Oct. 8, 1929. V. H. LAUGHTER 1,731,012

RADIO FREQUENCY AMPLIFICATION SYSTEM

Filed Jan. 16, 1924

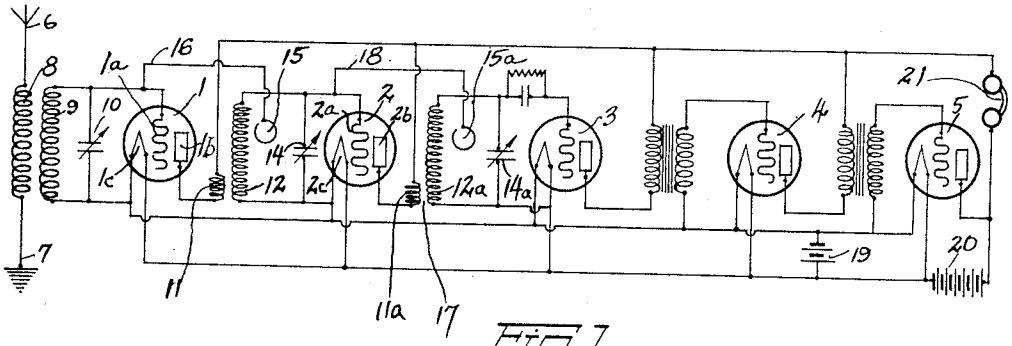


Fig. 1

Fig. 2

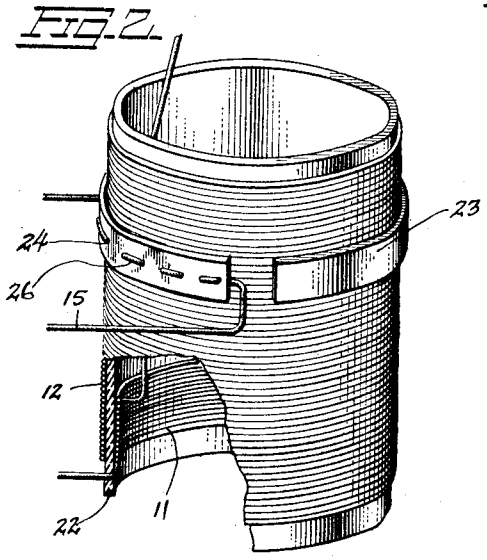


Fig. 4

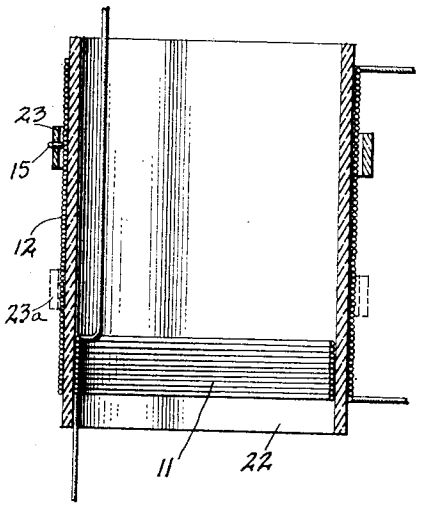


Fig. 3

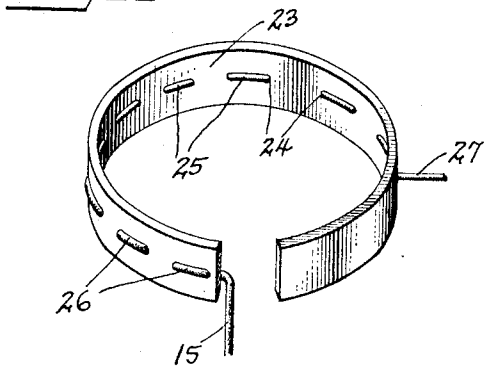
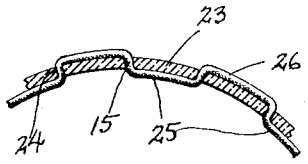


Fig. 5



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UNITED STATES PATENT OFFICE

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RADIO-FREQUENCY AMPLIFICATION SYSTEM

Application filed January 16, 1924. Serial No. 686,629.

My invention relates broadly to electron tube radio frequency amplification circuits, and more particularly to a method of neutralizing the capacity coupling between the several tubes of a radio frequency amplification system whereby it efficiently employs desirable characteristics of radio frequency amplification.

One of the objects of my invention is to provide a system of coupling a plurality of electron tubes for amplification of radio frequency energy in which the capacity between the tubes of the receiver may be individually adjusted to secure a point of perfect balance for the particular receiver and thereby insure uniformity in quality of receivers manufactured on a quantity production basis.

Another object of my invention is to provide a neutralization system for radio frequency amplifiers in which the neutralizing capacity may be varied simultaneously with a variation in the relative position of the neutralizing capacity and a potential point on the intervalve coupling devices in the amplifier.

Another object of my invention is to provide a simplified construction of coupling device for connection between the output circuit of one electron tube and the input circuit of a succeeding electron tube with means forming a part of the coupling device for neutralizing capacity coupling between the tubes.

A still further object of my invention is to provide a coupling device for the neutralization of capacity coupling between electron tubes for the efficient transfer of energy from one electron tube circuit to another, in which one plate of the neutralizing capacity is formed by a conductor of variable length less than a complete turn arranged to be moved to the position of a potential point on the coupling device whereby to secure a perfect balance of capacity between the circuits.

Other and further objects of my invention will be understood from the specification hereinafter following by reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic illustration showing my invention as applied to a radio frequency amplifier in a radio receiving apparatus; Fig. 2 is a perspective view of one embodiment of my invention in a coupling device for connection between the output circuit of one electron tube and the input circuit of a succeeding electron tube; Fig. 3 is a perspective view showing the construction of the sliding loop employed for varying the neutralizing capacity and selecting the position of the neutralizing capacity with respect to a potential point on the coupling device; Fig. 4 is a vertical cross-sectional view through the coupling device and variable neutralizing capacity indicating in dotted lines the position which the neutralizing capacity may assume with respect to the windings of the coupling device; and Fig. 5 is a fragmentary cross-sectional view showing the method of supporting the neutralizing capacity on the slidable ring adjustable with respect to a potential point on the coupling device.

Heretofore in the art in order to neutralize capacity coupling between the stages of a radio frequency electron tube amplifier, it has been the practice to provide separate balancing condensers connected between the grid circuits of the several tubes. The windings of the coupling transformers have been so connected that the induced currents in the primary and secondary windings in the circuits in which the balancing condensers are connected are 180° out of phase, so that other conditions being equal, neutralization of the current values will occur. In practical operation it is found that conditions other than a true capacity balance must exist. It has been proposed to tap a connection from the secondary winding of the coupling transformer at a point where the voltage will be exactly equal to the voltage on the grid of the preceding tube. In order to secure perfect neutralization it is therefore necessary for both the voltage and capacity values to be equal. The characteristics of tube circuits are not identical with different sets and accordingly, while methods heretofore employed for the neutralization of capacity coupling may have been theoretically satisfactory, they have been inadequate where receivers are produced on a quantity production basis.

By my present method of securing the proper capacity balance I am enabled to ob-

tain an exact balance at an exact potential point. I provide a coupling device including a primary and secondary winding, with the primary interiorly positioned with respect to the secondary and having a smaller number of turns than the said secondary. Positioned over the secondary I provide an adjustable support consisting of a partially closed ring of insulating material. This ring is provided with apertures approximately three-fourths the distance about its circumference, and in these apertures there is threaded a conductor which may be readily adjusted in length. The free end of this conductor is connected to the grid of the preceding electron tube of the amplifier. The conductor forms one side of a neutralizing capacity and by varying the length of the conductor adjacent the secondary the right capacity is determined, and likewise, by varying the position of the conductor with respect to the coupling coils by sliding the support up and down, the neutralizing capacity may be placed at an exact potential point. This gives the point of perfect capacity neutralization without the undesirable feature of taps. I am enabled to vary both the neutralizing capacity and the potential point, and in this way receivers which are manufactured on a quantity production basis may be uniform in character, whereas heretofore the attempted neutralization in some receivers by reason of peculiar characteristics which might exist in the circuits thereof has been relatively ineffective.

Referring more particularly to the drawings, I have illustrated the application of my invention in connection with a two stage radio frequency amplifier, including electron tubes 1 and 2 connected in circuit with an electron tube detector 3 and two stages of audio frequency amplification formed by tubes 4 and 5. The receiver is connected with an antenna ground system 6 and 7, including the primary winding 8 of a tuning system having secondary winding 9 and variable condenser 10. The electron tube 1 functions as the first stage of radio frequency amplification. The tubes employed comprise grid electrode 1^a, plate electrode 1^b, and filament electrode 1^c. The plate electrode 1^b is connected in circuit with primary coupling coil 11. The primary coupling coil 11 is inductively related to secondary winding 12 which may be tuned by variable condenser 14 connected across the input circuit of the second stage of radio frequency amplification formed by electron tube 2. One side of the neutralizing capacity is formed by a length of conductor 15 which surrounds the secondary winding 12 and is electrically connected with the grid 1^a of the preceding tube 1 through conductor 16. The second stage of radio frequency amplification formed by electron tube 2, including the grid electrode 2^a, plate electrode 2^b, and filament electrode 2^c, has a coupling device 17 connected in its output circuit which is similar to the coupling device heretofore described. That is, a primary winding 11^a is included in the plate circuit 2^b, and a secondary winding 12^a is inductively coupled with the primary winding 11^a and connected with the input circuit of detector 3. The adjustable conductor 15^a is positioned around secondary 12^a and electrically connected with grid 2^a of the preceding electron tube 2 through conductor 18. The input circuit to the detector 3 may be tuned by condenser 14^a. The filament supply for all of the tubes, including detector tube 3 and the audio frequency amplifying tubes 4 and 5, may be supplied from A battery 19 and plate potential may be obtained from B battery 20, the responsive device 21 being included in the output circuit of the set.

The primary winding 11 may be wound on a support positioned inside of an insulated support 22 upon which the secondary winding 12 is wound, and the primary winding may begin adjacent the end of the secondary winding but extend only approximately one-sixth the length of the secondary winding. The neutralizing capacity formed by conductor 15 is supported on a partially closed ring of insulating material 23 in which apertures 24 are provided equally spaced apart for a distance of approximately three-fourths the circumference of the ring 23. The conductor 15 is threaded through these apertures, as more clearly represented in Fig. 5, in such manner that the portions 25 of the conductor 15 will be directly adjacent the turns of the secondary winding 12 and the portions 26 of the conductor 15 spaced away from the turns of the secondary winding 12 in accordance with the thickness of the material of the ring 23. The ring 23 is slidable with respect to the secondary winding 12 to any position, such as the dotted line position 23^a illustrated in Fig. 4, where an exact potential point is obtained. The length of the conductor 15 is varied by drawing it through apertures 24 in the ring 23 until the free end 27 is in such a position as to provide the exact value of the neutralizing capacity with respect to the windings of the coupling device which provide the other side of the neutralizing capacity.

It will be apparent that receivers manufactured according to the improvement herein described may be uniformly adjusted by simultaneously varying the neutralizing capacity and the potential point. It will be understood that the principles of my invention may be embodied in various forms and that details are not material. The present embodiment of the invention therefore is to be considered as merely indicative. The form illustrated in the drawings and described herein in detail has been found to be one of the practical

embodiments and capable of efficient operation and practical in construction. Modifications in form may be made however, and I intend no limitations upon the invention other than are imposed by the scope of the appended claims.

What I claim and desire to secure by Letters Patent of the United States is as follows:

1. A radio frequency amplification system, comprising in combination a plurality of electron tubes each having grid, filament, and plate electrodes, an input and output circuit, coupling coils inductively relating the output circuit of one electron tube with the input circuit of a succeeding electron tube, and a conductor of variable length arranged to surround one of said coupling coils and electrically connected with the grid of a preceding electron tube whereby capacity coupling between said electron tubes may be adjusted and neutralized.

2. A radio frequency amplification system, comprising in combination a plurality of electron tubes each having grid, filament, and plate electrodes, an input and output circuit, coupling coils inductively relating the output circuit of one electron tube with the input circuit of a succeeding electron tube, and a conductor having a maximum length substantially less than a complete turn and variable in amounts less than said length surrounding one of said coupling coils and electrically connected with the grid of a preceding tube whereby capacity coupling between said tubes may be neutralized.

3. A radio frequency amplification system, comprising in combination a plurality of electron tubes each having grid, filament, and plate electrodes, an input and output circuit, coupling coils inductively relating the output circuit of one electron tube with the input circuit of a succeeding electron tube, and a conductor surrounding one of said coupling coils, said conductor having portions thereof directly adjacent the turns of said coupling coil and other portions offset at a distance from the turns of said coupling coil, said conductor being electrically connected with the grid of a preceding electron tube whereby capacity coupling between said tubes may be neutralized.

4. A radio frequency amplification system, comprising in combination a plurality of electron tubes each having grid, filament, and plate electrodes, an input and output circuit, coupling coils inductively relating the output circuit of one electron tube with the input circuit of a succeeding electron tube, and a filar conductor consisting of less than a complete turn and surrounding one of said coupling coils, said conductor having portions within its length positioned directly adjacent the turns of said coupling coil and other portions spaced away from the turns of said coupling coil, one end of said conductor being connected with the grid of a preceding electron tube whereby capacity coupling between said tubes may be neutralized.

5. A radio frequency amplification system, comprising in combination a plurality of electron tubes each having grid, filament, and plate electrodes, an input and output circuit, coupling coils inductively relating the output circuit of one electron tube with the input circuit of a succeeding electron tube, and a filar conductor having less than a single turn of substantially the same gauge as the aforesaid coupling coils and arranged to be moved to a selected position along one of said coupling coils to an exact potential point, said conductor being connected to the grid of a preceding electron tube whereby capacity coupling between said tubes may be neutralized.

6. A radio frequency amplification system, comprising in combination a plurality of electron tubes each having grid, filament, and plate electrodes, an input and output circuit, coupling coils inductively relating the output circuit of one electron tube with the input circuit of a succeeding electron tube, and a conductor of variable length arranged to be moved to a selected position along one of said coupling coils to an exact potential point, said conductor being connected to the grid of a preceding electron tube whereby capacity coupling between said tubes may be neutralized.

7. A device for coupling electron tube circuits, comprising in combination a primary and secondary winding, a partially closed apertured ring positioned to slide over one of said windings, a conductor threaded through said apertures in said ring and adjustable in length with respect to the turns of said winding whereby the position of said conductor with respect to said winding and the electrical capacity between said conductor and said winding may be varied.

8. A radio frequency amplification system, comprising, in combination, a plurality of electron tubes each having grid, filament and plate electrodes, an input and an output circuit, coupling coils inductively relating the output circuit of one electron tube with the input circuit of a succeeding electron tube, and a conductor having a strand arranged to partly surround one of said coupling coils and electrically connected to the grid of a preceding electron tube, whereby the capacity coupling between said electron tubes may be neutralized.

9. A radio frequency amplification system, comprising, in combination, a plurality of electron tubes each having grid, filament and plate electrodes, an input and an output circuit, coupling coils inductively relating the output circuit of one electron tube with the input circuit of a succeeding electron tube, and a conductor having a strand arranged to

partly surround one of said coupling coils and electrically connected to the grid of a preceding electron tube, said conductor being mounted for adjustment axially of said coil, whereby the capacity coupling between said electron tubes may be adjusted and neutralized.

10. A radio frequency amplification system, comprising in combination, a plurality of electron tubes each having grid, filament and plate electrodes, and input and output circuits, coupling coils inductively relating the output circuit of one electron tube with the input circuit of a succeeding electron tube, and a filar conductor consisting of less than a complete turn surrounding one of said coupling coils and connected with the grid of a preceding electron tube.

11. A radio frequency amplification system, comprising in combination, a plurality of electron tubes each having grid, filament and plate electrodes, and input and output circuits, coupling coils inductively relating the output circuit of one electron tube with the input circuit of a succeeding tube, a filar conductor of less than a complete turn embracing one of said coupling coils, and means for supporting said conductor on said coil adapted for adjustment of said conductor along said coil.

VICTOR H. LAUGHTER.