July 14, 1931. G. MEYER 1,814,006

MEANS FOR SUPPRESSING GROUND CURRENTS

Filed June 28, 1929

Fig. 1

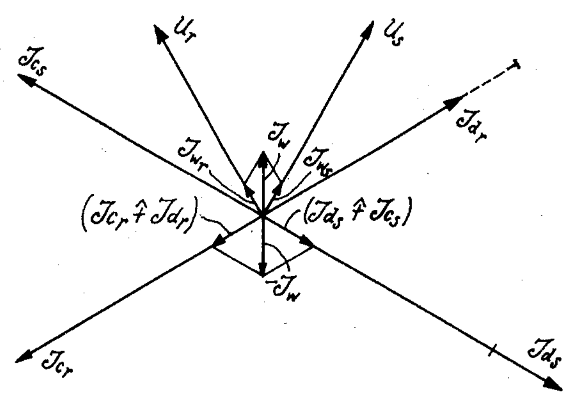


Fig. 2

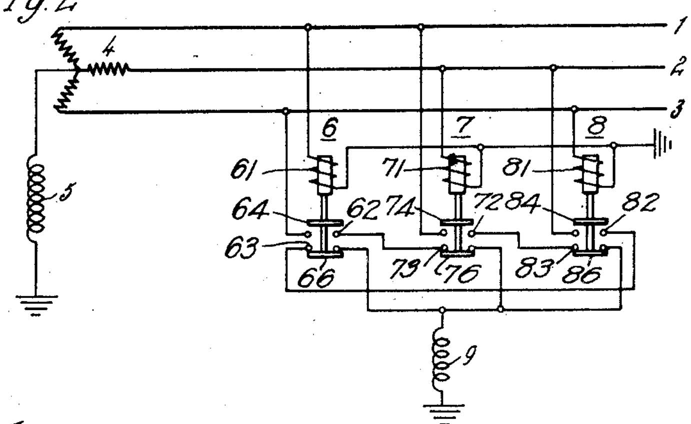
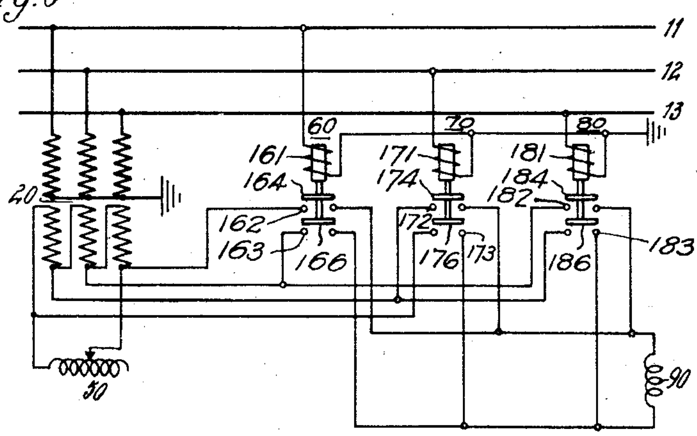


Fig. 3



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Patented July 14, 1931

1,814,006

UNITED STATES PATENT OFFICE

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MEANS FOR SUPPRESSING GROUND CURRENTS

Application filed June 28, 1929, Serial No. 374,349, and in Germany July 3, 1928.

My invention relates to improvements in means for suppressing ground currents, and more particularly for compensating completely the active residual ground current.

If an accidental ground develops the ground capacity of the sound conductor is according to my invention under-compensated to the same extent as that of the other sound conductor is overcompensated. The amount of this under-compensation or over-compensation respectively depends on the value of the active or line charging residual ground current to be suppressed.

In the drawings affixed hereto and forming part of my specification

Fig. 1 shows a vector diagram of my improved ground suppressing device,

Fig. 2, a connection diagram of one embodiment of my invention, and

Fig. 3, a connection diagram of another embodiment of my invention.

I will now describe my invention with reference to Fig. 1 of the drawings. U_r and U_s are the voltage vectors of the sound conductors in case of an accidental ground to ground, the value of which is equal to the voltage from each of the sound phases to ground, as well known in the art, and the phase displacement between which amounts to 60°. Under the action of the voltage U_r a capacitive current flows across the point where the accidental ground has developed which leads by 90° in respect to the voltage U_r and is indicated in the diagram by the reference J_{cr}. In the same way a capacitive current J_{cs} flows under the action of the voltage U_s across the point where the accidental ground has developed. There also flows under the action of the voltage U_r an active current J_{wr} and under the action of the voltage U_s an active current J_{ws}.

According to my invention these four currents are compensated by an inductive current J_{dr} by a certain amount smaller than the corresponding capacitive current J_{cr} and an inductive current J_{ds} larger by this amount than the corresponding capacitive current J_{cs}. The capacitive currents J_{cs} and J_{cr} are consequently not completely compensated by these inductive currents, but the residual components $(J_{cr}+J_{dr})$ and $(J_{ds}+J_{cs})$ remain behind the value of which must be so chosen that they neutralize the active residual ground current $(J_{wr}+J_{ws})$. Preferably the inductance (Petersen coil, regulating choke coil) common to all the phases is according to my invention chosen slightly smaller than would be necessary for the complete compensation of the capacitive residual ground current and in the event of a ground a second inductance is then connected to only one of the sound or intact phases, whereby is obtained the desired compensation of the active residual ground current. When using a ground suppressing transformer the second inductance is preferably connected to one of the two sound secondary phase voltages of this ground transformer. The switching in of the second inductance is in both cases preferably made dependent on an under-voltage relay which is fed from the phase in which the accidental ground has developed. In view of the large voltages which must be utilized, it is obvious that the combination of circuit breakers and relays would ordinarily be used. Since the second inductance is to be dimensioned only for the algebraic difference of the currents $(J_{ds}-J_{dr})$, it becomes considerably smaller than the common inductance. Furthermore, in the event of an accidental ground the algebraic difference of the currents $(J_{ds}-J_{dr})$ only need be changed over, so that the rupturing capacity for the switches of the second inductance is far smaller than if a change over of the full inductive ground current would have to be effected.

Referring to Fig. 2 of the drawings, 4 is a transformer or generator from which issue the lines 1, 2, 3 of a high tension system. The neutral point of this generator or transformer is grounded through an inductance 5, the value of which at a system voltage of 220 kv., 50 cycles, at a capacitive ground current of 112 amps. and at an active residual ground current of 10.4 amps. amounts to 4.3 henry. Undervoltage relays 6, 7 and 8 have their respective energizing windings connected between the respective phases and ground. One terminal of the energizing winding 61 of relay 6 is connected to the line 1. One terminal of the energizing winding 71 of relay 7 is connected to line 2. One terminal of the energizing winding 81 of relay 8 is connected to line 3. The other terminals of the respective energizing windings 61, 71 and 81, are connected to ground.

The relays 6, 7 and 8 are normally energized to complete a circuit across contacts 63, 73 and 83, respectively, by means of contact members 66, 76 and 86, respectively. In their deenergized conditions the relays 6, 7 and 8 complete a circuit across contacts 62, 72 and 82, respectively, by means of contact members 64, 74 and 84, respectively.

One of the contacts 62, of relay 6, is connected to line 3 of the high tension system and the other contact 62 is connected to one of the contacts 73 of relay 7. One of the contacts 72, of relay 7, is connected to line 1 of the high tension system and the other contact 72 is connected to one of the contacts 83 of relay 8. In a similar manner, one of the contacts 82, of relay 8, is connected to line 2 of the high tension system and the other contact 82 is connected to one of the contacts 63 of relay 6. 9 is a second inductance, one terminal of which is connected to ground and the other terminal connected to the remaining contacts 63, 73 and 83 of the respective relays 6, 7 and 8. Its value for the case stated as example is 33.5 henry.

The mode of operation of my improved system is as follows:

In the sound or intact state of the lines 1, 2, 3 the relays are in the position shown in the drawings. If an accidental ground develops in one of the lines, for instance in the line 3 the relay 8 is deenergized and connects the line 2 through the contacts 82, contact member 84, contacts 63, and contact member 66 to one terminal of the second inductance 9, and thence to ground, whereby the active residual ground current is compensated, as fully described with reference to the diagram of Fig. 1 of the drawings. For a ground on either lines 1 or 2, the corresponding relays 6 or 7 would also be actuated to insert the inductance 9 in the circuit.

In Fig. 3 of the drawings lines 11, 12, 13 of a high tension system are shown to which are connected the star-connected primary windings of the transformer 20. The neutral point of the transformer is directly grounded. The secondary windings of the transformer are delta connected through a variable inductance 50, as shown in the drawings. The value of this inductance at a system voltage of 220 kv., 50 cycles, at a capacitive ground current of 112 amps. at an active residual ground current of 10.4 amps., at a ratio of the turns of the windings of the transformer 20 of 38:1 and at a leakage of the transformer of approximately 50 per cent amounts to 0.0145 henry.

Undervoltage relays 60, 70 and 80 are provided with energizing windings 161, 171 and 181, respectively. One terminal of the respective energizing windings 161, 171 and 181, is connected to the lines 11, 12 and 13, respectively, and the other terminals of the respective energizing windings are connected to ground.

The relays 60, 70 and 80 are normally energized to maintain their respective contacts 162—163, 172—173, and 182—183 open and no circuit is completed unless a fault occurs on the high tension system. One of the contacts 162 and 163 of the relay 60 is connected to the secondary winding of the transformer 20 corresponding with the line 13. One of the contacts 172 and 173 of the relay 70 is connected to the secondary winding of the transformer corresponding with the line 11. One of the contacts 182 and 183 of the relay 80 is connected to the secondary winding of the transformer 20 corresponding with the line 12. One terminal of a second inductance 90 is connected to the remaining contacts 162, 172 and 182 of the respective relays 60, 70 and 80 and the other terminal thereof is connected to the remaining contacts 163, 173 and 183 of the respective relays 60, 70 and 80. Their value for the case stated by way of example is 0.0098 henry.

This system functions in the following manner: In the sound or intact state of the network the relays are in the switching position shown in the illustration. If an accidental ground develops in the line 13, for instance, the relay 80 connected in this line is deenergized and connects through the contacts 182, 183 and contact members 184, 186 respectively, the second inductance 90 parallel to the secondary winding of the transformer corresponding with the line 12, whereby the active residual ground current is again compensated. In the event of a ground on either line 11 or 12, the associated relays 60 or 70 would be deenergized to close its respective contacts 162—163 or 172—173 by means of the respective contact members 164, 166 and 174, 176, respectively, to insert the inductance 90 in the circuit.

Various modifications and changes may

be made without departing from the spirit and the scope of the invention, and I desire, therefore, that only such limitations shall be placed thereon as are imposed by the prior art.

I claim as my invention:

1. In a high tension system, an inductance connected between the neutral point of said system and ground and so dimensioned that in case of accidental grounding of one line the ground capacities of the sound lines are undercompensated, a second inductance, and means adapted to connect said second inductance between a sound line and ground, said second inductance so dimensioned, that the ground capacity of the sound line to which said second inductance is connected is overcompensated to the same extent as the other sound line is undercompensated, the value of the undercompensation or overcompensation being so chosen that the current resulting from the capacitive and inductive ground currents is equal and opposite to the line charging residual ground current.

2. In a high tension system, an inductance connected between the neutral point of said system and ground and so dimensioned that in case of accidental grounding of one line the ground capacities of the sound lines are undercompensated, a second inductance, a plurality of relays, electrically associated with said high tension system and ground and adapted in case of an accidental ground in one line to connect said second inductance between a sound line and ground, said second inductance so dimensioned that the ground capacity of the sound line to which said second inductance is connected is overcompensated to the same extent as the other sound line is undercompensated, the value of the undercompensation or overcompensation being so chosen that the current resulting from the capacitive and inductive ground currents is equal and opposite to the line charging residual ground current.

3. In a high tension system, a transformer having its star-connected primary winding connected to the system and the neutral point of said winding connected directly to ground, and an inductance of suitable value connected to its secondary winding in order to load it in such a manner that in case of an accidental ground the ground capacities of the sound lines are undercompensated, the inductance opposing the ground current being considerably smaller than the inductance of the system, a second inductance, means for connecting said second inductance in case of a ground to a secondary winding of said transformer corresponding with one of the sound lines, said second inductance being so dimensioned that the ground capacity of the sound line to the corresponding secondary winding of the transformer to which the said second inductance is connected, is overcompensated to the same extent as the other sound line is undercompensated, the value of the undercompensation or overcompensation respectively being so chosen, that the current resulting from the capacitive and inductive ground currents is equal and opposite to the line charging residual ground current.

4. In a high tension system, a transformer having its star-connected primary winding connected to the system and the neutral point of said winding connected directly to ground, and having its secondary winding connected in delta and an inductance of suitable value connected to said secondary winding to electrically load it to such an extent that in case of accidental grounding of the system the sound lines are undercompensated, and characterized in that the inductance acting counter to the accidental ground current is considerably smaller than the working inductance of the system, a second inductance, a plurality of relays electrically associated with said high tension system and ground and adapted in case of an accidental ground on one line to connect said second inductance to a secondary winding of said transformer corresponding with a sound line, said second inductance being so dimensioned that the ground capacity of the sound line to the corresponding secondary winding of the transformer to which the said second inductance is connected, is overcompensated to the same extent as the other sound line is undercompensated, and the value of the undercompensation or overcompensation respectively being so chosen, that the current resulting from the capacitive and inductive ground currents is equal and opposite to the line charging residual ground current.

5. In a high tension system, a transformer having its star-connected primary winding connected to the system and the neutral point of said winding connected directly to ground, and having its secondary winding connected in delta and an adjustable inductance of suitable value connected with said secondary winding to adapt said transformer to the variable conditions of the high tension system in such a way that in case of an accidental ground of one line the ground capacities of the sound lines are undercompensated, and characterized in that the inductance acting counter to the ground current is considerably smaller than the working inductance, a second inductance, means for connecting said second inductance in case of accidental ground to a secondary winding of said transformer corresponding with a sound line, said second inductance being so dimensioned that the ground capacity of the sound line to the corresponding secondary winding of the transformer to which

the said second inductance is connected is overcompensated to the same extent as the other sound line is undercompensated, and the value of the undercompensation or overcompensation respectively being so chosen, that the current resulting from the capacitive and inductive ground currents is equal and opposite to the line charging residual ground current.

6. In a high tension system, a transformer having its star-connected primary winding connected to the system and the neutral point of said winding connected directly to ground, and having its secondary winding connected in delta and an adjustable inductance of suitable value connected with said secondary winding to adapt said transformer to the variable conditions of the high tension system in such a way that in case of an accidental ground of one line the ground capacities of the sound lines are undercompensated, and characterized in that the inductance acting counter to the ground current is considerably smaller than the working inductance, a second inductance, a plurality of relays electrically associated with said high tension system and ground, and adapted in case of an accidental ground on a line to connect said second inductance to a secondary winding of said transformer corresponding with one of the sound lines, said second inductance being so dimensioned that the ground capacity of the sound line to the corresponding secondary winding of the transformer to which the said second inductance is connected is overcompensated to the same extent as the other sound line is undercompensated, the value of the undercompensation or the overcompensation respectively being so chosen, that the current resulting from the capacitive and inductive ground currents is equal and opposite to the line charging residual ground current.

7. In a polyphase electrical system, means for suppressing the ground currents occurring in the event of a phase-to-ground fault, including relay means electrically associated with said polyphase electrical system, inductance means associated with said system and said relays, means electrically associated with said system for undercompensating the capacitive current of one of the non-faulty phases of said system and means for inserting said inductance means in circuit with said system only upon the actuation of one of said relay means to overcompensate the capacitive current of another of said non-faulty phases.

8. In a three phase system having undervoltage relay means electrically associated therewith, means for suppressing the ground currents occurring in the said system on the occurrence of a phase-to-ground fault including means electrically associated with said system for undercompensating the capacitive current in one of the non-faulty phases and inductance means associated with said relay means for overcompensating the capacitive current of the other non-faulty phase, said inductance means being electrically associated with said system only upon the occurrence of a phase-to-ground fault and the actuation of one of said relay means.

In testimony whereof, I have hereunto subscribed my name this 17th day of June, 1929, at Berlin-Siemensstadt, Germany.

GERHART MEYER.