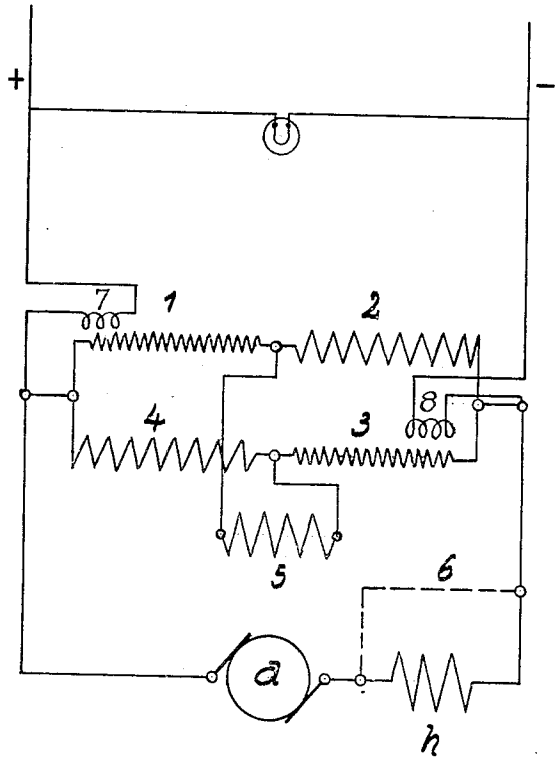
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SERIES WOUND MACHINE WITH ADDITIONAL EXCITATION IN BRIDGE CONNECTION

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## SERIES-WOUND MACHINE WITH ADDITIONAL EXCITATION IN BRIDGE CONNECTION.

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This invention relates to series wound generators and has for its object to provide a generator of this type which will produce a constant voltage at all speeds.

Since the building of the first direct current machine it has been the endeavor in the electrical art to produce a direct current dynamo which would give a uniform voltage in spite of variation in speed of revolution, load, and temperature, in order to meet the demands of lighting systems, particularly those of the incandescent bulb type. The need of means for maintaining a constant voltage occurs particularly in train lighting systems, in which the dynamos are driven by the car axles, the speed of which necessarily varies, and in systems in which dynamos driven by ungoverned water motors are used.

Heretofore, to overcome the changes in voltage in ordinary shunt wound dynamos due to changes in speed, shunt voltage regulators have been used, but these all had the technical disadvantage of requiring moving parts and contact devices. By the present invention constant voltage is secured by means of a boosting exciting winding which forms an arm of a Wheatstone bridge connected across the main circuit.

The invention will be described in connection with the accompanying drawing in which one form of the invention is diagrammatically represented.

The reference letter *a* represents the armature of a series wound generator of which *h* is the main field winding, which is so constructed as to produce a predetermined voltage at the lowest speed and normal current. The voltage can be adjusted by means of resistances in the shunt circuit 6. A boosting coil 5, which forms an arm of a Wheatstone bridge, is interposed in the main winding *h*. The Wheatstone bridge consists of arms 1 and 3, which are made as resistances dependent on voltage, that is, whose resistance varies with the applied voltage, and the arms 2 and 4, whose resistance is likewise dependent on voltage, but to a lesser extent, or in a reversed sense. The connections of the arms 1 and 4, and 2 and 3 lie in the armature circuit. The boosting winding 5 is connected to the connections of the arms 1 and 2, and 3 and 4. Every change in the potential difference between the bridge points 1—4 and 2—3 immediately creates a change in the potential difference between the bridge points 1—2 and 3—4, and thereby causes a variation of the current in the auxiliary exciting winding 5. The current in this winding flows according to the conditions either in the same direction as the current in the main winding *h*, or in opposed direction thereto, and the additional excitation therefore needs to be only a very small part of the total excitation.

The bridge can be so adjusted to the fundamental speed and full-load terminal voltage that it produces a positive or an opposed excitation, or no excitation in the boosting coil 5. By this simple means variation of the characteristic can be obtained. This is shown particularly clearly in an important use of the dynamo, namely, as a generator of constant voltage driven by an ungoverned water motor. As is well known the idling speed of a water motor (water-wheel, Pelton wheel, or turbine) is about 1.8 times the full load speed. If it could be assumed that the speed increases and decreases in inverse proportion to the load, and that the voltage characteristic of the dynamo is made a straight line by a corresponding choice of saturations, by so choosing the main current excitation that with a small load, and correspondingly higher speed, the same normal voltage is maintained as with the lower full load speed, with correspondingly higher load and exciting currents, the generator would produce a constant voltage over the whole range of speed. But as a matter of fact the curve of the dependence between load and speed in a water motor is a parabola, for as full load is approached the speed decreases faster than the load increases, while in the vicinity of racing speed the speed increases slower than the load decreases. On account of this characteristic of water motors the above mentioned assumption is not correct and a series wound motor will not produce a constant voltage at various speeds without something further.

If in accordance with the invention the main field winding is supplemented by an auxiliary winding which is made very sensitive to changes in voltage between its terminals by the Wheatstone bridge, the differences between the water motor characteristic and the dynamo characteristic are equalized, and a practically uniform voltage of the generator is obtained.

The same observations apply to generators

driven by any source of power which does not give a constant speed of rotation, or a speed varying in exact dependence upon the load. In these cases the total excitation must be made to correspond with the speed inverse ratio by corresponding adjustment of the main current excitation by the load current and of the boosting excitation by the boosting coil current, which is dependent upon the relationships of the Wheatstone bridge. In all these cases the dependence of voltage upon the temperature of the generator windings is very slight, due to the far greater effect of the main current excitation.

It is of the greatest importance for the rapid adjustment of the uniform terminal voltage under variations in speed, and for the maintenance of such voltage, that the resistances 1, 2, 3, and 4 be of such construction that they will adjust themselves to their stationary temperature after a change in current or voltage in the shortest possible time. For example if resistances 2 and 4 were made in whole or in part as exciting windings, variations from the desired voltage of as much as 20% would be possible, since as is well known, the resistance of exciting windings varies only slowly with variations in load. The use of resistances without any thought as to the length of time they require to adjust themselves to the necessary temperature will lead to no useful technical result. According to the present invention, therefore, resistances are used whose value is adjusted practically instantaneously with variations in voltage.

If the resistances of the Wheatstone bridge satisfy these requirements, with very slight changes in voltage in the armature (*a*) large currents will flow in the bridge arm or boosting coil 5. For example resistances 1 and 3 may be positively dependent upon voltage and increase with increasing voltage (e. g. iron resistances, or metal filament lamps) and the resistances 2 and 4 may be constant, or negatively dependent upon voltage (e. g. carbon-like resistances. or carbon filament lamps).

The operation of the Wheatstone bridge can be further influenced and increased by an additional heating of the resistances 1 and 3, or 2 and 4, or even all the resistances by means of the useful current of the machine or a part of the same. In the drawing are shown by way of example the heating coils 7 and 8 connected in series in the main circuit and arranged in heat exchange relation with the resistances 1 and 3. The heating of the iron resistances by the useful current offers among other things the possibility of reducing the current requirement of the bridge for the same voltage characteristic.

Having thus described my invention, I claim:

1. In a series wound machine, a Wheatstone bridge the adjacent resistances of which are differentially variable under a change in voltage, connections between two opposite connections of said resistances and the terminals of the machine, and a boosting winding connected across the other two opposite connections of said resistances.

2. A series wound machine according to claim 1 in which the resistances of the Wheatstone bridge are of such construction that their temperature is adjusted practically instantaneously by changes in voltage.

3. A series wound machine according to claim 1 in combination with means for heating the resistances of the Wheatstone bridge by means of the useful current of the machine.

4. A series wound machine according to claim 1 in combination with electrically operable heating means for the resistances of the Wheatstone bridge and means for supplying current from the system for operating said heating means.

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