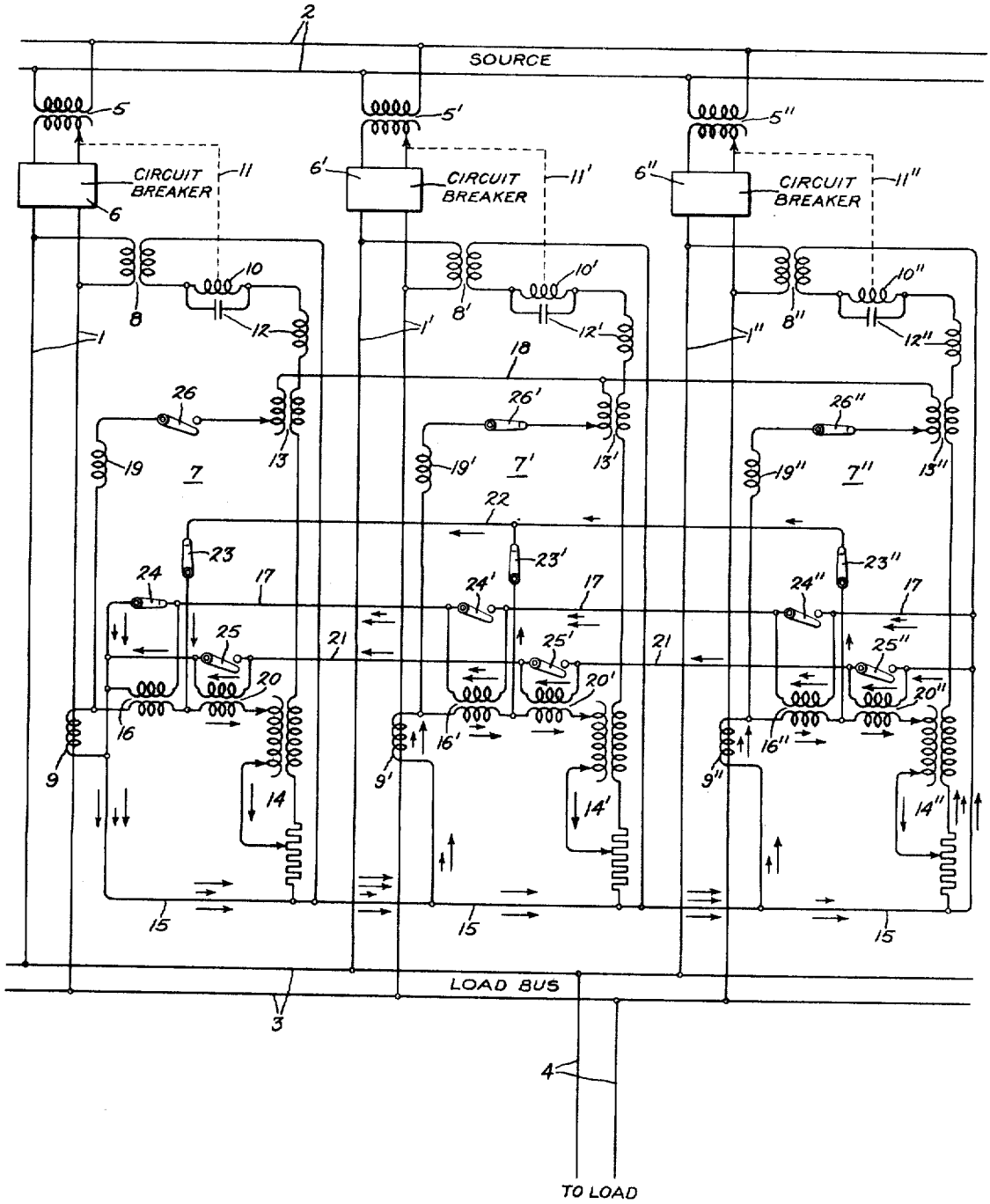
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ELECTRIC CIRCUIT

Filed May 26, 1942




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## ELECTRIC CIRCUIT

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Application May 26, 1942, Serial No. 444,523

15 Claims. (Cl. 171—119)

This invention relates to electric circuits and more particularly to improvements in voltage control circuits for interconnected power circuits.

When a number of automatically-controlled voltage regulating transformers are operated in parallel, one or more of them are sometimes removed from service to save transformer losses during light load periods. If the voltage regulating transformers are automatically controlled through individual line drop compensators, as, for example, in the circuits forming the subject matter of an application, Serial No. 444,999, filed May 29, 1942, in the name of T. C. Lennox and assigned to the assignee of the present application, and the power circuits of the regulating transformers are paralleled on their load side, the removal of one or more units from service will cause a larger portion of the remaining load current to pass through the line drop compensators on the units left in service. Because the numerical value of the impedance between the regulating transformers and the load center on the power line to which the regulating transformers are connected in parallel does not change, the increased value of load current passing through the line drop compensators left in service will cause the regulating transformers to hold a voltage which is higher than it should be. This is obviously a condition which cannot be tolerated and, therefore, means must be provided to avoid it. Several ways of obtaining this desired result may be employed, such as changing the ratio of the current transformers which energize the line drop compensators or changing the compensator setting in each unit to conform to the new value of load current whenever one or more units are removed from service. Still another way would be to energize all of the line drop compensators in accordance with the total output current of all of the parallel-connected power circuits or regulating transformers, such as by energizing them in series from a single current transformer connected in the main load circuit to which the individual power circuits are connected in parallel. However, all of these schemes have certain drawbacks and most of them involve considerable complications in the control circuits.

In accordance with the present invention there is provided a novel and simple scheme for causing the energization of the line drop compensators on the units which remain in service to be independent of the number of such units. The preferred embodiment of the invention is characterized by special interconnections between the control circuits whereby any excess current tending to flow in the line drop compensators is diverted therefrom through an auxiliary circuit.

Not all systems involving a plurality of power circuits which supply a common load and in which at least one unit is sometimes removed from service during light load conditions comprise parallel-connected power circuits. For example, three such circuits may comprise three single-phase load ratio control power transformers which are normally delta-connected but which may be operated open-delta or V-connected by the removal of one transformer from service. Furthermore, voltage regulating transformers may be of many different types, such as load ratio control power transformers whose power ratings are equal to the ratings of the circuits in which they are connected, load ratio control step voltage regulators which are usually autotransformers and whose power ratings are usually proportional to the range of voltage regulation they produce, and induction voltage regulators. In addition, there are generator voltage regulators in cases where the power circuits are fed by individual dynamo-electric generators. My invention is applicable to systems employing all such variations in interconnections and variations in regulators.

An object of the invention is to provide a new and improved electric circuit.

Another object of the invention is to provide an improved control system for interconnected power circuits having individual automatic voltage regulators.

A further object of the invention is to provide an improved system in which the current in separate translating devices energized by respective current transformers in a group of interconnected power circuits is rendered independent of the number of such power circuits which are in service.

The 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 now to the single figure of the accompanying drawing, which illustrates diagrammatically a preferred embodiment of the invention, I show therein a power system comprising three power circuits 1, 1′ and 1″. These circuits and the apparatus associated with them are substantial duplicates so that the same reference numerals will be used to describe similar ele-

ments in the three circuits and they will be distinguished by prime and double-prime marks for identifying them with their associated circuits. These circuits are connected in parallel as by connecting them between a source or supply bus 2 and a load bus 3. To the latter is connected a common load line 4 which may be a single or a multi-circuit line, as desired. Included in each of the parallel-connected circuits is a voltage regulator, in the form of a tap-changing power transformer 5, and a circuit breaker 6 for selectively making and breaking the circuit. Transformers 5 are voltage regulating transformers because the tap-changing means varies their ratio. Each regulating transformer is automatically controlled by its individual control circuit indicated generally at 7. These control circuits are each divided into a potential circuit which is energized by a potential transformer 8 connected across its associated power circuit and a current circuit which is energized by a main current transformer 9 connected in its associated power circuit.

Included in each potential circuit is a main or primary control winding 10 which is connected by any suitable and well-known electromechanical system, shown schematically as 11, to control the operation of the voltage regulating means for its associated main circuit. Thus, an increase in voltage across winding 10 causes the regulating transformer to decrease its voltage output and a decrease in voltage across the winding 10 causes the regulating transformer to increase its output voltage with the result that the automatic regulating system acts to maintain constant voltage. For compensating the primary control winding 10 for temperature and frequency errors a ballast in the form of a monocyclic circuit 12 is included in each potential circuit. This monocyclic ballast comprises a capacitor and a reactor having substantially equal ohmic values, one of which is connected in parallel circuit relation with the winding 10 and the other of which is connected in series circuit relation with the parallel connection. Either reactance device may be the parallel one and, as shown, it is the capacitor which is so connected. This ballast has the property of maintaining the current in the winding 10 substantially independent of relatively wide variations in its effective impedance so that the current in this winding is substantially independent of any normally encountered variable except the net voltage impressed on the potential circuit by the potential transformer 8.

For insuring stable operation of the regulators each one is provided with a so-called circulating current compensator in the form of a reactance transformer 13 whose secondary winding is connected in the potential circuit. This reactance transformer is characterized by having its core worked over a linear portion of its magnetization characteristic throughout the normal operation of the circuit. This is usually accomplished by providing the core with an air gap which also has the effect of greatly increasing the magnetizing current of its primary winding. The device is essentially a high magnetizing current reactor with respect to its primary circuit, and its secondary winding, therefore, has voltage which is directly proportional to the voltage drop in the reactor which constitutes its primary winding so that, in other words, the voltage of the secondary winding is substantially in quadrature with the current in its primary winding.

By "stable operation" of the automatic regulator is meant operation which does not result in the regulators running to their extreme limits of operation except when main circuit voltage conditions require it. The reason that this might otherwise occur is that if the voltages of the transformers 5 should for any reason become even slightly unequal, the higher voltage transformer will cause a circulating current to flow through the power circuits. This current is lagging with respect to the voltage of the high voltage circuit and leading with respect to the voltage of the low voltage circuit or circuits with the result that the reactance voltage drop in the inductive portions of the circuits will tend to lower the voltage of the high voltage circuit and raise the voltage of the low voltage circuits in the inherent action of the circuits to equalize their voltages. However, this inherent action is interfered with by the action of the automatic regulators, which will respond to the decrease in voltage caused by the circulating current in the high voltage circuit to raise its voltage still higher, whereas the automatic regulators in the lower voltage circuits will respond to the rise in voltage to cause the voltages of these circuits to be still further decreased. The result is that the regulators tend to get further and further apart thereby increasing still further the circulating current until the high voltage regulator has been run to its maximum voltage raising position and the low voltage reglators have been run to their maximum voltage lowering positions. Actually, under such conditions the circulating currents would be so high as to cause damage to the circuits and regulating transformers. However, by passing currents through the primary windings of the circulating current compensators which are proportional to the circulating currents in their associated power circuits, the circulating current compensators can be made to raise the voltage applied to the main control coil of the circuit whose regulator voltage is too high, thereby to cause this regulator to lower its voltage, and the opposite effect will be produced in the circuits having too low voltage with the result that the compensators automatically act to bring the regulators together, so to speak.

Also connected in each potential circuit is a line drop compensators 14 consisting of a reactance transformer similar in construction to the circulating current compensator and a rheostat, the secondary winding of the transformer and the resistance element of the rheostat being connected in series in the potential circuit. The purpose of this device is to compensate for the voltage drop in the load line 4 between each regulator and the load or load center on the circuit 4. The line has both reactance and resistance so that its line drop has both reactance and resistance components and the reactance and resistance elements of the line drop compensator are so adjusted that they produce voltages in the potential circuit which are proportional to the reactance and resistance components of the line drop.

The current circuits of each regulator have a common conductor 15 to which a corresponding terminal of each of the main current transformers is connected. For separating the output current of each current transformer into its circulating and load components there are provided auxiliary current transformers 16 whose primary windings are connected respectively between the remaining terminal of each main current transformer and its associated line drop

compensator. A terminal of each circulating current compensator 13 is connected to the terminal of the main current transformer of its associated power circuit which is also connected to the primary winding of the auxiliary current transformer 16 and all of the secondary windings of the auxiliary current transformers 16 are normally connected in series through conductors 17, the series circuit being completed through the common conductor 15.

The normal ratio or distribution of currents in the parallel power circuits may be anything desired. If they are equal, the main current transformers can have equal ratios, whereas if they are unequal the ratios of the current transformers may be made such that with normal current distribution the secondary currents of all of the current transformers are equal. For the sake of simplicity it will be assumed that the currents in the three parallel circuits are normally equal and that the main current transformers 9 have equal ratios. The auxiliary transformers 16 should have equal ratios and for the sake of simplicity they are assumed to have 1:1 ratios. As all of the secondary windings of the auxiliary current transformers 16 are in series, they must necessarily all carry the same current, which means that their primary windings also must carry the same current. The result is that under normal conditions all of the output of the main current transformers flows through their associated line drop compensators and none of it flows through their associated circulating current compensators. However, as soon as any circulating currents come into existence they will add to the output current of the main current transformer in one or more of the circuits and will subtract from the load current in the remaining circuits with the result that the total or average current in all of the circuits remains unchanged. Consequently, the difference between the load current in each circuit and the actual current therein will be equal to the circulating current. When this is a current excess it will be prevented from flowing through the line drop compensator by the auxiliary current transformer 16 so it must pass through the circulating current compensator for that particular circuit having an excess current. All of the circulating current compensators are joined by a common connection 18 so that this excess current will flow through the common conductor 18 and will distribute itself among the circulating current compensators associated with the power circuits in which the total current is less than the normal current; that is to say, among the compensators for the circuits in which the circulating current subtracts from the load current and will then return to the main current transformers for these circuits.

For providing additional protection against circulating currents a winding 19 is connected in series with each circulating current compensator so that it carries a current which is proportional to the circulating current in its associated circuit. This winding may be caused to operate any suitable auxiliary protective means, such as an alarm or auxiliary contacts for incapacitating the regulators so that upon the occurrence of a predetermined maximum safe value of circulating current the regulators will be positively prevented from going farther apart.

These features of the segregation of the load and circulating components of the current are described and claimed in the above-referred-to Lennox application.

For insuring that each line drop compensator carries the same value of current regardless of the number of parallel circuits which are active or in service, each current circuit is provided with a second auxiliary current transformer 20 whose primary winding is connected in series with the auxiliary current transformer 16. These transformers preferably have the same ratio as the transformer 16, namely, a 1:1 ratio, and their secondary windings are connected in series by means of conductors 21, the series circuit being completed through the common conductor 15. The junctions of the primary windings of the auxiliary current transformers for each current circuit are connected to an equalizer bus 22 through individual switches 23.

For changing the control connections so as to prevent a change in the line drop compensator currents when the number of parallel circuits is changed, each auxiliary current transformer 16 is provided with a switch 24 for short circuiting its secondary winding and likewise each auxiliary current transformer 20 is provided with a switch 25 for short circuiting its secondary winding. In addition, switches 26 are provided for making and breaking the energizing circuits for the circulating current compensators.

The operation of the illustrated embodiment of the invention is as follows: Assume that under a given load condition each of the parallel-connected circuits carries one unit of load current when all three of them are active or in service and that circuit 1 has just been rendered inactive by the opening of its circuit breaker 6. Under these conditions the various switches should be in the positions shown in the drawing in which switch 26 is open, switches 26' and 26'' are closed, switch 24 is closed, switches 24' and 24'' are open, and switches 23, 23' and 23'' are all closed. The operation can best be understood by following the arrows, of which each long arrow represents one unit of load current and each short arrow represents one-half unit of load current. As the total load current remains the same, it will now be redistributed so that 1½ units flow through the secondary winding of each main current transformer 9' and 9''. It is assumed for the time being that the voltages of circuits 1' and 1'' are equal so that no circulating current flows in them. The 1½ units of load current flowing in the secondary winding of each of the current transformers 9' and 9'' must flow through the primary windings of the auxiliary current transformers 16' and 16'' respectively. This induces an equal 1½ units of current in the secondary winding of each of the auxiliary current transformers 16 and 16' and as these secondary windings are connected in series in a closed circuit which excludes the secondary winding of current transformer 16, because the closed switch 24 short circuits it, these 1½ units merely circulate through the conductors 17 and the common return conductor 15. However, all of the 1½ units of current cannot flow through the primary windings of the current transformers 20' and 20''. This is because the secondary winding of the current transformer 20 is connected in series with the secondary windings of the current transformers 20' and 20''. Thus, if more than one unit of current tends to flow in the primary windings of the current transformers 20' and 20'' the same excess over one unit of current will

flow in all of the series-connected secondary windings of the current transformers **20**, **20'** and **20''**, thus inducing an equal current in the primary winding of the current transformer **20** and this current can only return by flowing through the line drop compensator **14** or the secondary winding of the main current transformer **9**. Ordinarily, the impedance of the line drop compensator will be less than the impedance of the secondary winding of the current transformer **9** whose primary circuit is, of course, open-circuited. so that practically all of such excess current over unity would tend to flow through the line drop compensator, but the impedance of this device reflected through the current transformer **20** into the series connection of the secondary windings of the current transformers **20'** and **20''** is such as to cause some of the 1½ units of current to flow through the closed switches **23'** and **23''** and through the equalizer bus **22** and through the closed switch **23** and thence through the primary winding of the current transformer **20** and the line drop compensator **14**. By reason of the 1:1 ratios of all of the auxiliary current transformers an exact balance will be attained when ½ unit of current flows through each of the switches **23'** and **23''** and the remaining single unit of current flows on through the secondary windings of the current transformers **20'** and **20''**. This is because the two ½ units of current through the switches **23'** and **23''** combine to form one unit of current which flows through the closed switch **23** and then through the primary winding of the current transformer **20** and the line drop compensator **14**. Consequently, it will be seen that the one unit of current which is induced in each of the secondary windings of the current transformers **20'** and **20''** can now flow through the series connection including the secondary winding of the current transformer **20** because its primary winding already carries one unit of current so that all of the windings of the auxiliary transformers **20** will now have the same single unit of current flow therein.

In tracing the arrows around through their circuits the 1½ units of current from the secondary windings of the current transformers **16** and the one unit of current from the secondary windings of the current transformers **20** combine to form 2½ units of current which flow from left to right beginning at the left-hand end of the common conductor **15**. After the line drop compensator **14** is passed the current becomes 3½ units because to the one unit of current from the line drop compensator **14** is added the 2½ units of current already in the conductor **15**. After the connection to the current transformer **9'** is passed the ½ unit of current which flowed away from the current transformer **9'** through the switch **23'** is returned to it so that three units of current continue on toward the right but one unit of current flows in the opposite direction from right to left between the line drop compensator **14'** and the current transformer **9'** so that a net current of two units flows in this part of the return conductor. After the line drop compensator is passed the three units of current continue on until the connection to the current transformer **9''** is reached. At this point the ½ unit of current which left the current transformer **9''** through the switch **23''** is returned to the current transformer so that 2½ units of current continue on to the right but as one unit of current flows to the left from the line drop compensator **14''** to the main current transformer **9''**, the net current in this part of the common conductor is 1½ units of current. After the line drop compensator **14''** is passed the 2½ units of current return and one unit flows into the secondary winding of the current transformer **20''** and the remaining 1½ units flow in the secondary winding of the auxiliary current transformer **16''**. It will thus be seen that the current in the line drop compensators is unchanged as a result of the elimination of the circuit **1**.

By reason of the exact balance of currents in the windings of all of the auxiliary current transformers, any circulating current which might exist in the circuits **1'** and **1''** could not flow through the auxiliary current transformers as this would disturb the balance of their currents so that all such circulating current would be forced through the switches **26'** and **26''** and through their associated circulating current compensators.

Although only three parallel circuits have been shown it should, of course, be understood that any greater number can be used, the connections being similar to the connections of the circuit **1''** with respect to the others; that is to say, as many additional units as desired may be connected in between, the end units **1** and **1''**. Thus, if there were $n$ units or circuits, $x$ of which were interconnected or connected in parallel, there would need to be at least $(n+x)$ auxiliary current transformers. Thus, there would need to be $2x$ auxiliary current transformers for the $x$ parallel units as each of the parallel units would need two current transformers whereas the remaining $(n-x)$ auxiliary current transformers would be distributed one to each of the inactive circuits. If unit current flowed in each of the circuits when $x$ equaled $n$, then the current in each circuit would be proportional to $n/x$ and the excess current in each of the $x$ circuits over unity would be $(n-1/x)$ or $(n-x/x)$.

When it is desired to operate the illustrated circuit with all of the units in parallel, all of the switches **26** will be closed because circulating current can then flow in all of the units and therefore it is desirable and necessary to have their circulating current compensators all connected so that the sum of these circulating currents can add up to zero. All of the other switches **23**, **24** and **25** are preferably left open, under which conditions the secondary windings of all of the transformers **16** will be connected in series and the secondary windings of all of the transformers **20** will be connected in series and unit current will flow in all of them.

If it is desired to operate any one circuit alone and to render the other two inactive or open-circuited, the switches **23** and **26** of the unit which is to be operated alone are opened, its switches **24** and **25** are closed and all of the other switches remain in the positions for normal parallel operation. With this connection it will be seen that the auxiliary current transformers of the single unit to be in service are short circuited and the circulating current compensator is open-circuited as, of course, there can be no circulating current when a single circuit is in operation. Consequently, all of the output current of the main current transformer can flow through the line drop compensator as all of the circuit current will be load current.

While there has been shown and described a particular embodiment of this invention, it will be obvious to those skilled in the art that various changes and modifications can be made therein

without departing from the invention and, therefore, it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

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

1. In combination, a plurality of interconnected circuits for supplying power to a common load through a line whose impedance is substantially independent of the number of circuits feeding it, means for selectively varying the active number of said circuits, separate line drop compensated voltage regulators for said circuits, and means for rendering the line drop compensation which is produced by the compensators associated with the active ones of said circuits substantially independent of the number of said circuits which are active.

2. In combination, a plurality of interconnected circuits for supplying power to a common load through a line whose impedance is substantially independent of the number of circuits feeding it, means for selectively varying the active number of said circuits, separate line drop compensated voltage regulators for said circuits, and means for preventing the line drop compensators associated with the active circuits from responding to the redistribution of load current among such active circuits when their number is varied.

3. In combination, a plurality of interconnected circuits for supplying power to a common load through a line whose impedance is substantially independent of the number of circuits feeding it, means for selectively varying the active number of said circuits, separate line drop compensated voltage regulators for said circuits, and auxiliary current transforming and switching means for rendering the line drop compensation which is produced by the compensators associated with the active ones of said circuits substantially independent of the number of said circuits which are active.

4. In combination, a plurality of interconnected circuits for supplying power to a common load through a line whose impedance is substantially independent of the number of circuits feeding it, means for selectively varying the active number of said circuits, separate line drop compensated voltage regulators for said circuits, and auxiliary current transforming and switching means for causing the energizing currents for the line drop compensators which are associated with the ones of said circuits which are active to have a fixed ratio to the combined load current of said active circuits regardless of their number.

5. In combination, a plurality of parallel-connected alternating-current power supply circuits, a common load circuit for said supply circuits, a separate automatic voltage regulator for each supply circuit, a separate line drop compensator for each regulator, a separate switch for selectively opening and closing each of said supply circuits, and means including auxiliary switches for maintaining the current in each line drop compensator independent of the number of said parallel supply circuits which are open and closed.

6. In combination, a supply bus, a load bus, a plurality of parallel circuits interconnecting said busses, a load, a power line interconnecting said load and load bus, a separate automatic voltage regulator for each of said parallel circuits, a separate line drop compensator for each regulator so adjusted that each regulator acts to hold constant voltage at a common point of said power line, switching means for selectively opening said power circuits so as to reduce the number thereof which are in parallel, a separate current transfomer in each of said circuits for supplying the line drop compensator current for its associated regulator, and auxiliary control interconnections between said line drop compensators for diverting from each compensator, the increase in current resulting from such reduction in the number of parallel power circuits.

7. In combination, a plurality of parallel alternating-current power circuits connected to a common load line, an individual automatic voltage regulator for each of said parallel circuits, individual line drop and circulating current compensators for each regulator, a current transformer in each of said parallel circuits for supplying current to its associated compensators, means for separating the output current of each current transformer into two components proportional respectively to the load and circulating current components in its power circuit, each line drop compensator being connected to be energized by its associated current transformer's load current component, each circulating current compensator being connected to be energized by its associated current transformer's circulating current component, means for open circuiting one of said parallel power circuits, and means for diverting from each line drop compensator the increase in load component current which results from said open circuiting of one of said power circuits.

8. In combination, a plurality of interconnected circuits for supplying power to a common load through a line whose impedance is substantially independent of the number of circuits feeding it, means for selcetively varying the active number of said circuits, separate line drop compensated voltage regulators for said circuits, a separate current transformer in each of said circuits for supplying the line drop compensator current for its associated regulator, and means for rendering the line drop compensation which is produced by the compensators associated with the active ones of said circuits substantially independent of the number of said circuits which are active.

9. In combination, a plurality of interconnected circuits for supplying power to a common load through a line whose impedance is substantially independent of the number of circuits feeding it, means for selectively varying the active number of said circuits, separate line drop compensated voltage regulators for said circuits, a separate current transformer in each of said circuits for supplying the line drop compensator current for its associated regulator, and means for preventing the line drop compensators associated with the active circuits from responding to the redistribution of load current among such active circuits when their number is varied.

10. In combination, a plurality of interconnected circuits for supplying power to a common load through a line whose impedance is substantially independent of the number of circuits feeding it, means for selectively varying the active number of said circuits, separate line drop compensated voltage regulators for said circuits, a separate current transformer in each of said circuits for supplying the line drop compensator current for its associated regulator, and auxiliary current transforming and switching means for rendering the line drop compensation which is produced by the compensators associated with the

active ones of said circuits substantially independent of the number of said circuits which are active.

11. In combination, a plurality of interconnected circuits for supplying power to a common load through a line whose impedance is substantially independent of the number of circuits feeding it, means for selectively varying the active number of said circuits, separate line drop compensated voltage regulators for said circuits, a separate current transformer in each of said circuits for supplying the line drop compensator current for its associated regulator, and auxiliary current transforming and switching means for causing the energizing currents for the line drop compensators which are associated with the ones of said circuits which are active to have a fixed ratio to the combined load current of said active circuits regardless of their number.

12. In combination, a plurality of parallel-connected alternating-current power supply circuits, a common load circuit for said supply circuits, a separate automatic voltage regulator for each supply circuit, a separate line drop compensator for each regulator, a separate switch for selectively opening and closing each of said supply circuits, a separate current transformer in each of said circuits for supplying the line drop compensator current for its associated regulator, and means including auxiliary switches for maintaining the current in each line drop compensator independent of the number of said parallel supply circuits which are open and closed.

13. In combination, $n$ power circuits, switching means for selectively connecting any $x$ of them to a common load circuit when $x$ has a minimum value of two and a maximum value of $n$, a separate main current transformer connected in each of the $x$ interconnected circuits, said main current transformers each having a corresponding secondary winding terminal connected to a common conductor, a separate translating device connected across the secondary winding of each of said main current transformers, and means for causing the current in each of said translating devices to be independent of the value of $x$ comprising at least $(n+x)$ auxiliary current transformers of which $2x$ of them are grouped in pairs, the primary windings of each pair being connected in series between the remaining terminals of the secondary windings of said main current transformers and said translating devices respectively, the junctions of each of said pairs of primary windings being interconnected, the primary windings of the remaining $(n-x)$ auxiliary current transformers being connected between said common conductor and said interconnection of said junctions, the secondary windings of the auxiliary current transformers whose primary windings are connected between said junctions and said remaining terminals of said main current transformers being connected in series with each other, all of the secondary windings of the remaining auxiliary current transformers being connected in series in another circuit.

14. In combination, a source of alternating current, a load circuit, $n$ substantially identical power transformers of which $x$ of them are connected in parallel between said source and said load circuit, equal ratio main current transformers connected respectively in series with each of said $x$ parallel-connected power transformers whereby the load current output of each main current transformer is $(n-x/x)$ units higher than it would be if $n$ of said transformers were in parallel, separate line drop compensators for automatic voltage regulators for said transformers connected respectively to be energized by said main current transformers, a corresponding terminal of each main current transformer being connected directly to a common conductor, and means for diverting said $(n-x/x)$ units of load current from said line drop compensators comprising $(n+x)$ equal ratio auxiliary current transformers, $2x$ of said auxiliary current transformers being grouped in pairs, whose primary windings are connected in series respectively between said main current transformers and their line drop compensators, an interconnection between the junctions of each pair of serially-connected auxiliary current transformer primary windings, the remaining $(n-x)$ auxiliary current transformers having their primary windings connected between said interconnection and said common conductor, the secondary windings of the auxiliary current transformers whose primary windings are connected between said main current transformers and said junctions being connected in series with each other in a closed circuit, all of the remaining secondary windings of said auxiliary current transformers being connected in series in a second closed circuit.

15. The combination as set forth in claim 13 plus means for varying $x$ between the values of $n$ and 2.

SALVATORE MINNECI.

## Certificate of Correction

Patent No. 2,322,249. June 22, 1943.

SALVATORE MINNECI

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, lines 3–4, for "circuts" read *circuits*; page 4, first column, line 12, strike out the period after the syllable "ed" and insert instead a comma; and second column, line 41, for "$(n-1/x)$ or $(n-x/x)$" read

$$\left(\frac{n}{x}-1\right) \text{ or } \left(\frac{n-x}{x}\right);$$

page 6, second column, lines 21 and 29, claim 14, for "$(n-x/x)$" read

$$\left(\frac{n-x}{x}\right);$$

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 17th day of August, A. D. 1943.

[SEAL]

HENRY VAN ARSDALE,
*Acting Commissioner of Patents.*