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TRANSMISSION REGULATION SYSTEM

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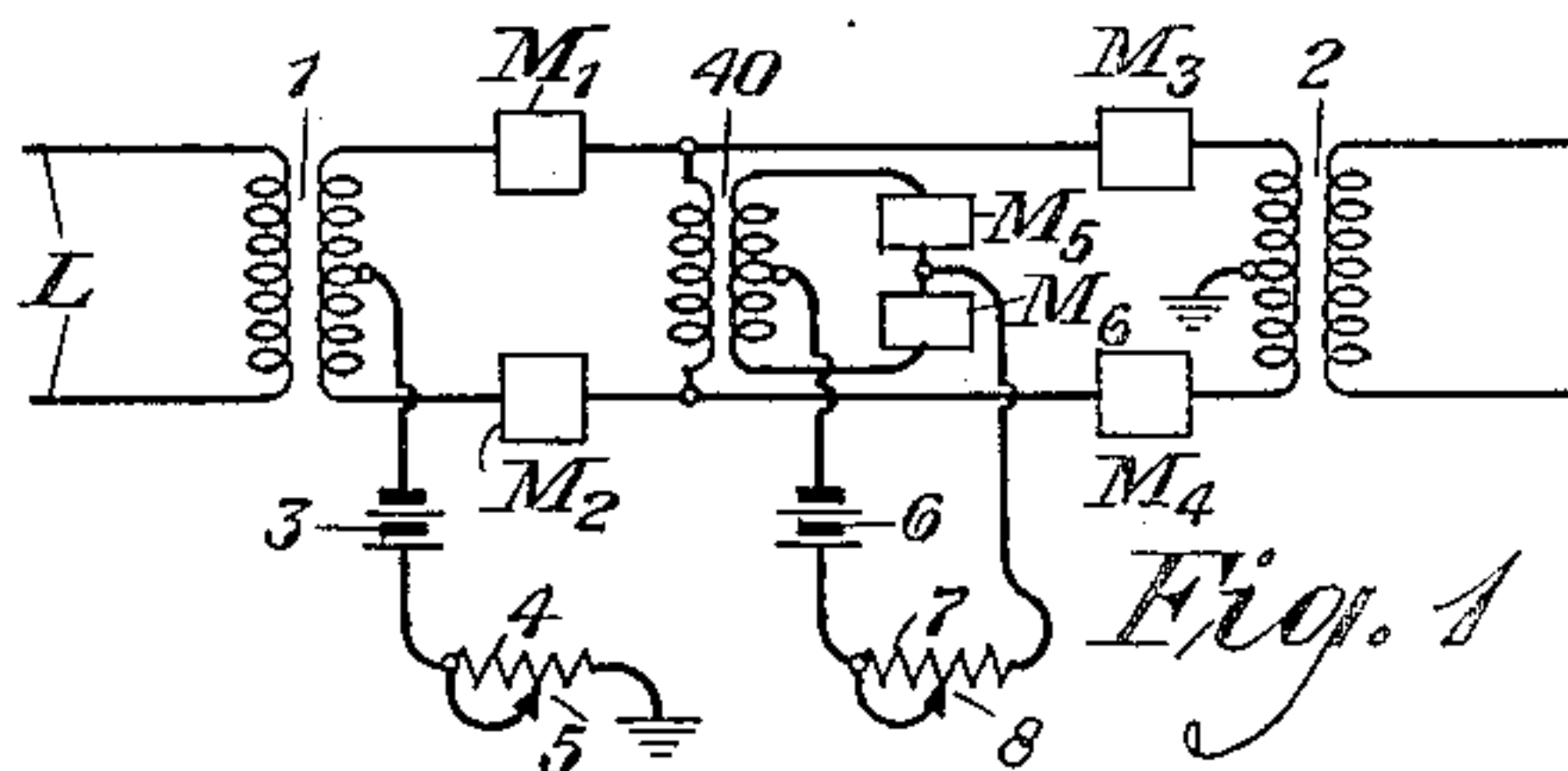


Fig. 1

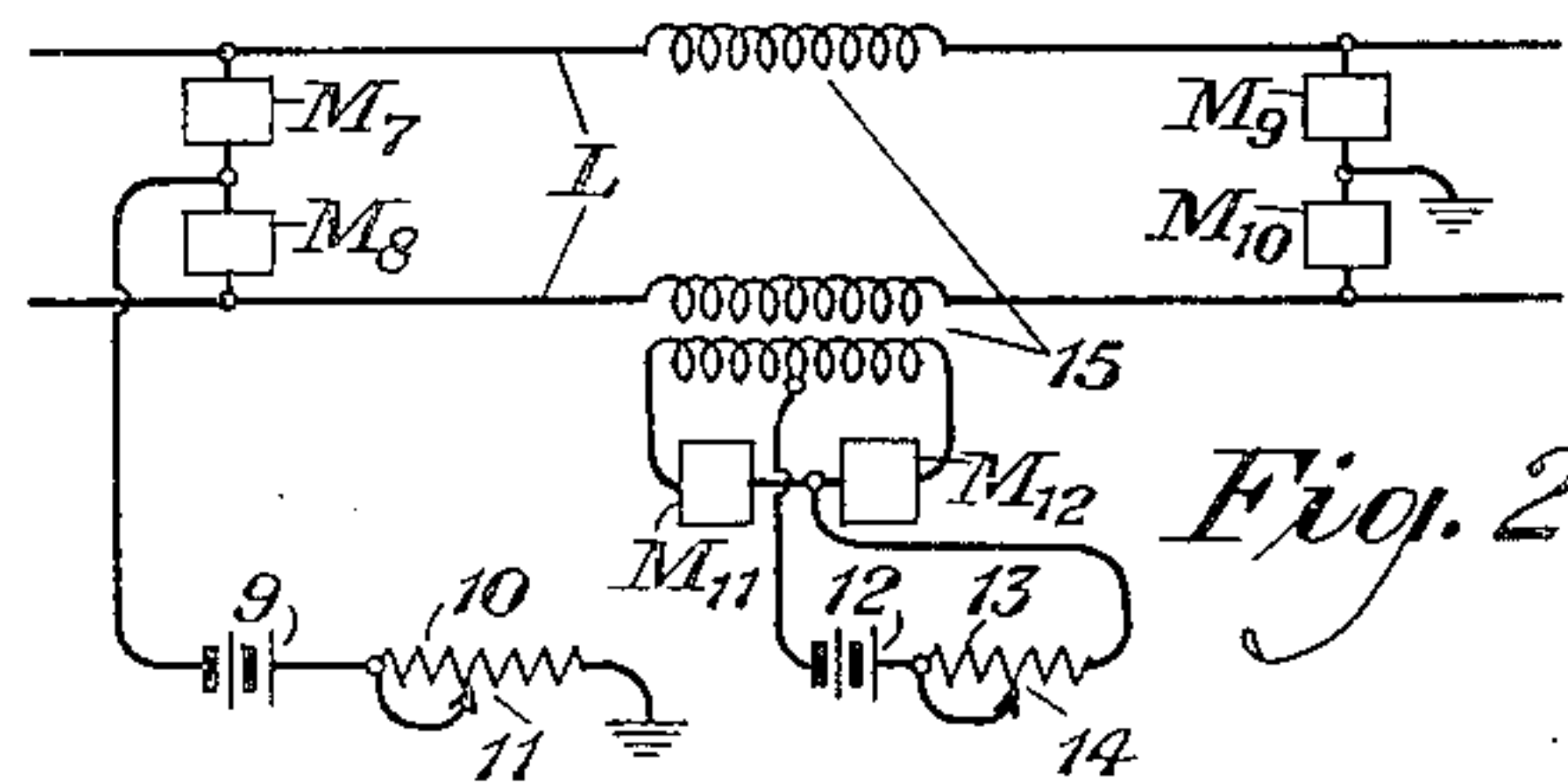


Fig. 2

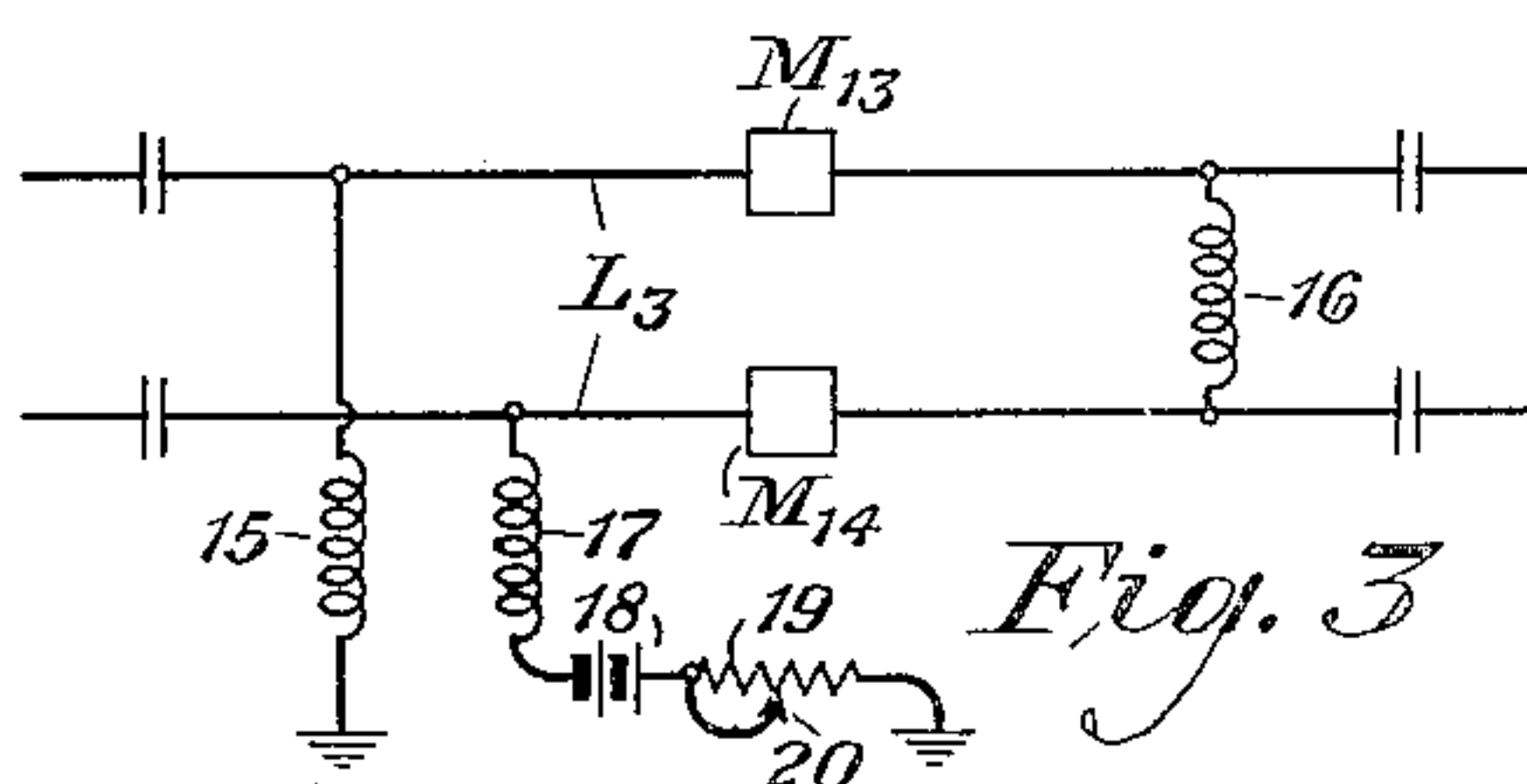


Fig. 3

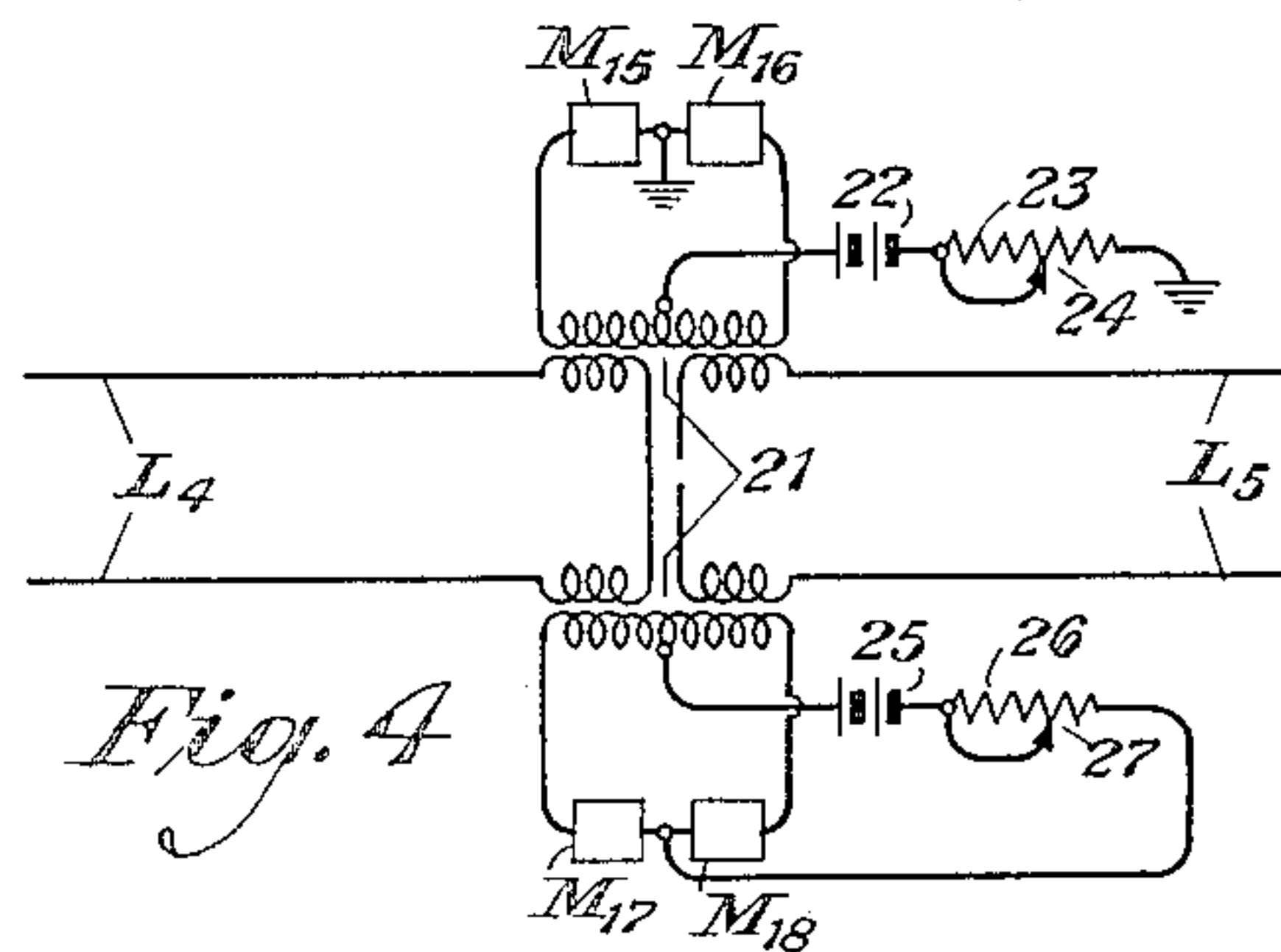


Fig. 4

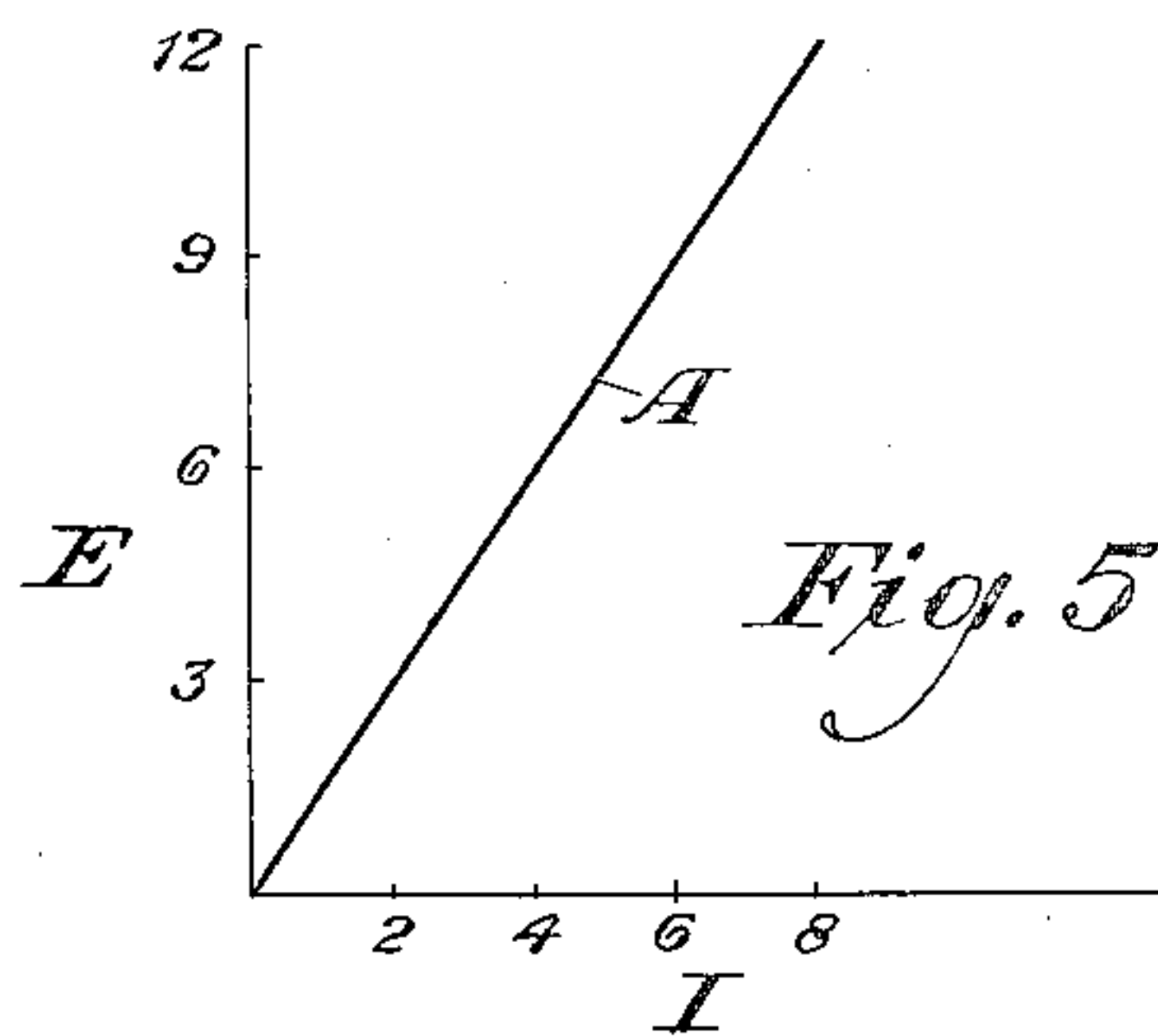


Fig. 5

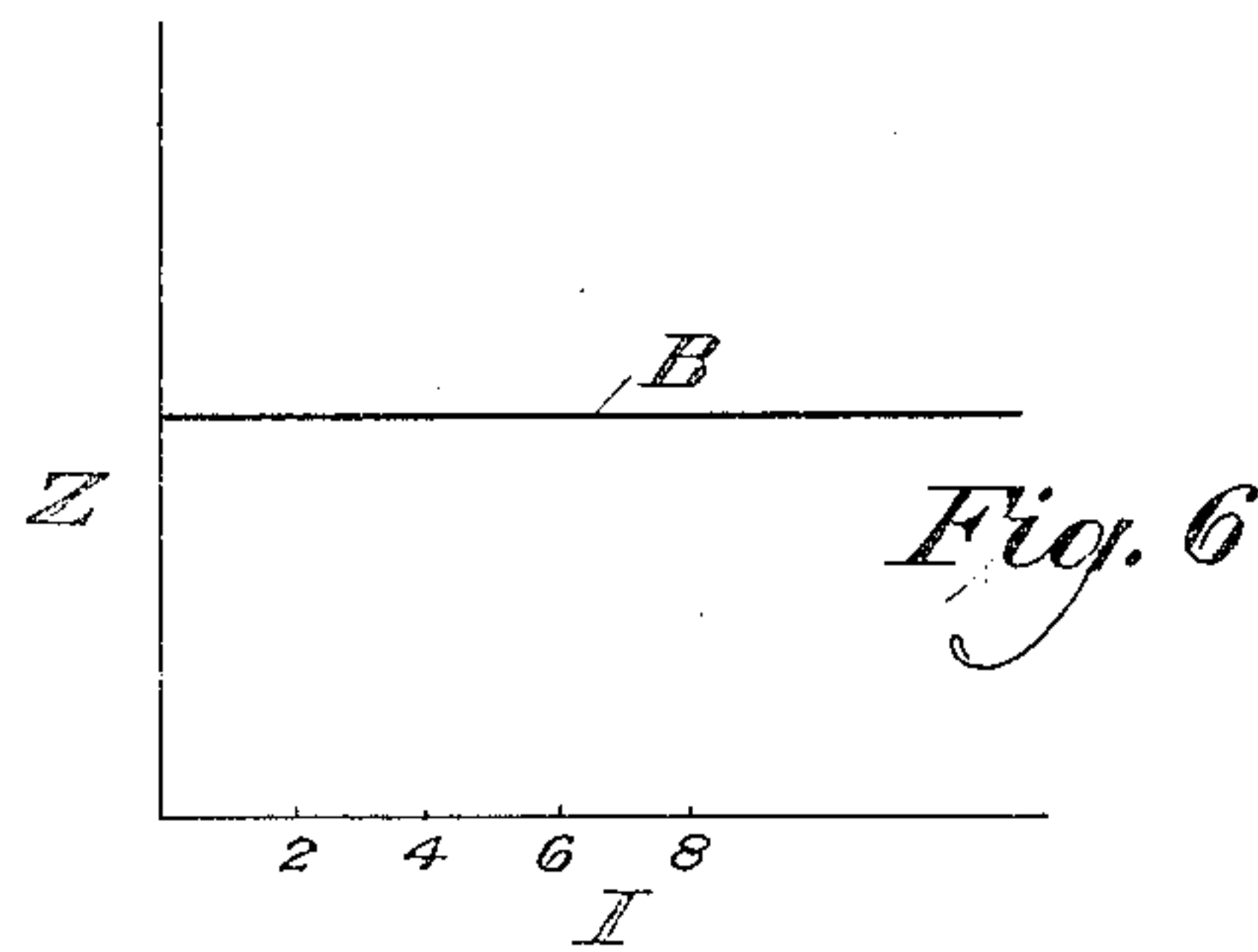


Fig. 6

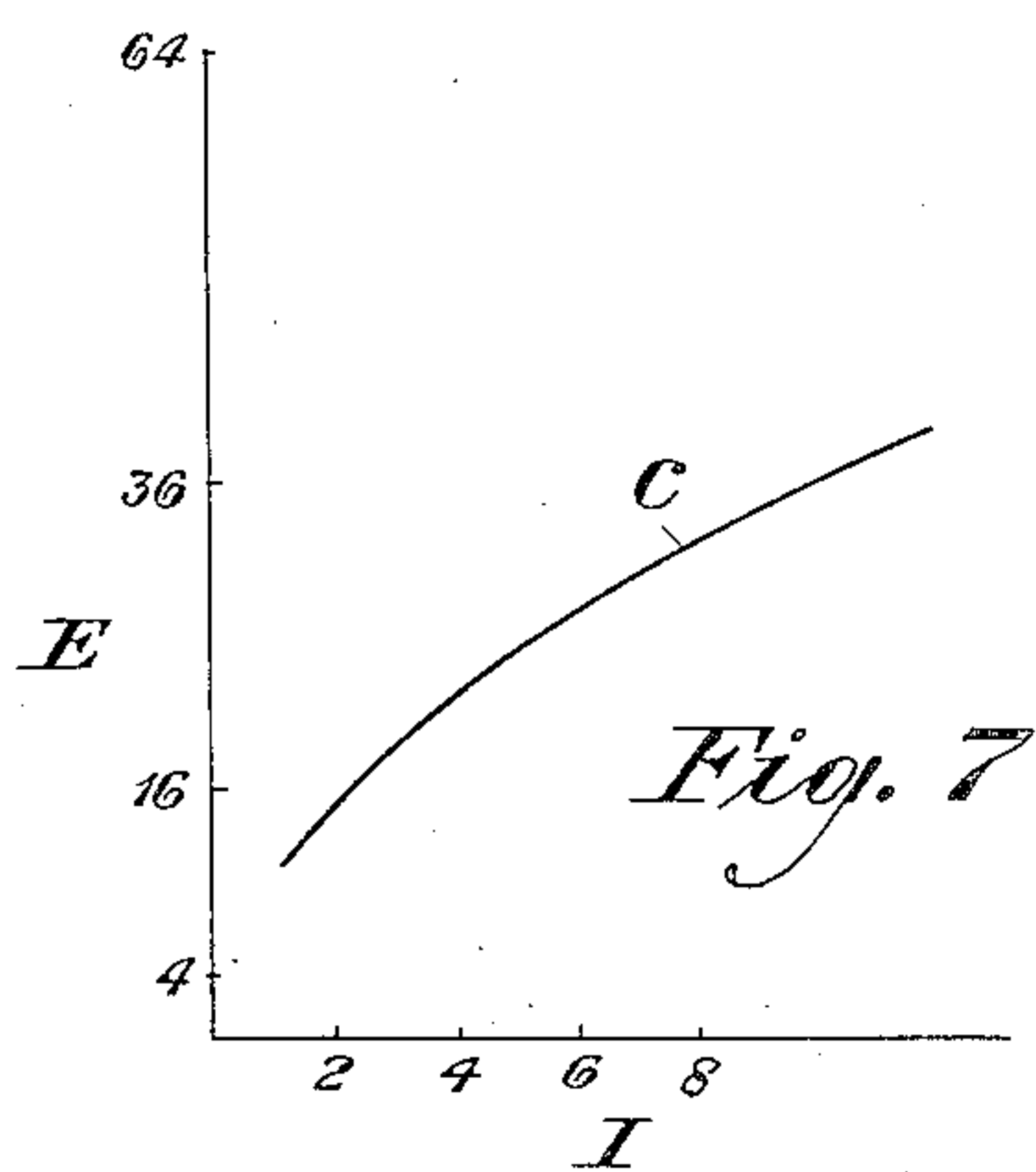


Fig. 7

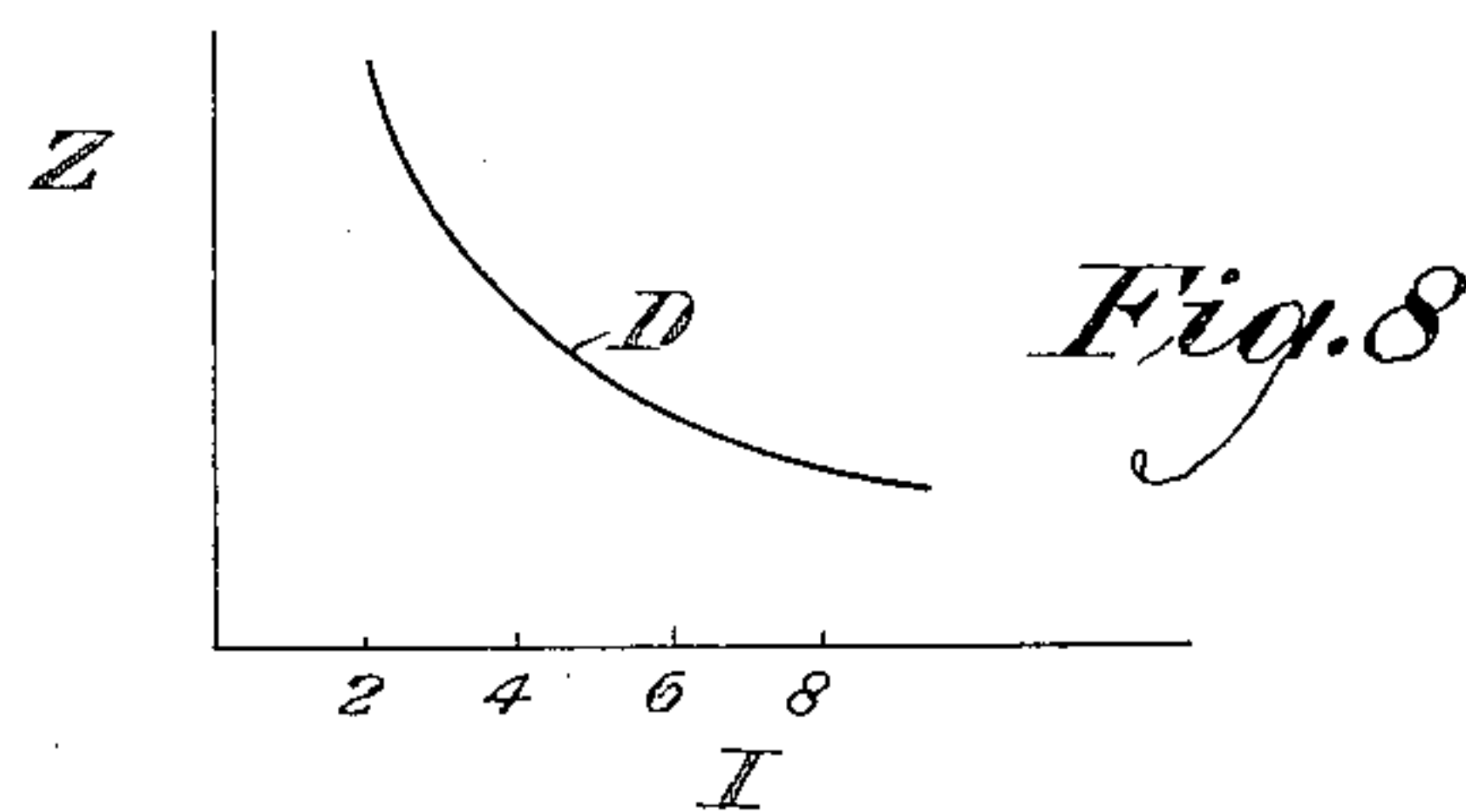


Fig. 8

Note: $\square^M$ - represents instantaneous operating device having non-linear voltage current characteristics

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TRANSMISSION REGULATION SYSTEM

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9 Claims. (Cl. 178—44)

This invention relates to transmission lines and more particularly to improved arrangements for effecting transmission regulation on such lines.

Former systems of effecting transmission regulation on telephone circuits are quite complex and may require reliable operation of a large number of relays. The present invention is an improvement over such systems in that the method of operation thereof is greatly simplified. The method of operation of the arrangements of the invention consists in controlling the transmission loss in an artificial line or network in the transmission line by varying the impedance of the individual elements of the line or network by varying the amount of direct current transmitted through them. Other objects and features of the invention will appear more fully from the detailed description thereof hereinafter given.

In general the problem involved in regulating transmission in a circuit is to obtain a loss which may be inserted in the circuit to be regulated and which may be controlled by some suitable means. If, for example, a material could be found, the impedance of which could be controlled by the amount of direct current flowing through it, then several networks utilizing such a material could be devised for regulating transmission in accordance with the principles of the invention. The impedance of a material depends upon the slope of the voltage-current curve. If, therefore, it is desired to obtain a material such that the impedance is a function of the current, it is necessary to look for one having a non-linear voltage-current characteristic. Measurements have shown certain materials, such as copper oxide rectifying units and "Thyrite", to have non-linear voltage-current characteristics. These measurements have indicated that the admittance of copper oxide elements to small alternating currents superimposed on the direct current flowing through the element depends upon the value of the direct current. This is also true of the material "Thyrite". In accordance with the arrangements of the invention, elements having the above characteristics are utilized to form networks in a transmission line. By varying the impedance of these individual elements by changing the amount of direct current flowing there-through, the loss of the network may be changed and the transmission over the line controlled and regulated.

The invention may be more fully understood from the following description together with the accompanying drawing in the Figures 1 to 8 of which the invention is illustrated. Figs. 1 to 4

are circuit diagrams embodying certain preferred forms of the invention. Figs. 5 to 8 illustrate graphically certain principles of operation of the arrangements of the invention. Similar reference characters have been utilized to denote like parts in the various figures of the drawing.

As has been heretofore pointed out the impedance of a material depends on the slope of its voltage-current curve. In Fig. 5 is shown the curve A of a material or device having a linear voltage-current characteristic. In Fig. 6 the impedance of such a material or device is shown by the line B. It appears from B that as the current increases the impedance will remain constant for a material having a linear voltage-current characteristic. In Fig. 7 is shown the curve C of a material or device having a non-linear voltage-current characteristic. If the impedance for this device is plotted as shown by the line D of Fig. 8 it will appear that the impedance will change as the current varies, when the device has a non-linear voltage-current characteristic.

In accordance with the arrangements of the invention, the network for obtaining a loss to be inserted in the transmission circuit to be regulated is constructed of elements or materials having a non-linear voltage-current characteristic and the impedance of these elements of the network is controlled by varying the direct current therethrough. By this means the impedance of the network may be controlled and the transmission regulated. From certain measurements various materials have been found which have suitable non-linear voltage-current characteristics for use in the networks of the invention. For example, among materials of this kind are copper oxide rectifying units and a material known as "Thyrite". Measurements have indicated that the admittance of copper oxide rectifying elements to small alternating currents superimposed on the direct current flowing through the element depends upon the value of the direct current. This is also true of the material "Thyrite". Accordingly either of these materials might be used in constructing the networks of the invention. It is understood that these specific materials are referred to herein for purposes of illustration only and that other materials having non-linear voltage-current characteristics may equally well be utilized in the arrangements of the invention.

In Fig. 1 is shown a transmission line L having included therein a regulating network constructed in accordance with the principles of the invention for controlling the transmission in said

line. Inserted in each side of the line L would be the devices M_1 , M_3 , M_2 and M_4 . These devices might be copper oxide rectifying units or a material known as "Thyrite" or any other suitable material having a non-linear voltage-current characteristic. Connected to the midpoint of one of the windings of transformer 1 would be the battery 3, and the resistance 4 which in turn might be varied by switch 5. The midpoint of a transformer 2 in the line would also be grounded. With the above arrangement the impedance of devices M_1 , M_2 , M_3 and M_4 could be varied by the operation of switch 5 and the consequent changing of the flow of direct current from battery 3 through said materials. Connected across the line as shown would be the transformer 40. To one winding thereof would be connected the devices or materials M_5 and M_6 similar to those heretofore mentioned. Connected to these devices as shown would be a circuit including the battery 6, and the resistance 7 adapted to be varied by the switch 8. The impedance of devices M_5 and M_6 may thus be varied by changing the amount of direct current flowing therethrough from battery 6. The network as shown constitutes an "H" pad or network of resistance elements utilized to regulate transmission. By operating the switches 5 and 8, the impedance of the various elements of the network may be varied by changing the amount of direct current flowing therethrough and hence the impedance of the network as a whole may be varied to control and regulate transmission in the line L. Because of the balanced arrangement, the direct currents from batteries 3 and 6 will not affect the magnetic state of the cores of the transformers 1 and 2 and the alternating currents will not flow in the direct current circuits.

A modification of the network of the invention is shown in Fig. 2. Bridged across the line L_2 at one point would be the devices M_7 and M_8 . These devices would be similar to those heretofore mentioned and would have non-linear voltage-current characteristics. Bridged across the line L_2 at another point would be the devices M_9 and M_{10} . Between the last mentioned two devices would be connected a ground and between the first mentioned two devices would be a circuit including the battery 9, and the resistance 10 adapted to be varied by the switch 11. By this arrangement the impedance of the elements M_7 , M_8 , M_9 and M_{10} may be varied by changing the amount of direct current from battery 9 flowing through them. Between the two points mentioned in the circuit would be located the transformer windings 15. Connected to one of the transformer windings would be the devices or materials M_{11} and M_{12} . Connected to these devices would be the battery 12, and the resistance 13 adapted to be varied by the switch 14. By this arrangement the impedance of elements M_{11} and M_{12} may be varied by changing the amount of direct current from battery 12 flowing therethrough. By operating switches 11 and 14 the impedance of the various elements of the network may be varied by changing the amount of direct current flowing therethrough and hence the impedance of the network as a whole may be varied to control and regulate transmission in the line L_2 .

In Fig. 3 is shown a further modification of the arrangements of the invention. Connected in each side of the line L_3 are the devices or materials M_{13} and M_{14} similar to those heretofore mentioned—bridged across the line at one point

would be the choke coil 16. Connected from one side of the line to ground would be the choke coil 15. Connected to the other side of the line would be a circuit including the choke coil 17, the battery 18, and the resistance 19 adapted to be varied by the switch 20. Condensers are inserted in the wires as shown to confine the direct current from battery 18 to the desired parts of the circuit. By operating the switch 20 the impedance of elements M_{13} and M_{14} may be varied by changing the amount of direct current flowing therethrough from battery 18. In this manner the impedance of the network as a whole may be varied to control and regulate transmission in the line L_3 . The inductances provide a path for the direct current without shunting the alternating current away from the line. The condensers keep the direct current from the line wires.

In Fig. 4 two line sections L_4 and L_5 are interconnected through the windings of a hybrid coil 21. Connected to one of the hybrid coil windings would be the devices or materials M_{15} and M_{16} similar to those heretofore mentioned. A ground would be connected between these devices. Connected to the last mentioned winding would be a circuit including the battery 22, and the resistance 23 adapted to be varied by the switch 24. Connected to another of the hybrid coil windings would be the devices or materials M_{17} and M_{18} . Connected thereto would be a circuit including the battery 25, and the resistance 26 adapted to be varied by the switch 27. By operating the switches 24 to 27 the impedance of the individual devices M_{15} , M_{16} , M_{17} and M_{18} may be varied by changing the amount of direct current flowing therethrough from batteries 22 and 25. This will vary the impedance of the hybrid coil windings. In this manner the degree of balance between the hybrid coil windings may be varied to control and regulate transmission between the lines L_4 and L_5 .

Obviously the switches, such as 5, 8, 11, 14, 20, 24 and 27, might be controlled by any well known form of pilot wire regulator if desired.

While the invention has been disclosed as embodied in certain specific forms which are deemed desirable, it is understood that it is capable of embodiment in many and other widely varied forms without departing from the spirit of the invention as defined by the appended claims.

What is claimed is:

1. A signal transmission line over which alternating currents are transmitted, a network included in said line composed of elements in series in said line and elements in shunt in said line between said series elements, said elements being composed of materials having instantaneous non-linear voltage-current characteristics, circuits for transmitting direct current through said elements, and means for varying the resistance of said circuits to vary the impedance of said elements to alternating currents.

2. A signal transmission line over which alternating currents are transmitted, a network included in said line composed of elements connected in series and in shunt of said line, said elements having instantaneous non-linear voltage-current characteristics, circuits for transmitting direct current through said elements, and switching means for varying the resistance of said circuits to vary the impedance of said elements to alternating currents.

3. The method of controlling the transmission of signals over a line which consists in introduc-

ing a network in said line comprising a plurality of rectifier units and varying the loss of said network by changing the impedances of the individual units composing said network by varying the amount of direct current flowing from the input to the output of said individual units.

4. A signal transmission line, a network included therein composed of a plurality of individual rectifier units, means for transmitting direct current from the input to the output of each of said units and means for varying the amount of direct current thus transmitted through said units.

5. The method of controlling the transmission of alternating current signals in a line, which consists in introducing a network in said line comprising a plurality of units having non-linear voltage current characteristics and exhibiting a positive resistance at all points in said characteristics and effecting a practically instantaneous variation in the loss of said network by instantaneously changing the impedances of the individual units composing said network with respect to the alternating current signals by transmitting direct current between the input and output terminals of said individual units and varying the amount of direct current thus transmitted through said units.

6. The method of varying the alternating current signal transmission loss of a network composed of individual units having instantaneous non-linear voltage current characteristics and exhibiting a positive resistance at all points in said characteristic, which consists in transmitting between the input and output terminals of said individual units direct current in varying amounts

to vary the impedance of said units to alternating currents.

7. A signal transmission line over which alternating currents are transmitted, a network included therein composed of individual elements having instantaneous non-linear voltage current characteristics and exhibiting a positive resistance at all points in said characteristic, means for transmitting direct current between the input and output terminals of said elements, and means for varying the amount of direct current thus transmitted through said units to vary the impedance of said units to alternating current.

8. A transmission line comprising two line sections connected through the windings of a hybrid coil, elements connected in circuit with one of the windings, further elements connected in circuit with another of the windings of said coil, said elements having non-linear voltage current characteristics, and means for transmitting variable amounts of direct current from the inputs to the outputs of said elements whereby their impedance may be varied and the balance of the hybrid coil changed to control transmission over said line.

9. The method of varying the transmission loss for alternating current signals of a network composed of individual elements each having practically instantaneous non-linear voltage current characteristics and exhibiting a positive resistance at all points in said characteristic independent of temperature, which consists in transmitting between the inputs and outputs of said individual elements direct current in varying amounts to vary the impedance of said elements to alternating currents.

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