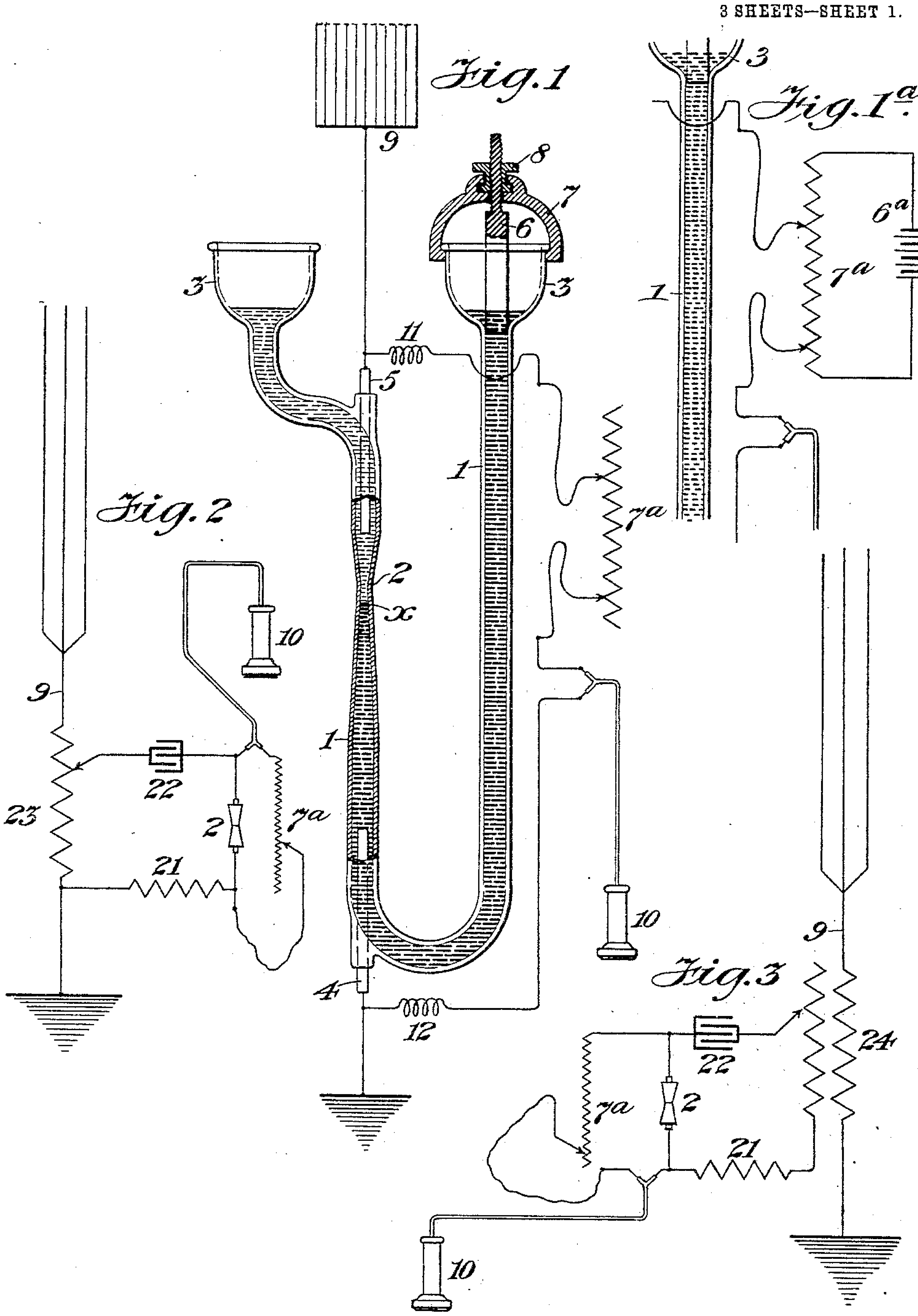
J. M. BOYLE.

ELECTRICAL RECEIVING APPARATUS.

APPLICATION FILED JULY 28, 1905.

**962,417.** Patented June 28, 1910.

3 SHEETS—SHEET 1.

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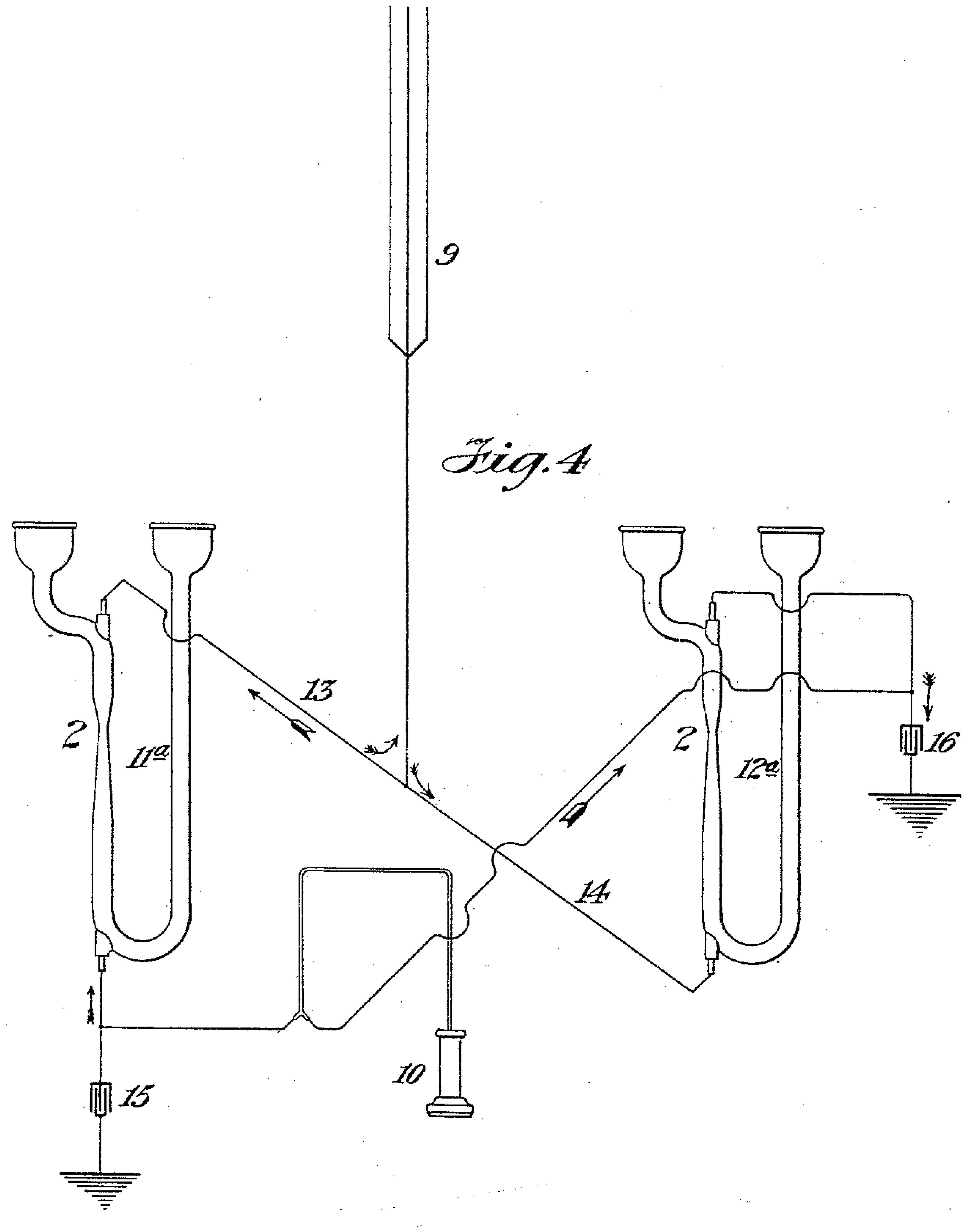


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3 SHEETS—SHEET 3.

Fig. 5

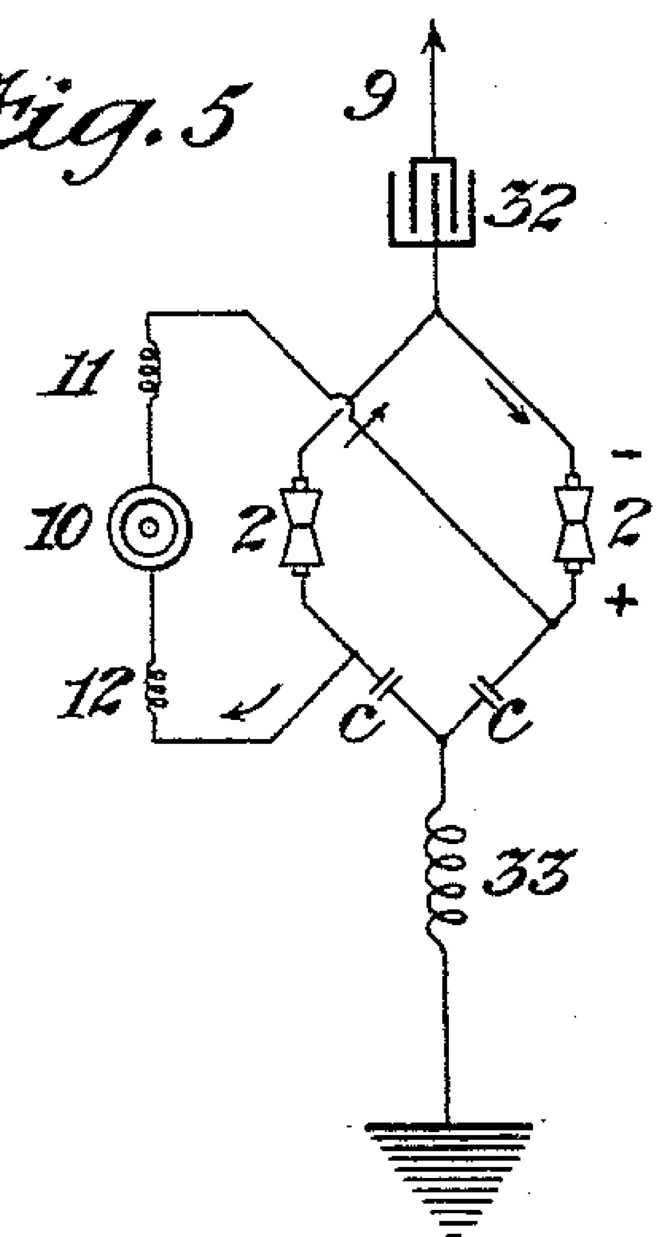



Fig. 7

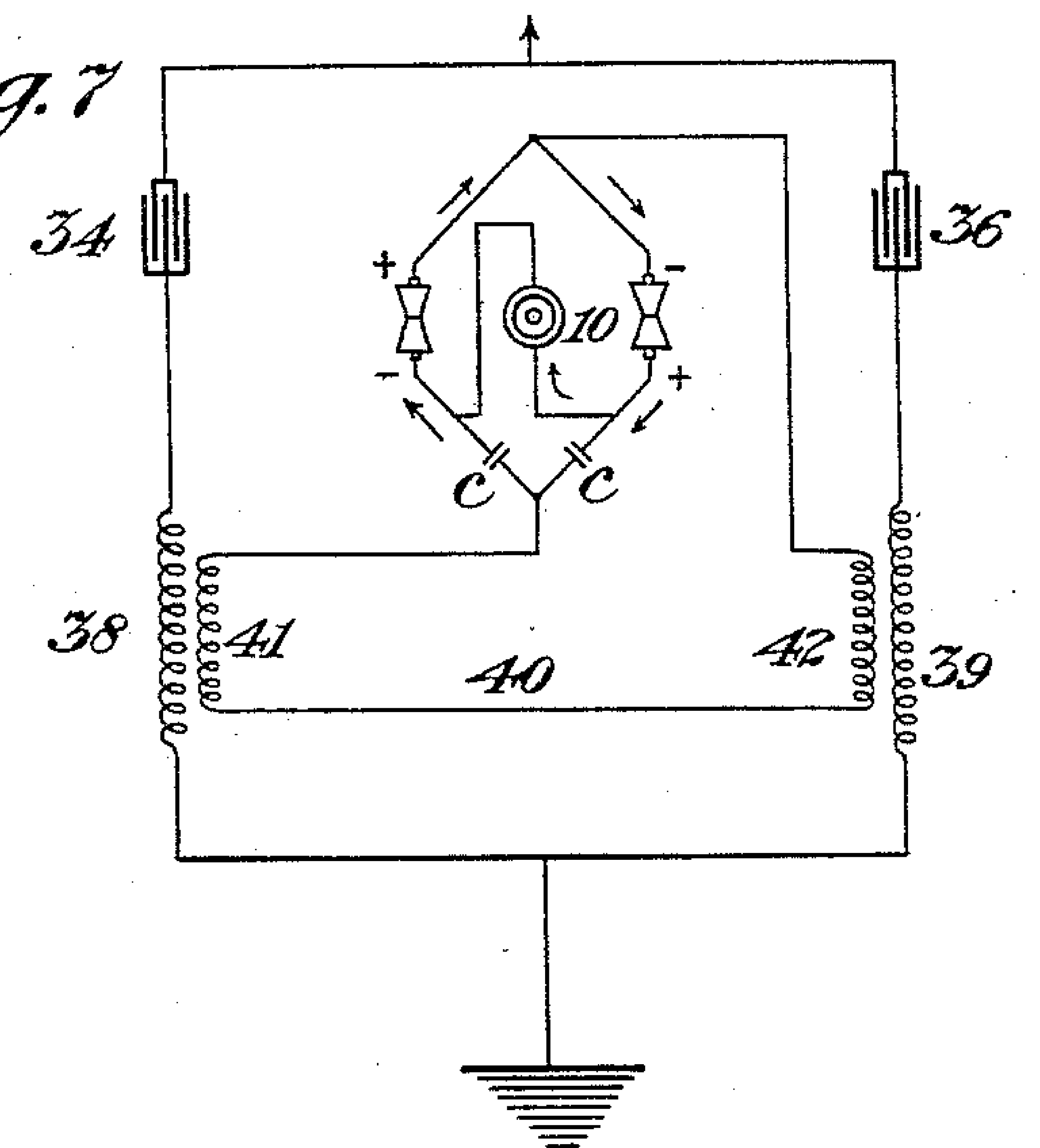



Fig. 6.

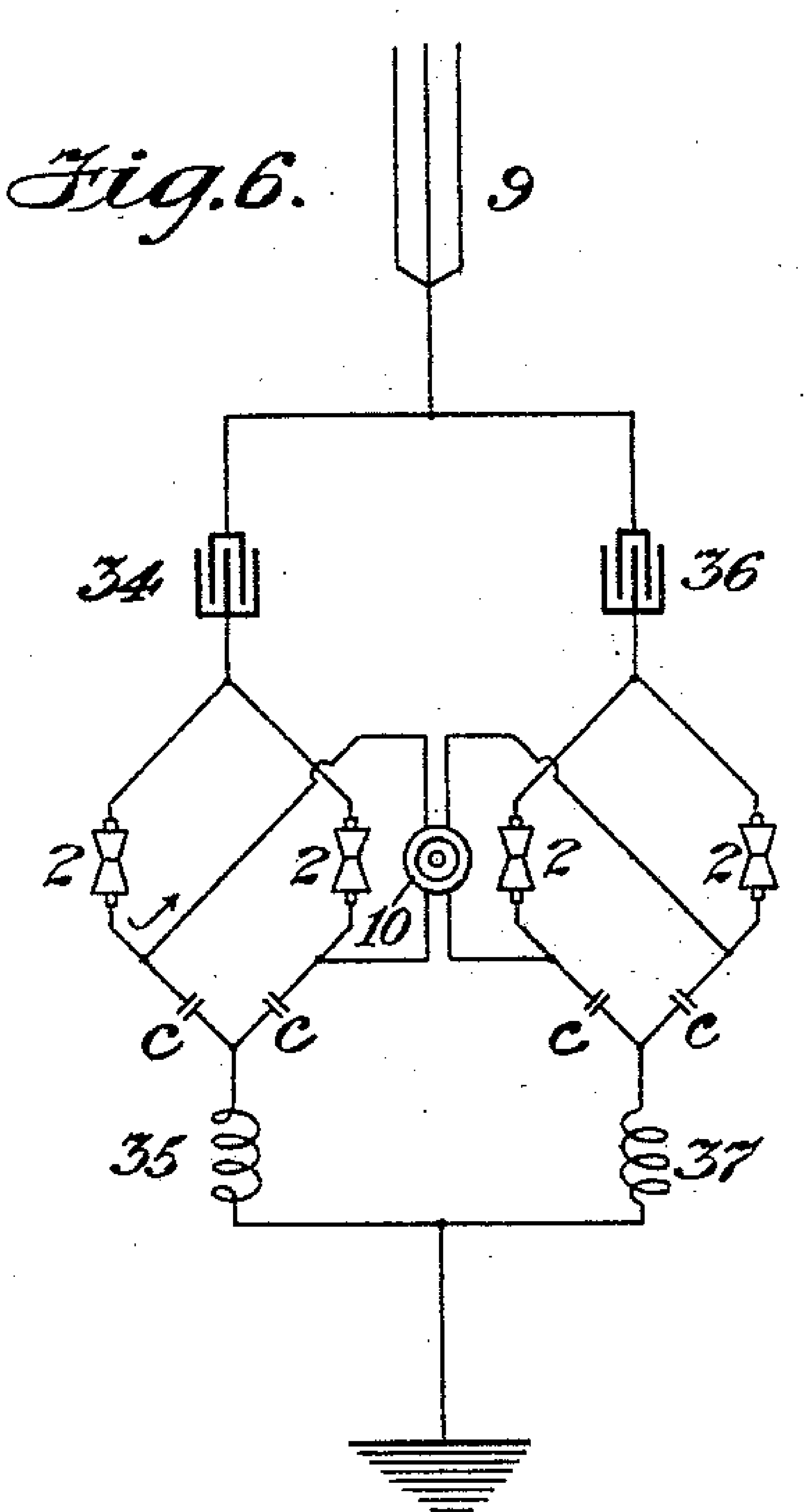
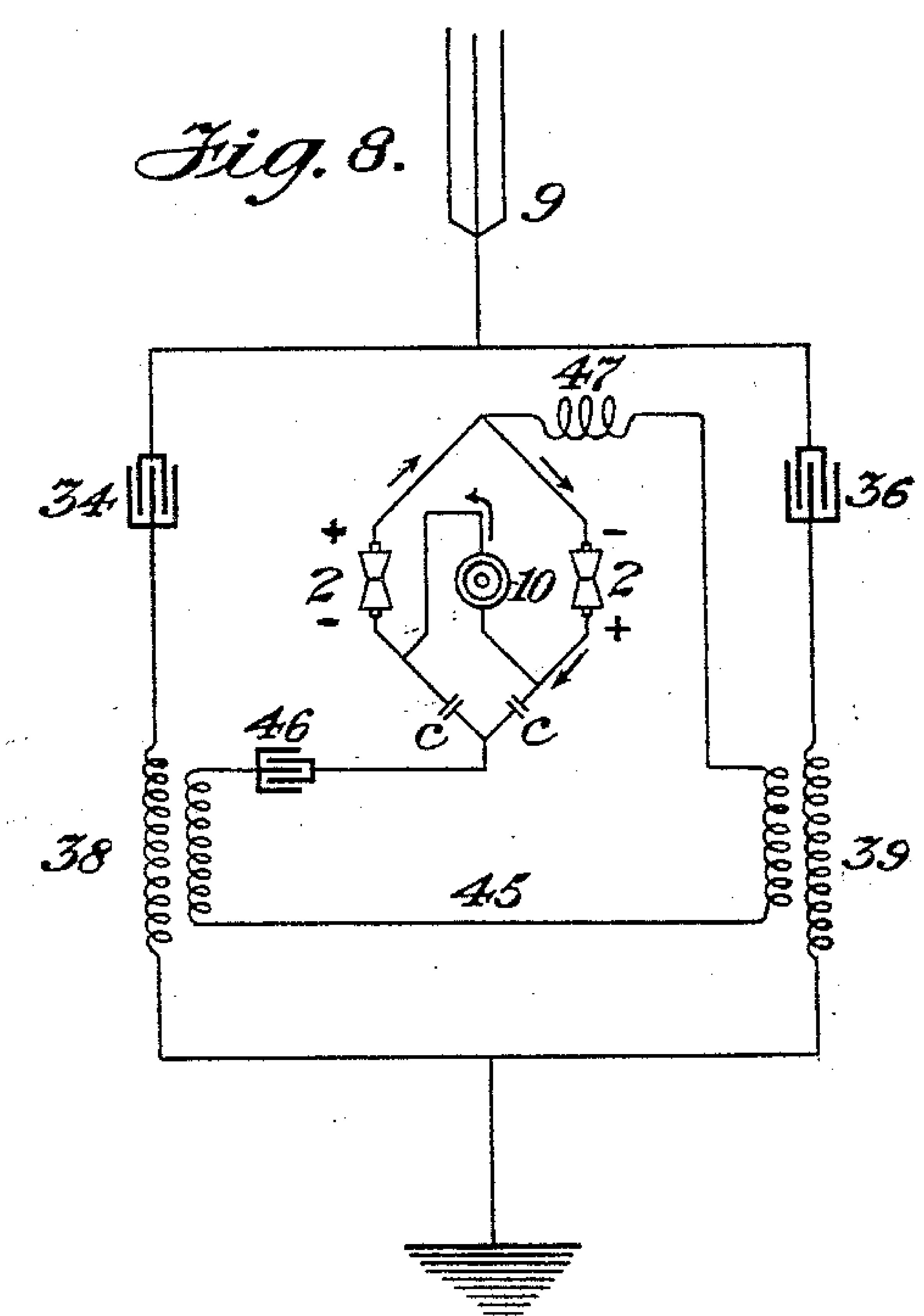



Fig. 8.

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ELECTRICAL RECEIVING APPARATUS.

962,417. Specification of Letters Patent. Patented June 28, 1910.

Application filed July 28, 1905. Serial No. 271,709.

*To all whom it may concern:*

Be it known that I, JAMES MURRAY BOYLE, a citizen of the United States, and a resident of New York city, in the county of New York and State of New York, have invented certain new and useful Improvements in Electrical Receiving Apparatus, of which the following is a specification.

Inventions set forth herein relate to receiving, detecting or utilizing electrical impulses, fluctuations or alternations, particularly those of high frequency and of oscillatory frequency; more specifically those which are extremely feeble or of extremely small quantity as for instance, those employed in wire or submarine telegraphy or in wireless telegraphy by electro-magnetic waves.

The principal invention hereof may be generally described as involving the employment of one or more comparatively restricted fluid paths for the oscillations. The path is traversed by direct currents from a source of preferably small current supplying capacity and said path preferably constitutes part of such source. The restricted fluid path comprises an electrolytic conductor preferably two liquid electrolytes arranged in series and having a small area of connection or mingling, preferably capable of being varied in extent. The variation of this extent or connection of the two electrolytes is preferably effected by adjustment of the region thereof along a passage or tube of varying cross section. The liquid electrolytes are preferably of different specific gravities preferably vertically arranged with the lighter liquid on top.

In each liquid is arranged an electrode or plate so that the two liquids and the restricted region of connection between them is in series with said electrodes. The latter are preferably electro-chemically attackable each by the liquid with which it is in contact, to a sufficient extent to constitute the device a small capacity generator of direct electromotive force.

One efficient means which I have devised for securing the adjustable restricted region or surface of connection between the electrolytes, consists of a U-shaped tube comprising two sides preferably vertically arranged, one of them drawn down to form a tube or passage converging to a minimum small diameter. The region of connection between the two electrolytes is in this converging passage and the restriction of the contact may be adjusted by varying the relative hydrostatic pressures of the columns of liquid in the two sides or by other means.

The electrodes may be made both of similar metals and may be such for instance as platinum or gold and not chemically active but rather inert with respect to the electrolyte with which they are in contact. In the latter case the electrodes may have serially impressed thereon an adjustable small direct electromotive force from a source of preferably small current supplying capacity.

Devices of the character described are shown in connection with various useful forms of receiving circuit such as closed tuned and resonant circuits and also in connection with the parallel differently tuned or resonant circuits of the Fessenden interference preventer. Also insomuch as the device has some tendency to act asymmetrically or selectively with respect to half waves or oscillations of opposite sign, arrangements are shown in which two such devices connected serially with each other are arranged in separate parallel branches of the receiving circuit.

In the operation of the device its sensitiveness is dependent to some degree, and indeed within limits is vitally dependent, upon the extent of the region of contact of the two electrolytes, nevertheless in most cases it is not found necessary to make the internal diameter of the tube microscopically small, though such a diameter may be useful in some connections. In general it will be found that with a converging tube having a sufficiently small minimum diameter there is an adjustment of the region of contact within such converging tube which will give the best results under given conditions and in practice it will be found that such adjustment does not always bring the region of contact of the electrolytes to the point of minimum diameter of the tube. This will be referred to hereinafter.

Having briefly outlined something of the nature and object of my invention I will now proceed to describe very specifically certain concrete devices or embodiments which I have found to be useful, referring to the accompanying drawing in which—

Figure 1 is a view of a form of the device partly in vertical section together with circuit connection, Fig. $1^a$ being a diagram of a modified battery connection. Figs. 2 and 3 show arrangements of receiving conductor and inductively associated closed tuned or resonant receiving circuits, the receiving device being conventionally indicated. Fig. 4 shows two of the devices arranged in parallel branches of a receiving circuit and connected serially with each other and with an indicating instrument shown as a telephone. Fig. 5 shows a similar parallel arrangement the receiving circuit being tuned. Fig. 6 shows a similar arrangement duplicated as to two parallel tuned branches of a receiving circuit the indicating device having separate differentially wound coils each in series with a pair of the devices in either of said parallel tuned branches of the receiving circuit. Fig. 7 illustrates a single pair of the receiving devices connected as before described in parallel branches of a local receiving circuit which is excited through differential windings constituting secondaries, the primaries of which are in parallel tuned or resonance branches of the receiving system which branches are tuned in accordance with the principle of the Fessenden interference preventer. Fig. 8 is a view of a similar arrangement wherein the differentially excited local circuit is tuned or made resonant by a condenser and inductance.

While I am now about to describe specifically certain concrete devices or embodiments of my invention which I have actually constructed and used, my invention is nevertheless not limited to any specific arrangement or construction of parts or details of operation and my claims are not limited as to any feature or step not specifically set forth and defined therein.

Referring now to Fig. 1 it will be seen that the specific device referred to may be considered as a specific form of gravity battery comprising a U-shaped tube 1 preferably vertically arranged and converging to a small diameter at the point 2. If desired the ends may be left open and provided with enlarged bowls which may be conveniently utilized as funnels in charging the device with the electrolyte. The diameter of the tube is not of great importance provided it be of proportions capable of being drawn down to the necessary minimum diameter at the point 2. The interior diameter may be 3/8 to 3/16 of an inch more or less throughout its length except where it converges to something like 3 mils. more or less at the point 2. The electrodes 4 and 5 project into the tube on opposite sides of the point 2 and are preferably sealed therein as shown although where sealing is difficult or unsatisfactory because of the nature of the metal used, they may be secured by any desired means as for instance by water tight packing. The electrodes may be of similar metals or materials or of different metals or materials. When they are similar and are not attackable by the liquids employed as for instance when composed of platinum or gold an outside source of electromotive force, as, for instance, battery $6^a$ shown in Fig. $1^a$ may be connected therewith as is well known it being frequently preferable to use the device as a liquid barretter, using an outside source of current. When the electrodes are of different materials and are electro-chemically attackable by the electrolytes with which they are in contact the cell itself may constitute the source of electromotive force. In either case the desired amount of normally flowing battery current may be properly adjusted by means of the series resistance $7^a$.

The electrolytes preferably have different electro-chemical values and are of sufficiently different specific gravities and sufficiently different chemical character not to readily diffuse and intermix beyond a certain limited region of contact. They may be such liquids as zinc chlorid and copper sulfate. One way of arranging matters is to carefully dry the tube 1 and fill the unconstricted side shown at the right in Fig. 1 with copper sulfate up to a point where this liquid rises in the other branch a desired distance above the narrowest point at 2, then carefully and, preferably drop at a time, add zinc chlorid or other desired lighter electrolyte through the left hand tube until it rises well above the point of junction or contact of the two liquids; then the two branches may be filled by adding approximately equal amounts of additional copper sulfate and zinc chlorid maintaining the surface or region of contact X, in the neighborhood of the constriction 2 preferably below the same. If below the final adjustment may be effected by inserting the plug 6 in the right hand branch of the tube and adjusting the same by means of the nut 8 which is secured from vertical movement by means of the clamp 7 secured to the bowl 3.

The electrode 4 may be of copper wire about 18 gage projecting a short distance, say a quarter to a half inch into the copper sulfate and the elctrode 5 may be zinc of similar dimensions projecting a similar distance into the zinc chlorid. The zinc electrode or plate may be made slightly larger than the copper if desired. The electrodes are connected in series in a receiving system as for instance by connecting 4 to ground and 5 to an aerial 9 as shown.

The indicating instrument 10 is connected in series with the device, choke coils 11 and 12 being provided if desired. An adjustable resistance $7^a$ may be used but in any event the resistance of this circuit including the resistance of the choke coils and the indicating instrument, should be such as to permit a continuous flow of current of an amount large as compared with the capacity of the cell for generating current and preferably the amount should be such that the cell is in a condition where a comparatively small increase of current flowing will produce a comparatively great drop in the voltage. This condition has been approximated with one form of cell which I have used where the resistance of the circuit was something like 1200 ohms. This feature of the device I find to be one which is dependent on the construction and conditions of use and is best determined by experimental adjustment until the condition of maximum sensitiveness is found. This receiving cell is a battery of small generating capacity and the latter may be yet further decreased by decreasing the area of the electrodes as by varnishing a portion thereof, though I have not noted that with the proportions described above a further decrease in the electrode area gives very marked improvement. It may be that this is because the operation of the device is in some sort dependent for maximum sensitiveness on getting the certain ratio of current flow to current generating capacity, referred to above and that for this reason very much the same result may be achieved by changing the external resistance $7^a$ so as to get that current flow which is best in connection with the particular current generating capacity of the cell. Moreover it is probable that the size of electrodes given is small enough for good working current generating capacity with a high resistance telephone receiver.

The material of the electrodes may be the same as for instance both of them may be of platinum and yet the differential action of the zinc chlorid and copper sulfate will be sufficient to constitute the device an efficient receiver.

With either similar or dissimilar electrodes the device will operate efficiently in connection with an exterior source of direct electromotive force applied thereto either in series with or in opposition to its own electromotive force. Thus the battery $6^a$ may be connected to the resistance $7^a$ in the manner shown so that the latter may be used as a potentiometer.

From the above detailed description it will be obvious that the device may be used after the manner of the Fessenden liquid barretter and that in using the same the operator will adjust the position and thereby the extent of the region of contact of the two electrolytes and will adjust the resistance of the circuit of the indicating instrument until the maximum effect is observable. This detector is of extraordinarily low resistance one form which I have used substantially like that above described being only a fraction of one ohm. This makes the device exceptionally well adapted for use in resonant circuits, especially when two of them are used in parallel so that taken together they offer asymmetrical resistance or opposition to half waves of opposite sign. In such case the half waves running in one direction pass through the path offering the least resistance, and the other half waves running in the opposite direction pas through the other parallel path, thus the two sets of waves flow against substantially equal resistances.

In Fig. 4 I have shown such a parallel arrangement in a tuned or resonant aerial circuit wherein the devices $11^a$, $12^a$ are connected in series like 2 cells of a battery, the oscillatory circuit being connected thereto so that said devices $11^a$, $12^a$, are in parallel branches thereof. In such a case it is very desirable to make the length of wire 13 equal to the length 14 and the length of wire 15 and condenser therein equal and similar to the similar connection at 16. This double symmetrical arrangement of asymmetrical receiving devices may be employed wherever the single device may be employed and is especially desirable in tuned or resonant circuits.

In Figs. 2 and 3 I have conventionally indicated single receivers 2, 2 in closed receiving circuits tuned or made resonant by inductance 21 and capacity 22 and associated with a tuned receiving aerial, in Fig. 2, by means of an auto-transformer 23, and in Fig. 3, by the ordinary transformer 24 which may be in either case step-up or step-down.

In Fig. 5 I have shown the double symmetrical arrangement as in Fig. 4 but the aerial is made resonant by condenser 32 and inductance 33 as shown.

In Fig. 6 I have shown an arrangement wherein the aerial receiving circuit is divided into parallel branches each provided with a condenser 34, 36 and an inductance 35, 37 whereby each may be tuned to a slightly different frequency one of them being the frequency of the sending station. In each of the parallel tuned branches is arranged a pair of symmetrically arranged receivers, 2, 2, the indicating circuit of each pair being connected to a separate winding of a single indicating instrument 10 said windings being differential or differentially connected.

In Fig. 7 the arrangement is somewhat like that of Fig. 6 as to parallel tuned or resonant receiving branches but the receivers are not directly in the branches but in a circuit 40 differentially connected therewith by transformers 38, 39.

In Fig. 8 the receiving circuit has the described characteristics of Figs. 6 and 7 with the additional feature that the circuit 45 corresponding to the circuit 40 of Fig. 7 is tuned or made resonant by condenser 46 and inductance 47 to the frequency of that one of the branches which is tuned to the frequency of the sending station.

The peculiar operation of the differential interference preventer need not be more fully described herein but it is important to point out that the closed tuned secondary circuit 45, 46, 47 of Fig. 8 is exceptionally efficient because of the low resistance and the symmetrical resistance of my receivers arranged as shown.

In the various figures the condensers *c*, *c*, are not tuning condensers but are condensers of large capacity employed to prevent short circuiting of the direct electro-motive force around the indicating device.

From the above description of my new receiver it will be obvious that the variations of construction and form in which the receiver may be embodied are innumerable since it is immaterial how the adjustment of extent of the region of contact of the two liquids is varied or maintained and what may be the size or shape of the container on each side of the converging passage along which the region of contact is adjusted. It is unnecessary to have the converging passage 2 extend beyond the point of smallest diameter. There are infinite varieties and strengths of electrolytes and of materials and sizes for the electrodes. The location of the electrodes has no particular significance in the operation of the device. Finally the device itself may be used in any kind of a receiving system.

The displacement body or piston, 6, is shown merely as representative of a great variety of means which may be employed for adjusting and fixing the surface or region, *x*, where the two electrolytes meet. It is desirable, however, that this displacement member act directly against the column of liquid in an unyielding manner and without the interposition of any yielding or elastic body such as gas, to the end that all movements of said displacement body or piston will be certainly and non-elastically transmitted to take effect at *x*. As shown the member 6 is of rather large cross section as compared with the cross-section of the restricted portions of the tube and for fine adjustment a displacement body of cross section as small as desired may be caused to act upon the rigidly confined column of liquid at any desired point in its length.

The device may be successfully used quite independently of any knowledge of supposed theory of operation, by following the instructions hereinbefore given, taking care to get a definite and preferably very sharply defined surface of contact or region of intermingling of the two electrolytes and then adjusting that area and also the flow of current during the receipt of signal waves or impulses until the response of the indicating instrument to such impulses shows that the resulting fluctuations in the circuit thereof are at a maximum. Under such conditions it is possible for the detector to cause such fluctuations as a result of one or more of a number of reactions which according to the conditions may be effective in greater or less degree either separately or simultaneously. There is necessarily some heating effect more or less concentrated in the restricted portion of the electrolytic path which may well be particularly effective in the minute surface of contact or region of intermingling thereof wherein take place the well-known electro-chemical exchanges and reaction commonly set up in this portion of a two fluid primary battery. Unquestionably also the device is asymmetric and to some extent of asymmetric resistance with respect to the two halves of a current alternation or oscillation. The half oscillation whose electromotive force is in opposition to the normal electromotive force of the detector may tend to cause a decrease in the flow of current therefrom; also the counter electromotive force of the device particularly when it is itself the primary battery, being comparatively small, it may be that the half oscillation of current flux in the same direction with the current flow of the battery, passes readily through the detector thereby overloading the same, particularly if the comparatively low resistance indicating circuit has been adjusted in the manner hereinbefore described so that it is at the point where a comparatively small increase of current produces a relatively great drop in voltage. Finally it is possible that because of the minuteness of the region of contact or intermingling of the two electrolytes, particularly where the device itself is a two fluid primary battery, there is some sort of electrical or chemical fatigue, or some physical or chemical change in the extent or character of the diffusion or intermingling or change of the liquids, molecules, atoms or ions, brought into prominence by the passage of the waves which produces a momentary cessation diminution or modification of the chemical or ionic action upon which the battery function of the device is dependent. The fact that the device is not always most sensitive when the region of contact or intermingling of the two electrolytes is adjusted to the point of minimum diameter of the converging tube tends to indicate that the reactions are complex and that the changes of current in the indicating circuit are a resultant and perhaps the algebraic sum of the effects of a plurality of reactions.

I claim:

1. A receiver comprising two bodies of electrolyte of different characteristics, hav-

ing a minute surface or region of connection, and suitable electrodes in series therewith.

2. A receiver comprising two bodies of electrolyte having a minute region of connection or intermingling and means for adjusting the latter.

3. A receiver comprising two physically different bodies of electrolyte having a minute region of connection and means for modifying said region.

4. A receiver comprising two physically and chemically different electrolytes connected by a passage of non-uniform cross section and means for varying the position of the region of division or connection of said electrolytes along said passage.

5. A receiver comprising a body of liquid having physically different characteristics in different parts thereof, the region of transition of characteristics being of relatively small cross section and electrodes with respect to which said liquid is electrochemically active, said electrodes being serially arranged on opposite sides of said portion of small cross section.

6. A receiver consisting of a battery cell comprising two bodies of electrolyte of different characteristics having a minute region of connection, means for changing said region, and suitable electrodes on opposite sides thereof.

7. A receiver comprising two electrolytes having a minute region of connection and electrodes on opposite sides thereof chemically changeable by said electrolytes.

8. A receiver consisting of a battery cell comprising two bodies of electrolyte of different characterists having a minute region of connection and electrodes on opposite sides thereof composed of materials chemically changeable by said electrolytes.

9. A receiver consisting of a battery cell comprising two electrolytes having a region of contact or intermingling restricted to a small area, and electrodes differing in material but each chemically changeable by the electrolyte with which it is in contact.

10. A receiver comprising a primary battery containing two electrolytes having a minute surface or region of connection.

11. A receiver consisting of a two fluid primary battery, the conductive fluid connection of said fluids being of extremely small cross section.

12. A receiver consisting of a two fluid primary battery the conductive fluid connection of said fluids being of extremely small adjustable cross section.

13. A receiver comprising a minute adjustable portion of chemically interactive fluid of a two fluid battery.

14. A receiver comprising the minute interactive region or surfaces of serially arranged electrolytes having different characteristics and impressed serially by a direct electromotive force.

15. A receiver comprising a minute interactive region or surface of serially arranged chemical electrolytes having different characteristics and impressed serially by a small adjustable direct electromotive force.

16. In a receiving system a two fluid battery having minute clearly defined surfaces or regions of conductive connection, and means for adjusting continuous current flow across the same.

17. In wireless telegraphy apparatus a wave responsive device comprising a two-fluid primary cell, electrodes in the respective fluids arranged to pass oscillatory currents between them wholly through the contacting surfaces of the fluids, and means to produce a signal by the resulting change of conductivity in the region of fluid contact.

18. In a receiving system the combination of a closed, tuned or resonant receiving circuit with two primary batteries in series with each other and energized in parallel by said resonant circuit.

19. In a receiving system the combination of a receiving circuit and two sensitive devices consisting of the region of contact of two bodies of electrolyte, the sensitive devices being arranged in parallel in the receiving circuit, the bodies of electrolyte comprising the same being reversely arranged with respect to said circuit.

20. In a receiving system the combination of a resonant receiving circuit and two sensitive devices in said circuit in parallel with each other and comprising two bodies of electrolyte having a minute region of contact, the electrolyte being reversely arranged with respect to said receiving circuit.

21. In wireless telegraphy a wave responsive device consisting of a two-fluid primary cell having two electrodes respectively immersed in the fluids thereof and connections to pass oscillatory currents through the cell and vary the resistance in the region of contact and thereby vary the current of the cell.

Signed at New York city, in the county of New York and State of New York, this 30th day of June, A. D. 1905.

JAMES MURRAY BOYLE.

Witnesses:
George C. Dean,
Katharine A. Morris.