Aug. 23, 1932. H. A. WHEELER 1,873 236

VOLUME CONTROL FOR RADIORECEIVERS

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Fig. 1.

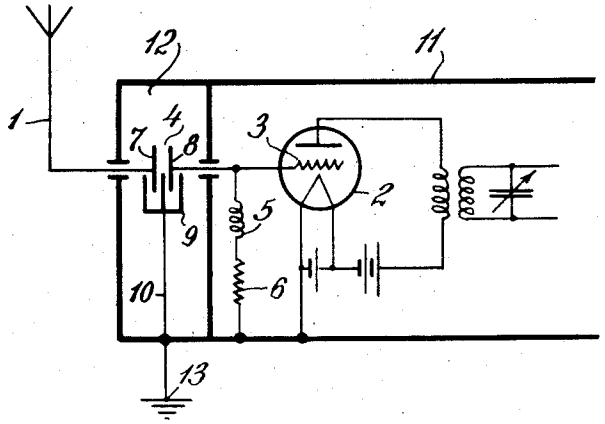
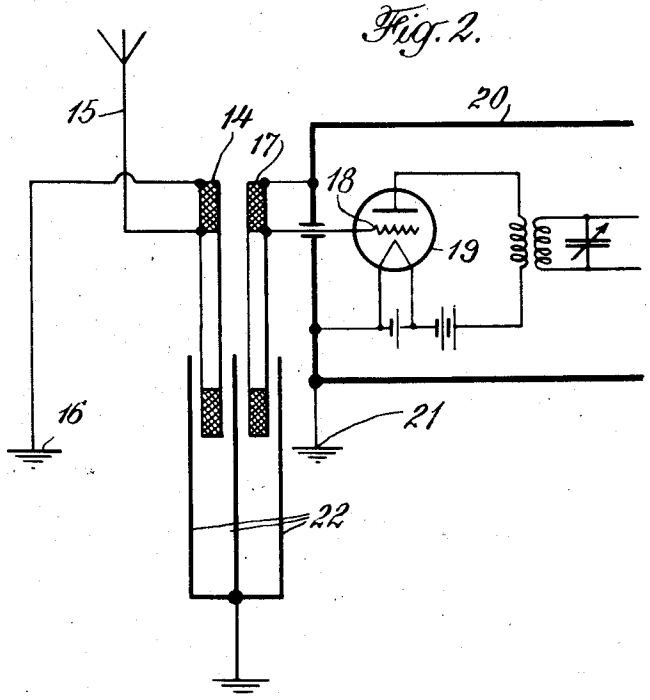


Fig. 2.



INVENTOR
Harold A. Wheeler

BY
Pennie, Davis, Marvin & Edmonds
ATTORNEYS

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Fig. 3,

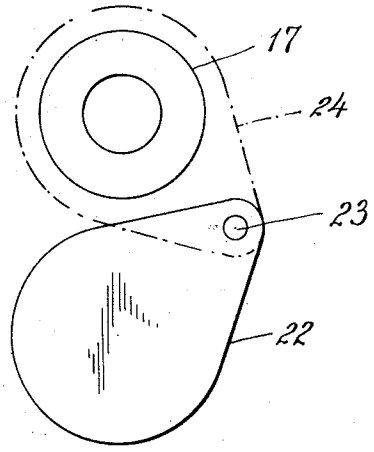


Fig. 4,

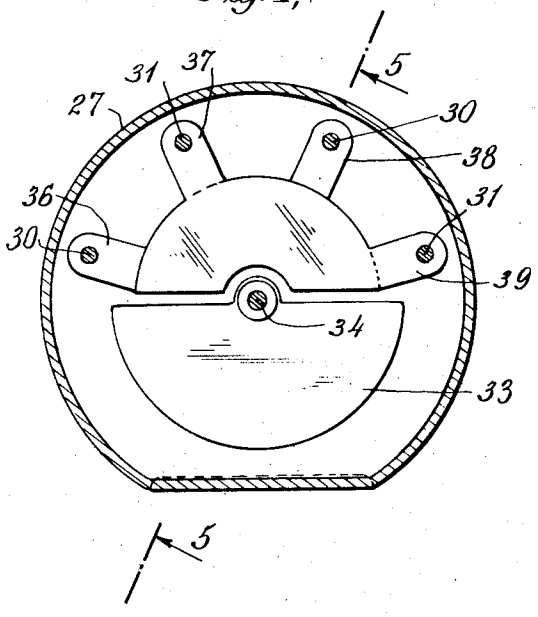
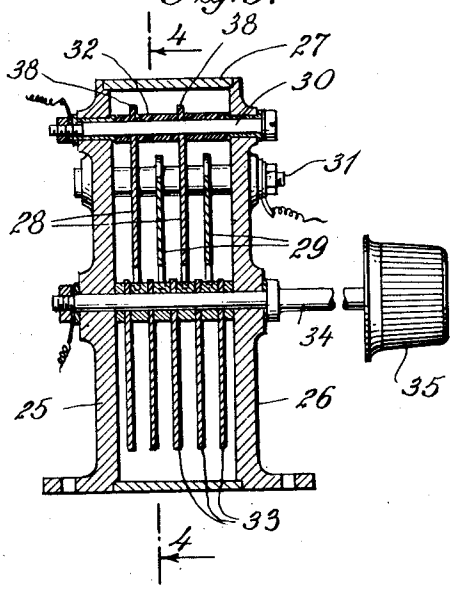


Fig. 5.



INVENTOR
Harold A. Wheeler

BY
Pennie, Davis, Marvin & Edmonds.
ATTORNEYS

Patented Aug. 23, 1932 1,873,236

UNITED STATES PATENT OFFICE

HAROLD A. WHEELER, OF JACKSON HEIGHTS, NEW YORK, ASSIGNOR TO HAZELTINE CORPORATION, OF JERSEY CITY, NEW JERSEY, A CORPORATION OF DELAWARE

VOLUME CONTROL FOR RADIORECEIVERS

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This invention relates to radio receiving systems and is directed more especially to volume control arrangements and devices for regulating the loudness of signal reproduction.

The object of the invention, primarily, is to provide volume control arrangements and devices which are particularly adapted for use in connection with radio receiving equipment with alternating current vacuum tubes—that is, tubes in which the cathodes are heated by alternating current.

The ordinary method of regulating the output volume of a radio receiver consists in adjusting the cathode heating current of the radio-frequency amplifier tubes. For reasons to be presently stated, this practice is satisfactory with direct-current tubes, but not with alternating-current tubes. There are two varieties of alternating-current tubes: (1) those in which the cathode is simply a filament of large diameter designed to operate at a very low voltage, and characterized by high inertia with respect to temperature variations; and (2) those in which the cathode is indirectly heated by means of an auxiliary heating filament. The first-mentioned type of tube is characterized in that the filament temperature is quite critical i. e., any material deviation from optimum filament current being likely to result in an alternating-current hum. In the second type of tube the cathode temperature variations follow the heater current changes too slowly to permit of satisfactory volume control through the medium of heater current regulation. Hence it follows that heating-current regulation is not satisfactory for either of the two varieties of alternating-current tubes.

The invention herein described embraces certain novel arrangements for effecting volume control by varying the coupling between the receiving antenna and the first radio-frequency amplifying tube or coupling tube. In this way the effectiveness with which the incoming signal voltage is transmitted from the antenna to the radio-frequency amplifier can be regulated and, in consequence, the output volume controlled at will. While, on its face, this is the simple and obvious procedure in view of the aforementioned characteristics of alternating-current tubes, it nevertheless cannot be done satisfactorily under practical conditions through the agency of ordinary coupling devices such as variable inductance couplers or variable condensers. The reason for this is that such devices will not permit of a sufficient reduction in coupling when the incoming waves are very strong. An ordinary adjustable air condenser can be used as a variable coupling medium for volume control purposes, but such a condenser cannot be made with a small enough minimum capacity to reduce strong signal waves to the required extent. In the case of an ordinary inductive coupler in which one of the coils is rotatable or otherwise adjustable with respect to the other, the inductive coupling can be reduced substantially to zero, but the zero position is too critical, and there remains the capacitive coupling between the coils. The latter is usually excessive from the volume control standpoint when the incoming signal waves are very strong.

The solution of the problem, then resolves itself into a matter of devising ways and means of reducing the inductive or capacitive coupling, or both, to a very small value without having to utilize an excessive amount of space. Moreover, it is essential that the arrangement or device employed for this purpose be capable of providing a sufficient degree of coupling when the incoming waves are very weak.

The present invention provides for the attainment of these ends and objects through the use of adjustable shielding means which are effective to bring about coupling reductions—both inductive and capacitive—to such a degree that the effect of the strongest incoming waves likely to be encountered can be reduced by a sufficient extent to meet all practical requirements. The invention is applicable both to capacitive and inductive coupling arrangements—an example of each being illustrated in the accompanying drawings and described in detail hereinafter.

In the drawings:

Fig. 1 is a fragmentary circuit diagram

representing the input end of a radio receiver. In this figure there are shown an aperiodic antenna circuit and a radio frequency coupling tube, together with a variable capacitive coupling device in accordance with the present invention.

Fig. 2 is also a fragmentary circuit diagram of the input end of a radio receiver. This figure illustrates an antenna circuit and a coupling tube coupled together with an inductive coupler provided with an adjustable shielding device in accordance with the present invention.

Fig. 3 is a detail view illustrating the manner in which adjustable inductive shielding in accordance with Fig. 2 may be carried out.

Figs. 4 and 5 are sectional views of a capacitive coupling device suitable for use as a component part of Fig. 1. Fig. 4 is taken along the line 4—4 of Fig. 5 and Fig. 5 is taken along the line 5—5 of Fig. 4.

Figs. 1 and 2, respectively, are intended to represent, merely by way of example, two general and alternate embodiments of the invention, both of which may assume numerous specific forms.

In Fig. 1 the aerial 1 is coupled to the grid 3 of coupling tube 2 through the medium of a direct capacity 4. The grid 3 may be provided with a leakage path to cathode comprising an inductance 5, or high resistance 6, or both as shown. It is to be observed that the cathode of the coupling tube in Fig. 1 (as well as in Fig. 2) is indicated as being heated by a battery. This showing is intended to be symbolic merely of a source of heating current; for as already pointed out, the present invention is especially useful when employed in connection with systems wherein the cathodes are heated by alternating current. The magnitude of capacity 4 should be adequate to provide a sufficiently low impedance path to the weakest signal waves of the lowest frequency dealt with. As shown in Fig. 1, this direct capacity may exist between two opposed plates 7 and 8, respectively. In actual practice there are usually more than two plates, as will be pointed out in connection with the description of Figs. 4 and 5. Assuming that the maximum direct capacity between plates 7 and 8 is sufficient to provide an adequately low impedance path for the weakest signal wave of lowest frequency dealt with, it would usually be impossible to sufficiently reduce this capacity by merely separating the plates as in the ordinary adjustable condenser designs. According to the present invention the same result as might be accomplished by extreme separation of plates 7 and 8 is accomplished within a very small space through the use of adjustable shielding plates 9. The shielding plates are interleaved with and are adjustable with respect to plates 7 and 8, and they are grounded to the metal shielding 11 through the conductor 10. Although it is usually preferable to "ground" the coupling shield 9 by connection to ground or earth, it is sufficient to connect it to a point of substantially zero high-frequency potential with respect to the grid 3 of the coupling tube, such, for example, as the cathode thereof. Accordingly, the term "ground" as employed in this specification is intended to have this significance. When the shielding plates 9 are completely interleaved with plates 7 and 8 the coupling between the aerial 1 and grid 3 through the capacity 4 is reduced to a value closely approaching zero. A specific device comprising the capacity coupling and shielding elements of Fig. 1 is illustrated in Figs. 4 and 5, and will be described later.

In order to obtain the maximum reduction of coupling the radio-frequency amplifier circuits should preferably be well shielded from the antenna circuits by means of suitable sheet-metal shielding, as indicated at 11 in Fig. 1. This may consist of the ordinary compartment type of shielding or any type which will serve to sufficiently isolate the radio-frequency stages from the antenna. In addition to shielding the amplifier it is highly desirable that the coupling device comprising the plates 7, 8 and 9 be enclosed within a metal shielding box or compartment as shown in Fig. 1. This compartment is designated by reference numeral 12. The shielding of the coupling device, as illustrated, is effective in the prevention of incidental coupling between the antenna and the condenser plate 8 connected with the grid 3 of the coupling tube. All the common terminals are shown connected to the shielding 11 which in turn is grounded at 13. When the arrangement described is designed to deal with exceedingly strong incoming waves the auxiliary shielding provisions, as shown, are especially necessary.

In Fig. 2 an arrangement employing predominantly inductive coupling is illustrated. The coupler comprises two parallel "pancake" type coils of which the primary 14 is in series with the aerial 15 and ground 16. One terminal of the secondary winding 17 is connected to the grid 18 of the coupling tube 19 while the other terminal is connected to the metal shielding 20 which is grounded at 21.

An arrangement somewhat similar to that of Fig. 1 is provided for regulating the effective coupling between coils 14 and 17. This comprises a set of adjustable, grounded shielding plates 22 interleaved with the coils. Here, again, as in Fig. 1, the term "grounded" as applied to the shielding plate 22 is intended to signify that the shield is connected to a point of substantially zero high-frequency potential with respect to the grid 18 of the tube 19; for example, the cathode thereof. When such connection is made the plates 22 comprise a capacitive as well as an

inductive shield. When completely interleaved with the coils the plates 22 reduce the coupling, both inductive and capacitive, to substantially zero. The coupling tube and succeeding amplifier are enclosed within a shielding compartment 20, but no shielding corresponding to the compartment 12 of Fig. 1 is indicated in Fig. 2. Whether such additional shielding should be provided depends upon the particular requirements in any given case.

Fig. 3 is an end view of an arrangement applicable to the system of Fig. 2. The shielding plates 22 are pivoted on an axis 23, and a suitable knob, not shown, is provided for rotating the shielding plates 22 about their axis. The dot-dash line 24 indicates the position of the shielding plates when the two coupling coils 14 and 17 are completely shielded from each other. The plates 22 function to regulate simultaneously both inductive and capacitive coupling between the coils. In the full-line position of the shielding plates the maximum coupling is obtained. It follows that any desired degree of coupling can be attained by rotating the shielding plates.

The arrangement of Figs. 2 and 3 may be utilized to vary the coupling between any two coils. In the circuit of Fig. 2, however, it is suggested that the two coils 14 and 17 may be the primary and secondary of a step-up transformer for transferring the signal from the antenna circuit to the grid 18. This transformer may comprise two coils of the so-called "pancake" construction mounted in a parallel coaxial position and approximately resonant with antenna and tube capacities to all frequencies within a given band—for example, the broadcast frequency band (from 550 to 1450 kilocycles.)

In Figs. 4 and 5 there is illustrated an adjustable coupling condenser suitable for use in an arrangement such as that of Fig. 1. Fig. 4 is a sectional view taken along the line 4—4 of Fig. 5 while the later figure is a cross sectional view taken axially along the line 5—5 of Fig. 4. This device comprises a metal box consisting of end pieces 25 and 26 and a cylindrical wall 27 supported by the end pieces. The plates 7 and 8 of Fig. 1 are respectively represented in the structure of Figs. 4 and 5 by alternate sets of plates. One such set is designated 28, while the other is designated 29. These plates are supported on rods 30 and 31, respectively, which in turn are supported by insulating bushings in the end pieces 25 and 26. The plates 28 and 29 are properly spaced by suitable metal separators, such as 32, and are interleaved as shown. The number of plates employed and their dimensions are determined by the maximum coupling capacity required. The shielding plates corresponding to 9 in Fig. 1, and designated by reference numeral 33 in Figs. 4 and 5, are mounted on shaft 34 which is rotatably supported in the end pieces 25 and 26. There is shown a knob 35 for rotating the shaft 34 and plates 33. These latter plates are adjustably interleaved with the plates 28 and 29 which are thereby shielded from each other, electrostatically, to any desired degree. In order to reduce as much as possible the minimum unshielded capacity between the coupling plates 28 and 29, they are provided with staggered mounting lugs 36, 37, 38 and 39 as shown in Fig. 4. The lugs 36 and 38 are integral parts of the same and corresponding plates, while the alternate lugs 37 and 39 are integral parts of the opposite plates. As a result of their wide separation and shielding, the capacity betwen the mounting lugs is restricted to a very small value. It will be noted that the rotary plates 33 have a considerably larger radius than that of the stationary plates 28 and 29 and, accordingly, with the former are interleaved with the latter they overlap radially, thereby cutting down residual coupling capacity to as small a value as may be required.

An additional advantage of the herein described methods of controlling volume by adjustable shielding, is that the rate of change of volume while moving the shielding plates can be controlled, when the set is designed, by the shape of the shielding plates. For example, the plates may be made of such a shape that the signal will be reduced one-half for each 10° rotation on the volume control dial, giving a signal reduction in the ratio of approximately 1:1000 for the last 100 degrees of a 180° scale.

Another advantage over prior devices for volume control is that the degree of shielding varies gradually and continuously during adjustment, while the usual wire wound resistance volume control device varies in small steps discontinuously, thereby causing clicking noises in the loud speaker. It should be apparent that the invention is susceptible of embodiment in a variety of forms, and should not be construed as limited to the particular arrangements and devices hereinbefore described. For example, the capacitive coupling device of Figs. 4 and 5 is applicable to certain forms of tuned antenna circuits as well as to the untuned or a periodic antenna circuit of Fig. 1. Also, any of these devices are applicable to secure adjustable coupling between two circuits of any nature for alternating currents of any frequency range.

What is claimed is:

A radio receiving system including an antenna circuit, a vacuum tube circuit electrically shielded therefrom, a capacitive coupling device having three cooperative elements enclosed in a metallic casing, two of said elements being connected in the two said circuits, respectively, and the third element

being connected to said casing and adjustably associated with said other two, whereby the electrostatical or electromagnetical transfer of energy between said circuits can be adjusted from a maximum value to a substantially zero value.

In testimony whereof I affix my signature.

HAROLD A. WHEELER.