Feb. 7, 1928. 1,658,680

C. A. HOXIE

ELECTRICAL APPARATUS

Original Filed Oct. 29, 1920 4 Sheets-Sheet 1

Fig. 1.

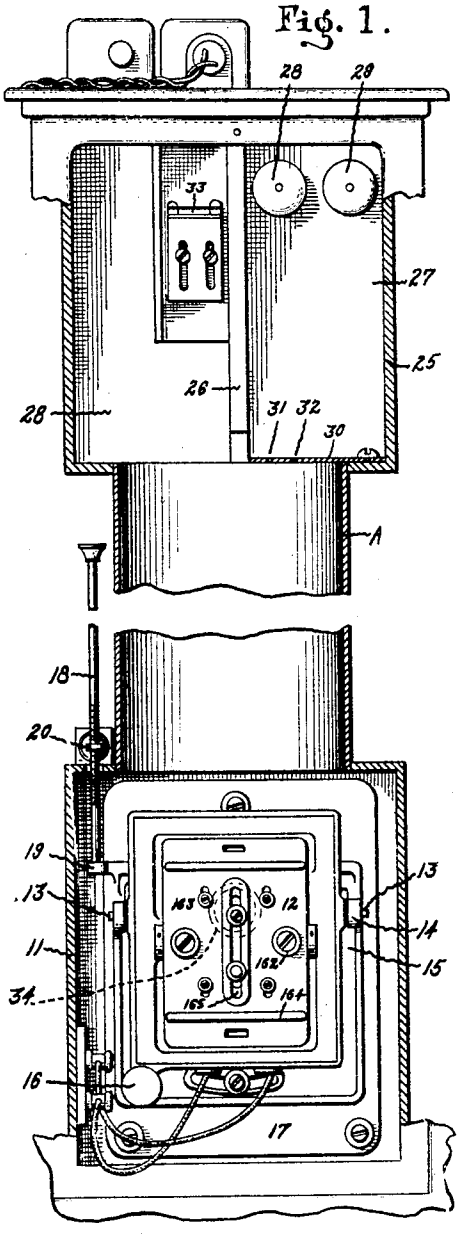


Fig. 8.

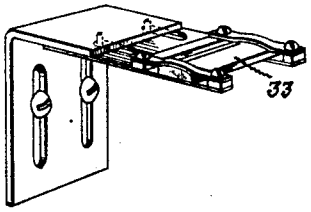


Fig. 12.

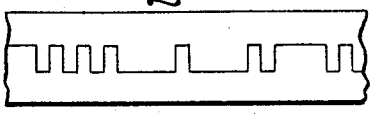


Fig. 10.

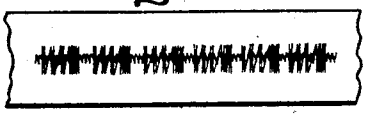


Fig. 3

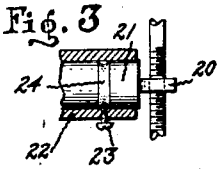
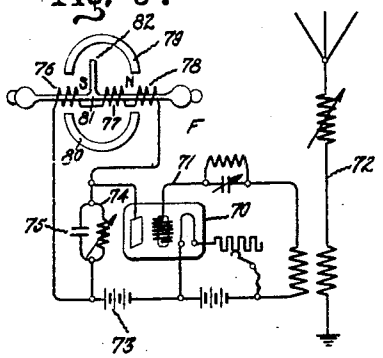


Fig. 9.



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ELECTRICAL APPARATUS

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Fig. 2.

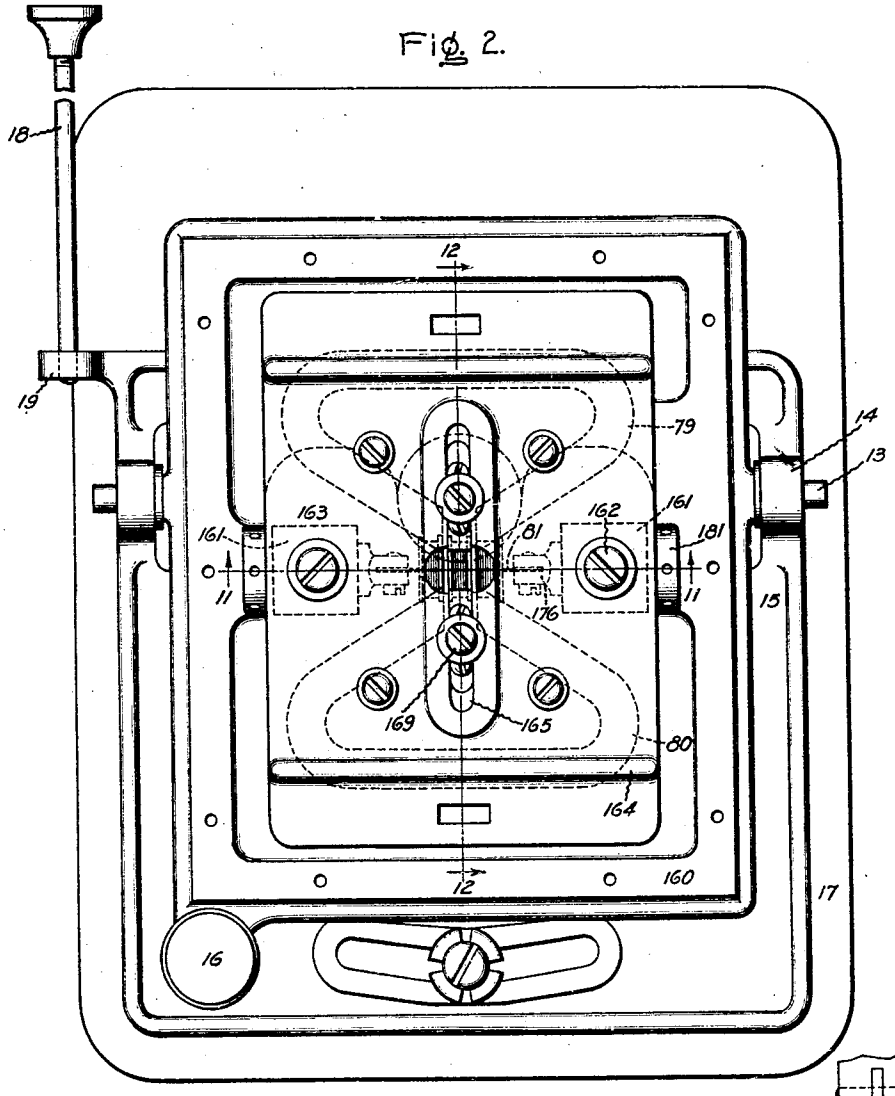


Fig. 4.

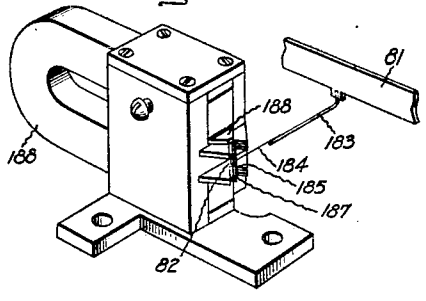
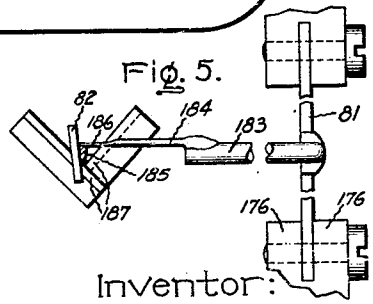


Fig. 5.



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ELECTRICAL APPARATUS

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Fig. 6.

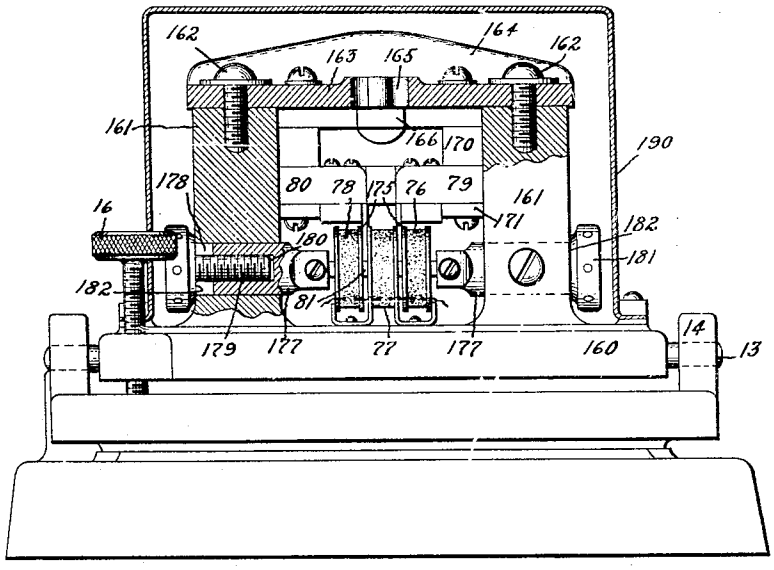
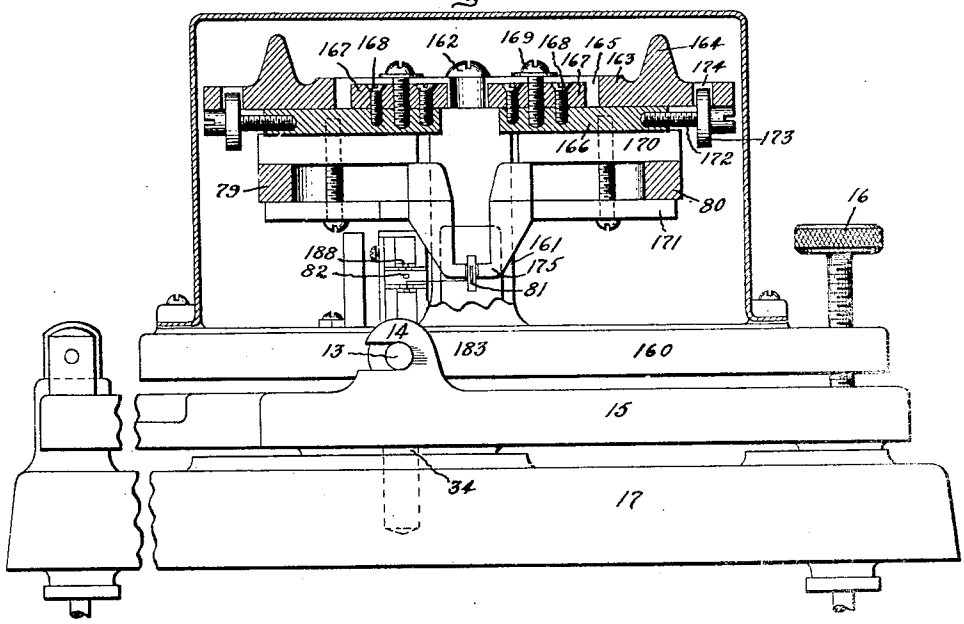


Fig. 7.



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ELECTRICAL APPARATUS

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Fig. 11.

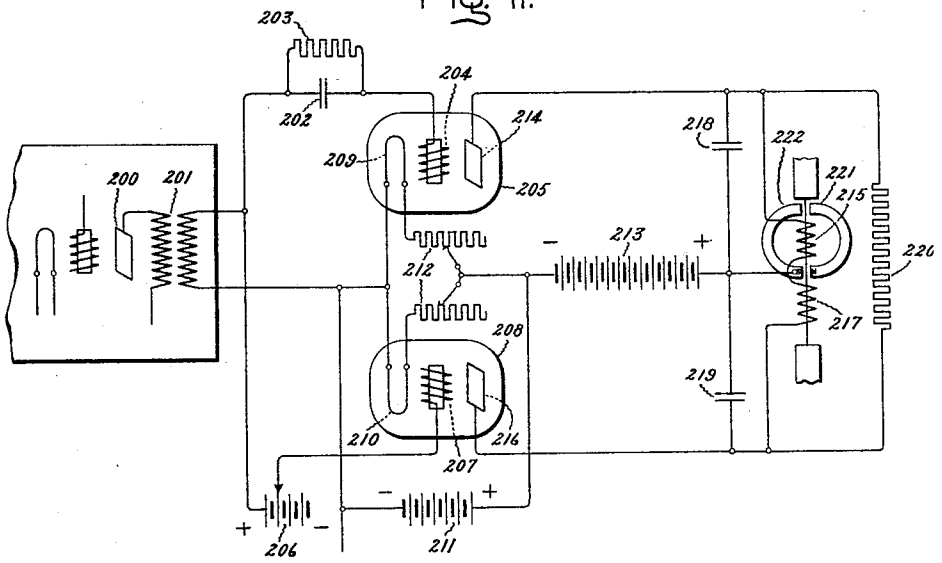
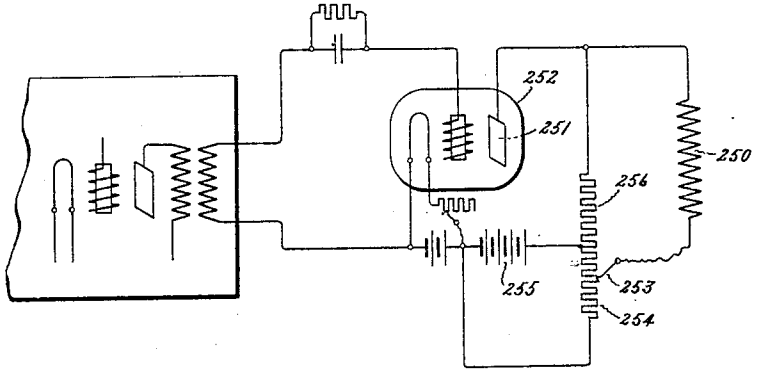


Fig. 13.



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Patented Feb. 7, 1928. 1,658,680

UNITED STATES PATENT OFFICE.

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ELECTRICAL APPARATUS.

Original application filed October 29, 1920, Serial No. 420,491. Divided and this application filed October 10, 1922. Serial No. 593,615.

My present invention, which is a division of my application, Serial No. 420,491, filed Oct. 29, 1920, relates to apparatus for selectively receiving and making a record of small current impulses and more particularly for recording photographically impulses corresponding to rapidly transmitted signals.

In my Patent No. 1,456,595, issued May 29, 1923, I have described an apparatus for receiving radio signals, the same comprising means for causing a current whose variations correspond to the signals received to traverse a series of coils which surround a vibratory reed or diaphragm of magnetic material. This reed or diaphragm is supported between the poles of two permanent magnets in such a manner that by varying the magnetic field produced by the currents in the coils the diaphragm is caused to vibrate. Means is provided to adjust the tension of the diaphragm to cause it to assume a natural period of vibration corresponding to the period of the received signals. It was found that the disturbing effects due to stray impulses could be eliminated to a large extent by operating with frequencies above 1500 and tuning the diaphragm accordingly. My present invention seeks still further to eliminate these disturbing effects by introducing in shunt to the operating coils for the magnetic diaphragm what may be termed a tone trap. This comprises an inductance and capacity, each of which is connected across the operating coils and which together may be adjusted so that the local circuit in which they are included may be tuned to a frequency corresponding to that of the signals received.

One object of the present invention is to provide an improved receiving system wherein an alternating current whose intensity corresponds to the received signals is rectified and alternate rectified impulses are passed through each of two coils surrounding the diaphragm of the galvanometer in such a manner that the effect of each impulse is to move the diaphragm in the same direction.

Other objects and advantages of my invention will appear as the description proceeds.

Referring to the accompanying drawings, Fig. 1 is an end view of an apparatus embodying my invention with the end wall removed and showing the reflecting galvanometer, its mounting, the source of light and condensing lenses; Fig. 2 is a plan view of the galvanometer and its mounting; Fig. 3 is a detailed view of a mounting of the galvanometer adjusting rod; Fig. 4 is a perspective view of a portion of the vibrating diaphragm of the galvanometer and the vibrating mirror and its mounting; Fig. 5 is a bottom plan view, showing a portion of the structure disclosed in Fig. 4; Fig. 6 is an end view of the galvanometer, certain of the parts being shown in a section on the line 11—11 of Fig. 2; Fig. 7 is a side view of the galvanometer, certain of the parts being shown in a section taken on the line 12—12 of Fig. 2; Fig. 8 is an enlarged detail of the condensing lenses and its supporting bracket; Fig. 9 is a diagrammatic view of a receiving circuit with the galvanometer connected thereto; Fig. 10 shows a section of photographic record produced by apparatus employing the receiving circuits shown in Fig. 9; Fig. 11 is a diagrammatic view of a modified form of receiving circuit; Fig. 12 shows a section of photographic record produced by apparatus employing the receiving circuit shown in Fig. 11; and Fig. 13 is a view similar to Fig. 11 but showing a simplified circuit arrangement.

Referring to Fig. 1 of the drawing, A represents a light proof casing provided with a lower chamber 11 which contains the galvanometer. This galvanometer which will be more particularly described hereafter is mounted upon trunnions 13 pivoted in brackets 14 extending from the sides of the supporting plate 15. The galvanometer may be turned in a horizontal plane on the trunnions 13 by operation of the screw 16. Plate 15 is pivoted at 34 to the base 17 and may be turned in a vertical plane on the pivot by rotation of the rod 18. This rod is loosely coupled to the bracket 19 formed on the supporting plate 15 and is threaded to a collar

20 formed on the outer end of the shaft 21 (see Fig. 3 of the drawing). Shaft 21 is pivotally mounted in a bearing 22 and is prevented from moving longitudinally in the bearing by engagement of a screw 23 with the walls of an annular groove 24 formed in the shaft 21. The upper portion of the casing A is formed with an enlarged portion 25 divided at its center by a partition 26 into two compartments 27 and 28'. In compartment 27 are located two incandescent lamps 28 and 29 and across the bottom of this compartment is secured a plate 30 provided with openings 31 and 32. In the compartment 28' is the cylindrical lens 33. One of the sources of light in the compartment 27 is employed to furnish the operating beam to trace the desired curve upon the photographic tape. The other source of light is applied for the purpose of indicating the position of the galvanometer and also to enable the operator to make the necessary adjustments in the receiving circuit to insure the proper recording of the signal. The beam of light from this latter source is reflected from the galvanometer mirror through a spherical lens (not shown) which is located in proximity to the reflecting mirror onto a ground glass plate located at the top of the casing A and by the position of the spot of light on this plate the operator is enabled to ascertain the adjustment of the galvanometer. This indicating means is clearly disclosed in my prior application above referred to and as the same forms no part of the present invention, it will not be further described. The photographic tape or film may, by suitable apparatus which is described in the parent application, be fed along continuously and exposed to the beam of light from the source 28.

In Fig. 9 I have indicated a wireless receiving apparatus which comprises a vacuum tube detector 70 having coupled to its grid circuit 71 an antenna circuit 72. Included in the plate circuit of the vacuum tube device is the source 73, the variable inductance 74 and in parallel with the inductance the condenser 75. Bridging this inductance and condenser are the coils 76, 77 and 78 of the galvanometer. These coils are arranged in series and the middle coil is wound to oppose the end coils as shown in the drawing. 79 and 80 are two permanent magnets and 81 is a metallic reed or diaphragm secured at its ends and extending between the poles of the permanent magnets. Coils 76, 77 and 78 surround the diaphragm 81 and when current is flowing therethrough serve to produce in the diaphragm consequent north and south poles as is indicated in the drawing. The permanent magnets are arranged so that opposite poles occur on the same sides of the diaphragm. Attached to the diaphragm and movable therewith is a mirror 82 which serves to reflect the light from the source 28 onto the moving tape.

Impulses received in the antenna circuit cause a varying potential to be applied to the grid of the vacuum tube device 70 and this produces a corresponding change in the current of the plate circuit which includes the coils 76, 77 and 78 of the galvanometer 12. As the current in these coils varies the strength of the poles produced in the diaphragm 81 by the coils varies and thus the portions of the diaphragm upon which these poles are formed and which as previously stated lie between the poles of the permanent magnets, are attracted toward certain of the poles of the permanent magnets to a greater or less extent depending upon the intensity of the current of the coils. The movement of the diaphragm 81 moves the mirror 82 which is attached thereto and the reflected beam of light from the source 28 which acts upon the photographic tape to produce when the tape is developed a line of the form similar to that shown in Fig. 10. By means hereinafter to be described the tension of the diaphragm 81 is adjusted so that its natural rate of vibration corresponds to the frequency of the waves which it is desired to receive.

I have found that it is desirable that the rate of vibration of the diaphragm be as high as it may conveniently be made. Experiments have shown that when the diaphragm vibrates at a frequency of 2000 cycles per second, the effect of stray atmospheric impulses or the so-called "static" is very much less than when the diaphragm is vibrated at the rate of 1200 per second. The elimination of the effect of static on the vibration of the diaphragm 81 is further increased by the particular arrangement and adjustment of the receiving circuits herein disclosed. The inductance 74 and the capacity 75 should be so adjusted that the local circuit in which they are included is "resonant" to the frequency of the current produced in the plate circuit by the signals. This results in a much greater portion of the current of signalling frequency passing through the coils 76, 77 and 78 than through the inductances and capacity, whereas currents of less frequency are almost entirely short circuited by the inductance and capacity and therefore do not have an appreciable influence on the coils of the galvanometer. In choosing the proper values for inductance and capacity, it has been found necessary to use a rather small capacity and a large inductance, the latter preferably having as small a resistance as possible. In this arrangement it is to be noted that the vacuum tube and battery 73 act as a source of current having a high impedance. This inductance 74 acts as a short circuit for the direct current component of the plate current,

Referring particularly to Figs. 2, 6 and 7, the reflecting galvanometer which I propose to use preferably comprises a base member 160 formed with two uprights 161. Secured to these uprights by screws 162 is a top plate 163 formed with end strengthening ribs 164 and a central slot 165. Depending from the plate and guided by the slot 165 are supports for the permanent magnets 79 and 80. These supports comprise blocks 166 upon which are secured guide strips 167 by means of screw 168. Screws 169, provided with washers, serve to retain the guide strips 167 within the slots 165. Each of the magnets is clamped between blocks 170 and 171 by means of a bolt which passes through both blocks into block 166. Screws 172 mounted in the ends of blocks 166 and formed with disc-shaped engagements 173 adapted to project within slots 174 in the plate 163 serve to provide means for moving the magnets 79 and 80 toward or away from one another. These magnets are each formed of a bar of steel of rectangular cross section and bent as outlined in dotted lines in Fig. 2. Sheet metal pole pieces 175 which are secured to the ends of the bars extend downwardly and are provided with lateral offset portions arranged to lie in close proximity to the diaphragm 81. This diaphragm is securely held between lips 176 formed at the ends of members 177. Members 177 are arranged to slide in openings 178 formed in the uprights 161. Adjustable screws 179 engage threaded openings 180 formed in the ends of the members 177. These screws are provided with operating heads 181 formed with bearing surfaces 182 adapted to engage the outer faces of the uprights. In practice the tension of the diaphragm 81 will be adjusted so that its natural period of vibration will correspond to the frequency of the current to be recorded. As so constructed the lines of stress set up in said diaphragm by vibrations are substantially all in the same direction. Surrounding the diaphragm are the coils 76, 77 and 78 suitably mounted upon sheet metal clips. All supporting parts for the diaphragm, coils and permanent magnets are preferably formed of brass. Connected to the diaphragm 81 by means of members 183 and 184 is a triangular shaft 185 of magnetic material. See Figs. 4 and 5. The end of the member 184 is flattened at 186 where it is secured to the shaft 185 so as to provide in effect a flexible connection therewith which will permit the shaft to rotate about its bearings without any lost motion. Shaft 185 is held against V-shaped jeweled bearings 187 by means of a permanent magnet 188, these bearings being formed adjacent the poles of the magnet. Mirror 82 which serves to reflect the beams of light from the sources 28 and 29 is mounted upon the shaft 185. A casing 190 secured by screws to the base 160 is provided with suitable openings for the passage of the incident and reflected beams of light.

In Fig. 11 which shows a modified form of receiving circuit the plate 200 of the thermionic vacuum tube device is connected to the primary of the transformer 201. One terminal of the secondary of the transformer 201 is connected through the condenser 202 and resistance 203 to the grid 204 of the vacuum tube device 205 and through the battery 206 to the grid 207 of the vacuum tube device 208. The other terminal of the secondary of the transformer is connected to one terminal of each of the filaments 209 and 210. The filaments are supplied with heating current from a battery 211 which is connected to the filament 209, 210 though adjustable resistance 212. Supplying the plate circuits of the vacuum tube devices 205 and 208 is a battery 213 which is connected to the plate 214 through a galvanometer coil 215 and to plate 216 through galvanometer coil 217. Coil 215 is bridged by condenser 218 and coil 217 by a condenser 219 while both coils 215 and 217 are bridged by a high resistance 220. It is to be noted that there are but two coils 215 and 217 surrounding the diaphragm of the galvanometer. These are wound so that with current flowing from the battery 213 through each coil will tend to produce a pole of the same sign at the center of the diaphragm. Permanent magnets 221 and 222 are arranged upon opposite sides of the diaphragm. Adjacent north and south poles are positioned in close proximity to the central portion of the diaphragm. The remaining north and south poles are not active in producing a movement of the diaphragm.

Alternations of current in the transformer 201 produce changes of potential on the grid 204, 207. This results in pulsating or intermittent flow of direct current from the filament 209, 210 to the plate 214, 216 and through the coil 215, 217 of the galvanometer, each impulse of current tending to create a magnetic pole of the same sign at the center of the diaphragm. During the time when the flow of current through the vacuum tube device 205 and coil 215 is a minimum, the potential of the grid 207 of the vacuum device 208 is such as to permit a maximum current to flow from the filament 210 to plate 216 and through coil 217 of the galvanometer. This difference in phase of the plate currents through two vacuum devices is due to the presence of the battery 206 in the circuit to the grid 207 which has the effect of maintaining the grid 207 at an initially different potential from that of the grid 204. The effect therefore of an alternating current through the primary of the transformer is to cause the

galvanometer diaphragm to be uniformly urged toward one of the poles of the permanent magnets 221 or 222. A change in the amplitude of the alternations in the primary circuit of the transformer due to the reception of signals results in a change in the intensity of the intermittent or pulsating current through the plate circuits of the vacuum tube devices 205 and 208 with the result that the intensity of the magnetic pole formed by these currents through the coils 215 and 217 is changed and the diaphragm is urged toward one of the poles of the permanent magnets by a force of greater or less intensity than before. The diaphragm will therefore assume a different position and the reflected beam will be moved to form upon the tape an impression corresponding to the signal received. In this form of receiving apparatus it is desirable to have the galvanometer dead beat and for this purpose the tension of the diaphragm should be adjusted so that it is out of tune with the frequency of the receiving signal. I have found with this type of apparatus when the diaphragm is adjusted to the frequency of approximately 2000 and the frequency of the incoming signals is from 20 to 50% higher that the signals are clearly recorded at a rate of approximately 600 words per minute and this through extremely bad static conditions. The character of record made by the apparatus with the type of receiving circuit disclosed in Fig. 11 is shown in Fig. 12.

Fig. 13 shows the somewhat simplified form of circuit arrangement in which but a single galvanometer coil is employed. The coil 250 is connected from the plate 251 of the thermionic vacuum tube device 252 to an adjustable contact 253 adapted to move over a resistance 254 which latter is connected to opposite terminals of the battery 255. A resistance 256 is connected between the battery 255 and plate 251, as shown. From the drawing it will be seen that coil 250 in effect constitutes the bridge circuit of a wheatstone bridge of which two of the legs are the path through the thermionic device 252 and the lower portion of the resistance 254 and the remaining two legs are the resistance 256 and the upper portion of the resistance 254.

It is obvious that the current which in the form of apparatus, shown in Fig. 9, passes through the galvanometer coils 76, 77 and 78 may be rectified and thence passes around the diaphragm in the manner shown in Figs. 11 or 13.

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

1. The combination in a signal receiving system of a thermionic vacuum tube device so connected that audio frequency signaling currents will be produced in its output circuit, an indicating device comprising permanent magnets, a vibratory diaphragm of magnetic material arranged between the poles of said permanent magnets, means for adjusting the tension of said diaphragm to change its natural period of vibration, coils connected in the output circuit of said thermionic device and surrounding said diaphragm, and an adjustable inductance and capacity each connected in shunt to said coils and adapted to be tuned to the same frequency as that of the diaphragm.

2. In an electrical apparatus, a movable magnetic member arranged in a magnetic field, two coils arranged end to end and surrounding said magnetic member, two thermionic vacuum tube devices each of which have a plate, grid and filament, a source of current, connection from each of the plates to an outer end of each of said coils, a connection from said source of current to the inner end of each of said coils, a connection from said source to said filaments, means for impressing an alternating potential upon the grids of each of said thermionic devices and a source of potential included in the circuit to one of said grids.

3. The combination of a thermionic vacuum tube device having grid and plate, means for impressing upon the grid varying potentials corresponding to the signals received, a transformer, the primary of which is in circuit with said plate, a second vacuum tube device having a grid, plate and filament, the grid of said second device being connected to one terminal of the secondary of said transformer, a third vacuum tube device having grid, plate, and filament, the grid of said third device being likewise connected to the above mentioned terminal of the secondary of said transformer, a source of potential included in the circuit to said last named grid, one terminal of each of said filaments being connected together and to the other terminal of the secondary of said transformer, an indicating device comprising a vibratory magnetic member arranged in a permanent magnetic field, oppositely wound coils surrounding said magnetic member and arranged end to end the outer terminals of each of said coils being connected to each of the plates of said second and third devices, and a connection between the intermediate point of said coils and the other terminals of each of said filaments, said last made connection including a source of current.

4. In a selective receiving apparatus, two thermionic vacuum tube devices having plate and grid circuits, an indicating device comprising a movable magnetic member arranged in a permanent magnetic field, coils surrounding said magnetic member and arranged end to end, one of said coils arranged in the plate circuit of one of said thermionic

vacuum devices and the other coil arranged in the plate circuit of the other of said thermionic tube devices and means for impressing upon the grid circuits of said thermionic vacuum tube devices alternating potentials whose amplitude corresponds to the impulses it is desired to record, and means in the grid circuit of one of said vacuum tube devices for impressing thereon an additional potential.

In witness whereof, I have hereunto set my hand this 9th day of October, 1922.

CHARLES A. HOXIE.