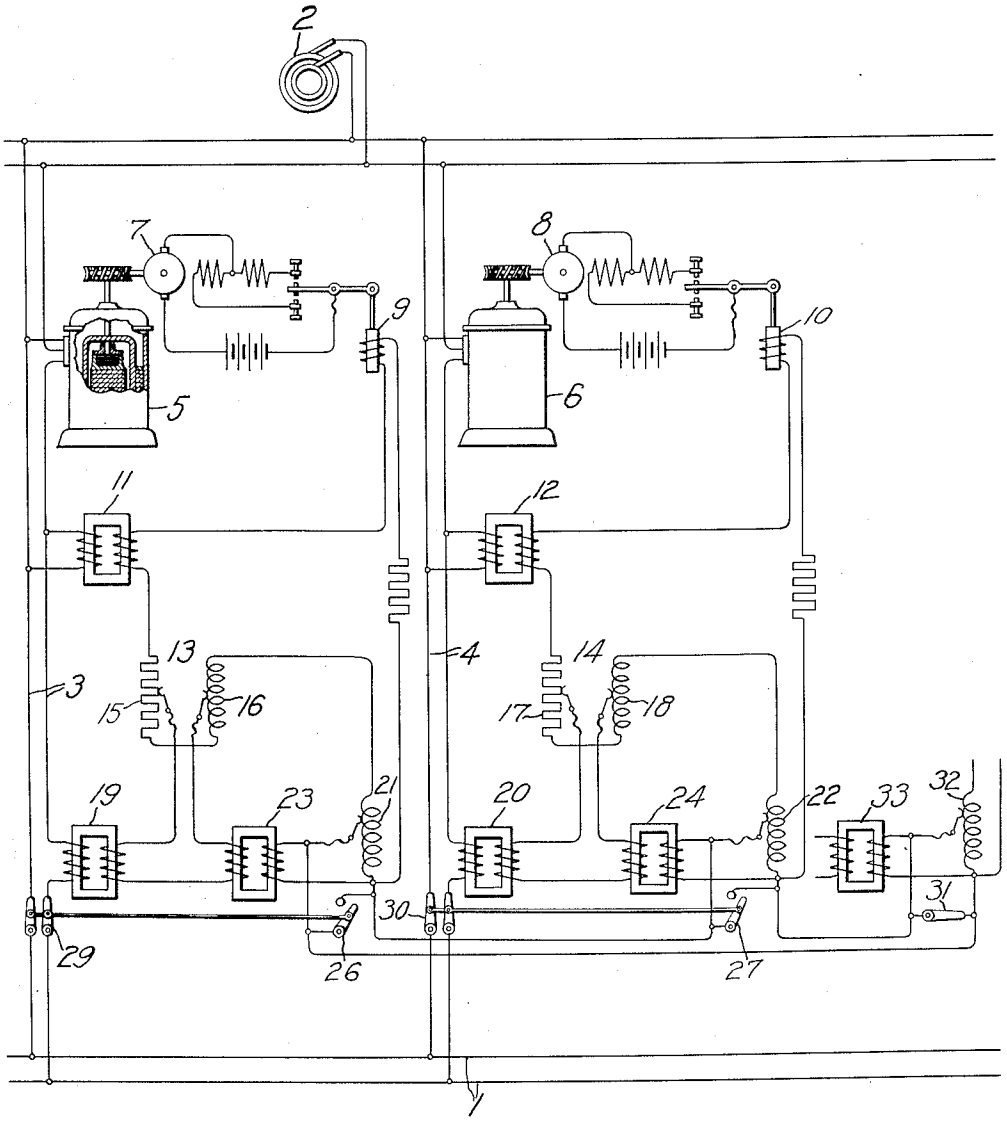
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SYSTEM OF ELECTRIC DISTRIBUTION

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SYSTEM OF ELECTRIC DISTRIBUTION.

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My invention relates to systems of electric distribution and particularly to systems comprising a plurality of parallel feeders between a common source and a common distribution circuit.

In Letters Patent 1,373,923 granted April 5, 1921, to Magnus Unger a regulating arrangement is disclosed and claimed for automatically controlling suitable voltage modifying means such as induction regulators in parallel feeders between a common source and a common distribution circuit so as to maintain a predetermined voltage at a predetermined point on the distribution circuit. That arrangement requires two current transformers in each feeder which in some cases may be objectionable.

One object of my invention is to provide an improved arrangement for automatically controlling voltage modifying means in parallel feeders whereby only one current transformer is used in each feeder and whereby the number of feeders in service may be varied without changing the adjustment of any of the apparatus.

My invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

Referring to the drawing, which shows diagrammatically a single phase system of electric distribution embodying my invention, 1 represents a distribution circuit supplied from a suitable source of current 2 by means of a plurality of parallel feeders. I have shown only two feeders 3 and 4 in the drawing, but it will be evident that my invention may be applied to any number of parallel feeders.

In order to maintain the voltage constant at a predetermined point on the distribution circuit voltage modifying means of any suitable type are connected in each feeder whereby the voltage thereof may be varied. As shown in the drawing the voltage modifying means are single phase induction regulators 5 and 6 in the feeders 3 and 4 respectively.

Each regulator is provided with a suitable actuating means therefor whereby the movable member thereof may be moved in either direction. As shown, the regulator 5 is actuated by a reversible motor 7 and the regulator 6 is actuated by a reversible motor 8. The circuits of the motors 7 and 8 are controlled respectively by the contact making voltmeters 9 and 10. The coil of the voltmeter 9 is connected to the secondary of a potential transformer 11, the primary of which is connected across the feeder 3 and the coil of the voltmeter 10 is connected to the secondary of a potential transformer 12, the primary of which is connected across the feeder 4.

In order that the regulators 5 and 6 may be automatically adjusted in accordance with variations in the voltage at some other point than where the respective transformers are connected suitable line drop compensators 13 and 14, examples of which are well known in the art, are provided respectively in the coil circuits of the voltmeters 9 and 10. As shown, the line drop compensator 13 comprises a resistor 15 and a reactance 16 connected in series with the coil of the voltmeter 9 and the line drop compensator 14 comprises a resistor 17 and a reactance 18 connected in series with the coil of the voltmeter 10. 19 is a current transformer, the primary of which is connected in series with the feeder 3 and the secondary of which is connected by means of suitable adjustable switching means to the resistor 15 and the reactance 16 so that a current, which is proportional to the feeder current flows through a portion of the resistor and the reactance. This current produces a drop across the portions of the resistor and the reactance through which it flows, which causes a variation in the impedance of the voltmeter coil circuit as the feeder current varies so that the voltage is maintained constant at the desired point on the distribution circuit. 20 is a similar current transformer which is connected in the feeder 4 and to the resistor 17 and the reactance 18 so as to vary the impedance of the circuit of the coil of the voltmeter 10 as the current in the feeder 4 varies.

In accordance with my invention I provide an improved arrangement for controlling the voltmeters 9 and 10 so that the regulators 5 and 6 are operated to eliminate any circulating current that flows around the loop circuit formed by the parallel feeders.

As shown in the drawing, my improved arrangement comprises a suitable impedance 21 connected in series with the coil of the voltmeter 9 and a similar impedance 22

connected in series with the coil of the voltmeter 10. Preferably the impedances are reactors but a certain amount of resistance and reactance may be used. The impedances 21 and 22 are respectively connected directly across the secondaries of the transformers 23 and 24, the primaries of which are respectively connected in the secondary circuits of the current transformers 19 and 20. The secondaries of the transformers 23 and 24 also are connected together for circulating currents. Therefore, so long as the currents in the two feeders are equal in phase and magnitude no current from either of the secondaries of the transformers 23 and 24 flows through the impedances 21 and 22.

Suitable switching means 26 and 27 are provided for respectively short circuiting the impedances 21 and 22. These switches may be interlocked respectively with the main feeder switches 29 and 30 in any suitable manner so that when a feeder switch is opened the respective short circuiting switch is closed and vice versa.

In order to indicate how my invention may be applied to systems of electric distribution having more than two parallel feeders I show a short circuiting switch 31, an impedance 32 and a transformer 33 of a third feeder. The secondary of the transformer 33 is connected to the secondaries of the other transformers 23 and 24 for circulating currents.

The operation of my improved system will appear from the following description. It will be assumed that the feeders 3 and 4 are the only ones that have their main switches closed. Therefore, the short circuiting switch 31 of the third feeder is closed and the short circuiting switches 26 and 27 are open.

It will be observed that as the current through each feeder increases, the drop across the portion of the associated line drop compensator which is in circuit with the secondary of the associated current transformer varies and modifies, in a manner well known in the art, the impedance of the associated voltmeters circuit so that the associated regulator is adjusted to maintain a constant voltage at a predetermined point on the distribution circuit.

So long as the voltage of the two feeders are equal, the currents in the two feeders are equal, and no current from the secondaries of the transformers 23 and 24 flows through the impedances 21 and 22 because the secondary currents of these two transformers are equal and therefore merely circulate around through the secondary windings of the transformers. When, however, the voltage of one of the feeders exceeds the voltage of the other, a circulating current flows through the feeders and the secondary currents of the two transformers 23 and 24 are no longer equal. The difference between the two secondary currents flows through the impedances 21 and 22 and produces a drop therein that so modifies the voltages impressed upon the voltmeters 9 and 10 that they cause the regulators 5 and 6 to operate in a manner to eliminate the circulating current.

It will be observed that the connections of the secondaries of the transformers are such that when a circulating current flows through the feeders, the difference between the two secondary currents of the transformers 23 and 24 flows through the impedances 21 and 22 in opposite directions. The secondaries of the transformers 23 and 24 are so connected to the impedances 21 and 22 that the drop produced across the impedance associated with the feeder having the higher voltage, which is the one through which the circulating current flows from the source to the distribution circuit 1, increases the potential impressed on the associated voltmeter so that the regulator which is controlled thereby is operated to reduce the voltage of the feeder and the drop produced across the impedance associated with the feeder having the lower voltage, which is the one through which the circulating current returns from the distribution circuit to the source, decreases the potential impressed upon its associated voltmeter so that the regulator, which is controlled thereby, is operated to increase the voltage of the feeder. For example, if the voltage of the feeder 4 exceeds the voltage of the feeder 3 so that a circulating current flows through the feeders in a clockwise direction, a drop is produced across the impedance 22 in such a direction that the regulator 6 is operated in a direction to reduce the voltage of the feeder 4 and a drop is produced across the impedance 21 which causes the regulator 5 to be operated so as to increase the voltage of the feeder 3. It will be observed, therefore, that the regulators are operated automatically, whenever a circulating current flows around the feeders, so as to eliminate the circulating current.

It will be evident that the operation is the same when more than two feeders are in use. If the voltage of one of the feeders exceeds the voltages of the other two, the circulating current that flows through the feeders causes a current to flow through each of the impedances. For example, let it be assumed that the feeder with which the transformer 33 and impedance 32 are associated is in service so that the short circuiting switch 31 is open and that the voltage of the feeder 4 is increased relatively to the voltages of the other two feeders so that a circulating current flows to the distribution circuit 1 through the feeder 4 and returns through the other two feeders in par-

allel. Under these conditions a portion of the secondary current of the transformer 20 divides and flows through two parallel circuits. One of these circuits comprises the impedance 22 which is connected directly across the secondary of the transformer 20. The other circuit comprises the two impedances 21 and 32 in series. It will be noted, however, that the current through the impedance 22 flows through it in one direction and that the current through the impedances 21 and 32 flows through them in the opposite direction. Therefore the potentials impressed upon the voltmeters are so modified that the regulators are actuated to eliminate the circulating current.

It will be observed from the above description that by means of my improved arrangement stable operation of automatically controlled induction regulators may be obtained by the addition of only a small amount of apparatus and the number of feeders may be varied as desired without requiring the adjustment of any of the control apparatus of the other feeders.

While I have, in accordance with the patent statutes, shown and described my invention as applied to a particular system and as embodying various devices diagrammatically indicated, changes and modifications will be obvious to those skilled in the art, and I therefore aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In a system of electric distribution, a source of alternating current, a distribution circuit, a plurality of parallel feeders connecting said source to said distribution circuit, voltage modifying means associated with each feeder for controlling the voltage impressed on said distribution circuit, a voltage responsive device associated with each feeder for controlling the associated voltage modifying means, a circuit for each voltage responsive device, transforming means associated with each feeder, each transforming means having a primary winding connected so that the current therein varies with the current in the associated feeder, and an impedance connected directly across a secondary winding of each of said transforming means and connected in the circuit of the associated voltage responsive device, said secondary windings of said transformers being connected together for circulating currents.

2. In a system of electric distribution, a source of alternating current, a distribution circuit, a plurality of parallel feeders connecting said source to said distribution circuit, voltage modifying means associated with each feeder for controlling the voltage impressed on said distribution circuit, a voltage responsive device associated with each feeder for controlling the associated voltage modifying means, a circuit for each voltage responsive device, a line drop compensator associated with each voltage responsive device, transforming means associated with each feeder, each transforming means having a primary winding connected so that the current therein varies with the current in the associated feeder, an impedance connected directly across a secondary winding of each of said transforming means and connected in the circuit of the associated voltage responsive device, said secondary windings of said transforming means being connected together for circulating currents, and switching means for shortcircuiting each of said impedances.

3. In a system of electric distribution, a source of alternating current, a distribution circuit, a plurality of parallel feeders connecting said source to said distribution circuit, voltage modifying means associated with each feeder for controlling the voltage impressed on said distribution circuit, a contact making voltmeter associated with each feeder and responsive to the voltage thereof for controlling the associated voltage modifying means, a circuit for each voltmeter, a line drop compensator associated with each voltmeter comprising an impedance in the circuit of the associated voltmeter and a current transformer having its primary winding energized in accordance with the current in the associated feeder and its secondary winding connected to said impedance, transforming means associated with each feeder having primary windings connected in the secondary circuit of the associated current transformer, secondary windings of said transforming means being connected together for circulating currents, and a second impedance connected in the circuit of each voltmeter and across said secondary windings of said transforming means which is associated with the feeder with which the respective voltmeter is associated.

4. In a system of electric distribution, a source of alternating current, a distribution circuit, a plurality of parallel feeders connecting said source to said distribution circuit, voltage modifying means associated with each feeder for controlling the voltage impressed on said distribution circuit, a contact making voltmeter associated with each feeder and responsive to the voltage thereof for controlling the associated voltage modifying means, a circuit for each voltmeter, a line drop compensator associated with each voltmeter comprising an impedance in the circuit of the associated voltmeter and a current transformer having its primary winding energized in accordance with the current

in the associated feeder and its secondary winding connected to said impedance, a second transformer associated with each feeder having its primary winding connected in the secondary circuit of the associated current transformer, the secondary windings of said second transformers being connected together for circulating currents, a second impedance connected in the circuit of each voltmeter and across the secondary winding of the second transformer which is associated with the feeder with which the respective voltmeter is associated, and a short circuiting switch associated with each of said impedances.

5. In a system of electric distribution, a source of alternating current, a distribution circuit, a plurality of parallel feeders connecting said source and distribution circuit, an induction regulator in each feeder, actuating means for each regulator, a contact making voltmeter associated with each actuating means for controlling the operation thereof, a circuit for each voltmeter connected so that a voltage which is proportional to voltage of the associated feeder is impressed thereon, a line drop compensator associated with each voltmeter comprising a resistor and a reactance in the circuit of the voltmeter and a current transformer having its primary winding energized in accordance with the current in the associated feeder and its secondary winding connected so that the secondary current flows through said resistor and reactance, a second transformer associated with each voltmeter having its primary winding connected in the secondary circuit of the associated current transformer, the secondary windings of said second transformers being connected for circulating current, and a second reactance in the circuit of each voltmeter connected across the secondary winding of the second transformer associated therewith.

6. In a system of electric distribution, a source of alternating current, a distribution circuit, a plurality of parallel feeders connecting said source and distribution circuit, an induction regulator in each feeder, actuating means for each regulator, a contact making voltmeter associated with each actuating means for controlling the operation thereof, a circuit for each voltmeter connected so that a voltage which is proportional to voltage of the associated feeder is impressed thereon, a line drop compensator associated with each voltmeter comprising a resistor and a reactance in the circuit of the voltmeter and a current transformer having its primary winding energized in accordance with the current in the associated feeder and its secondary winding connected so that the secondary current flows through said resistor and reactance, a second transformer associated with each voltmeter having its primary winding connected in the secondary circuit of the associated current transformer, the secondary windings of said second transformers being connected for circulating current, a second reactance in the circuit of each voltmeter connected across the secondary winding of the second transformer associated therewith, and switching means for short circuiting each of said second reactances.

In witness whereof, I have hereunto set my hand this 2nd day of July, 1925.

FRANKLIN J. CHAMPLIN.