

May 25, 1926.

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METHOD AND MEANS FOR TELEPHONE TRANSMISSION MEASUREMENTS

Filed August 10, 1922

2 Sheets-Sheet 1

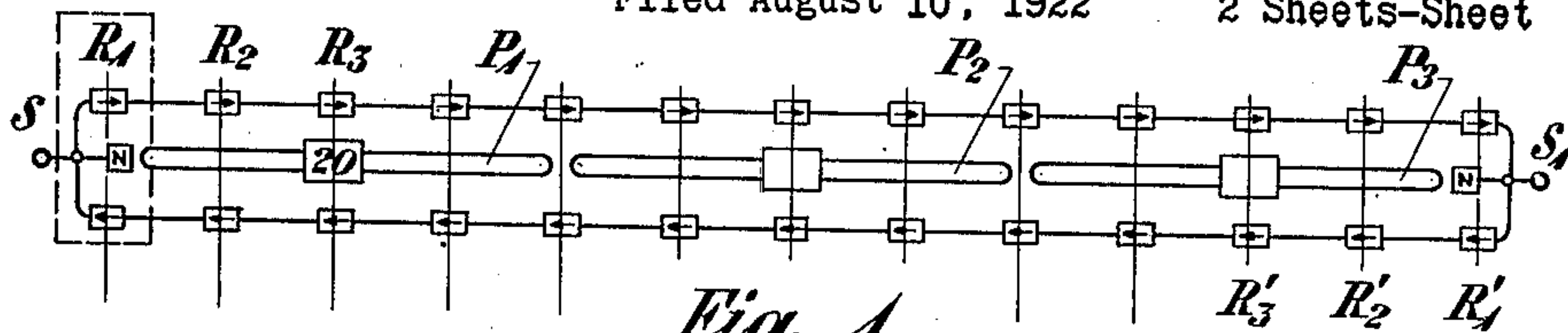


Fig. 1

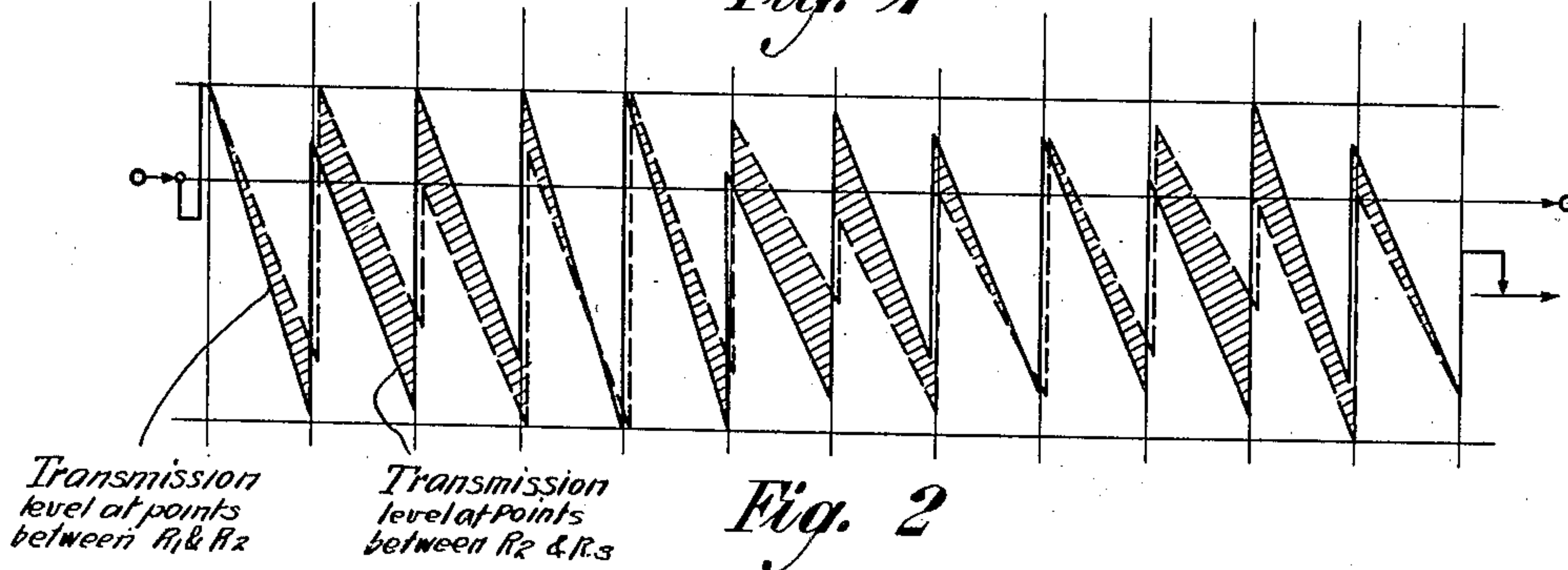


Fig. 2

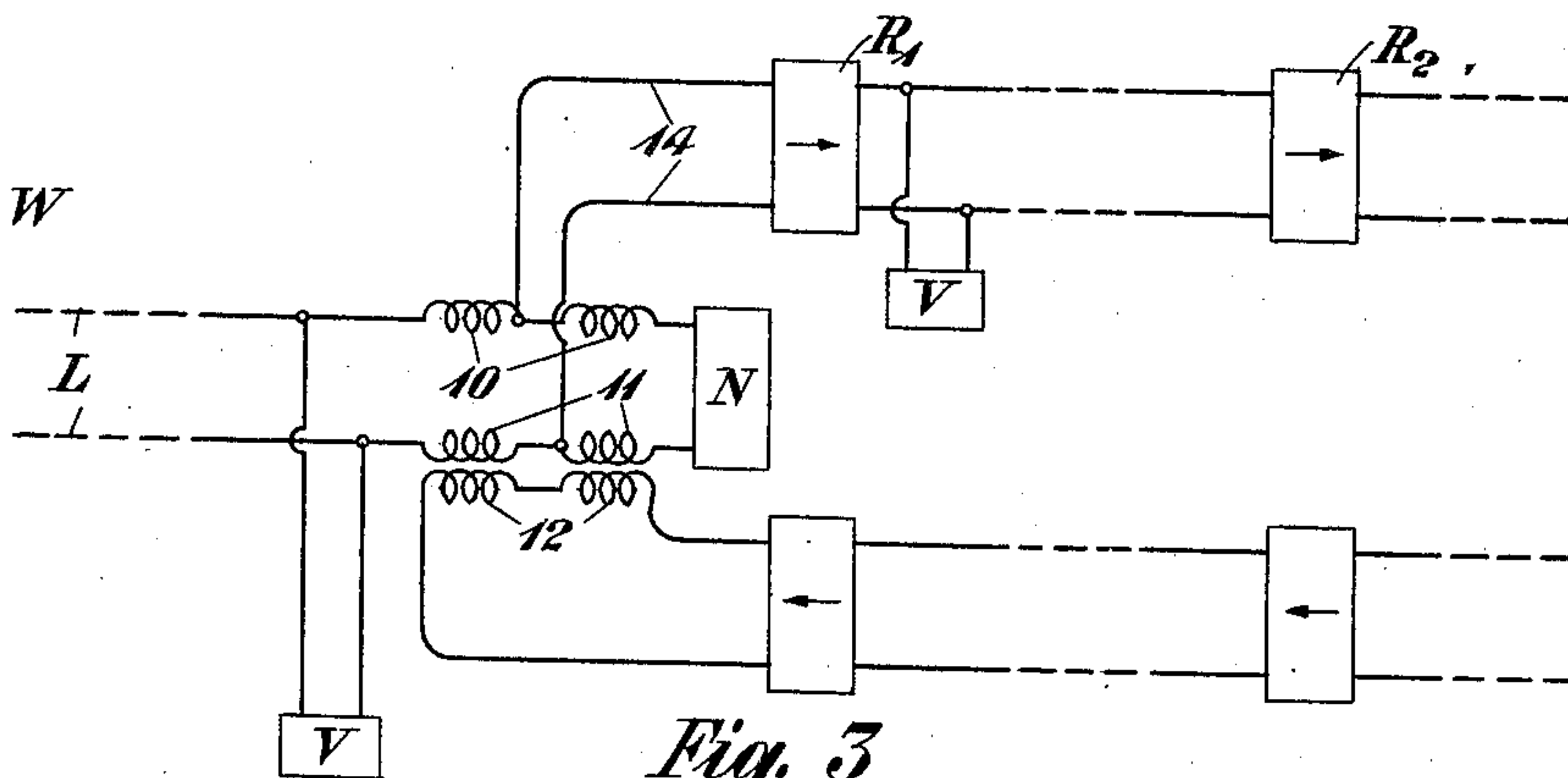


Fig. 3

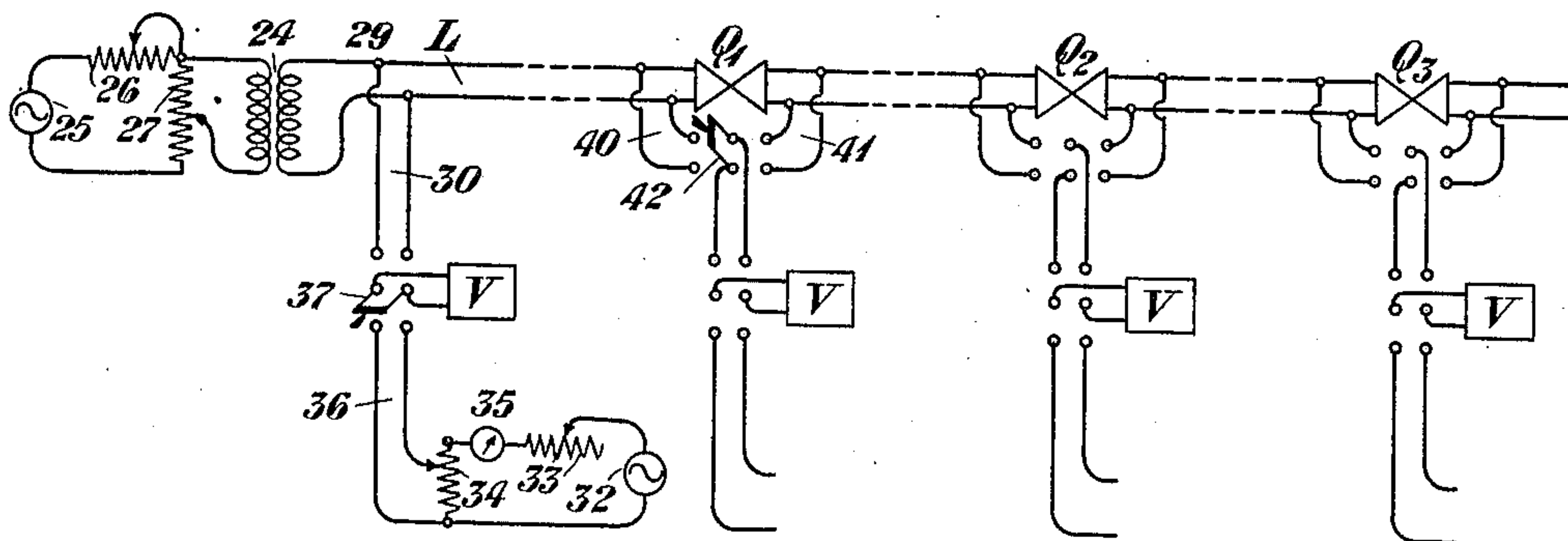


Fig. 4

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2 Sheets-Sheet 2

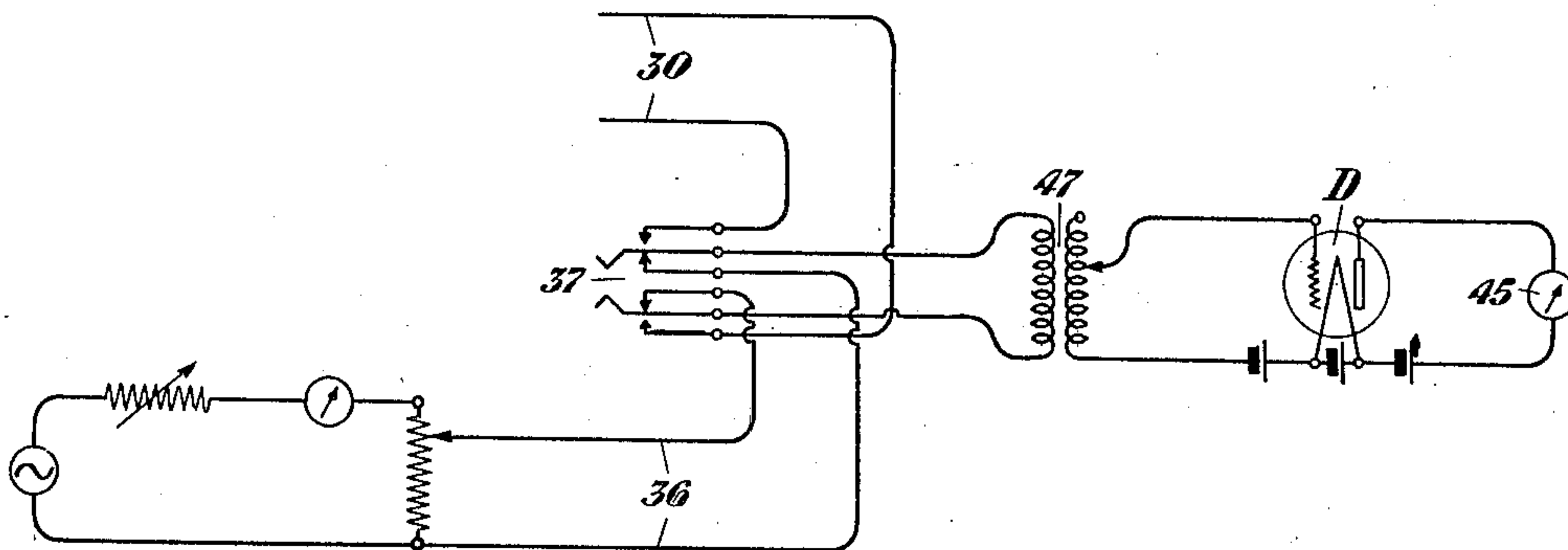


Fig. 5

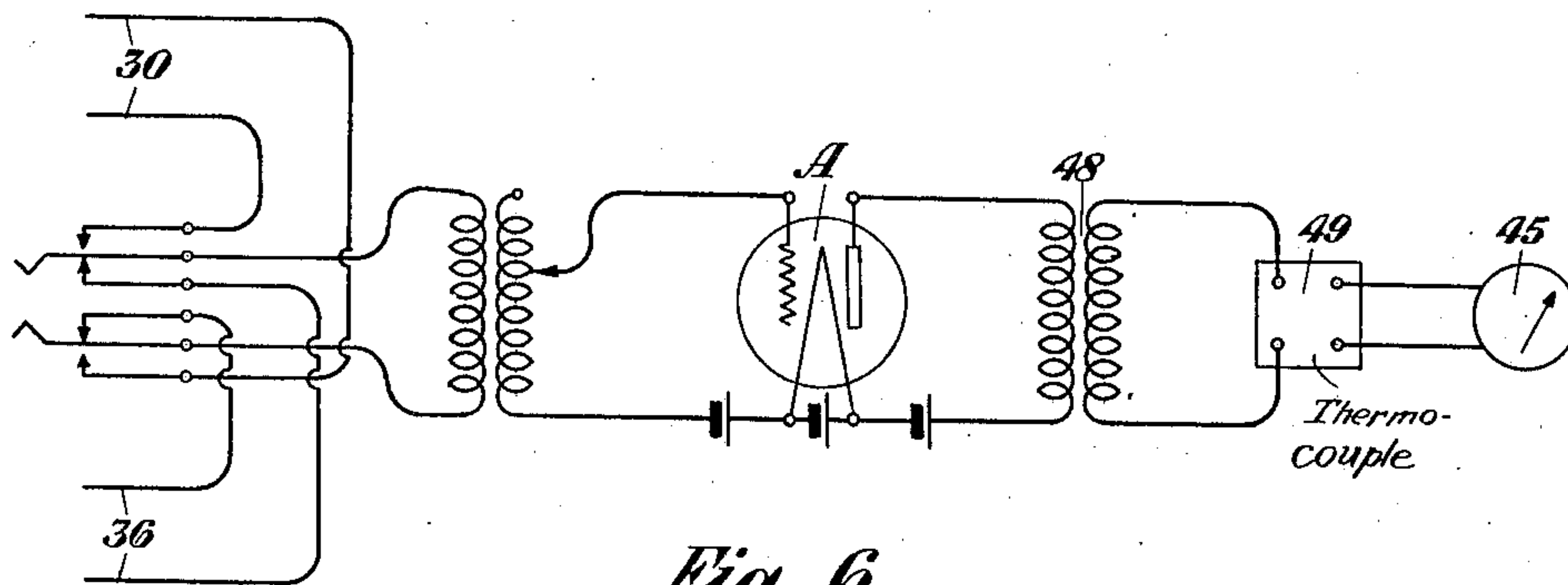


Fig. 6

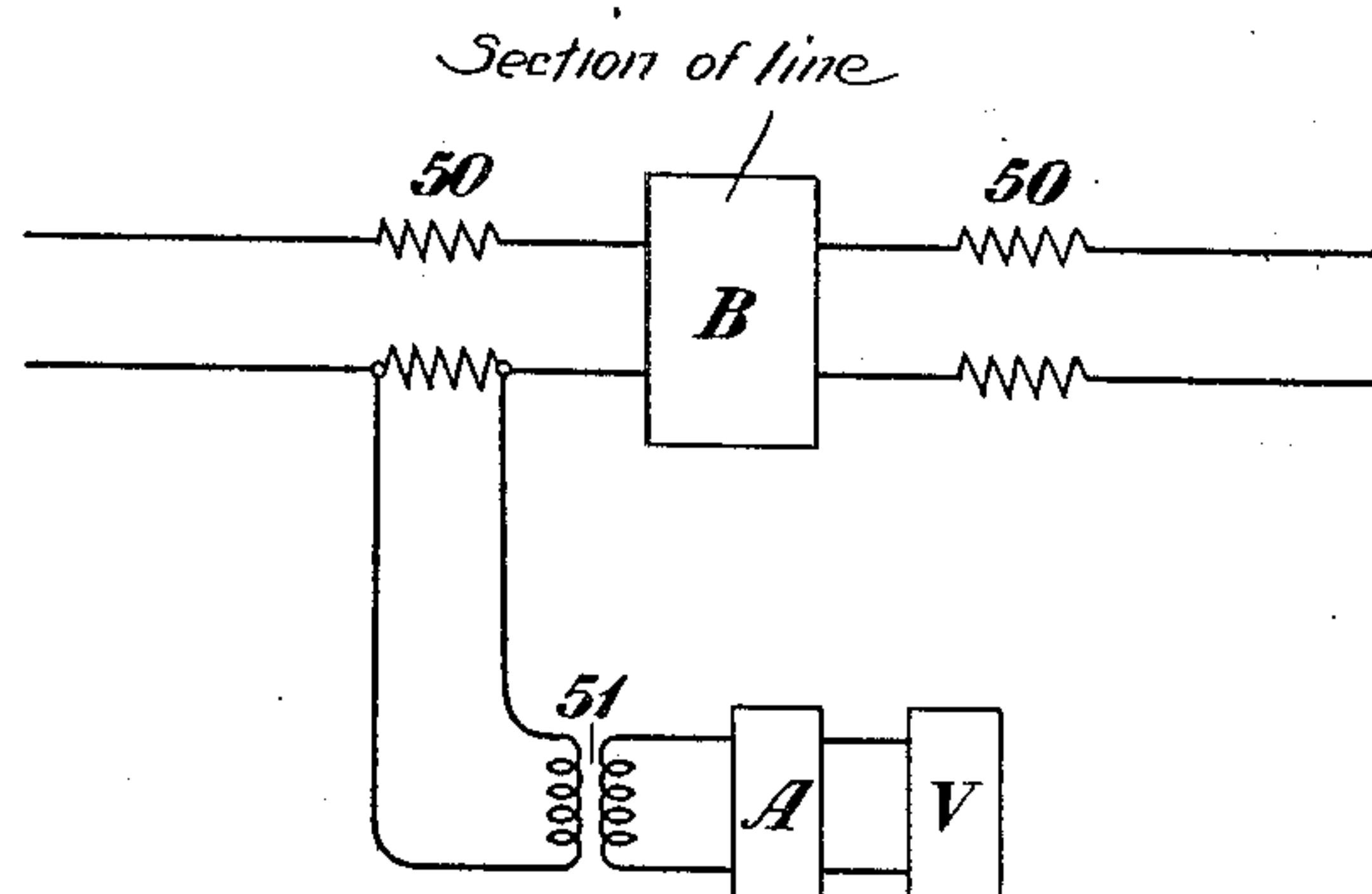


Fig. 7

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METHOD AND MEANS FOR TELEPHONE TRANSMISSION MEASUREMENTS.

Application filed August 10, 1922. Serial No. 580,937.

This invention relates to methods of and means for making measurements on the characteristics of telephone transmission lines. More particularly it relates to the measurement of the condition of transmission level at any point of a telephone line. It also affords a convenient method for determining the gain or loss due to any portion of a transmission line or any piece of apparatus associated therewith, such, for example, as a repeater inserted on such a line.

In transmission lines, especially in transmission lines which include a number of repeaters between the terminal stations, it is of importance to know what the transmission level is at any point of the line, where the transmission level is taken as a measure of the amount of energy passing the point in question. In actual operation it is desirable that the transmission level at any point of the line shall not fall below a certain minimum or rise above a certain maximum, values for which have been determined from experience. This is true even though it is possible to restore the level to any desired value by means of suitable amplification, for it is found that if the transmission level falls below the specified minimum the effect of inductive and other extraneous disturbances become unduly large. On the other hand if it rises too high there is danger of overloading the amplifiers. It is obvious that with the large fluctuations in climatic conditions affecting the transmission line and the various disturbances which influence the apparatus at repeating stations, the transmission level may vary over a wide range at a given point without knowledge of the operators, unless provision is made for observing the transmission level from time to time. The purpose of this invention is to provide a suitable and convenient method for obtaining such information and to provide apparatus by which the necessary measurements may be made.

The invention will be better understood by reference to the accompanying drawings, in which Figure 1 represents schematically a four-wire circuit equipped with repeaters and certain other apparatus to be mentioned later; Fig. 2 is a diagram representing the transmission level of such a line as is shown in Fig. 1; Fig. 3 is a more detailed showing

of one portion of the transmission line of Fig. 1; Fig. 4 shows a two-wire transmission line equipped with two-way, two-element repeaters and equipped also with the measuring means, shown schematically, which comprises my invention; Fig. 5 shows in detail the measuring apparatus comprising my invention, Fig. 6 shows a modification thereof, and Fig. 7 shows an alternative method of making the necessary measurements.

Referring more particularly to Fig. 1, S and S₁ represent two terminals of a transmission line, these terminals leading off with standard two-wire transmission lines which are associated with a four-wire circuit comprising hybrid coils and balancing networks N. This connection from the two-wire to the four-wire circuit is standard, but for the sake of clearness I have shown it in greater detail in Fig. 3. In this figure the hybrid or three-winding transformer is shown as comprising windings 10, 11 and 12, 10 and 11 being in series with the line and being connected with the network N. Bridged across the midpoints of the transformer windings 10 and 11 are conductors 14 leading to a one-way repeater R₁, the output of which then goes to a series of repeaters R₂, etc., connected in tandem, as shown in Fig. 1, these repeaters being adapted for transmitting voice currents from west to east. Similarly, a series of repeaters in tandem and coming from the station S₁ supply power through the winding 12 to the transmission line L for transmitting voice currents from east to west. The spacing of these repeater stations obviously may or may not be uniform.

In long transmission lines of this character it is found that weather conditions affect the transmission line so substantially that it is desirable to control the gain at various repeater stations to compensate for such changes. This is ordinarily accomplished by using a pilot channel extending over a portion of the transmission line and indicated at P₁, P₂ and P₃, at the approximate center of each of which is placed some mechanism 20, the operation of which is controlled by the physical condition of the pilot channel and which in turn controls the gain at one of the repeating stations, such as R₃. Fig. 2 shows a typical experimental trans-

mission level diagram of such a transmission line as is shown in Fig. 1. On a certain day, for example, transmission currents entering the line at S would undergo a transmission loss as a result of the hybrid coil. Following this, the transmission level would be raised substantially by the repeater R₁, and from there on the level would fall and rise from time to time as the current passed along a part of the line or reached a repeater station, the transmission level at all points being indicated then by the full line of Fig. 2. For some other day, when the weather conditions are different, the transmission level may be that shown by the dotted line. The cross-hatched portion between these two lines shows the variation in the transmission level indicating that even though regulating repeaters are used on the line, the transmission level varies at different points. In addition, it is obvious that from time to time one or another repeater in the system may cease to operate properly and the importance is apparent of having means to find how any particular repeater is functioning or to learn what the transmission level is at any part of the line.

Broadly, my invention consists in providing means for impressing on the line at one station an alternating current, and in providing means for measuring or indicating the power impressed on the line at this sending station and comparing therewith the power as measured at any desired point on the line. In order to obtain a fair measure of the condition of the line, it is apparent that the frequency of the current impressed at the sending end must be within the audible range, and preferably should be variable in order that the conditions may be observed for any frequency desired. In general, any apparatus which may be attached to or associated with the line will modify its impedance characteristics, and therefore, will modify the amount of power flowing in the line. A part of my invention, therefore, consists in providing apparatus which may be associated with the line and yet will not produce any substantial change in the impedance thereof. In order to measure the power in the line or to compare it with that impressed at the sending station, it is sufficient to measure either the voltages across the line at the points under consideration or to measure the current flowing in the line at these points. In case the voltage is to be measured, the requirement is that the apparatus bridged across the line shall be of so high an impedance that it shall not have any substantial effect on the circuit. On the other hand, if the current is to be measured, the apparatus associated with the line, preferably in series therewith, must be of such low impedance as to have substantially no effect. For the first measure-

ment I provide a high impedance voltage indicator which will be described in detail later. For the second measurement I find it desirable to insert in the line a low resistance element which may be used to give an indication either by the drop of potential along that element or by the heating effect produced by the current therein.

I prefer to use the voltage method, and Fig. 4 illustrates the application of the necessary equipment to a standard two-wire transmission line equipped with standard two-way repeaters, Q₁, Q₂, etc. In this figure the line L is shown extending from one terminal station at the left towards the right. At this terminal station, there is associated with the line L by means of a suitable transformer 24 and oscillator 25, of any suitable type, such as a vacuum tube oscillator. In order to control the amount of power which is impressed on the line, variable resistances 26 and 27, in series and in shunt, respectively, may be supplied, although any other suitable means for varying the impressed power may be used. At a point 29, corresponding to what may be termed the beginning of the transmission line, there is bridged a pair of conductors 30, adapted for connection to the high impedance voltage indicator V.

At each repeater station there is also supplied a similar indicator, for it is generally at such points that it is desired to make the measurements. By means of conductors 40 and 41, taken with a double-throw switch 42, it is made convenient to connect the indicator to the circuit either before or after the repeater Q₁. A comparison then of the measurement across the line at the point 40 with that obtained at the point 29 gives information as to the drop in transmission level in going from the one point to the other. Also, a comparison of the measurement at the point 41 after the repeater with that obtained before the repeater, gives information as to the gain introduced by the repeater Q₁. Obviously, a comparison of the measurement obtained at 41 with that obtained at 29 would give a measure of the transmission level at that point. Having then obtained information as to the transmission level of the line for transmission in the one direction, similar alternating current power could be impressed upon the line at the other end and corresponding measurements made to find the transmission characteristics for transmission in the opposite direction.

An important aspect of this invention is that means are provided by which measurements may be taken simultaneously at all important points. In a long transmission line, for example, on which a number of repeaters are installed, measurements may be made at the two terminals, giving an in-

dication as to whether the line is in a satisfactory condition. But if it is not satisfactory, the trouble may be at any point on the line and its location is difficult and involves much time. This invention provides a method for largely obviating the difficulty. At a prearranged time, the attendants at the various points along the line, presumably repeater points, would connect in their respective indicators. At the same time, the terminal attendant would disconnect the usual telephone apparatus and connect in the generator 25. All attendants along the line would now take their measurements simultaneously. The attendant at the other end of the line would then, at a prearranged moment, connect in his generator and measurements would again be made. Each intermediate attendant thus obtains direct information as to the transmission level at his station and reports to the terminal station or other selected point where a comparison of the data immediately locates a source or sources of trouble. The advantages of these simultaneous readings are that all readings are taken under the same condition and that the time during which the line is out of commission is reduced to a minimum. The importance of this method is the more apparent when it is borne in mind that measurements on line conditions are and should be made several times a week. It is apparent that in case a number of readings are to be made simultaneously, it is all the more important to have measuring instruments which will not absorb an appreciable amount of power from the line.

It will be desirable from time to time to calibrate the measuring instrument or indicator, and for that purpose there is supplied a calibrating circuit comprising a source of alternating current 32 in series with a variable resistance 33, a fixed resistance 34 and an alternating current meter 35. By means of the resistance 33 the current flowing through the circuit may be adjusted to any desired value. The resistance 34 then may be used as a potentiometer resistance and any portion thereof applied to the indicator by means of the conductors 36. A double-throw switch 37 enables the operator to connect the indicator to the line or to the calibrating circuit, and thus the voltage across the line at the point 29 can be determined either by reference to a calibration curve or by direct reading of the voltage from the potentiometer wire 34 which will produce an equal deflection.

While the indicator may take on a variety of forms, so long as it is of sufficiently high impedance, I have found it convenient to make use of the characteristics of a three-electrode, thermionic vacuum tube. Fig. 5 shows a form comprising essentially a vacuum tube detector D with the usual grid,

plate and heated filament. Voltage from the line is impressed on the input terminals of this detector by means of the double-throw switch 37, which connects alternately with the line 30 or 36 as described heretofore. In the output circuit of the thermionic tube is connected a direct current meter 45. Normally there will be a small steady space current flowing through this meter, which space current will be changed upon the application of the alternating voltage from the line. The change in this reading is a measure of the voltage across the line and, as mentioned above, may be obtained by a suitable calibration curve, although I prefer to obtain it directly by comparison with the voltage from the potentiometer wire 34, which is required to produce the same deflection on this meter when the switch 37 is moved in the proper direction. If desired, a transformer 47 may be introduced between the switch 37 and the tube D. The instrument 45 or the potentiometer 34 may be calibrated in any suitable units such as miles above or below a standard transmission level.

In the circuit of Fig. 5, the vacuum tube is used as a detector. However, as in the modification of Fig. 6, the tube may be used as an amplifier and the amplified output may be impressed, by means of a transformer 48, on a hot wire thermo-couple 49 or other apparatus of this type, to produce a direct current effect which may be recorded on the meter 45. In both cases, advantage is taken of the exceedingly high impedance of the input circuit of a vacuum tube.

In case measurements of current in the line are to be made an arrangement such as shown in Fig. 7 may be used in which B represents a section of line or a piece of apparatus separating two points at each of which measurements are to be made. Low resistance elements 50 are inserted in one or both conductors at the points for measurement. Across an element 50 is connected any suitable measuring device V such as the indicator described above. If desired a transformer 51 may be interposed between the line and the indicator and further, if desired, one or more amplifiers A, may be used.

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

Having now described my invention, what I claim is:

1. In a long distance telephone transmission line containing a plurality of repeaters, the method of finding the transmission condition which consists in impressing on the

line at one end an alternating current power, simultaneously measuring a characteristic of the electrical power at a plurality of points along the transmission line, and comparing these measurements.

2. In a long distance telephone transmission line containing a plurality of repeaters, the method of finding the transmission condition, which consists in impressing on the line at one end an alternating current power, simultaneously measuring a characteristic of the electrical power at a plurality of points along the transmission line and comparing these measurements with the measurement for the same characteristic of the power at the sending end.

3. In a long distance telephone transmission line containing a plurality of repeaters, the method of finding the transmission condition, which consists in impressing on the line at one end an alternating current, measuring the voltage across the line at a plurality of points simultaneously, and comparing these measurements.

4. In a long distance telephone transmission line containing a plurality of repeaters, the method of finding the transmission condition, which consists in impressing on the line at one end an alternating current, measuring the voltage across the line at the sending end and at a plurality of points along the line simultaneously and comparing

the line measurements with the measurements at the transmitting end.

5. In a long distance telephone transmission line, means for indicating the transmission condition at points on the line, comprising a generator for impressing alternating current power on one end of said line, means for measuring the voltage across the line at the sending end, and similar means at a plurality of points along the transmission line for measuring the voltage across the line at such points, whereby the power at any point in the line as compared with that at the sending end may be obtained.

6. In a long distance telephone transmission line, means for indicating the transmission condition at any point on the line, comprising a generator for impressing alternating current power on one end of said line, a thermionic voltage indicator connected across the line at the sending end, and similar thermionic indicators adapted to be connected across the line at a plurality of points and adapted for simultaneous readings, whereby the voltages across the line at any point may be compared with the voltage across the line at the transmitting end under identical conditions.

In testimony whereof, I have signed my name to this specification this 8th day of August, 1922.

ALVA B. CLARK.