

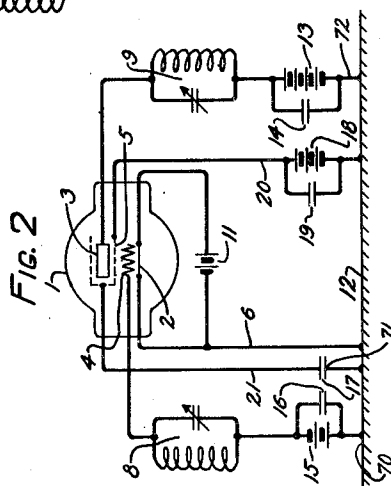
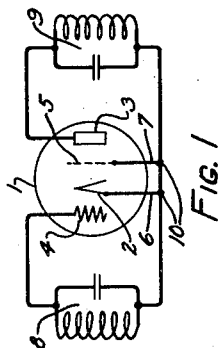
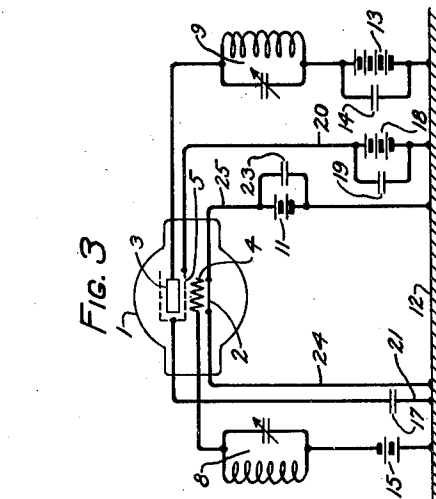
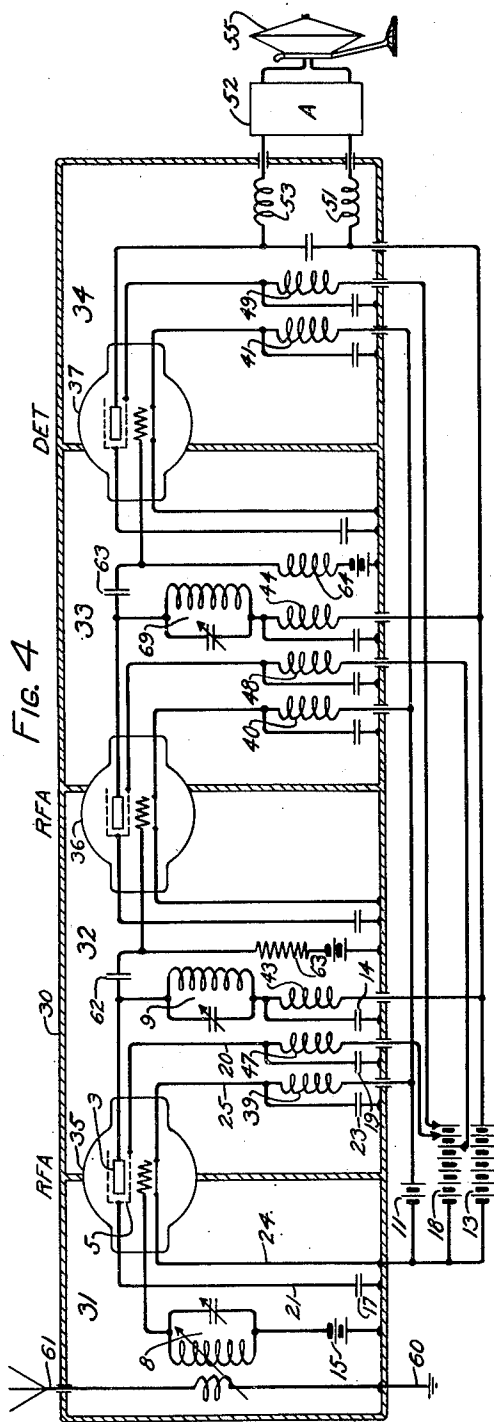
Jan. 13, 1931.

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1,788,521

SHORT WAVE AMPLIFYING SYSTEM

Filed Jan. 2, 1929



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SHORT-WAVE AMPLIFYING SYSTEM

Application filed January 2, 1929. Serial No. 329,881.

The present invention relates to electric space discharge devices and circuits therefor. The invention has particular reference to such devices and circuits for use in radio signaling at relatively short wave lengths.

An object of the invention is to prevent or reduce effective coupling between elements of the circuit which would impair the proper operation of the space discharge device or devices.

Reactive coupling between elements of a vacuum tube or portions of the circuit give rise to such well-known effects as regeneration, loss of amplification or degeneration, distortion and, in extreme cases, the production of actual oscillations or "singing." Among the principal undesired couplings in such a circuit may be mentioned the inherent capacity between electrodes of the tube, especially that between the plate and grid; inductive coupling between windings in the input and output circuits of the tube, and reactance in the lead wires or between lead wires connecting portions of the circuit.

Various methods have been devised for reducing the harmful effects of the inherent capacity, such as: 1. The use of circuit elements external to the tube for developing current or voltage components tending to counteract those arising from the inherent capacity; and 2. The use of an internal shield or screen to reduce the inherent capacity.

The effects of inductive coupling have been guarded against by shielding and in some cases disposing the leads or windings so as to reduce the mutual inductance between certain portions of the circuit.

It has been recognized that the difficulty of securing protection against undesired coupling increases enormously at higher and higher frequencies. For example, shielding, anti-singing connections or other capacity neutralizing means that suffice in the range of frequencies employed for radio broadcast may prove useless or inadequate at frequencies twenty or thirty times higher. While the invention is not limited in its use to any range of frequencies, it provides effective protection against undesired coupling at the extreme high frequencies utilizable in radio signaling,

frequencies of the order of fifty or a hundred times as high as broadcasting frequencies or even higher.

Applicant has found that a particularly troublesome coupling in a vacuum tube circuit, especially at very high frequencies, is the coupling which arises from the use of a common lead for connecting the grid and plate circuits to an element of the tube. Such a lead may be the common connection to the cathode. In the case of a screen-grid tube, another common lead which introduces detrimental coupling effects is the lead from the screen to the plate and grid circuits. So long as these common leads are present and contain appreciable inductance, no amount of shielding can eliminate the coupling between the input and output circuits of the tube.

Applicant has devised as one feature of the invention, a circuit which reduces the effects of common leads to an innocuous degree even at the extreme high frequencies corresponding to the so-called short-wave range used in radio signaling.

Another feature of the invention relates to a novel type of shielding especially effective in preventing detrimental coupling between elements of a vacuum tube circuit.

The invention in a preferred form contemplates a practically complete elimination of all harmful coupling effects in a vacuum tube circuit and to accomplish this combines reduction of the inherent capacity between elements of the vacuum tube, reduction of the common lead effects, and isolation of input and output circuit elements by proper shielding. The actual type of means for reducing inherent tube capacity may comprise a screen-grid construction but the invention is not limited to such means since other capacity-reducing or capacity-annulling means may be used. Features of the invention, as noted above, relate to particular connections or constructions for reducing the common lead effects and for shielding, and will be claimed herein in addition to the general combination referred to above as the preferred form which the invention may take.

In the drawings Fig. 1 represents a prior art circuit which is disclosed here for the

purpose of describing the undesired effects which the invention overcomes;

Figs. 2 and 3 are single-stage vacuum tube circuits showing two different forms which the invention may take; and

Fig. 4 shows the circuit of a complete radio receiver embodying the invention. Each of the figures is in the nature of a schematic circuit diagram.

Referring first to Fig. 1 a vacuum tube is shown having an envelope 1 within which are contained a cathode 2, an anode 3, a grid 4 and a screen 5. These elements are connected by lead wires to an input and an output circuit containing respectively the tuned circuits 8 and 9 which, it will be assumed, may be tuned to any desired frequencies.

The connection of the filament to the grid and plate circuits is made through the wire 6 to one of the points 10 and the connection of the screen is through conductor 7 to one of the points 10. It is obvious that the plate current flows in a circuit including elements 2 and 3 within the tube and the external circuit 9, 10 and 6. (For simplicity batteries have been omitted in this figure.) The grid 4 is connected through the external tuned circuit 8 to the point 10 and thence through conductor 6 to the filament so that any drop of potential in conductor 6 caused, for example, by the flow of space current is applied as a voltage to the grid 4. The conductor 6 therefore forms a coupling element between the plate and grid circuits, since it is common to both circuits.

In a similar manner conductor 7 forms a coupling element between the plate and grid circuits. For example the screen 5 forms one plate of a capacity, another plate of which is the anode 3. Charging current for this capacity flows in the path 5, 3, 9, 10, 7. Screen 5 also has capacity with respect to the grid 4, so that charging current for this capacity flows in the path 5, 4, 8, 10, 7. A drop of potential in conductor 7 therefore produced by the flow of charging current due to the capacity 5-3 is imparted to the grid 4.

Ordinarily the reactive impedance of leads 6 and 7 would be negligibly small at speech frequencies and at frequencies considerably higher. At extremely high frequencies, however, the impedance of lead 6 or 7 becomes appreciable and applicant has found that with any ordinary construction employed, a common lead 6 or 7 between the plate and grid circuits shows sufficient impedance in the common lead 6 or 7 at very high frequencies to produce a noticeable amount of retro-active effect between the plate and grid circuits.

With the types of tubes ordinarily used the retro-active effects due to capacity between the grid 4 and plate 3 would, in the absence of some protective means, such as the screen 5 predominate over the retro-active effects due to the common lead 6. If the retro-active

effects due to the grid plate capacity are substantially eliminated, however, then at very high frequencies the coupling produced by the common lead 6 may become so large as to produce undesired effects, particularly a degenerative action, reducing the amplification obtainable with the tube. The invention comprises in one aspect a means for reducing or eliminating the effects of coupling due to the common lead 6 in connection with a means for substantially eliminating the grid plate capacity. Where the latter means comprises the screen 5 the invention further comprises a means for eliminating or reducing the effects of coupling produced in the common lead 7.

The common lead 6 is in series with the plate impedance of the tube which is ordinarily high and it has been found that it is less important to eliminate the effects of coupling due to the common lead 6 than that due to the common lead 7, since the shield 5 presents very much lower impedances toward both the plate and the grid than the impedance between the plate 3 and filament 2 of the tube.

Referring now to Fig. 2 a circuit in accordance with the invention is here shown for reducing the retro-active effects due to the coupling of the common lead 7 of Fig. 1. In Fig. 2 a tube construction is shown somewhat different from that of Fig. 1, but containing the same elements, that is, cathode 2, anode 3, grid 4 and screen or shield 5. The filament or cathode 2 has its leads extended through opposite walls of the envelope 1 and connected to filament heating battery 11, one pole of which is shown connected by common lead 6 to a ground plate 12 which may be a wire conductor, but in the preferred construction where shielding is used this element would be constituted by a portion of the shield. The plate 3 is connected by a lead passing through the right-hand wall of the envelope 1 and connecting to the output tuned circuit 9, thence through plate battery 13 shunted by condenser 14 to ground plate 12. The grid 4 is connected by a lead passing through the opposite wall of the envelope 1 to the input tuned circuit 8 and through a grid biasing battery 15 to ground plate 12. Battery 15 may be shunted by condenser 16. The screen 5 is provided with two connecting leads passing through opposite walls of the tube. The lead 21 at the left passes through condenser 17 to ground plate 12 and lead 20 at the right is connected through battery 18 shunted by condenser 19, and thence to ground plate 12. Battery 18 serves to place a suitable polarizing voltage on the screen, while capacity 17 acts as a blocking condenser for the direct current from battery 18.

Capacity exists between the anode 3 and the screen 5 and between the grid 4 and the

screen 5 as described in connection with Fig. 1. However, in the circuit of Fig. 2, charging current for the capacity 3—5 passes principally through the conductor 20, plate 12, condenser 14 and tuned circuit 9, whereas charging current for the capacity 4—5 passes through conductor 21, condensers 17 and 16 and tuned circuit 8. The two circuits followed by the charging currents of the respective capacities 3, 5 and 4, 5 are therefore separated in the circuit of Fig. 2 and made individual respectively to the plate circuit and grid circuit. In an actual practical embodiment, the circuit 8 is associated with the grid as intimately as convenient. Conductor 21 is therefore made as short as possible. Sometimes condenser 17 is located as near to the tube envelope as possible so as to make the connection between condenser 17 and shield 5 as short as possible, and the connection from battery 15, indicated at 70, is made with the lower end of condenser 17 (at point 71) instead of to the point shown. Condenser 19 and connection 72 are treated likewise. In this manner the impedance of the connecting leads is kept to the smallest practicable value, so that practically all of the charging current between the screen 5 and the anode 3 is confined to the output circuit, while that due to the capacity between screen 5 and grid 4 is practically confined to the grid circuit.

Although conductors 20 and 21 are to a certain extent in parallel due to being connected by the ground plate or conductor 12, the impedance of conductor 12 will ordinarily at very high frequencies be high enough to be influential in making the grid circuit and plate circuit charging currents remain confined within their own circuit branches or compartments. This is further emphasized by the "skin effect action" produced when two frequency circuits are in parallel, which causes the major part of the current to flow in the section that is nearest the loop circuit in which they are connected and to have little relation to the impedances of the two branches themselves. In the circuit as disclosed in this figure no attempt has been made to eliminate the effect of common lead 6, since as explained above the effect of this common lead is less than that produced by a common lead for the screen which is avoided in this figure.

In Fig. 3 a circuit is disclosed for reducing the common lead effect of both the cathode lead and a lead to the screen or shield. In this figure the various elements correspond to those bearing the same reference characters in Fig. 2. In this figure the screen 5 has leads projecting from opposite walls of the tube and connected as in Fig. 2 to the ground plate 12. Also the filament 2 has leads extending through opposite walls of the tube and connected by leads 24 and 25 to ground

plate 12. The filament heating battery 11 is shunted by capacity 23. As described in connection with conductors 20 and 21 of Fig. 2 the conductors 24 and 25 provide separate paths for respectively connecting the grid and the plate to the cathode. At high frequencies the A. C. plate current will flow principally through nearest conductor—25, whereas the grid is connected to the cathode through conductor—24. The drop of high frequency potential produced in lead 24 is smaller than that occurring in lead 25, so that less of this potential is impressed on the grid than would be the case if the grid were connected as in Fig. 2. This construction therefore reduces the effects of coupling due to the common lead to the cathode, as well as that due to the common lead for the screen.

Referring now to Fig. 4 a construction is here shown involving elimination of feed back due to coupling through common leads and employing a novel type of shielding in connection with vacuum tubes according to the invention.

The shield 30 is divided into compartments 31, 32, 33 and 34 and contains a circuit constructed according to the invention comprising two stages of radio frequency amplification and a detector. The radio frequency stages comprise tubes 35 and 36, while the detector stage includes tube 37. Each of these tubes projects through an aperture in a partition forming part of the shielded enclosure.

The type of circuit employed in connection with each tube is generally the same as that shown in Fig. 3 and the corresponding parts may be identified by the use of the same reference characters. The filaments of all three tubes are supplied with heating current in parallel from battery 11 through respective high frequency choke coils 39, 40 and 41. The anodes are supplied in parallel from plate battery 13 through respective high frequency choke coils 43, 44 and the audio circuit 51, 52, 53. Potential for the screen of each tube is derived from battery 18, the screen of each tube being connected through a separate high frequency choke coil 47, 48, 49 respectively. The audio part of the circuit, as shown diagrammatically, includes a suitable audio-amplifier 52 and a suitable receiver 55.

Referring more particularly to the type of shielding employed, it will be noted that compartment 31 includes the grid circuit of the first stage of amplification. Compartment 32 contains the output circuit of the first stage and the input circuit of the second stage. Compartment 33 similarly contains the output circuit of the second stage and the input circuit of the detector, the output of which is contained in compartment 34. The shield as a whole is grounded at 60 and each partition is intimately associated with and ex-

tends completely around each tube. These partitions are so placed as effectively to isolate all of the input wiring from all of the output wiring in the case of each stage. The partition may be placed mid-way of the tube as in the case of tube 35 or nearer to one or the other end of the tube (as far as the shield extends) as the case of tubes 36 and 37, these three positions of the shield being indicated for purposes of illustration. Any of these positions is suitable, the principal requirement being that the plane of the shield cuts through the tube at such a point that substantially all of the input leads are on one side of it, while substantially all of the output leads are on the opposite side. The shield and tube construction should be such that the shield approaches the tube elements or tube leads as intimately as possible without producing undue shunting effects to ground by capacity with respect to any of the elements or conductors.

The input of the first stage of amplification is adjustably coupled to an antenna circuit 61 for receiving radio waves.

The operation of the circuit of Fig. 4 will be apparent from the description already given, particularly in connection with the previous figures. Radio waves incident on antenna 61 are transmitted into tuned circuit 8 and applied to the grid of the tube 35. The grid circuit of this stage is traceable from the grid through tuned circuit 8, grid bias battery 15, a portion of shield 30 and conductor 24 to the cathode. The amplified signal variations appearing in the plate circuit flow through the path from the anode, output tuned circuit 9, condenser 14, a portion of shield 30 and condenser 23 to the cathode. The grid circuit is thus seen to be contained in a shielded compartment separate from and isolated from the plate circuit, except for such association as exists between the tube elements themselves.

The inherent capacity of tube 35 which if not annulled or reduced would result in undesired feed back especially at short waves is reduced by screen 5 which preferably surrounds the anode 3. Screen 5 has a screen-to-grid connection wholly contained within shielded compartment 31, this connection extending through conductor 21, condenser 17, battery 15 and tuned circuit 8 to the grid. Screen 5 also has a plate-to-screen connection wholly contained within shielded compartment 32, this circuit including conductor 20, condensers 19 and 14 and tuned circuit 9 to the plate.

Elimination of retro-active effects is thus realized which might arise from three causes. First, that which would arise from inherent tube capacity is eliminated by the shield 5; second, that which might arise from the use of a common lead for the screen is avoided by the use of individual grid and plate leads

contained in separate shielded compartments; and third that which would arise from the use of a common filament lead is eliminated by the use of individual grid and plate filament leads contained in separate shielded compartments. Choke coils 39 and 47 confine the high frequency currents to the shielded enclosure, while permitting direct current to be applied to the tube elements.

The amplified signal in the output of stage 35 is applied to the grid of stage 36 through series condenser 62. Grid leak resistance 63 connects the grid of this tube with the filament through suitable biasing means as desired. This stage is in all essential respects similar to stage 35 and needs no further description. The amplified wave from stage 36 is applied across anti-resonant circuit 69, which is similar to tuned circuit 9, and is applied to the grid of the detector through series condenser 63. The detector grid circuit is connected to the filament through choke coil 64 and suitable biasing means if desired. Detector 37 is connected to the audio amplifier 52 through series inductances 51 and 53 so that the signal may be further amplified at 52 and supplied to the loud speaker 55. Inductances 51, 53 and suitable shunt capacities form a low pass filter permitting the signal to pass freely to amplifier 52.

It will be understood, of course, that the invention is not limited to any particular number of stages or to the specific embodiments that have been shown for purposes of illustration, but that the invention is susceptible of various modifications within the scope of the appended claims.

What is claimed is:

1. In combination, a vacuum tube containing a cathode, an anode and a grid or the equivalent, a grid lead and a cathode lead extending through one wall of the tube, an anode lead and a cathode lead extending through the opposite wall of the tube, input and output circuits connected to said pairs of leads respectively, and means to reduce the inherent grid-anode capacity in said tube.
2. In combination, a vacuum tube for the transmission of electrical waves containing a cathode, an anode, a grid and a screen, said tube having individual anode-to-screen and grid-to-screen circuits external to said tube, substantially electrically independent of each other as regards the transmitted waves.
3. A space discharge device having cathode, grid, anode and screen grid elements, an external shield forming compartments, an alternating current connection from the cathode to said shield, a connection wholly within one compartment of the shield, between the grid and the shield, a connection wholly within the other compartment be-

tween the anode and the shield, and a separate connection in each compartment between the screen grid and the shield.

4. In combination, a space discharge device having a cathode, an anode, a grid or equivalent and a shield member within the enclosing envelope, an external shield forming compartments into which said device projects, an external grid-cathode circuit lying wholly within one of said compartments, an external anode-cathode circuit lying wholly within another of said compartments, and a separate shield-member-to-cathode connection in each compartment.

5. In a vacuum tube system, an envelope including cathode, grid, anode and screen-grid elements, grid-cathode and anode-cathode leads extending through opposite walls of said envelope respectively, a lead through each of said walls for said screen-grid, and separate external circuit connections between anode and screen grid, and grid and screen grid, respectively utilizing a different one of said leads to said screen grid.

6. A receiving circuit for short waves comprising a plurality of amplifier stages each including cathode, grid, anode and screen-grid electrodes, and means for reducing the coupling effects of a common lead from the screen-grid to the grid and anode, comprising, separate external screen-grid to anode and screen-grid to grid connections extending in different directions through the tube walls and enclosed in different shielded compartments.

In witness whereof, I hereunto subscribe my name this 31st day of December, 1928.

RAYMOND A. HEISING.