P. A. CAMPBELL.

METHOD OF AND APPARATUS FOR REPEATING TELEPHONE CURRENTS.

APPLICATION FILED JULY 20, 1909.

942,885.

Patented Dec. 14, 1909.

3 SHEETS—SHEET 1.

Fig. 1.

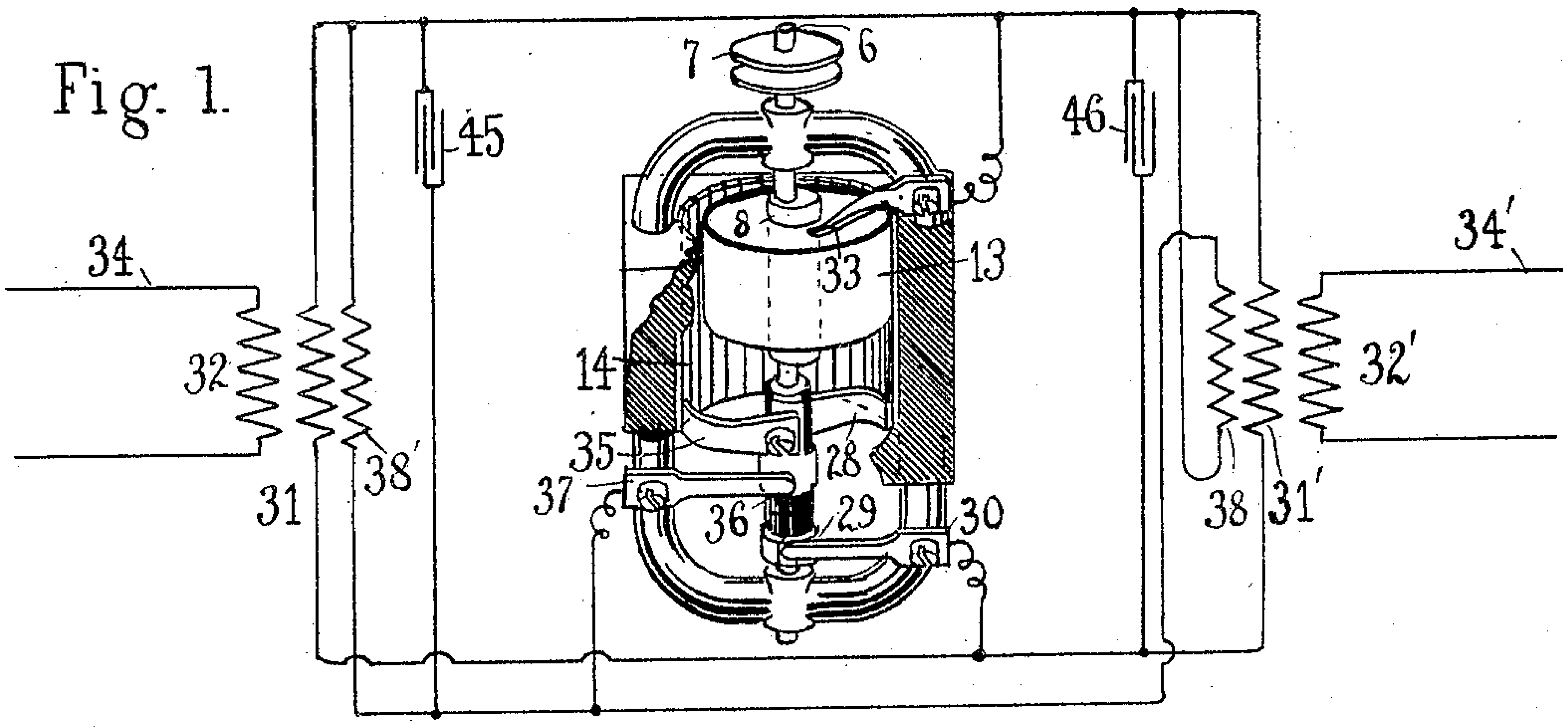


Fig. 2.

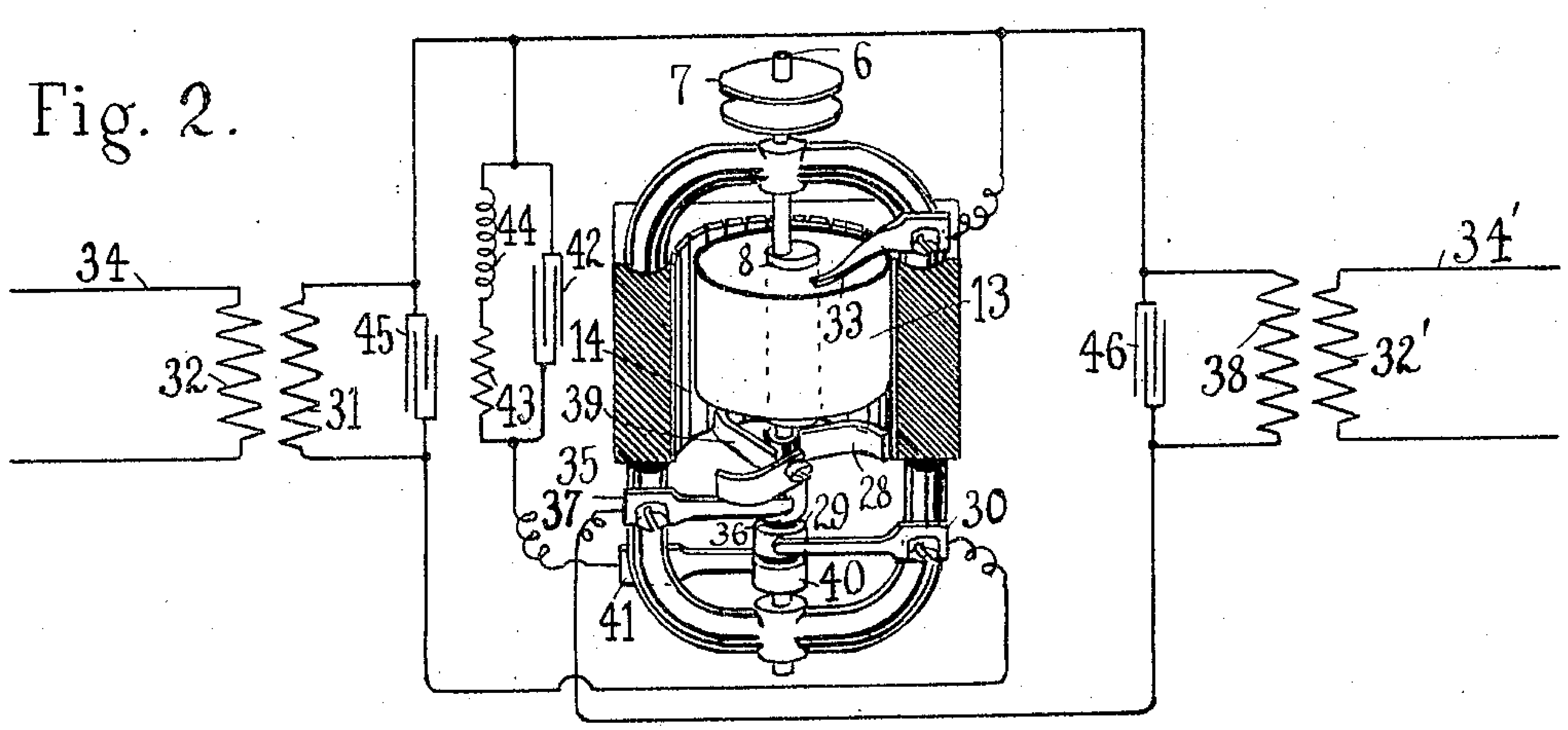
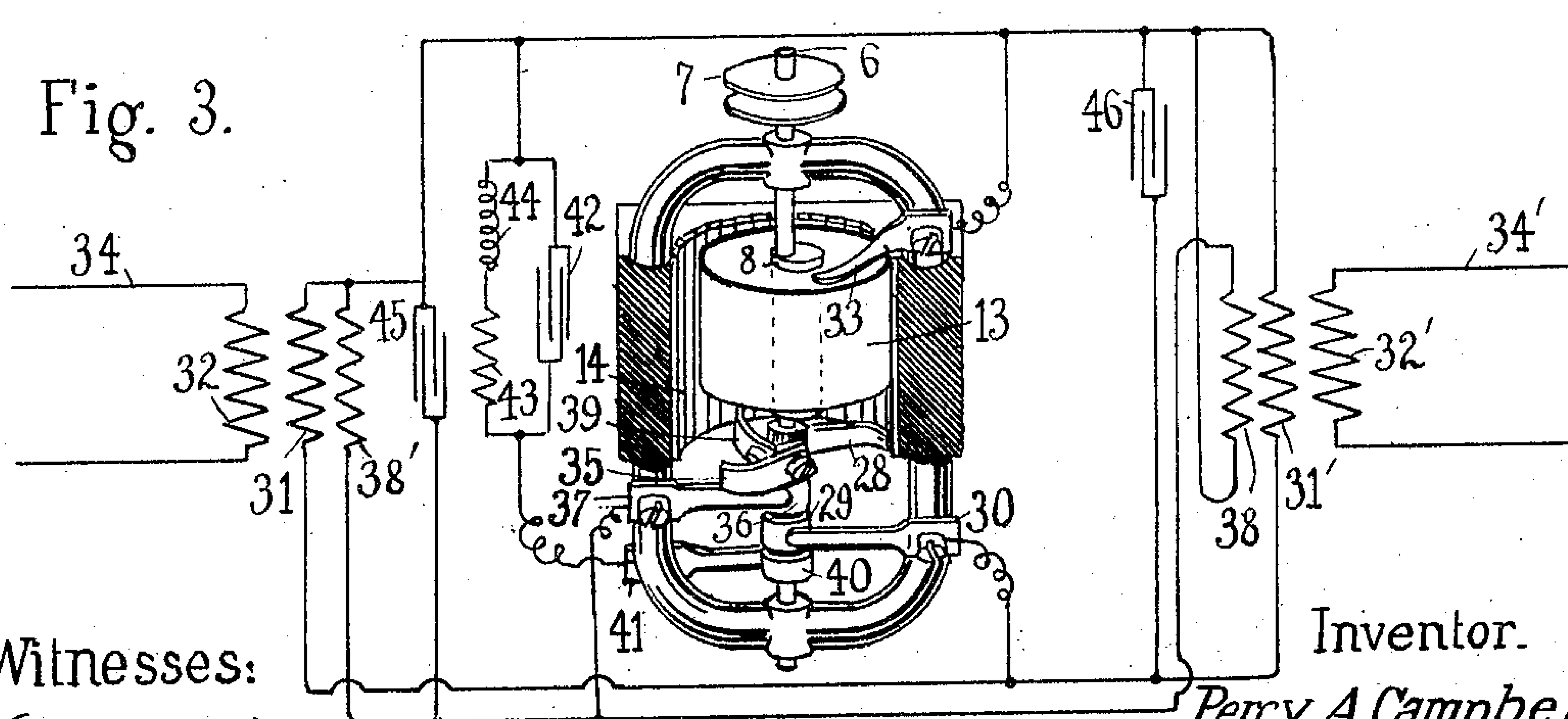


Fig. 3.



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3 SHEETS—SHEET 2.

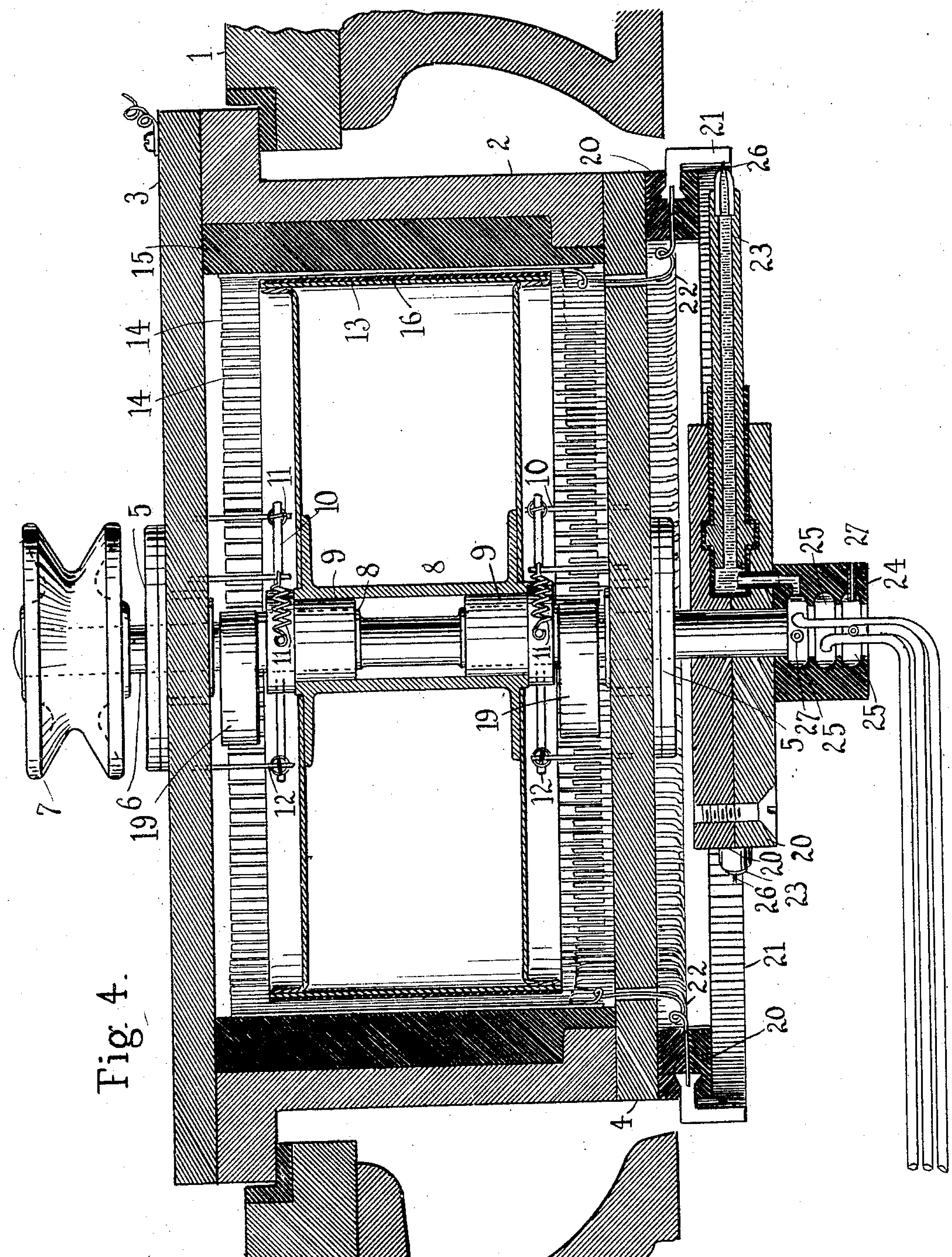

Fig. 4.

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3 SHEETS—SHEET 3.

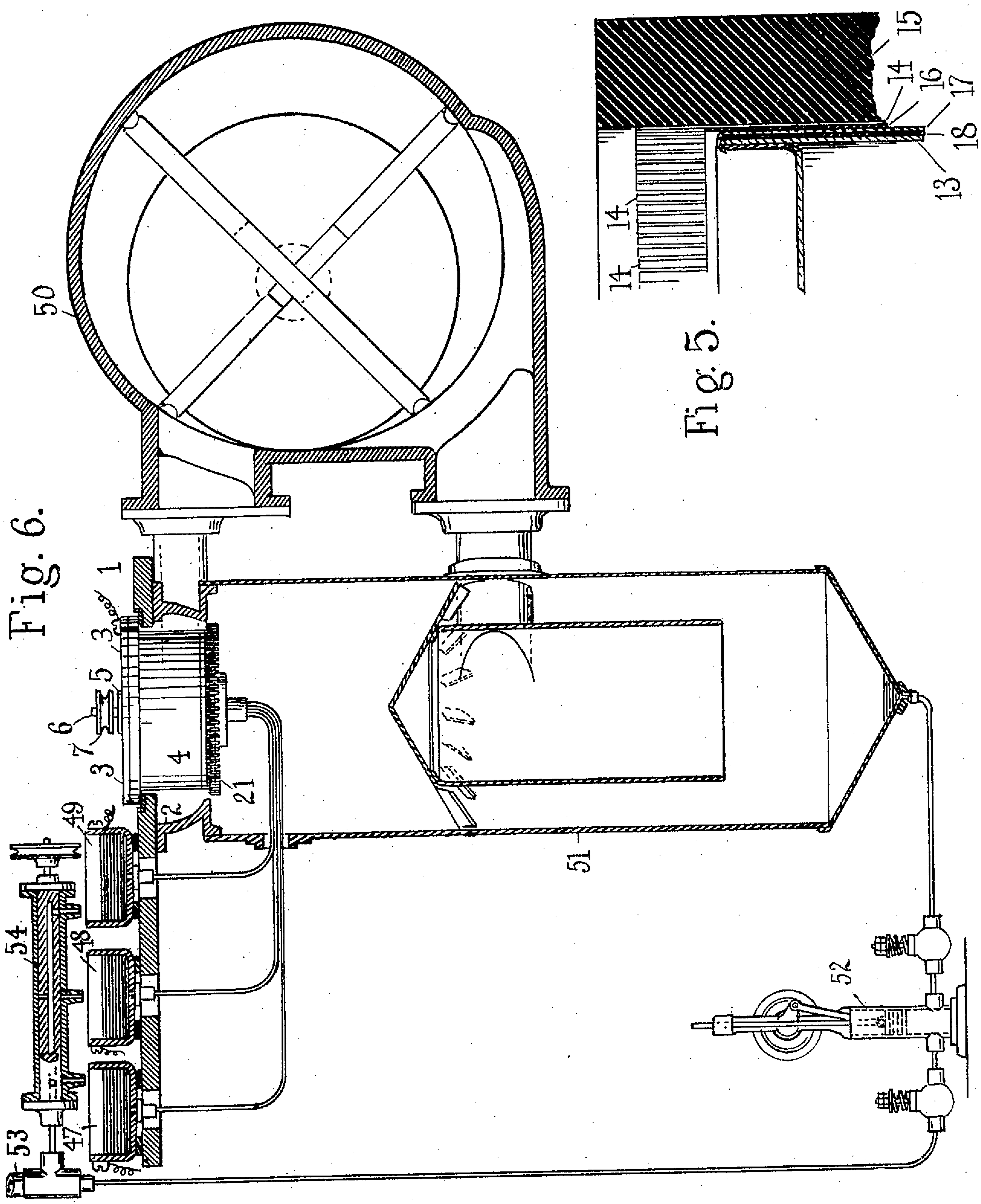

Fig. 5.

Fig. 6.

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UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR REPEATING TELEPHONE-CURRENTS.

942,885. Specification of Letters Patent. Patented Dec. 14, 1909.

Application filed July 20, 1909. Serial No. 508,633.

To all whom it may concern:

Be it known that I, Percy A. Campbell, a citizen of the United States of America, and a resident of Bloomfield, county of Essex, and State of New Jersey, have invented certain new and useful Improvements in Methods of and Apparatus for Repeating Telephone-Currents, of which the following is a specification.

According to this invention, the electrical energy of the currents in an incoming telephone circuit is stored in a series of condensers which are momentarily connected in turn in the incoming circuit; then the plates of the charged condensers are mechanically separated, thereby lowering their capacities and amplifying the energy of the charges; then the condensers are connected in turn in an outgoing circuit and the amplified charges are discharged.

The object of this invention is to amplify electric currents without converting the electrical energy into any other form of energy, to effect this without undue distortion of the electric waves, and to provide a method and apparatus which will allow of wide amplification in a single step.

In the accompanying three sheets of drawings, which form a part of this application—Figure 1 is a perspective, broken away, of a condenser repeater embodying my invention together with diagrammatic illustration of incoming and outgoing circuits and their inductive connection with line-circuit sections for transmission and amplification in both directions. Fig. 2 is a similar figure showing inductive connection with the line-circuit sections for transmission and amplification in one direction, and having a discharge circuit for residual condenser charges. Fig. 3 is a similar figure, embodying connections with the line-circuit sections for transmission and amplification in both directions, and having a discharge circuit. Fig. 4 is a vertical section through the condenser apparatus and commutator with mercury jets. Fig. 5 is an enlarged detail of a modification. Fig. 6 is a vertical section through the accessory apparatus for supplying mercury to the jets and clearing it from the commutator.

A table 1, Fig. 4, supports the condenser apparatus, which comprises a hollow vertical cylinder 2 with a top plate 3 and a bottom plate 4. The top and bottom plates carry bearings 5 5 for a shaft 6 which is rotated by a pulley 7. The shaft carries eccentrics 8 8. Around the eccentrics are sleeves 9 9 which partake of the eccentric movement of the eccentrics but are restrained from rotating by reason of their connection through pins 10 10, springs 11 11 and pins 12 12 with the top and bottom plates. A metal drum 13 is carried by the sleeved eccentrics. It travels eccentrically in rolling contact with a series of circularly disposed plates 14 14 which are supported by an insulating lining 15 within the hollow vertical cylinder. Each of these plates constitutes one plate of a condenser. That section of the drum opposite to each of the circularly disposed plates constitutes the second plate of each condenser. A thin sheet of insulating material 16, as mica, is interposed between the drum and the plates within the vertical cylinder, and is supported and carried either by the drum, as shown in Fig. 4, or by the circularly disposed plates as shown in Fig. 5. In this latter figure the drum is faced with foil 17 and an elastic layer 18, of gum rubber for example, underlies the foil to render the tread elastic. The foil, however, is electrically connected with the frame of the drum. The interposition of the sleeves between the eccentrics and the drum removes any tendency on the part of the revolving shaft to cause the drum to slip with respect to the circularly disposed plates and so avoids abrasion of the mica sheet. The centrifugal strain on the shaft from the weight of the eccentric drum is balanced by weights 19 19 carried by the shaft on the opposite side of its axis from the axis of the eccentrics. Below the vertical cylinder and carried by insulating rings 20 20 are a series of circularly disposed and spaced commutator-bars 21 21. The bars are connected by wires 22 22 with adjacent condenser plates. The shaft carries three nozzles 23 23 spaced 120 degrees. These nozzles are insulated from each other and are fed with mercury from a hollow cylindrical block of insulating material 24 carried by the shaft and having three circular grooves 25 25 25 cut in its interior surface. Mercury jets 26 26 issue from these nozzles and serve as brushes for the commutator. Each groove is provided with an overflow 27 27 which prevents the groove from becoming filled to overflowing and thus keeps the mercury in it insulated from the mercury in the other grooves.

The electrical connections will be clear from Figs. 1, 2 and 3 in which for simplicity the commutator bars are shown as continuations of the circularly disposed series of fixed condenser plates, and metal brushes are shown in lieu of mercury jets. There is an incoming repeater circuit which may be traced from the plate which is nearest to the drum through a brush 28, collector ring 29, brush 30, secondary 31, of an induction coil 31 32, brush 33 in contact with the drum, and the drum to that section of it which is opposite the plate at which the circuit here traced originated. The primary 32 of the induction coil is connected in an incoming line section 34. In the forms shown in Figs. 1 and 3, the incoming repeater circuit is branched, the second branch being through a secondary 31′, of an induction coil 31′ 32′, the primary 32′ being connected in a line circuit section 34′. There is also an outgoing repeater circuit from a plate which is separated more or less from the drum through a brush 35, collector ring 36, brush 37, primary 38 of an induction coil 38 32′, brush 33 in contact with the drum, and the drum to that section of it which is opposite the plate at which the circuit here traced originated. This outgoing repeater circuit is also branched, the second branch being through a primary 38′ of an induction coil 38′ 32, brush 33 in contact with the drum, and the drum to that section of it which is opposite the plate at which the circuit here traced originated. The coils in each of the line circuit sections serve as primaries or secondaries according to the direction of transmission. In the forms of Figs. 2 and 3 there is also a discharge circuit into which each condenser is brought after it has been connected to the outgoing repeater circuit and before it is returned to the incoming repeater circuit. This circuit is through a brush 39, collector ring 40, brush 41, two branches, one containing a condenser 42 and the other a resistance 43 and a choke coil 44, thence from the two branches through the brush 33 in contact with the drum and the drum to that section of it which is opposite the plate at which the circuit here traced originated. The circuit is so designed as to free, as far as possible, the condenser plates from residual charges before their next succeeding charging occurs in the incoming repeater circuit. Condensers 45 and 46 are introduced for the purpose of eliminating the irregularity and loss of energy due to the fact that the charging and discharging jets are not continuously in electrical connection with the commutator bars. The proper capacities for these condensers are readily found by trial.

In the preferred embodiments of my invention, as shown in Figs. 4, 5 and 6, the connections to the mercury jets are effected by leading wires to three tanks 47, 48, 49, from which mercury is supplied to the jets for the incoming repeater circuit, the outgoing repeater circuit, and the discharge circuit respectively. The electrical connection with the drum is effected by leading a wire to the frame of the machine. An air-pump 50 supplies a blast of air between the commutator bars in order to clear them quickly of mercury so that they will not become connected together. As the mercury will be finely comminuted by the blast, a settling tank 51 is provided and the mercury is drawn therefrom by a pump 52 and elevated to a stand-pipe 53 from which it flows into the three tanks by which the jets are supplied. The flow into the tanks is made intermittent by a gang-cock 54 so as not to electrically connect the tanks.

It is intended that the plates shall be narrower and more numerous than it has been convenient to illustrate, placing, for example, from two hundred to three hundred plates within a cylinder of nine inches interior diameter. The employment of mercury jets in lieu of metal brushes insures contact at each bar when the machine is run at 5,000 to 8,000 revolutions per minute. The mercury jets then each traverse from 20,000 to 40,000 bars per second, and the pulses arising from the commutation are of such high frequency as to be beyond the audible range. The mica sheet which is interposed between the drum and the fixed plates is of a thickness of one-thousandth part of an inch or less, and the eccentricity is such as to separate the elements of the condensers by about one-tenth of an inch of air space at discharge. The amount of the mechanical separation will, therefore, be one hundred times. Hence, as the dielectric value for mica relative to air is 5, the capacity of each condenser at the time of discharge should be approximately the one five-hundredth part of what it is at the time of charging. On account, however, of the losses of energy in the charging and discharging processes, the net amplification of the electrical energy due to the repeater action will be much less, being about one-tenth of that amount, or 50. The capacity of a single strip condenser being taken as one five-hundredth microfarad and the number of commutator bars passed by a mercury jet being thirty thousand per second, it follows that the secondary 31 of the induction coil 31 32 has a compound condenser with a total capacity of $\frac{1}{500} \times 30{,}000$, equal to 60 microfarads, to discharge into every second. In the one three-hundred and sixtieth part of a second, the fundamental oscillation period for an average speech current, the total capacity is therefore 60 divided by 360, equal to one-sixth microfarad per oscillation.

It has been found advisable to use a two microfarad condenser in the receiver circuit of a common battery telephone, and hence, the smallness of this capacity will prevent the condensers from storing the required amount of electrical energy unless the potential is stepped up by the induction coil 32 31. By stepping up the potential n times, for example five times, its initial value, the potential energy of a full charge of each of the strip condensers is increased n^2 times, for example twenty-five fold, and it becomes possible to use condensers of capacity $\frac{1}{n^2}$ part of the capacity necessary with no stepping up. Having stepped up the potential at the induction coil 32 31 it is necessary to step it down again at the induction coil 38 32′. If n represents the amount of stepping up at the first induction coil, and M represents the amount of stepping up due to the decrease in capacity of the strip condensers which occurs previous to discharge, then, neglecting losses, the expression $\frac{1}{n\sqrt{M}}$ represents the amount of the necessary stepping down at the second induction coil 38 32′. In practice, the best values for the primary-to-secondary ratios of induction coils are readily found by trial. In the forms of Figs. 1 and 3 which are arranged for repeating in both directions, the ratio of turns in the coil 32′ to coil 31′ equals the ratio of primary-to-secondary turns in the coil 32 to coil 31, and the ratio of turns in the coil 38′ to coil 32 equals the ratio of primary-to-secondary turns in the coil 38 to coil 32′.

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

1. The method of repeating telephone currents, which consists in charging a series of condensers in turn from an incoming circuit, mechanically separating the plates of the charged condensers in turn, and discharging the condensers in turn in an outgoing circuit, substantially as described.

2. The method of repeating telephone currents, which consists in charging a series of condensers in turn from an incoming circuit, mechanically separating the plates of the charged condensers in turn, discharging the condensers in turn in an outgoing circuit, and discharging the residual condenser charges in a discharge circuit, substantially as described.

3. In a telephone repeater, the combination of incoming and outgoing circuits, plates forming a series of condensers, means for connecting the condensers in turn in the incoming circuit, means for separating the plates of the condensers in turn, and means for connecting the condensers in turn in the outgoing circuit, substantially as described.

4. In a telephone system, the combination of line-circuit sections, an incoming repeater circuit with branches connected to the line-circuit sections, an outgoing repeater circuit with branches connected to the line-circuit sections, plates forming a series of condensers, means for connecting the condensers in turn in the incoming circuit, means for separating the plates of the condensers in turn, and means for connecting the condensers in turn in the outgoing circuit, substantially as described.

5. In a telephone repeater, the combination of incoming and outgoing circuits, a circuit for discharging residual condenser charges, plates forming a series of condensers, means for connecting the condensers in turn in the incoming circuit, means for separating the plates of the condensers in turn, means for connecting the condensers in turn in the outgoing circuit, and means for connecting the condensers in turn in the discharge circuit, substantially as described.

6. In a telephone system, the combination of line-circuit sections, an incoming repeater circuit with branches connected to the line-circuit connections, an outgoing repeater circuit with branches connected to the line-circuit sections, a circuit for dischargng resdual condenser charges, plates forming a series of condensers, means for connecting the condensers in turn in the incoming circuit, means for separating the plates of the condensers in turn, means for connecting the condensers in turn in the outgoing circuit, and means for connecting the condensers in the discharge circuit, substantially as described.

7. In a telephone repeater, the combination of incoming and outgoing circuits, a series of circularly disposed plates and an eccentrically mounted drum forming with the circularly disposed plates a series of condensers, commutator bars connected with the circularly disposed plates, means for connecting the commutator bars in turn in the incoming circuit, means for separating the drum from the circularly disposed plates in turn, and means for connecting the commutator bars in turn in the outgoing circuit, substantially as described.

8. In a telephone repeater, the combination of incoming and outgoing circuits, a series of circularly disposed plates and an eccentrically mounted drum forming with the circularly disposed plates a series of condensers, an insulating layer interposed between the circularly disposed plates and the drum and carried by one of said condenser parts, commutator bars connected with the circularly disposed plates, means for connecting the commutator bars in turn in the incoming circuit, means for separating the drum from the circularly disposed plates in turn, and means for connecting the commutator bars in turn in the outgoing circuit, substantially as described.

9. In a telephone repeater, the combination of incoming and outgoing circuits, a series of circularly disposed plates, a shaft mounted in the axis of the circularly disposed plates, eccentrics carried by the shaft, a drum carried by the eccentrics and forming with the circularly disposed plates a series of condensers in which the drum can be separated from the circularly disposed plates in turn, commutator bars connected with the circularly disposed plates, means for connecting the commutator bars in turn in the incoming circuit, and means for connecting the commutator bars in turn in the outgoing circuit, substantially as described.

10. In a telephone repeater, the combination of incoming and outgoing circuits, plates forming a series of condensers, commutator bars connected with the plates, a mercury jet for connecting the commutator bars in turn in the incoming circuit, means for separating the plates of the condensers in turn, and a mercury jet for connecting the commutator bars in turn in the outgoing circuit, substantially as described.

11. In a telephone repeater, the combination of incoming and outgoing circuits, a series of circularly disposed plates, a shaft mounted in the axis of the circularly disposed plates, eccentrics carried by the shaft, a drum carried by the eccentrics and forming with the circularly disposed plates a series of condensers in which the drum can be separated from the circularly disposed plates in turn, commutator bars connected with the circularly disposed plates, a mercury jet for connecting the commutator bars in turn in the incoming circuit, and a mercury jet for connecting the commutator bars in turn in the outgoing circuit, substantially as described.

12. In a telephone repeater, the combination of incoming and outgoing circuits, a circuit for discharging residual condenser charges, a series of circularly disposed plates, a shaft mounted in the axis of the circularly disposed plates, eccentrics carried by the shaft, a drum carried by the eccentrics and forming with the circularly disposed plates a series of condensers in which the drum can be separated from the circularly disposed plates, in turn, commutator bars connected with the circularly disposed plates, a mercury jet for connecting the commutator bars in turn in the incoming circuit, a mercury jet for connecting the commutator bars in turn in the outgoing circuit, and a mercury jet for connecting the commutator bars in turn in the discharge circuit, substantially as described.

13. In a telephone repeater, the combination of incoming and outgoing circuits, plates forming a series of condensers, commutator bars connected with the plates, a mercury jet for connecting the commutator bars in turn in the incoming circuit, means for separating the plates of the condensers in turn, a mercury jet for connecting the commutator bars in turn in the outgoing circuit, and an air-blast for clearing the commutator, substantially as described.

Signed at Bloomfield, New Jersey, this 16th day of July, 1909.

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