of operating winding 28 by wires 26a and 43a, contacts 48 and wire 49. Similarly, a linear impedance 72 is connected between restraint winding terminal 27 and the terminal of operating winding 28 by wires 27a and 44a, contacts 48 and wire 49. Relay 48—50 opens both contact sets 48 after a suitable time delay as described in connection with Fig. 1 and thereupon impedances 71, 72 are disconnected from the differential relay circuit to restore normal sensitivity after the initial transient is over. Any suitable values of the real and imaginary components of impedances 71, 72 may be used within the purview of the present invention.

For purposes of illustration, linear impedances 71, 72 have been illustrated in Fig. 3 as applied to the arrangement shown in Fig. 1. These impedances may be applied equally well to other circuit arrangements such as that shown in Fig. 2, it only being necessary to include a pair of contacts on the associated time-delay relay in series with each impedance in order to prevent current flow through said impedance at times where normal sensitivity of the differential relay is required.

In polyphase application of the circuit arrangements of Figs. 1 to 3, inclusive, relay 48, 50 or 58, 59 may include a single electromagnet winding 50 or 59 and separate sets of contacts 48 or 58 for each of the phases. Thus, for a three-phase circuit, current transformer secondary windings 16, 17 in a given phase may be isolated from corresponding windings in the other phases and relay 48, 50 or 58, 59 may include three sets of contacts and a single electromagnet winding. A similar relay arrangement may be used where the transformer windings 16A, 16B and 16C (the letters relate the circuit elements, previously described, to their respective phases) are Y connected and the windings 17A, 17B and 17C are likewise Y connected, the neutral point of the Y's being connected together. This arrangement is illustrated in Fig. 4, which for simplification includes only the circuit arrangements on the secondary sides 16, 17 of the current transformers 14, 15 in the three phases. One terminal of each of the transformer secondaries 16A, 16B and 16C are Y connected by a wire 73 and one terminal of each of the transformer secondaries 17A, 17B and 17C are Y connected by a wire 74, the wires 73 and 74 being connected together and grounded at 75. The other two terminals of each pair of transformer secondaries 16A and 17A, 16B and 17B, and 16C and 17C are connected to the restraining coil terminals of a differential relay and to the sensitivity adjuster corresponding to the differential relay 21 and sensitivity adjuster 40 of Figs. 1 and 2, the differential relay contacts 24 being omitted for the sake of simplifying the illustration. The terminals of the operating coils 28A, 28B and 28C of the differential relays are connected together by a wire 76, and this wire may also be connected to one of the contacts of three contact sets 77A, 77B and 77C of a relay having a single electromagnet winding 78. This relay may be of either type shown in Figs. 1-3. The other contacts of the sets 77A, 77B, and 77C are connected through resistors 47A, 47B and 47C (compare Figs. 1 and 2) to the midpoints 45A, 45B and 45C of the three sensitivity adjuster reactor windings. In

effect, when the relay contacts are closed, the terminals of the three operating coils 28A, 28B and 28C and the three circuits from the center taps 45A, 45B and 45C are all connected to a common point. However, the relay construction may be simplified in the manner illustrated in Fig. 5, if desired.

Fig. 5 illustrates a three-phase arrangement in which the secondary windings 16A, 16B, 16C are connected in delta by wires 79, as are the secondary windings 17A, 17B, 17C by wires 80. A differential relay 21 and sensitivity adjuster 40 is connected between each pair of transformer secondaries 16A and 17A, 16B and 17B and 16C and 17C, and the terminals of the operating coils 28A, 28B and 28C are connected together by a wire 81. The center taps 45A, 45B and 45C of the recator windings are also connected together during the period of desensitization of the differential relay by suitable relay means which may be of either type shown in Figs. 1-3. However, the relay construction can be simplified as compared with Fig. 4 by omitting the connection of the operating coils 28A, 28B and 28C to the relay contacts (i. e., by omitting the connection thereto of the wire 76 of Fig. 4). In this case only two sets of relay contacts are required. As shown in Fig. 5, the relay comprises a single electromagnet winding 82 and two pairs of contacts 83 and 84. The center tap 45A and resistor 47A are connected in series and to one contact 83, and the center tap 45C and resistor 47C are connected in series and to one contact 84. The center tap 45B and resistor 47B are then connected in series and to both of the other contacts 83 and 84 so that when the relay is closed, all three center taps are connected to a common point.

As an example of the operation of the present invention, the following test results are cited. The circuit arrangements of Fig. 5 were used in a test on a 40,000 kva., 33/110 kv. three-phase transformer. This transformer was protected by a General Electric type IJD differential relay. The normal sensitivity adjustment of the relay was such that operation would occur at approximately 400 amperes at 33 kv. The sensitivity adjuster was set to raise the adjustment of the differential relay during the magnetizing inrush current period by the use of a suitable resistance value for resistors 47A, 47B, 47C. The differential relay used with the sensitivity adjuster introduced a time delay of approximately 0.1 second before it closed its contacts. In a series of tests that were made with the sensitivity adjuster connected, inrush currents between 1140 and 1200 amperes were measured on specific phases but operation of the differential relay was prevented by the action of the sensitivity adjuster. When the sensitivity adjuster was made inoperative as by holding the circuit open at contacts 83, 84, inrush currents in the range of 1160 to 1200 amperes were measured on specific phases and in each case the differential relay connected to these phases closed its contacts to trip the transformer from the system.

It will be seen that the invention provides a simple and relatively inexpensive means which effectively desensitizes the differential relay and prevents its operation during the period when magnetizing inrush currents may flow. Sensitivity adjusters embodying the invention can be built into differential relays at the time of manufacture, if desired, but one of their advantages resides in their easy application to any existing

differential relay of the type having restraint windings symmetrically arranged with respect to an operating winding. Hence such sensitivity adjusters can be built as separate units for installation and use wherever desired. The extent of desensitization can be adjusted simply by varying the constants of the adjuster circuits. Because of the symmetrical arrangement of the sensitivity adjuster, moreover, uniform desensitization is obtained regardless of which side of the transformer is first energized. On the other hand, even during the period of desensitization the differential relay will be operated by a fault of sufficient magnitude occurring on either side of the transformer.

It is to be understood that the embodiments of the invention described above and illustrated in the drawings are by way of example only and that the invention is not restricted thereto as various changes can be made in the form, details and arrangement of the parts without departing from its spirit. Reference therefore should be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. In a differential protective arrangement for an electrical apparatus, current transformers responsive respectively to current entering and leaving said apparatus, a differential protective means connected to said transformers and comprising relay means operable to interrupt the flow of current through said apparatus and relay operating means including series-connected restraint windings and an operating winding connected to a point between said restraint windings, and sensitivity adjusting means comprising a circuit in shunt with said restraint windings having an intermediate point connected to said transformers, said circuit diverting current from said operating winding to decrease the sensitivity of said differential protective means, and time-delayed relay means connected for energization simultaneously with said apparatus for interrupting said circuit after a predetermined time interval and restoring normal sensitivity to said differential protective means.

2. A differential protective arrangement as defined in claim 1, said circuit including impedances in shunt with said restraint windings on both sides of said intermediate point, the impedance on each side of said intermediate point being small as compared with the impedance of said operating winding.

3. A differential protective arrangement as defined in claim 2, said impedances being linear and said relay means interrupting said circuit between said impedances.

4. A differential protective arrangement as defined in claim 2, said impedances being non-linear and said relay means interrupting said circuit between said intermediate point and said transformers.

5. A differential protective arrangement as defined in claim 1, said time-delayed relay means being connected to said apparatus for energization simultaneously therewith.

6. A differential protective arrangement as defined in claim 1, including a circuit breaker for controlling the supply of current to said apparatus and a circuit for closing said breaker to energize said apparatus, said time-delayed relay means being connected to said breaker closing circuit.

7. A differential protective arrangement as defined in claim 1, said time-delayed relay means comprising normally closed relay contacts and

operating means for opening said contacts after a predetermined time interval.

8. A differential protective arrangement as defined in claim 1, said time-delayed relay means comprising normally open contacts, operating means for closing said contacts upon energization thereof, and means for re-opening said contacts after a predetermined time interval.

9. In a differential protective arrangement for an electrical apparatus, current transformers responsive respectively to current entering and leaving said apparatus, a differential protective means connected to said transformers and comprising relay means for interrupting the flow of current through said apparatus and relay operating means including series-connected restraint windings and an operating winding connected to a point between said restraint windings, and sensitivity adjusting means comprising impedance means in shunt with said restraint windings and a connection from an intermediate point of said impedance means having a relatively high impedance as compared with said operating winding under normal operating conditions and diverting current from said operating winding to decrease the sensitivity of said differential protective means during the initial period of energization of said apparatus, and means including a time-delayed relay connected for energization simultaneously with said apparatus and adapted to interrupt the flow of current in said connection after a predetermined time interval thereby restoring normal sensitivity to said differential protective means.

10. In a differential protective arrangement for an electrical apparatus, current transformers responsive respectively to current entering and leaving said apparatus, a differential protective means connected to said transformers and comprising relay means operable to interrupt the flow of current through said apparatus and relay operating means including series-connected restraint windings and an operating winding connected to a point between said restraint windings, and sensitivity adjusting means comprising a circuit connected in shunt with said restraint windings and containing series-connected impedances, a connection from a point intermediate said impedances to said transformers, and time-delayed relay means connected for energization simultaneously with said apparatus for interrupting said connection after a predetermined time interval.

11. A differential protective system as defined in claim 10, said impedances being linear and said time-delayed relay means interrupting also the series connection between said impedances.

12. A differential protective system as defined in claim 10, said impedances being non-linear and arranged so that they cumulatively oppose flow of current in series therethrough when said connection is interrupted.

13. A differential protective system as defined in claim 12, said impedances comprising windings on a common core of magnetic material.

14. A differential protective arrangement for electrical transformers and like electrical apparatus comprising current transformers respectively responsive to current entering and leaving the apparatus to be protected, a differential protective relay comprising restraint windings connected in series with said transformers and an operating winding connected between a point intermediate said transformers and a point intermediate said restraint windings, a circuit in

shunt with said restraint windings and containing series-connected impedances, a connection from a point intermediate said impedances to a point intermediate said transformers, and time-delayed relay means connected for energization simultaneously with the apparatus to be protected for interrupting said connection after a predetermined time interval, said shunt circuit diverting current from said operating winding and decreasing the sensitivity of said differential relay until said connection is interrupted.

15. A differential protective arrangement as defined in claim 14, said time-delayed relay means having two operating coils connected with opposite sides of said apparatus to be protected.

16. A differential protective arrangement for three-phase electrical transformers and like apparatus comprising three pairs of current transformers, the transformers of each pair being responsive respectively to current entering and leaving the apparatus to be protected in a single phase, the three transformers responsive to entering current being connected together in three-phase relation and the three transformers responsive to leaving current being connected together in three-phase relation, differential protective relays one connected between the transformers of each pair and comprising series-connected restraint windings and an operating winding having one end connected to a point between said restraint windings, the other ends of the three operating windings being connected together, each of said differential relays also including sensitivity adjusting means comprising a circuit in shunt with said restraint windings and containing impedances and a conductor connected to a point intermediate said impedances, and time-delayed relay means connected for simultaneous energization with said apparatus to be protected for connecting said three conductors together for a predetermined time interval following energization of said apparatus to be protected and thereafter disconnecting said conductors.

17. Sensitivity adjusting means for a differential protective relay of the type having series-connected restraint windings and an operating winding having one end connected to a point between said restraint windings, said sensitivity adjusting means comprising a circuit adapted to be connected in shunt with said restraint windings and containing series-connected impedances, a circuit connected to said first circuit at a point intermediate said impedances and adapted to be connected to the other end of said operating winding, and time-delayed relay means for interrupting said second circuit.

18. Sensitivity adjusting means as defined in claim 17, said impedances being linear and said time-delayed relay means interrupting also the series connection between said impedances.

19. Sensitivity adjusting means as defined in claim 17, said impedances being non-linear and arranged so that they cumulatively oppose flow of current in series therethrough when said second circuit is interrupted.

20. Sensitivity adjusting means as defined in claim 19, said impedances comprising windings on a common core of magnetic material.

21. A differential protective arrangement as defined in claim 1, including a resistance in the connection between said intermediate point and said transformers, the value of said resistance determining the amount of desensitization of said differential protective means.

22. A differential protective arrangement as

11

defined in claim 9, including a resistance in said connection for controlling the amount of desensitization of said differential protective means.

23. A differential protective arrangement as defined in claim 14, said connection including a series resistance adjustable to vary the amount of current diverted from said operating winding and thereby to control the degree of desensitization of said differential protective relay.

24. Sensitivity adjusting means as defined in claim 17, said second circuit including a resistance the value of which determines the amount of desensitization of a differential relay to which said sensitivity adjusting means is connected.

CHESTER L. HEADLEY. 15

12**REFERENCES CITED**

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,491,402	Holbrook	Apr. 22, 1924
1,787,181	Traver	Dec. 30, 1930
2,196,411	Geise	Apr. 9, 1940
2,483,119	Bateman	Sept. 27, 1949