A. A. TIRRILL.

SYSTEM OF VOLTAGE REGULATION.

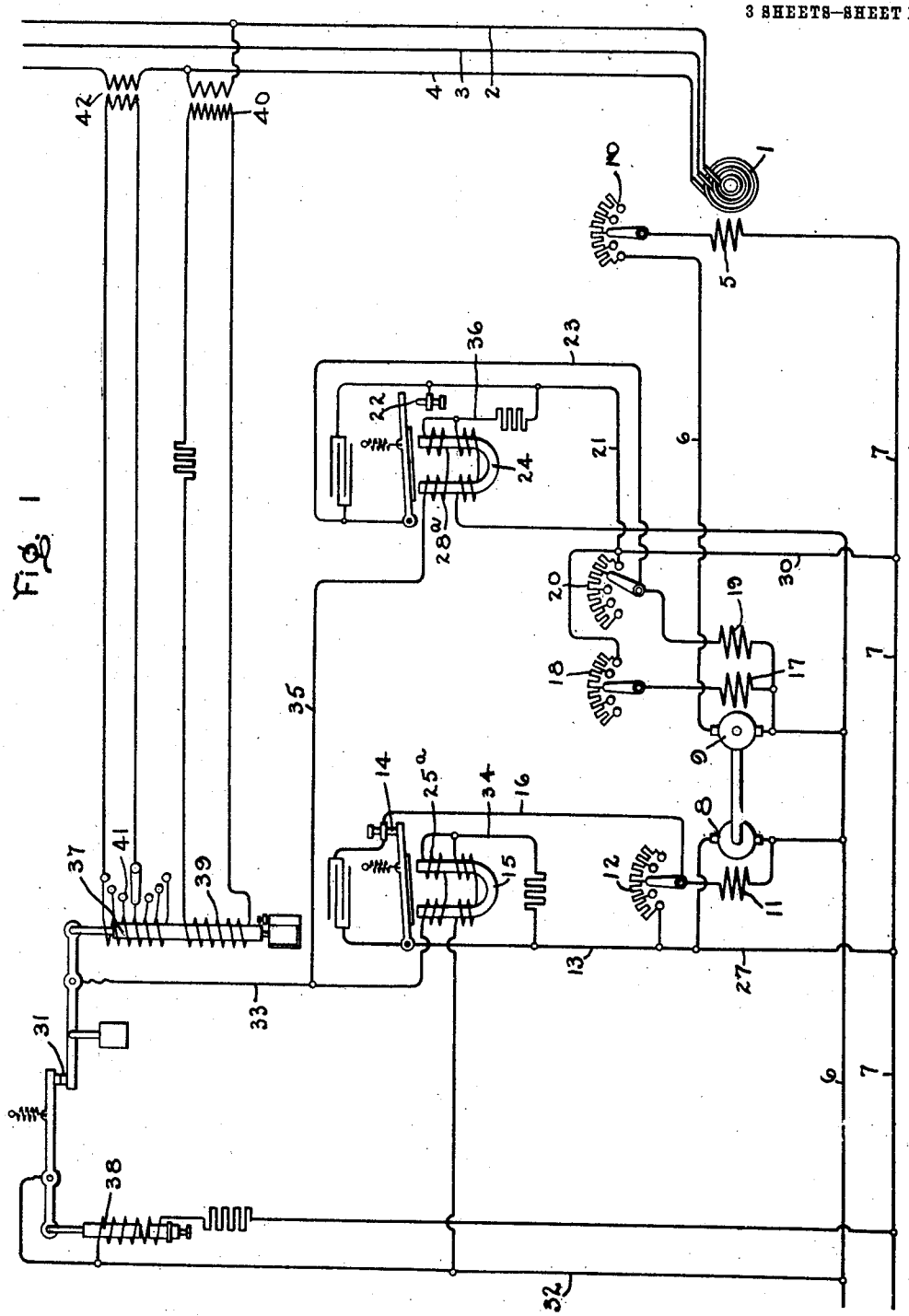
APPLICATION FILED JAN. 4, 1909.

1,001,711.

Patented Aug. 29, 1911.

3 SHEETS—SHEET 1.

Fig. 1



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3 SHEETS—SHEET 2.

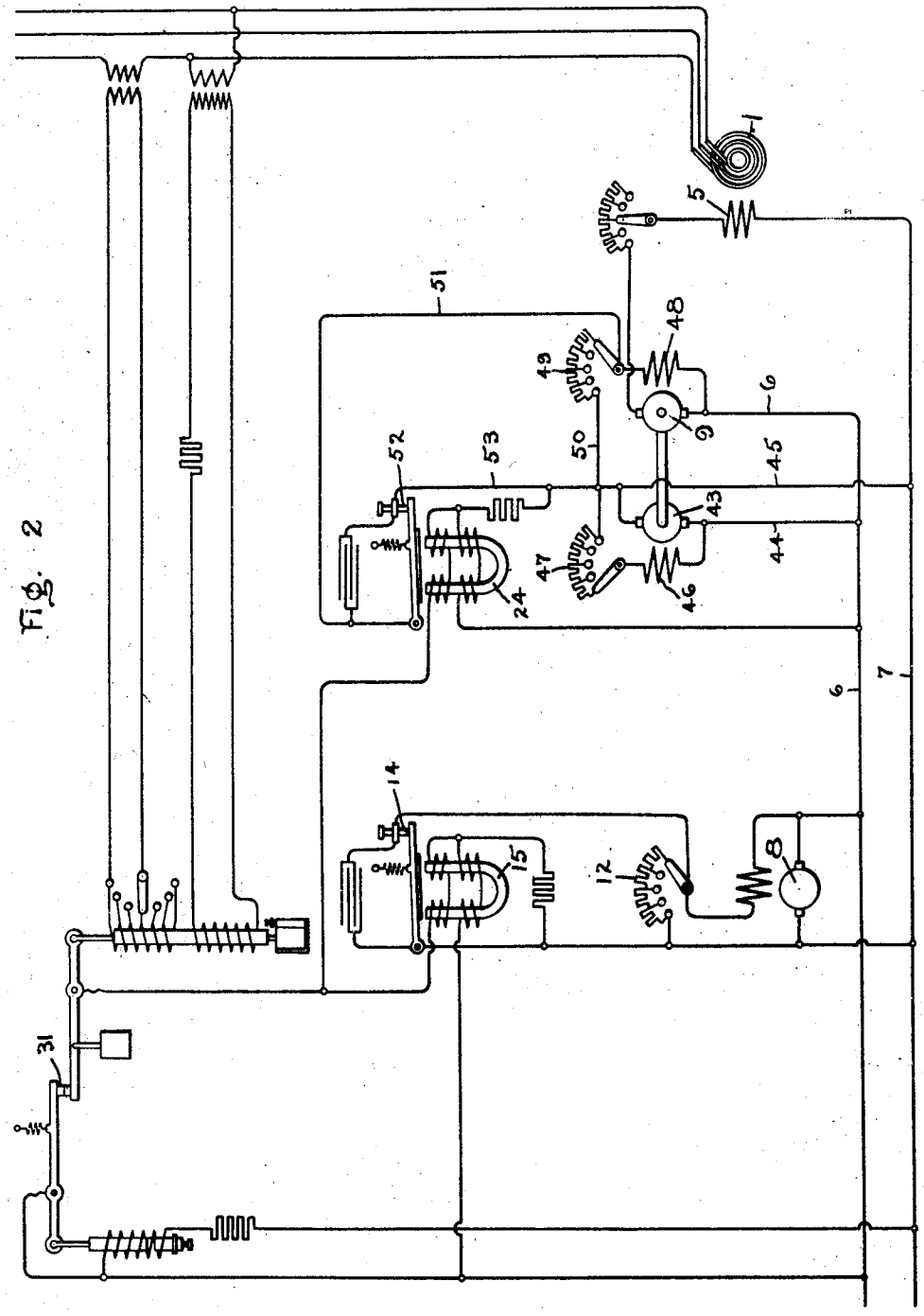

Fig. 2.

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3 SHEETS—SHEET 3.

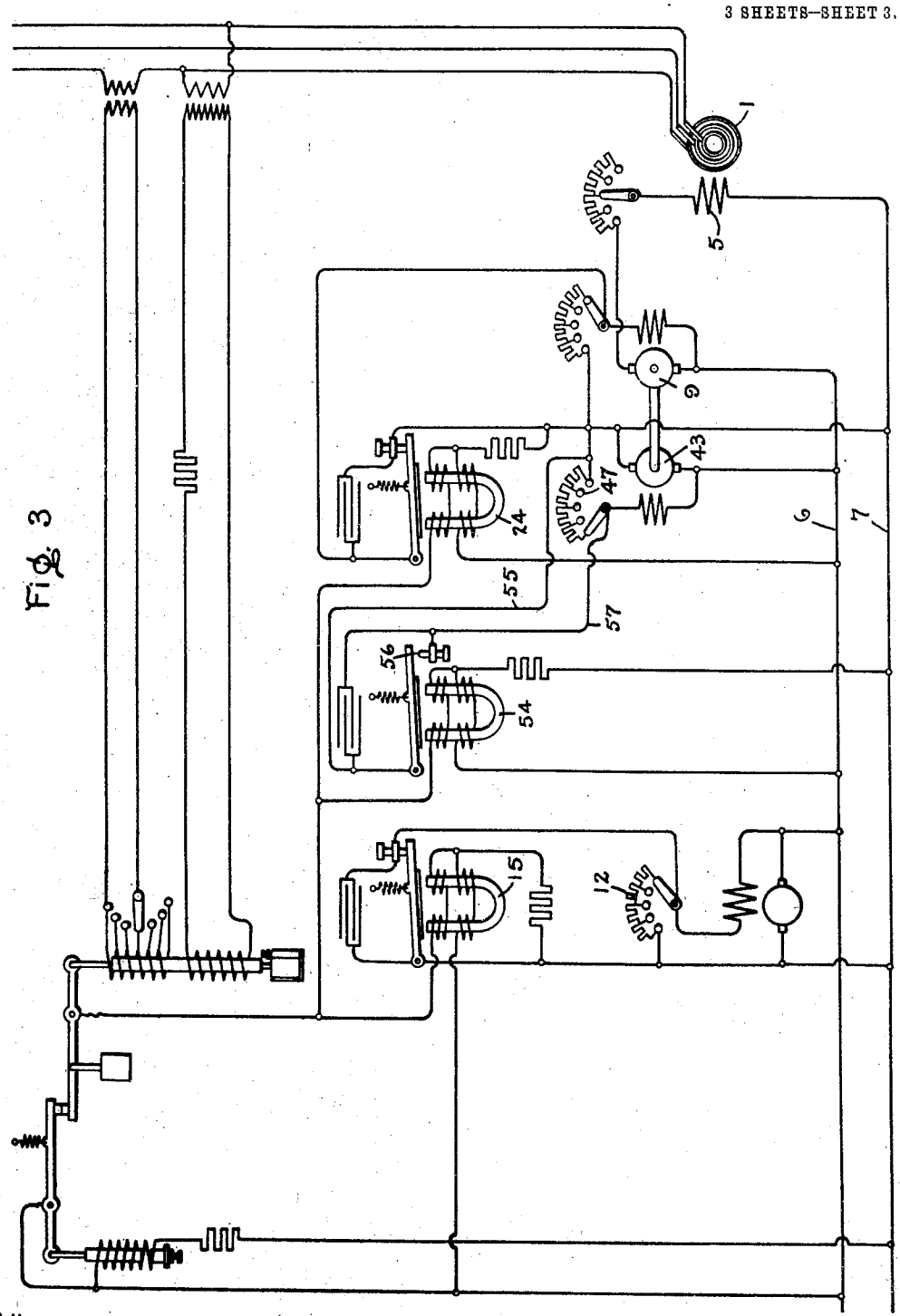

Fig. 3

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UNITED STATES PATENT OFFICE.

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SYSTEM OF VOLTAGE REGULATION.

1,001,711. Specification of Letters Patent. **Patented Aug. 29, 1911.**

Application filed January 4, 1909. Serial No. 470,659.

To all whom it may concern:

Be it known that I, ALLEN A. TIRRILL, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Systems of Voltage Regulation, of which the following is a specification.

My invention comprises a system of field excitation in connection with voltage regulators of the well-known Tirrill type, and its aim is to increase the range of regulation furnished with this type of regulator. The ordinary range of the Tirrill regulator is about 100%. With certain types of generators, for example, the inductor type, it is desirable to regulate between wider limits than is afforded by the use of the Tirrill regulator operating in the ordinary manner. According to my invention the range of excitation of the Tirrill regulator is extended 200% and more. This percentage of regulation is obtained by the use of an exciter operating in series with a booster generator, the regulator being used to vary simultaneously the field excitation of the exciter and the booster, and in this manner the two furnish a current which can be varied over wide limits in order to obtain the desired range of excitation of the field of the main generator.

The accompanying drawings illustrate several embodiments of my invention.

Figure 1 is a diagram of circuits, illustrating my invention in connection with a booster directly connected to the shaft of the exciter and provided with a differentially-wound field; Fig. 2 illustrates a modified system of excitation, in which the booster-generator is driven by a motor energized by the exciter current; Fig. 3 illustrates a modification in which a still wider range of excitation is obtained by an additional relay operating to vary the field of the motor driving the booster.

In Fig. 1 an alternating-current generator 1 is connected to a load circuit 2, 3, 4 and provided with a separately-excited field 5. This field is connected by means of conductors 6, 7 to an exciter 8, which may be driven by a separate source of power or from the generator shaft, and which is in series with a booster-generator 9 and a manually-adjustable rheostat 10. The exciter 8 has a shunt field 11, which is in series with a manually-adjustable rheostat 12. Around the rheostat 12 is a shunt circuit, consisting of conductors 13, the contacts 14 of the relay magnet 15, and the conductor 16. The booster 9 has two opposing field windings. The winding 17 is connected permanently across the exciter mains 6, 7 in series with a rheostat 18. The opposing winding 19 is connected across the exciter mains in series with a rheostat 20. The rheostat 20 is likewise provided with a shunt circuit, consisting of conductor 21, the contacts 22 and conductor 23. The contact 22 is controlled by the relay magnet 24. It will be observed that the contact 22 is on the lower side of the armature of magnet 24, while the contact 14 is on the upper side of the armature of magnet 15, so that when the contact 14, controlled by magnet 15, is closed, the contact 22, controlled by magnet 24, is open. The relay magnets 15 and 24 are differentially wound, one winding in each case being connected permanently across the exciter mains 6, 7. The opposing windings of each relay magnet are likewise connected across the exciter mains through the contacts 31 of the main control mechanism of the regulator. The circuit of the opposing winding 25^a on magnet 15 is through conductor 32, contacts 31, conductors 33, 34, 13, 27. The opposing winding 28^a of magnet 24 is connected across the exciter mains through conductor 32, contacts 31, conductors 33, 35, 36, 21 and 30. The construction of the main controlling mechanism of the regulator is similar to that usually found in regulators of the Tirrill type. It consists, briefly, of two conjugated magnets, an alternating-current magnet 37, which is under the influence of the current and voltage of the load circuit 2, 3, 4 of the main generator and a direct-current magnet 38, which is connected across the exciter mains and responds to variations of exciter voltage. The magnet 37 is provided with a voltage winding 39 connected to a potential transformer 40 and a compensating current winding 41 connected to a series transformer 42.

The operation of the system illustrated in Fig. 1 is as follows: The resistances 10

and 12 are turned to such position that if the shunt circuit around resistance 12 is open the exciter will furnish current for a desired minimum excitation in generator 1. The main regulating mechanism containing contacts 31 is adjusted to close when the voltage falls below normal thereby energizing the windings 25^a and 28^a of the relay magnets 15 and 24. This will bring about a closure of the contacts 14, short-circuiting the resistances 12. The exciter 8 will, therefore, begin to build up its voltage. When the relay contacts 14 are closed the reversed relay contacts 22 are open, therefore the shunt circuit around the resistance 20 is open. The current in the winding 19 of the booster 9 will be decreased and the booster field will be furnished almost entirely by the winding 17. This will cause the booster to assist the exciter voltage and in proportion increase the field excitation of generator 1. The voltage of the current in conductors 2, 3, 4 will, therefore, tend to increase until the contacts 31 of the main control magnet open, causing contacts 14 to open and contacts 22 to close in the manner already made clear. This will insert resistance 12 in the field of the exciter 8, and its voltage will, therefore, fall to a low value. As the resistance 20 of the opposing winding 19 of the booster has at the same time been shunted, the current in this winding will rise to a high value, weakening or reversing the field of the booster, depending upon the proportioning of these windings. The booster 9 will, therefore, either furnish only little assisting electromotive force, or furnish an opposing electromotive force, as desired, causing the excitation of the field 5 to fall to a low value. The opening and closure of the contacts 31 and, therefore, of the relay contacts will take place at a high rate of speed, and the range from minimum to maximum excitation caused by a series of vibrations of these contacts is amplified in accordance with the operation of the booster.

Referring to Fig. 2, the excitation of the field 5 of the main generator 1 is furnished in a manner similar to the arrangement shown in Fig. 1, by means of an exciter 8 and a series booster 9. The booster in this case is connected to a shunt-wound motor 43 connected across the exciter mains 6, 7 by means of conductors 44, 45. The field 46 of the motor may be varied by adjusting the field rheostat 47. In the present system the booster 9 is provided with but a single field winding 48, which is connected in series with a rheostat 49 across the exciter mains 6, 7 by means of conductors 50, 45. The resistance 49 is provided in a manner similar to that shown in Fig. 1, with a shunt consisting of conductors 51, contacts 52, conductors 53, 50. The contacts 52 are controlled by relay magnet 24, which is similar to the magnet 24 described in connection with Fig. 1, except that the contacts 52 are not reversed, but are similar to the contacts 14 of magnet 15.

In Fig. 3 the arrangement of the exciter with its separately-driven booster is similar to that shown in Fig. 2, with the modification that in this case the field rheostat 47 of the motor 43 has a shunt circuit controlled by a relay magnet 54 operating in conjunction with the relay magnets 15 and 24, so as to weaken the field of the motor when the exciter voltage rises to a high value. For this purpose the rheostat 47 is shunted by conductors 55, reverse relay contacts 56 and conductor 57. In other respects the system illustrated in Fig. 3 is similar to that illustrated in Fig. 2.

The operation of the system described in Fig. 2 is as follows: When the voltage of the exciter 8 rises to a high value by the shunting of its field rheostat 12, the field rheostat 49 of the booster 9 is short circuited at the same time, thereby more strongly energizing the booster field. The motor 43 tends to accelerate in speed when the voltage rises in conductors 6 and 7, and, therefore, drives the booster, with its increased field excitation, at a higher rate of speed, thereby reinforcing the voltage of the exciter current in conductors 6 and 7 to a proportionate amount. A still wider range is obtained by the system illustrated in Fig. 3, as in this case the field of the motor 43 is weakened by the insertion of the resistance 47 when the exciter voltage is rising. This causes a still greater acceleration of the speed of motor 43 and, thereby causes the booster 9 to generate a proportionately increased assisting electromotive force.

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

1. In combination, a generator, an exciter therefor, a booster generator in series with the exciter, and means for simultaneously varying the field excitation of the exciter and the booster generator.

2. The combination of a generator, an exciter therefor, a booster generator in series with the exciter, and a voltage regulator for simultaneously varying the field excitation of the exciter and its booster.

3. In combination, an alternating-current generator, an exciter therefor, a booster in series with the exciter, a motor for driving said booster connected across the exciter circuit, and means for simultaneously varying the field excitation of the exciter and its booster.

4. In combination, an alternating-current generator, an exciter therefor, a booster in series with the exciter, a motor for driving said booster connected across the exciter circuit, and means for simultaneously va-

rying the field excitation of the exciter, the booster and the said driving motor.

5. In combination, an alternating-current generator, an exciter therefor, a booster in series with the exciter, resistances in the fields of the exciter and of the booster, and a regulator for shunting said resistances.

In witness whereof, I have hereunto set my hand this second day of January, 1909.

ALLEN A. TIRRILL.

Witnesses:
BENJAMIN B. HULL,
HELEN OXFORD.