UNITED STATES PATENT OFFICE

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NETWORK CALCULATING BOARD

Glenn W. Bills, Portland, Oreg.

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3 Claims. (Cl. 235—61)

(Granted under Title 35, U. S. Code (1952), sec. 298)

The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalty thereon in accordance with the provisions of the act of March 3, 1933 (22 Stat. 629), as amended by the act of April 30, 1926 (45 Stat. 467, 35 U. S. C., 1946 Ed. Sec. 45).

This invention relates generally to calculating boards used for miniature representation of power networks. There have been many such calculating boards which have included resistances, inductances and capacitances to represent transmission lines, and transformers, both fixed core and variable core to represent generators and motors. The present invention utilizes the same kind of connections for lines and loads as in the calculating boards now in use but in place of some of the conventional simulated generators, a novel combination with a circuit with special characteristics is used.

Conventional calculating boards are provided with a real generator supplying the board with power at some convenient frequency such as 400 cycles per second. The generators of the power system are simulated by machines commonly referred to as self-synchronous motors with a polyphase stator and single-phase rotor which operate as induction regulators or phase shifters. When these machines are all connected to the same real generator, which is usually a three-phase machine, the polyphase, or primary, windings are all in phase due to interconnection. The single-phase, or secondary, windings are also interconnected through the simulated system network of lines and loads. Being thus interconnected, both through the primary and secondary windings, any change in phase angle between the two windings of the phase shifter changes the current flowing through the adjusted machine and also the currents through all other interconnected machines.

This defect could, theoretically, be remedied by using independent real generators each with independent prime movers in place of the phase shifters in the calculating board, but this solution would be prohibitively expensive. It is, however, of theoretical interest in that such a solution establishes an ideal criterion of operation with which the performance of other methods may be compared.

A principal object of my present invention is to produce a network calculating board in which a plurality of simulated generators can be independently adjusted to specified loads with the same degree of independence as with a plurality of independently driven real generators. Another object is to produce a calculating board in which a plurality of simulated generators can be set to represent a plurality of real generators each set to deliver a constant power output and to permit variations in the network load or variation in the output of a particular generator to be absorbed by one or more generators arranged to operate at variable load. A related object is to provide a board in which the phase relationship of one simulated generator to another can be changed without changing the output of a third and other generators.

What constitutes this invention is set forth in the specification following and the accompanying drawing, and succinctly described in the appended claims.

The drawing is a simplified circuit diagram illustrative of the principles of operation of this invention.

In the drawing, a conventional power system is represented by a network of resistances, 1 to 8 inclusive. Resistors 1, 2 and 3 represent transmission line between generators and other lines 4 and 5, and loads 6, 7 and 8. These resistors are generalized actually to include inductive and capacitive reactances which, being well understood in the prior art, are omitted from the drawing for convenience.

A conventional real generator 11 is connected to the network through a regulating transformer 12 which may be omitted if the voltage of generator 1 is suitable for direct connection.

A plurality of negative impedance networks 13 and 14 are connected into the network as if they were independent generators. The structural details and the characteristics of operation of negative impedance networks are well known.

Networks suitable for use as components 13 and 14 are described by Brunetti and Greenough, page 542 of Proceedings of the Institute of Radio Engineers, for December 1942; also by E. L. Gintz, page 140 of Electronics, for July 1945, and are also described in a copending application for Patent Serial No. 83,281, "Stabilized Negative Impedance Circuit" by Halvor T. Strandrud, in which application has matured into Patent No. 2,557,154. From Strandrud's patent, it will be apparent that each network 13 and 14 is provided independently with power which, being direct current, has no phase relationship to generator 11 or to each other. The power supplies for networks 13 and 14 are indicated by batteries 15, 16, 17, and 18. Each negative impedance network...
as described by Strandrud includes, as illustrated by the network 13, two generators 21 and 22 and a tuned filter circuit 23. Correspondingly, network 14 comprises amplifiers 24 and 25, and filter 26.

In the operation of this system, the simulated generator 11, which is actually also a small real generator, provides the frequency control for the network calculating board network. The negative impedance networks 13 and 14 do not generate a frequency but act as passive impedances which carry currents of the frequency of generator 11. The magnitudes of the currents carried by the negative impedances 13 and 14 are proportional to their terminal voltages and inversely proportional to the magnitudes of the values of the impedances. The directions of the currents are the reverse of the currents carried by ordinary (positive) impedances connected to the system and so they appear as generators when viewed from the system point of view whereas ordinary impedances appear as loads.

The usual adjustments of system loads are made in the appropriate resistors of the board and in the simulated generators 11, 13 and 14. Changes in the magnitude and distribution of the system load are made by variation of individual load and line resistors and by adjustment of individual simulated generators. The negative impedance networks, being independent of phase except through interconnection in the simulated line and load network, can be independently adjusted for load as well as for power factor without changing the load and power factor of the other negative impedances except insofar as there may be unadjusted changes in voltage. If, under these conditions, the total load of the system remains constant, the simulated generator 11 which, being a real generator, takes or drops load to compensate for the loads dropped or taken by the negative impedance under adjustment.

I claim:

1. In a network calculating board, the combination of an alternating current generator providing power at a predetermined frequency, said generator being connected to a network of impedances representing lines and loads, said network of impedances also being connected to a plurality of negative impedance networks simulating real generators, said negative impedance networks being controlled in frequency by said alternating current generator.

2. In a network calculating board, the combination of a network of impedances simulating the actual lines and loads of a power system, an alternating current generator connected to said network of impedances and determining the voltage and frequency in said network, and a plurality of negative impedance networks connected to said network of impedances and responsive to said voltage and frequency, said negative impedances taking current from the first said network in direction opposite to that of an ordinary impedance, thereby simulating the action of a real generator.

3. The combination of claim 2 in which the negative impedance networks are supplied with a source of unidirectional energizing potential.

GLENN W. BILLIS.

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