March 3, 1931. H. R. HAYDEN 1,794,897

RADIO FREQUENCY TRANSFORMER

Filed June 3, 1927

Fig. 2.

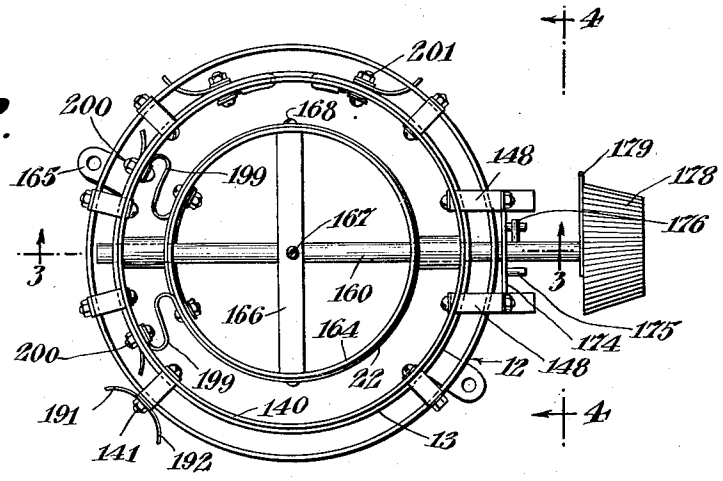


Fig. 3.

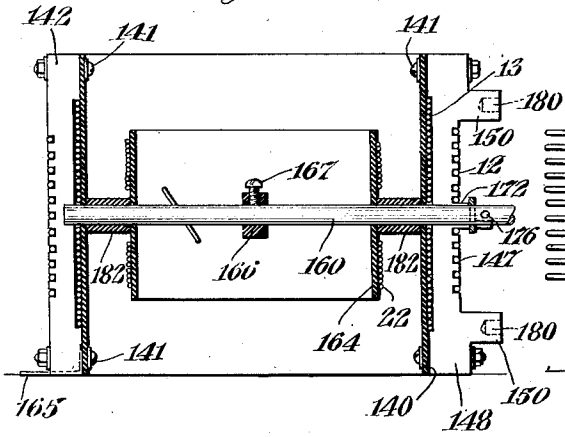


Fig. 4.

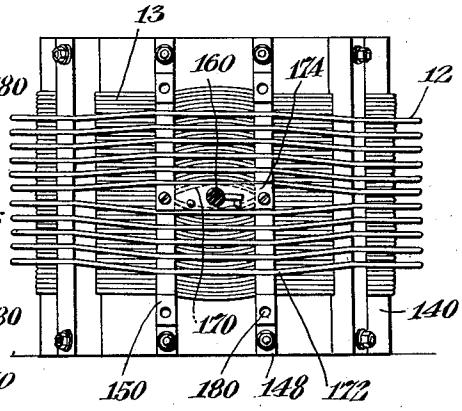


Fig. 1

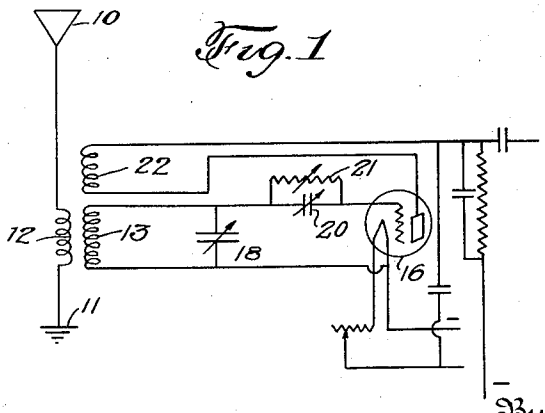
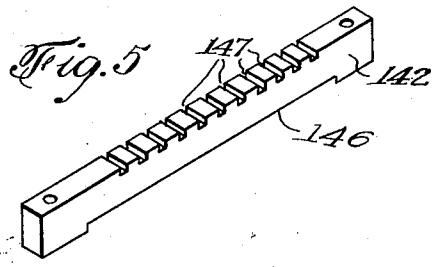


Fig. 5



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UNITED STATES PATENT OFFICE

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RADIO FREQUENCY TRANSFORMER

Application filed June 3, 1927. Serial No. 196,244.

This invention relates to electrical signal receiving systems employing three-electrode vacuum tubes as detectors and amplifiers, and particularly to certain apparatus adapted for use as parts of such a system.

In the preferred embodiment of my invention herein disclosed, the system is a multi-stage signal receiving system employing a detector stage followed by several stages of audio-frequency amplification, and each of the audio-frequency stages is coupled to the preceding stage by a so-called resistance coupling; the last audio-frequency stage serving to operate a loud speaker or other signal-translating device. Each stage of the system includes a three-electrode vacuum tube, the filament of which is heated by direct current from any suitable source such as a battery, and, if desired, means may be provided for maintaining the battery charged from a source of alternating current, such as the usual alternating current lighting mains, and the plate circuits of the several tubes are energized from the same source of alternating current through a rectifier and filter.

The antenna circuit, which is preferably untuned, includes the primary winding of a radio-frequency transformer, the secondary of which is in the grid circuit of the detector tube, and the plate circuit of the detector tube includes a third winding, positioned in inductive relation to the secondary or grid circuit winding; the last winding being adjustable to vary the coupling between the grid and plate circuit. The primary, or antenna winding, and the secondary, or grid winding, serve as a means for transferring signal energy from the antenna circuit to the grid circuit, and the third or plate circuit winding serves to transfer energy from the plate circuit back to the grid circuit to increase the amplification of the signals. Connected across the terminals of the grid circuit winding is a condenser which is adjustable to tune the grid circuit to the frequency of any desired incoming signals. One side of this condenser is connected in the usual manner with the filament supply circuit, and the other side of the condenser is connected to the grid of the detector tube through an adjustable condenser of small capacity, and shunting the condenser is a high resistance which is also adjustable.

The particular construction and arrangement of the detector tube grid and plate circuits and associated antenna circuit, form an important feature of the present invention. These circuits are designed to secure a maximum efficiency of operation, including a high degree of selectivity in tuning for the reception of signal carrier waves of different frequencies, and a maximum amplification of the received signals. The antenna, grid circuit and plate circuit windings are designed as an electrically balanced unitary structure, and these windings are so proportioned and arranged relative to one another as to secure a maximum transfer of energy from the antenna circuit to the grid circuit, with minimum resistance and dielectric losses, and these windings, co-operating with the remainder of the plate and grid circuits, permit a large amount of energy to be transferred from the plate to the grid circuit so as to produce high amplifications without producing disturbing effects common to systems of this character.

In the embodiment of my invention herein disclosed the antenna grid and plate circuit windings form a three circuit tuner or variometer which is simple and strong in construction, durable and stable in use and may be easily and economically manufactured.

Other advantages and objects of my invention will appear from the following description taken in connection with the accompanying drawing wherein

Figure 1 is circuit diagram of a signal receiving system showing one form of my invention.

Figure 2 is a top elevation showing the construction, arrangement and mounting of the antenna, detector grid circuit and detector plate circuit windings.

Figure 3 is a sectional view taken on the line 3—3 of Figure 2.

Figure 4 is a sectional view taken on line 4—4 of Figure 2 and

Figure 5 is a perspective view of one of

the wire holding strips shown in Figures 2 to 4.

Referring to Figure 1 of the drawing, 10 represents an antenna adapted to receive signal waves. The antenna is grounded at 11 through a winding 12 positioned in inductive relation to a winding 13, included in the grid circuit of the detector tube 16. Connected across the terminals of winding 13 is a condenser 18 which is adjustable to tune the grid circuit of the detector to the frequency of any desired incoming signals. One side of the condenser 18 is connected to the filament of tube 16, and the other side of condenser 18 is connected to the grid of tube 16 through an adjustable condenser 20 of small capacity, and in parallel with the condenser 20 a high resistance 21, which resistance is also adjustable. For the resistance 21 I prefer in many cases to employ a resistance having small distributed capacity.

Connected in series with the plate of detector tube 16 is a winding 22 positioned in inductive relation to the grid circuit winding 13. Winding 22 is adjustable relative to winding 13 so as to alter the mutual inductance between the two windings.

Figures 2 to 5 show my improved variometer, and the arrangement and mounting of antenna winding 12, detector grid circuit winding 13, and operating detector plate circuit winding 22. Figures 2 to 4 are drawn to scale, the spacing and other dimensions of the windings being one half that employed by me when used in connection with an overhead antenna measuring approximately 100 feet to the winding 12, and with a comparatively short ground connection, the total ohmic resistance of the antenna circuit being 3-tenths ohms.

Reference character 140 includes a supporting tube of bakelite or similar insulating material, upon which is wound the winding 13, which is a single layer coil of 42 turns of Number 17 double cotton covered copper wire. To the outer face of the tube 140 are secured by bolts 141, above and below the winding 13, six strips 142, spaced from one another as shown, and between two of the strips 142 are secured two strips 148. Strips 142 and 148 are formed along their outer sides with a series of transverse grooves or notches 147, in which are seated the turns of the antenna winding 12, which, in the present form of my invention, consists of a single layer coil of 11 turns of Number 14 bare copper wire. Each of the strips 142 and 148 is formed on its inner side with a recess 146, which provides a space for the turns of the winding 13 when the strip is secured to the tube 140. The ends of the recess 146 serve to retain the winding 13 in place on the tube 140, and prevent the turns of the winding from becoming separated along the tube. Passing diametrically through the tube 140 at points midway between the ends of the windings 12 and 13, is a rotary shaft 160, formed of insulating material. Shaft 160 passes through, and serves to support, a tube 164, also formed of insulating material. Tube 164 is secured to shaft 160 by means of a cross bar, or member 166, which has a central opening therein, through which the shaft 160 extends; the shaft and bar being secured together by means of a screw 167, and the tube 164 being secured to the ends of the cross bar 166 by screws 168, as shown. On the tube 164 is wound the detector tube plate circuit winding 22, which consists of two coils in series, each consisting of 14 turns of No. 22 double cotton covered copper wire, arranged symmetrically on opposite sides of the control shaft 160. The shaft 160 at opposite ends extends through the tube 140, and between adjacent turns of the winding 13, the conducting wire of the winding at these points being bent slightly above and below the shaft, as indicated at 170, so as to leave a space for passage of the shaft. One end of the shaft 160 also extends between adjacent turns of the winding 12, and the turns of winding 12 are bent slightly above and below the shaft, as shown in Figure 4, so as to leave a space for the passage of the shaft. The notches 147 in the strips 148 are so spaced as to permit the bending of the wire of the windings 12, as indicated.

The strips 148, between the notches 146, immediately above and below the shaft, are formed with lateral projections 172, having aligned outer faces which lie in a plane at right angles to the shaft 160. Secured to these outer faces, and connecting the projections 172, is a flat member 174, which is formed with a central opening, adapted to receive and form a bearing for the shaft 160. On opposite sides of this central opening, the member 174 carries outwardly extending projections 175, which are adapted to co-operate with a pin 176 secured to the shaft 160 to limit the turning movement of the shaft. When the variometer is mounted in a cabinet, the shaft 160 extends through the front panel, and carries at its outer end an operating knob 178 and a pointer 179, which may co-operate with a suitable dial to indicate the position of the shaft and winding 22.

For the purpose of securing the variometer in position in the cabinet, the strips 148 may be formed with lateral projections 150, the outer faces of which bear against the rear face of the front cabinet panel, and these projections are formed with inwardly extending screw-headed openings 180, for the reception of securing screws, which pass through the panel. If desired, instead of employing projections 150 for securing the variometer to the cabinet, I may employ an angle bracket 165, secured by bolts to the lower end of one

of the strips 148 at the rear of tube 140, and to the sub-panel 125.

To provide a slight frictional resistance to the turning of the shaft 160 so that the coil 22 will remain in the position in which it is adjusted, I employ sleeves 182 mounted on the shaft 160, which bear at their ends against the tubes 140 and 164. In mounting the tube 164 on the shaft 160, the shaft is inserted through the tubes, sleeves 182 and cross bar 166, and the cross bar is then secured to the shaft 160 and tube 164 by the screws 167 and 168.

The terminals of winding 12 are indicated by reference characters 191 and 192, which are located at the top and bottom of one of the strips 142, the securing bolts 141 for this strip serving as binding posts for the terminals. The terminals of movable coil 22 are connected by means of flexible conductors 199 to binding screw 200, and the terminals of coil 13 connect to binding screws 201 as shown.

The following are the dimensions of one coil constructed by me: diameter cylinder 140, 4 inches; diameter cylinder 164, 1¼ inches; distance from outside of secondary winding 13 to inside of primary winding 12, ¼ inch; length of primary winding 12, $1\frac{1}{16}$ inches.

The windings 12 and 13 are symmetrically arranged with respect to one another, and the turns of their windings lie along cylindrical surfaces which are parallel to one another. The spacing and dimensions of the windings is such that a maximum amount of energy is transferred from the antenna to the grid circuit, and the requisite amplification is obtained by the coupling arrangement between the plate and grid winding. On the other hand, the spacing of the windings is such as to avoid the occurrence of disturbances or reactions which interfere with accurate tuning of the grid circuit, or which cause the antenna to receive and radiate energy from the grid circuit. Relatively large wire is used for the windings, which minimize the resistance and ohmic loss in the circuits. It is to be noted that the turns of the antenna winding 12 are spaced apart so that this winding covers substantially the entire outer surface of the grid winding 13. In this manner each turn of each one of the windings 12 and 13 are in substantially the same spacial relation to adjacent turns of the other winding. Each turn of each winding is therefore equally effective in securing the desired reaction between the windings. I find that these features are important in securing the results desired. It is to be noted that windings 12 and 13 are each in effect one continuous coil, and except for the small space provided to accommodate the shaft 160, the successive turns are equally spaced from one another.

With the winding 22 and its adjusting parts removed, the remainder of the structure shown in Figures 2 to 5 may be advantageously used as a radio-frequency transformer. Thus, preceding the detector circuits shown in Figure 1, I employ one or more stages of radio-frequency amplification preceding the detector stage, in which case I may employ as radio-frequency couplings, the windings 12 and 13, constructed and arranged as shown in Figures 2 to 4.

I claim:

1. A radio frequency transformer comprising a cylindrical primary winding consisting of a single layer coil formed of a number of spaced turns, of relatively large wire, and a secondary winding consisting of a single layer coil of approximately four times said number of turns, of relatively small wire, closely spaced from one another and arranged inside and concentric with said primary winding, said secondary winding having its geometric center at approximately the geometric center of the primary winding, each winding covering substantially the peripheral area of the other winding and each turn of each winding, throughout its length having substantially the same spacial relation to adjacent turns of the other winding.

2. A radio frequency transformer comprising an insulating tube, a single layer cylindrical winding formed of closely spaced turns wound on said tube, insulating strips extending the length of said winding and secured at their ends to said tube, said strips being cut away intermediate their ends to form spaces through which said winding passes, and a second cylindrical winding formed of a few spaced turns of relatively large wire wound on said strips, each winding covering substantially the peripheral area of the other winding and each turn of each winding having substantially the same spacial relation throughout its length to adjacent turns of the other winding.

3. A radio frequency transformer having a substantially flat resonance response over a wave band of approximately ten thousand cycles, said transformer comprising a cylindrical primary winding consisting of a single layer coil of relatively few spaced turns of large wire and a secondary winding consisting of a single layer cylindrical coil of relatively small closely spaced wire, concentric with and having its geometric center at approximately the geometric center of the primary winding, each coil covering substantially the peripheral area of the other coil and each turn of each winding throughout its length having substantially the same spacial relation to adjacent turns of the other winding, the length of the secondary winding being half or more the diameter of the secondary winding.

4. A radio frequency transformer having a substantially flat resonance response over

a wave band of approximately ten thousand cycles, said transformer comprising a cylindrical primary winding consisting of a single layer coil of relatively few spaced turns of large wire and a secondary winding consisting of a single layer cylindrical coil of relatively small closely spaced wire, concentric with and having its geometric center at approximately the geometric center of the primary winding, each coil covering substantially the peripheral area of the other coil and each turn of each winding throughout its length having substantially the same spacial relation to adjacent turns of the other winding, and a third cylindrical winding having its geometric center coincident with the geometric centers of said primary and secondary windings, said third winding being rotatable about said center on an axis transverse to all of said windings.

HAROLD R. HAYDEN.