No. 713,479. Patented Nov. 11, 1902.

E. J. MURPHY.

RECORDING ELECTRIC WAVE FORMS.

(Application filed Nov. 23, 1901.)

(No Model.)

Fig.1.

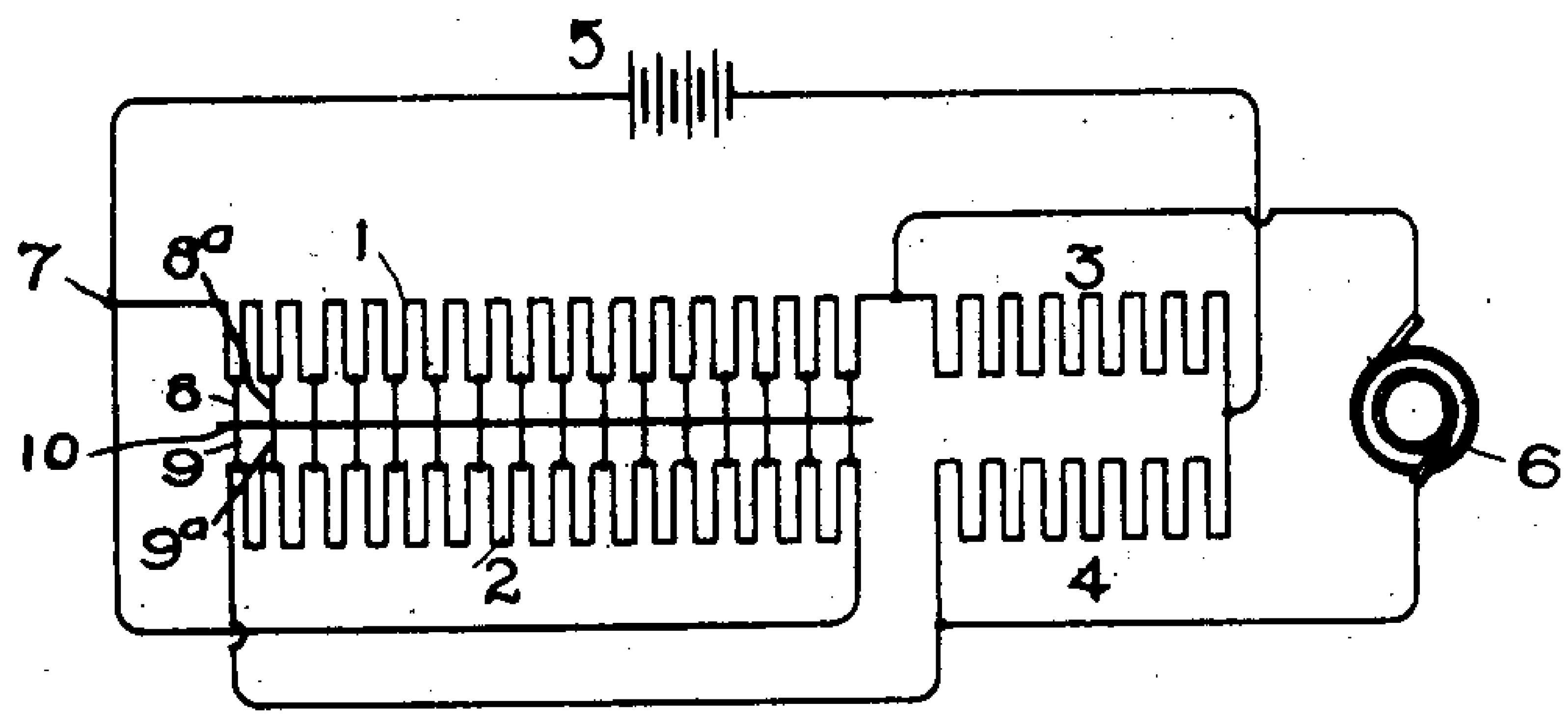


Fig.2.

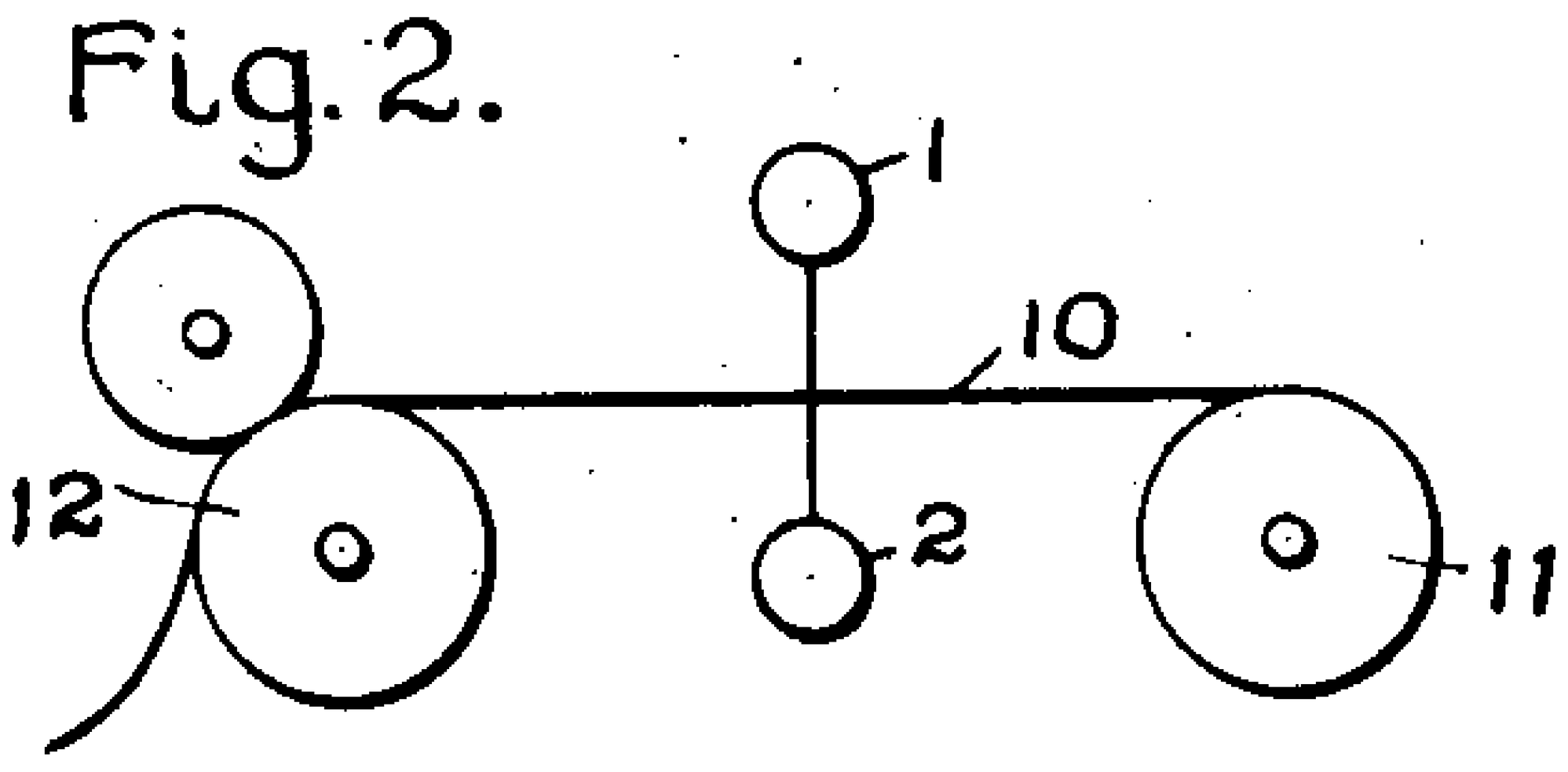


Fig.3.

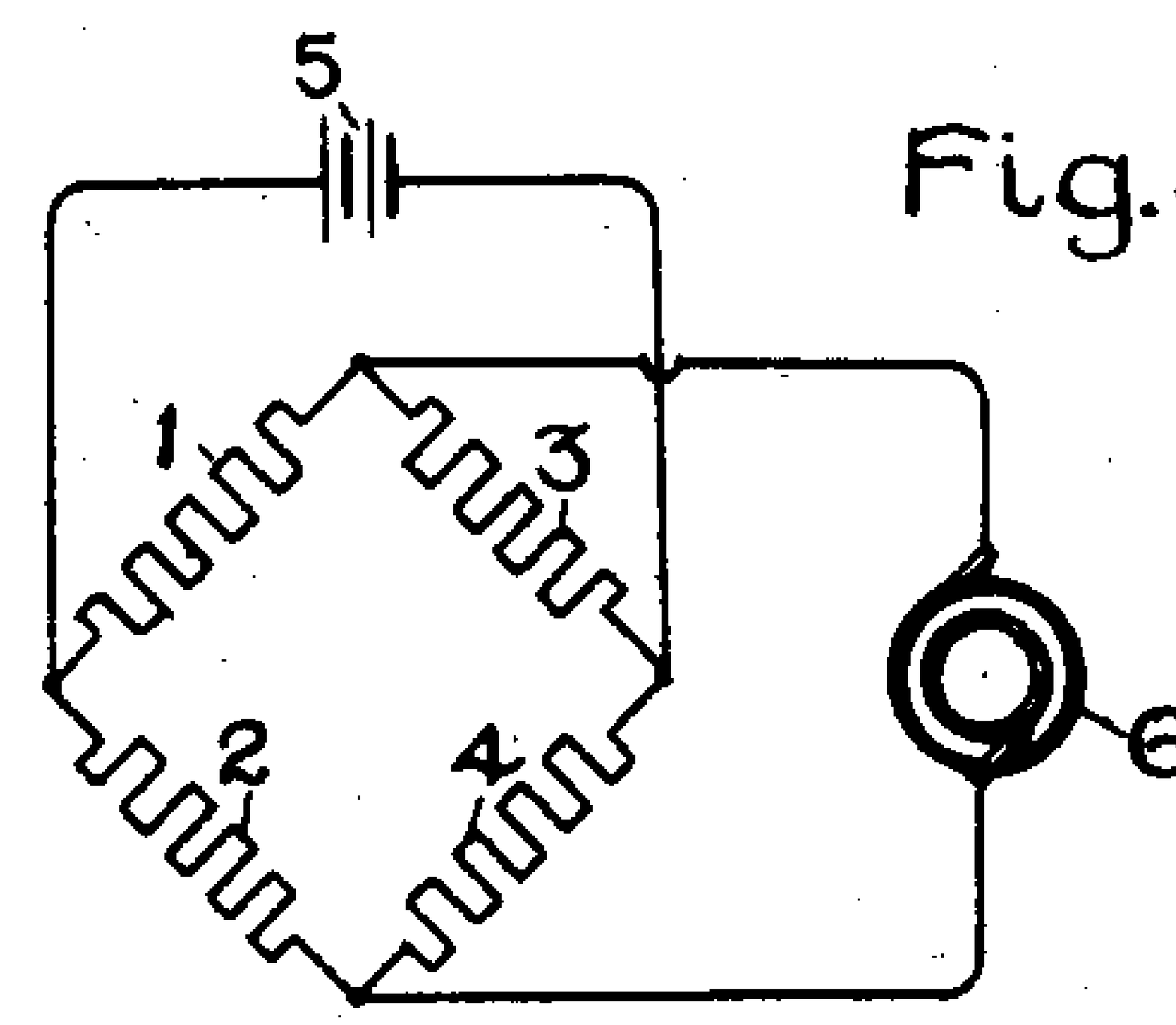


Fig.4.

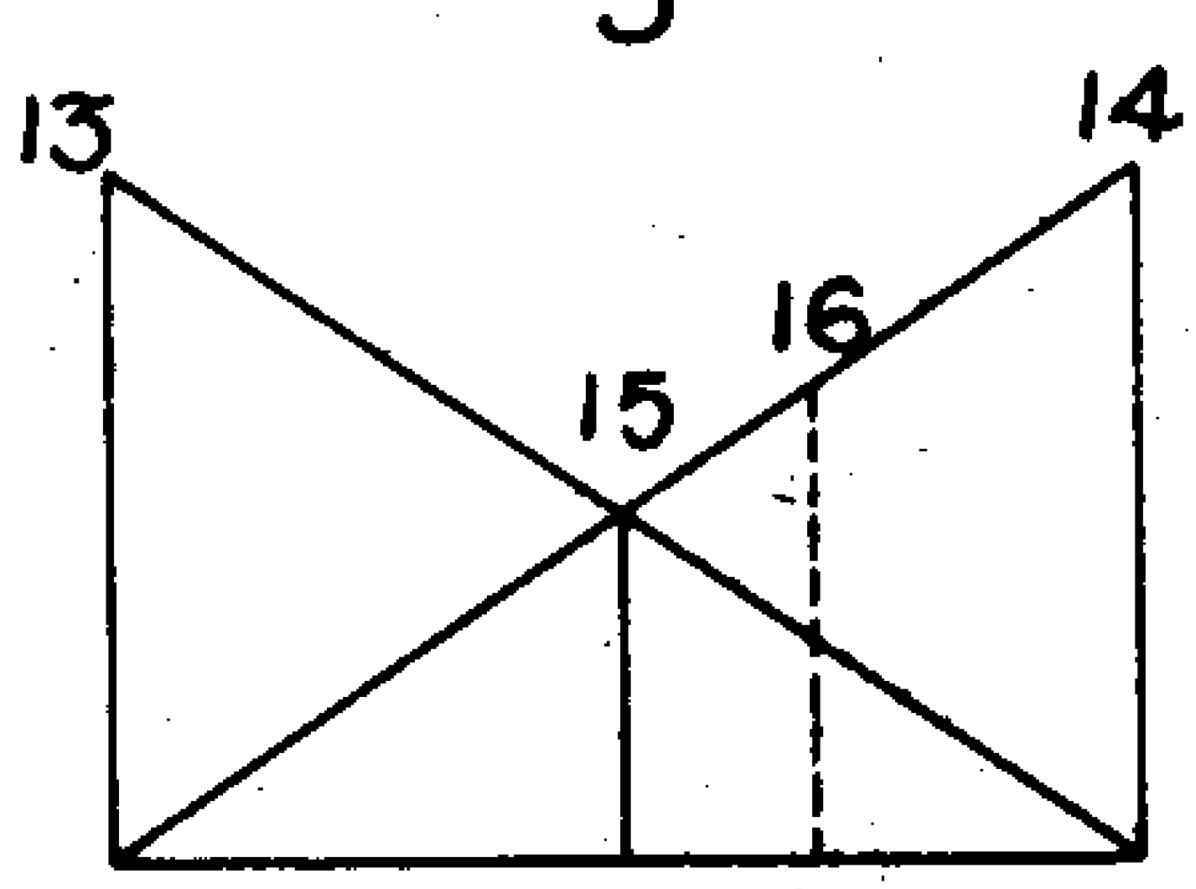


Fig.5.

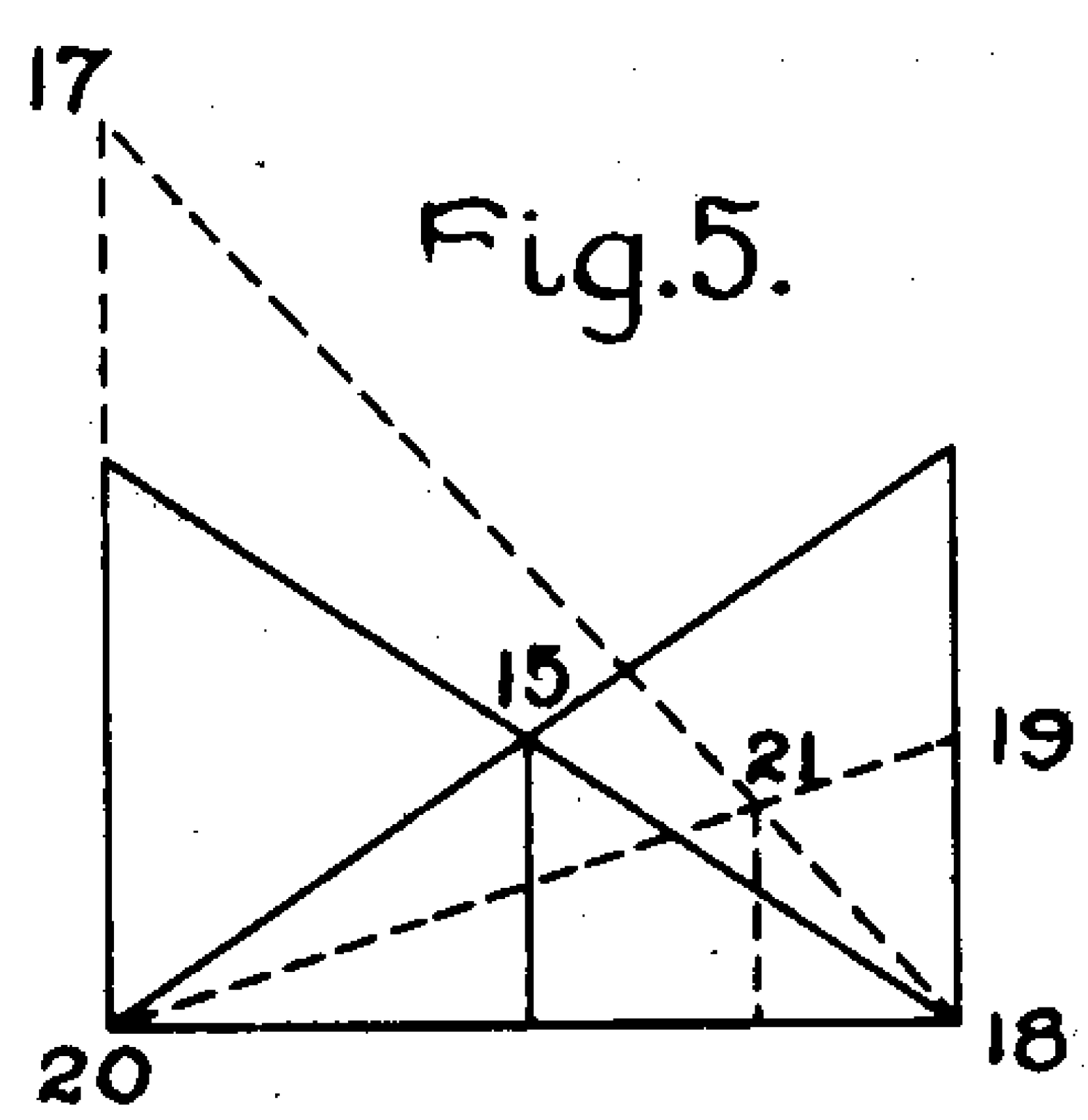


Fig.6.

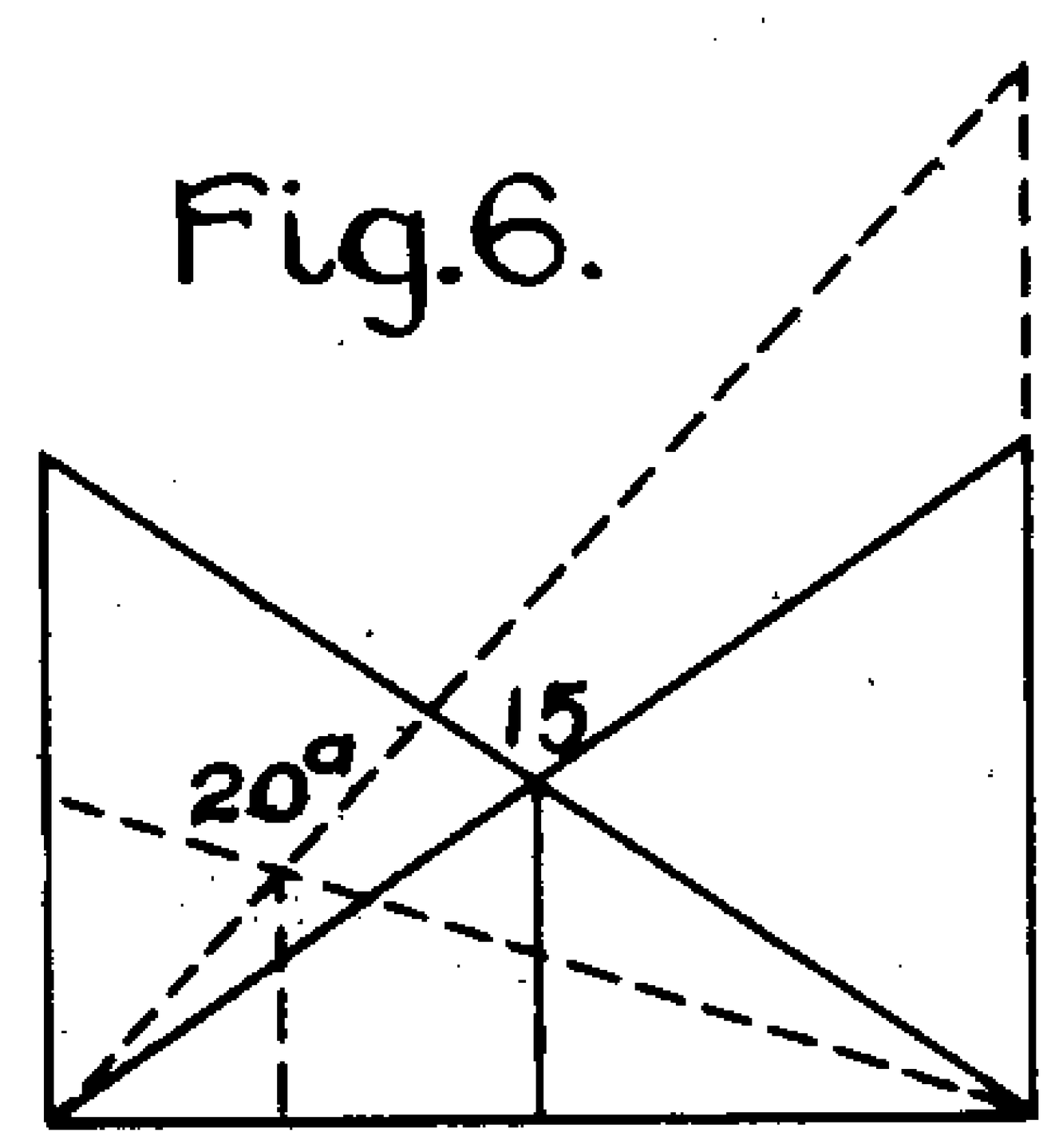
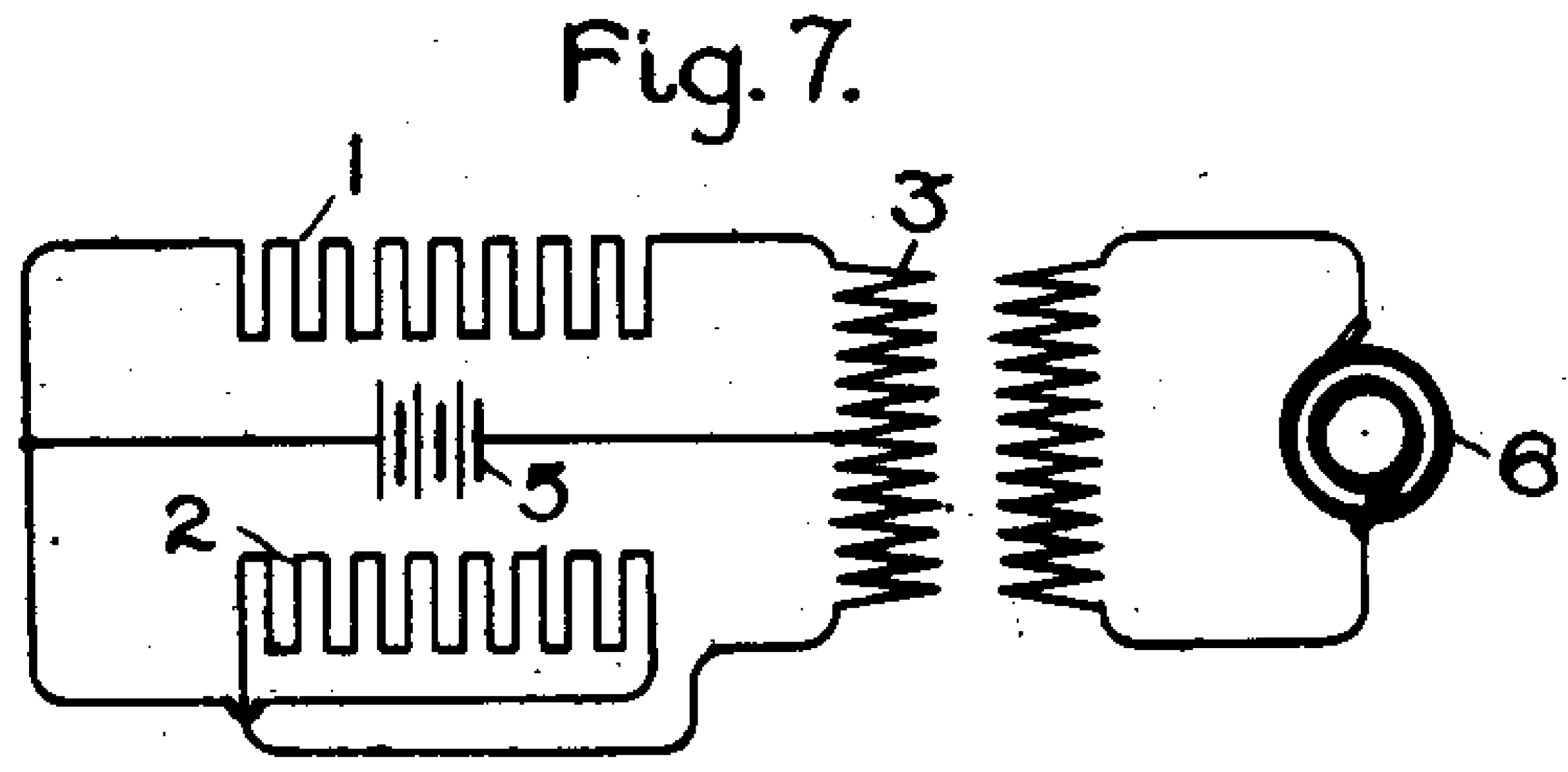


Fig.7.



Witnesses.
Emery R. Gurney
Benjamin B. Hull

Inventor:
Edwin J. Murphy.
by Albert G. Davis
Atty.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

EDWIN J. MURPHY, OF LYNN, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

RECORDING ELECTRIC-WAVE FORMS.

SPECIFICATION forming part of Letters Patent No. 713,479, dated November 11, 1902.

Application filed November 23, 1901. Serial No. 83,423. (No model.)

To all whom it may concern:

Be it known that I, EDWIN J. MURPHY, a citizen of the United States, residing at Lynn, in the county of Essex, State of Massachusetts, have invented certain new and useful Improvements in Recording Electric-Wave Forms, (Case No. 2,286,) of which the following is a specification.

In recording the wave forms of electric energy as potential or current the usual plan of procedure is to employ some electromagnetic device the movement of which under the changing strength of the wave is caused to trace its form, either by the movement of a mechanical stylus or in a more accurate manner by means of photographically fixing a reflected beam of light. In all of the methods heretofore employed, so far as I am aware, however, the device which actually traced the wave was maintained in movement by the rising and falling strength of the wave, and this is accompanied by the disadvantage of errors introduced by inertia of the moving parts. My invention aims to avoid this error as well as to simplify the mode and apparatus by which the wave form may be traced.

The invention comprises an electrochemical method of recording the wave form, and is carried out by creating in two opposed resistances slopes of potential by which at some point between the ends of the two conductors opposed points of equipotential are established and by causing this point of equipotential to shift by superimposing on the conductors the alternating electromotive force whose wave form is to be traced. Thus the point of equipotential is caused to shift by the reaction of the changing wave against an opposing steady electromotive force, and this shifting point is caused to electrochemically leave its trace on a sensitized sheet of paper by causing a movement of the paper between contacts electrically connected with corresponding points of the two conductors. The result of this method is a record in which the wave form is traced in a clear space on a lined surface or one uniformly covered with marks due to decomposition of the chemical solution at all points of the surface except the shifting point of equi-potential above referred to.

The invention may be carried out in a simple manner by employing two oppositely-extending resistances, connected as in a Wheatstone bridge, at two points of which are applied the poles of a source of direct electromotive force, as a battery, and at the other two points of which are applied the alternating leads. From points of corresponding potential drop in the two conductors extend leads, to which are connected pens or styles bearing on a ribbon or paper saturated with an electrochemical compound easily decomposed by a current—such, for example, as an aqueous solution of iodid and bromid of potassium containing starch or dextrine. The ribbon may be kept in movement by means of an electric motor or other device capable of giving uniform speed.

I believe it is broadly new with me to produce the trace of a wave form by electrochemical means unaccompanied by distortion from inertia of moving mechanical parts.

In the accompanying drawings, which diagrammatically illustrate the invention, Figure 1 shows the arrangement of resistances and a record sheet or ribbon embodying my improvements. Fig. 2 is a diagram showing the relative arrangement of the styles and the ribbon. Fig. 3 is a diagram showing a simplified relation of the operative parts. Figs. 4, 5, and 6 are explanatory diagrams showing the manner in which the shifting point of equipotential is established, and Fig. 7 is a modified arrangement of the system for application by means of a transformer.

Referring to Fig. 1, 1 and 2 represent two resistances, and 3 and 4 corresponding resistances, which together form a Wheatstone bridge, charged at two points by a source of steady electromotive force, as a galvanic battery 5. The arrangement is similar to the diagram Fig. 3, the source of alternating energy whose wave form is to be traced (indicated at 6) being applied at the two opposite points of the bridge. The arrangement, however, of Fig. 1 differs from that of Fig. 3 in the fact that the resistance-sections 1 2 are derived from the common point 7, but connected thereto at opposite ends of the section, so that a fall of potential over the resistance 1 takes place progressively from left

to right, while that of 2 takes place progressively from right to left. Connected at corresponding points in the two sections are conductors 8 9 8^a 9^a, &c., which bear upon an electrochemical ribbon 10. This is arranged in any suitable way, so that it may be rapidly drawn through the pens, as indicated roughly in Fig. 2, the ribbon being fed from a reel 11 at one side and drawn forward at uniform speed by motor-driven rolls 12. Motion may be derived from an electric motor or any other device having a uniform speed, and control devices for starting and stopping it are of course employed.

By an examination of the diagrams Figs. 4, 5, and 6 it will be seen that when the source of steady electromotive force 5 only is applied to the system there will be a gradual fall of potential in opposite directions from the points 13 14, and the point of intersection 15 will represent a point on the electrochemical paper at which exist equal potentials and at which for that reason there will be no current flow through the paper, and therefore no electrochemical decomposition. At all other points of contact between the paper and the pens 8 9, however, the potential on one side will be higher than that on the other—as, for example, at the point marked 16 in the diagram, Fig. 4—and at these points the excess electromotive force will decompose the paper, leaving a stain or trace. When the circuit is closed from the alternating source 6, however, this point of equipotential is forced to shift to and fro with respect to the central position, (indicated at the point 15,) since the positive side of the wave will gradually increase the drop of potential on one side of the bridge and lower that on the other. These conditions are diagrammatically illustrated in Fig. 5, from which it will be evident that the potential on one side of the bridge is raised, so as to correspond to the slope 17 18, and that of the other correspondingly lowered, so as to correspond to the slope 19 20. The point of equipotential will now be found at the intersection of these two slopes or at the point 21. With the reversal of the wave, however, this point will be shifted to the left of the point 15, as indicated at the point 20^a in Fig. 6, the fall of potential being increased now in the other side of the bridge. Thus by the changing values of the alternating electromotive force the point of equal potential in the two limbs of the resistance active with relation to the recording-surface is caused to shift to and fro and the sensitive surface being in movement through the pens is covered with a mass of closely-spaced lines except only at the point of shifting equipotential, and as this moves by and in accordance with the changes of strength of the wave being measured its final shape will be outlined in a white curved line on a colored close-lined surface. In order to render the trace as close in resemblance to the impressed wave form as possible, it is necessary that the resistance across the two sides of the bridge by way of the electrochemical paper should be high relatively to that of the sections themselves. In Fig. 7 is shown a plan by which the alternating wave may be derived through a transformer, 1 2 representing the recording sides of the bridge, as before, and 3 the secondary of the transformer, the middle point of which is connected with the battery.

It will be understood that the arrangement shown in the drawings is simply diagrammatic. In practice it will be found desirable to employ the recording-resistances in a somewhat different form—as, for example, by carrying the paper between two cylinders wound with wire, which may itself be a side of the bridge. High resistance of the shunt-path through the chemical paper may be promoted by covering the wire with a thin film of oxid or other poor conducting medium. In order to prevent a distorting effect on the wave form by the coil used in such cases, the wire may be doubled, one side being insulated and the other bare, and wound side by side in a manner similar to the construction of non-inductive resistance-coils.

Since the decomposition of the chemical salts will occur at times on one side of the recording-paper and at others on the other side, very thin tough paper should be employed, which permits the discoloration to be visible through the fabric.

It will thus be seen that by means of these improvements the form of the alternating wave may be traced without the employment of any moving device introducing an inertia factor to disturb the accuracy of the wave form.

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

1. A recording device for electric-wave forms, comprising two resistances mounted to create proportional potential drops in opposite directions of the potential to be recorded, a movable record-strip, and means for indicating the shifting point of potential equality in the two resistances.

2. Recording apparatus for electric waves, comprising two resistances, a source of steady electromotive force connected thereto to establish a falling potential in opposite directions, a recording-surface, styles governed by corresponding points of the resistances, a record-sheet moved across the styles, and reverse electric connections between the two resistances and the circuit carrying the wave to be recorded.

3. Recording apparatus for electric waves, comprising two resistances, a source of steady electromotive force connected thereto to establish a falling potential in opposite directions, contacts connected with corresponding points of the resistances, a chemical record-sheet, means for driving it past the styles, and reverse electric connections of the resistances with respect to the circuit whose wave

is to be recorded, whereby a shifting point of balanced potential is maintained by said wave.

4. Recording apparatus for electric waves, comprising a divided circuit, resistances in the two sides thereof, connections for opposing corresponding points of the resistances on a chemical recording-surface, and connection with the circuit carrying the wave to be recorded to effect a lateral shift of the resultant potentials on the surface.

5. Recording apparatus for electric waves, comprising a divided circuit, resistances in two sides thereof, a source of steady electromotive force reversely connected with respect to the ends of the resistances, and connections for the wave to be traced to assist the steady electromotive force in one limb of the circuit and to oppose it in the other.

In witness whereof I have hereunto set my hand this 21st day of November, 1901.

EDWIN J. MURPHY.

Witnesses:
DUGALD MCK. MCKILLOP,
ALEX. F. MACDONALD.