

May 26, 1931.

B. F. MIESSNER

1,806,813

ELECTRON TUBE ENERGIZING METHOD AND APPARATUS

Filed Feb. 4, 1928

2 Sheets-Sheet 1

Fig. 1.

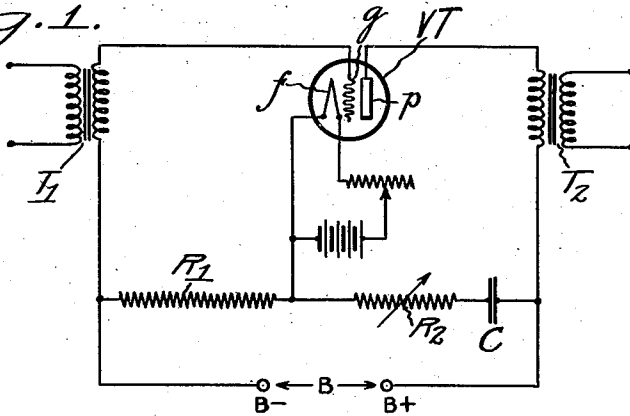


Fig. 2.

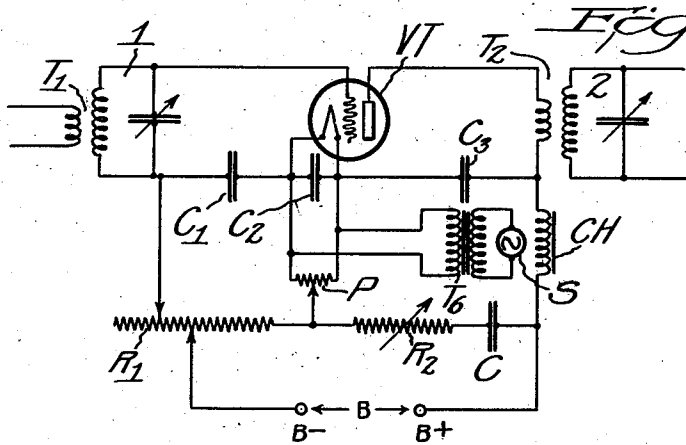
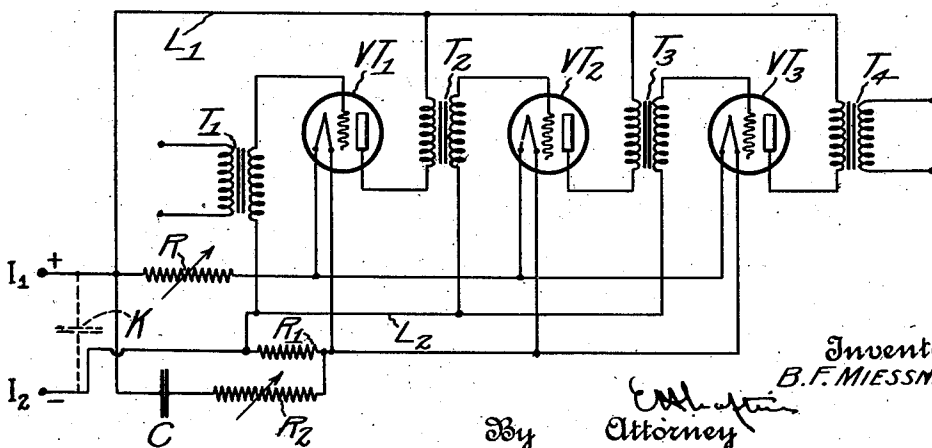


Fig. 3.



Inventor
B. F. MIESSNER

By

Attorney

May 26, 1931.

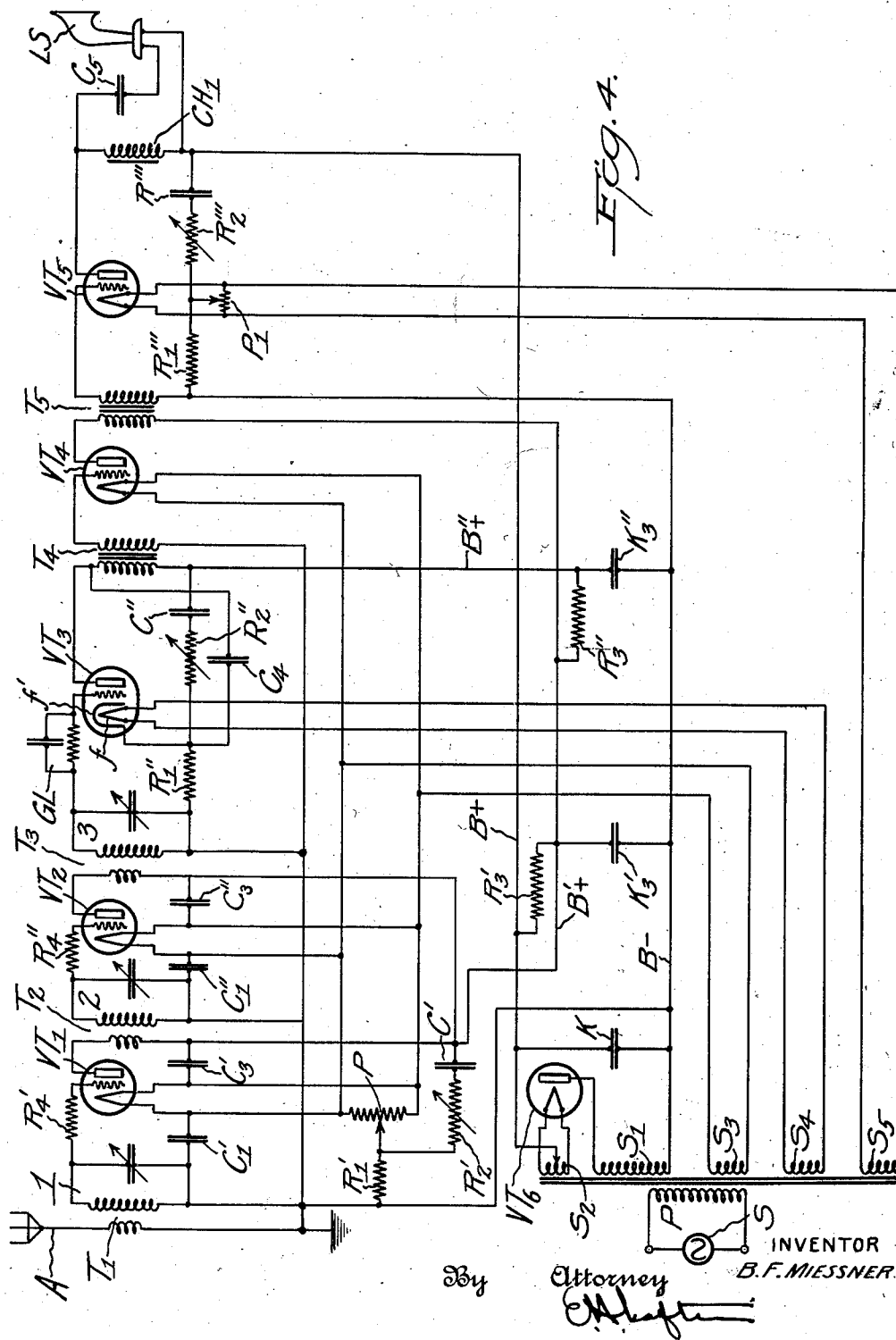
B. F. MIESSNER

1,806,813

ELECTRON TUBE ENERGIZING METHOD AND APPARATUS

Filed Feb. 4, 1928

2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

BENJAMIN F. MIESSNER, OF SHORT HILLS, NEW JERSEY, ASSIGNOR, BY MESNE ASSIGNMENTS, TO RADIO CORPORATION OF AMERICA, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE

ELECTRON TUBE ENERGIZING METHOD AND APPARATUS

Application filed February 4, 1928. Serial No. 251,807.

The present invention relates generally to methods and apparatus for energizing electron tubes for operation, and particularly the energizing of three electrode vacuum tubes for amplification and detection from unsteady sources of potential including commercially available alternating current sources.

An object of the invention is to so use and control the fluctuating components of the energizing currents that the hum effects at the output end of an amplifying system so energized are substantially eliminated or are made sufficiently small to satisfy practical requirements.

A particular object of the invention is the provision of methods and means for energizing single or multiple stage vacuum tube systems, such as radio receivers, in a way to effect a substantial reduction in the expensive and bulky materials heretofore used in the filter portions of such systems without sacrificing hum reduction efficiency.

Other objects and benefits will be obvious to those skilled in the art from the following description with its reference to the figures of the accompanying drawings, like reference characters representing like parts so far as possible in the several figures.

Fig. 1 diagrammatically illustrates the invention in the simple form of an energized single stage of audio frequency amplification, and is particularly suitable for an explanation of the fundamental features involved.

Fig. 2 illustrates the invention in like manner to Fig. 1 with the exception that it provides for radio frequency amplification.

Fig. 3 shows the invention extended to multiple stage amplification.

Fig. 4 shows the invention applied to a complete radio receiving system including radio frequency amplification, detection and audio frequency amplification, and includes additional novel features.

In Fig. 1 there is shown a three electrode vacuum tube amplifier VT including grid, filament and plate electrodes, *g*, *f* and *p* respectively, the filament being shown as heated by current from a battery through a vari-

able resistance in a conventional way, it being understood that any of the well-known methods of heating are applicable. The input circuit is shown to have an input through a transformer *T* for alternating currents to be amplified, and the output circuit is shown to have an output for the amplified currents through transformer *T*₂. The transformer *T*₁ and *T*₂ are conventionally indicated as low or audio frequency transformers, though transformers suitable for other frequencies, or other energy transfer elements suitable for any and all frequencies are applicable.

The grid electrode *g* and plate electrode *p* are indicated as energized for operation by a source of energy *B* having negative terminal *B*⁻ and positive terminal *B*⁺, which may be any kind of a unidirectional source of energy unsteady in character, such as alternating current rectified by commutation in a direct current dynamo, or alternating current rectified by some of the well known rectifying devices, such as discharge tubes, electrolytic rectifiers and the like. The source may have associated with it filtering or energy storing devices in kind and manners well known, including choke coils or resistances and condensers, though it is a particular purpose of the invention to reduce the extent of use of such filtering and energy storing devices to an extent heretofore not deemed practicable in practice, as will be later pointed out in detail.

Practically all manners of operation of three electrode vacuum tubes require a so-called negative grid bias to bring the point of operation of the device at a desired portion of the plate current characteristic curve when the plate electrode is positively energized sufficiently strong to permit of response throughout a desired extent of the characteristic curve, and some of the more or less recent power amplifying tubes common to radio receiver practice require rather high grid bias potentials, such as a negative 45 volts. Because the tubes are usually employed as amplifiers, and in many instances are followed by one or more additional stages of amplification, the procedure of deriving the grid biasing potential from an unsteady source has

been viewed with considerable apprehension in systems where hum elimination, when energizing from such a source as commercial alternating current is deemed essential, as in the case of commercially competitive broadcast receivers. For this reason considerable effort has been made to free the energy used for grid biasing from fluctuations or ripples before application to the grids.

Since the degree of grid bias is a more or less fixed requirement for proper functioning of a tube for a desired purpose the bias cannot well be tampered with even if doing so would aid in arriving at other desirable results. It is a feature of the present invention that any desired degree of grid bias for amplifying, detection or other purposes of tubes can be met when accompanied by a high order of fluctuating or rippling energy from an imperfectly filtered source, and hum production desirably controlled without any detrimental sacrifice in the desired function of the tube. In fact, in lieu of striving to avoid fluctuating energy at the grid the invention deliberately contemplates a substantial amount of it, but under such control that it is effectively used for hum elimination.

Continuing with Fig. 1 it is seen that the fluctuating current energy from source B passes from negative terminal B— through resistance R_1 in the grid circuit to filament f , then to plate p by reason of the positive potential thereon from source B, and back to positive terminal B+ by way of the primary of output transformers T_2 . Obviously this fluctuating current energy passing through primary of T_2 results in passing hum energy forward with the desired signal energy unless something is done to prevent the result. The usual practice is to minimize the hum effect by smoothing out the current from source B as much as practicable by the use of an elaborate amount of expensive filtering materials, such as choke coils and condensers.

The fluctuating current passing through R_1 in the grid circuit derives for the grid a negative fluctuating difference of potential the average value of which should, through choice of value of R_1 for value of current, be the negative grid bias that the particular tube requires for the particular function contemplated, as for example maintaining the average value of plate current at the middle of the plate current characteristic curve for amplified repeating. With the connections shown the rippling component of the grid bias will, including the amplifying ability of the tube, tend to neutralize tendency of the plate current to fluctuate by reason of the energizing current; that is, a ripple in the bias more negative than the average value of the produced negative bias will tend to reduce the plate current at the same moment

that a simultaneous ripple in the positive plate potential more positive than the average value of the produced positive plate potential tends to increase the plate current, and vice versa. The two effects thus being oppositely acting it would be most fortunate if in normal arrangements for operating the tube they were equal, as hum production would be automatically completely neutralized. In all the usual functions of tubes so far as practice has appreciated them the two effects are not equal, and therefore there is considerable residual fluctuating current passing through primary of transformer T_2 to transfer its hum effect forward to the ultimate output along with the desired signal. For example, in the case of amplified repeating if the resistance R_1 were so chosen that the rippling component of the grid bias were large enough to neutralize the rippling component of the plate potential then the average value of the grid bias would be large enough to stop flow of plate current or, as it is termed, block the tube, instead of permitting operation at the middle of the plate current characteristic curve, recognized as most desirable for amplified repeating. These considerations bring out the fallacy of a common practice in the art of shunting a bias developing resistance R_1 with a condenser to lessen the rippling component of the developed biasing potential when the plate electrode is energized from the same source. In general an increase in the rippling component of the grid bias is needed under such circumstances.

The present invention increases the rippling component of the biasing potential while maintaining the average value just right for the particular tube and its purpose of use, and at the same time decreases the rippling component of the plate current without interfering with the desired average value of the plate current, and all in such a way that with the aid of the amplifying ability of the tube any desired degree and phase of hum neutralization can be secured. It is a feature of some of the desirable modifications of the invention, particularly in multiple stage amplification operation, that hum currents of one or another phase be left in one stage for use in neutralizing hum currents in another stage. Obviously excess grid rippling energy will leave hum currents of one phase and deficient grid rippling energy will leave hum currents of opposite phase.

Again referring to Fig. 1, it is seen that I include a resistance R_2 , which may be variable for varied results, and a condenser C in series therewith in a connection between filament f and the negative side of the output element T_2 in the plate circuit. The condenser C prevents the direct current component of the energy from source B from taking this path, and thus still confines it to the path by way of filament f , plate p and primary of

transformer T_2 , but does permit the path to pass energy of the rippling component, thereby diverting some of the energy of the rippling component from primary of T_2 , and at the same time decreasing the impedance to rippling current energy of the circuit as a whole connected to source B, but in such a way that substantially all the energy passes through bias developing resistance R_1 , thereby increasing the rippling component of the bias for use against the decreased rippling component through primary of T_2 .

The effectiveness of the arrangement of Fig. 1 on hum elimination in practice is striking. For example, I have found when using as a source B current from an ordinary 60 cycle commercial alternating current house supply system rectified by a vacuum tube I can, by choosing proper values of resistances R_2 and condenser C, eliminate all of the choke coils of a well designed filter and reduce the capacity of the filter condensers to less than one-half value and yet produce a hum elimination superior to that had with the full equipped filter, and this while maintaining R_1 just right for best grid bias of the tube for amplified repeating.

In general I have found for good hum elimination a ratio of R_2 to R_1 of the order of the amplification of the tube being used where the system is operating as an amplifying repeater, and a capacity of condenser C such that its reactance to the rippling component of the energizing energy is substantially less in ohms than the resistance of R_2 in ohms.

In general I find it desirable to employ resistance R_2 for fixing the magnitude of the rippling current, and to make the capacity of C large in order to introduce as small a phasing effect as may be practically desirable. Excellent results may be had with a capacity of C much less than the capacities of the condensers employed in well designed filter systems. For example, I have eliminated along with all filters choke coils 10 microfarads out of 18 microfarads of a commercial filter when employing at C but 1 microfarad with improved results in hum elimination. It is of course appreciated that where the source B is rectified alternating current or poorly commutated direct current it may be desirable to use some condenser capacity across the rectifier as an energy storage element.

The operation may be viewed as a matter of ratio of average value of potential to potential of fluctuating component. In the ordinary system the energizing potentials of grid and plate are derived from the same fluctuating current passing through resistances for each electrode, so that the ratio of average value to fluctuating value of derived grid potential is equal to the ratio of average value to fluctuating value of derived plate potential. Since the correct operation of the

tube does not permit the average value of the grid potential to completely neutralize the average value of the plate potential, or block the tube so to speak, it is obvious that with this equality of ratios the fluctuating grid potential cannot fully neutralize the fluctuating potential. I overcome the difficulty by so distributing the energizing fluctuating current with respect to grid and plate circuits that this equality of ratios no longer exists with respect to the potentials on the electrodes per se, and so choose a ratio on the plate side greater than the ratio on the grid side, or a proportionately lesser ripple on the plate than on the grid.

Fig. 2 shows one way of applying the invention to a stage of radio frequency amplification, and differs from Fig. 1 in that T_1 and T_2 are radio frequency transformers associated with radio frequency tunable circuits 1 and 2 respectively. Condensers C_1 , C_2 and C_3 are the usual radio frequency by-pass condensers to confine radio frequency currents to the radio frequency portion of the system, radio frequency choke coil CH being also effective in this connection. These by-pass condensers are of too small capacity to have any noticeable effects on the functioning of the energizing system, usually of the 60 cycle order. In this figure, though it may apply to any system, the filament of tube VT is shown heated by alternating current from a source S through a transformer T_6 , usually of the step-down type. In order to lessen hum disturbances arising from energizing the filament with raw alternating current the grid and plate circuits are shown connected to the filament system at an approximate point of neutral potential through a potentiometer P. It is of course understood that the filament may be of the low voltage-low temperature type to further avoid hum difficulties if it is to be energized by raw alternating current. The provisions for energizing the grid and plate electrodes from a fluctuating source of potential and for neutralizing hum are shown as in Fig. 1 and do not require a repetition of explanation since the amplification of radio frequency currents does not alter the mode of operation.

Fig. 3 illustrates one manner of employing the invention with a plurality of amplifiers of the same kind which provides for using a single grid bias resistance and hum neutralizing connection for all of the stages. The amplifying tubes VT_1 , VT_2 and VT_3 are substantially alike in characteristics. There is a signal input through transformer T_1 . The tubes are connected in cascades through transformers T_2 and T_3 , and have a final output through transformer T_4 . The tubes are shown energized through two input terminals I_1 and I_2 , which may be for example a commercial direct current supply system

having an undesirable commutating ripple. The filaments of the tubes are connected in parallel across the line, the potential for the filaments being reduced to a suitable degree by means of a resistance R . The plate circuits of the tubes are connected in parallel across the line through a common lead L_1 connected to the positive side of the line. The grid circuits are connected to the negative side of the line through a common lead L_2 . The resistance R_1 develops a negative grid bias for all of the tubes while the resistance R_2 and condenser C , connected across the common plate circuit lead L_1 and the common filament system, provides a hum neutralizing connection effective for all of the tubes. As in the case of Fig. 1, the resistance R_1 can be chosen of proper value to give the correct grid biasing potential for operating all of the tubes as amplifying repeaters, and the values of resistance R_2 and condenser C are so chosen as to permit sufficient rippling current to pass through resistance R_1 to produce a rippling potential on the grids of the several tubes to neutralize the rippling components in the plate circuits of the several tubes. If the commutation at the source is very poor a condenser K , indicated in broken lines, may be employed in shunt to the input terminals as shown.

Fig. 4 shows the invention applied to a popular type of radio broadcast receiver having two stages of radio frequency amplification including vacuum tubes VT_1 and VT_2 , a stage of detection including vacuum tube VT_3 , and two stages of audio frequency amplification including vacuum tubes VT_4 and VT_5 . The radio frequency stages and detector stage are coupled through radio frequency transformers T_1 , T_2 and T_3 by way of tunable circuits 1, 2 and 3 respectively. The detector stage and audio frequency stages are interlinked through audio frequency transformers T_4 and T_5 . The output is shown to include a loud speaker, or other suitable translating device LS , which is connected to the output of tube VT_5 through choke CH_1 and condenser C_5 , a common mode of association of the translating device with the output end of such a system. An antenna A , or other suitable form of radio collector, is coupled to the input end of the system. Resistances R_1' and R_1'' in the grid connections of tubes VT_1 and VT_2 indicate one conventional method of stabilizing these tubes against oscillation. The combined resistance and condenser arrangement GL in the grid lead of detector tube VT_3 indicates the usual grid leak-stopping condenser arrangement used in connection with detector tubes. Condensers C_1' , C_3' , C_1'' , C_3'' and C_4 are the usual radio frequency by-pass condensers to confine radio frequency action to desired portions of the system.

Vacuum tubes VT_1 and VT_2 , the radio frequency amplifying tubes, and vacuum tube VT_4 , the first audio frequency amplifying tube, are usually of the same characteristics and energized with grid and plate potentials to the same degree, and are so arranged in Fig. 4. Detecting tube VT_3 is usually energized in the matter of plate and grid potentials differently from the other tubes of the system, and in recent commercial practice it is common to employ as a detecting tube a so-called indirectly heated cathode type, and I have shown this type having an indirectly heated cathode f' in conjunction with a heater element f . It is also usual to employ as the final or output tube one of higher power than the other tubes, requiring considerably higher grid and plate energizing potentials, and I have included this feature in the system of Fig. 4. The complete system therefore provides for handling tubes of three different types.

I provide for energizing all of the tubes in all respects from a source of alternating current S , such as the ordinary commercial 60 cycle lighting system, through a transformer system having a primary P and a series of secondaries S_1 , S_2 , S_3 , S_4 and S_5 . I rectify the alternating current of secondary S_1 by means of rectifying tube VT_6 as a source of energy for the plate and grid circuits of all of the tubes, the secondary S_2 providing for heating the filament of the rectifying tube VT_6 . The filaments of the two radio frequency tubes VT_1 and VT_2 , and the first audio frequency tube VT_4 , are heated with raw alternating current from secondary winding S_3 . Recent practice provides for the filaments of these tubes being of the low voltage-low temperature type, as an expedient towards reducing hum effects resulting from voltage and temperature effects by reason of the use of raw alternating currents, and therefore usually require a transformer secondary adapted for low voltage and high current, and different from secondary windings adapted for the detector tube and the power output tube. The heater element of the detector tube VT_3 is shown energized by raw alternating current from secondary winding S_4 . The filament of the power output tube VT_5 is shown energized by raw alternating current from secondary winding S_5 .

A storage condenser K is connected across the output terminals of the rectifier system, the positive terminal $B+$ of which is connected to the plate electrode of power tube VT_5 to give the maximum developed energizing potential to the plate of this tube. The negative terminal $B-$ of the rectifier system is connected to the grid electrode of tube VT_5 . The resistance R_1''' develops the necessary grid bias, usually high, for tube VT_5 , and the resistance R_2''' and condenser

C''' provides the hum neutralizing connection, these elements being connected to the filament system through a potentiometer P₁, a usual connection where raw alternating current is employed for energizing the filament. The arrangement therefore provides for completely energizing tube VT₅ from an original alternating current source and eliminating hum in the manner described in connection with Fig. 1.

Since the plate electrodes of the three amplifying tubes VT₁, VT₂ and VT₄ do not require the same high energizing potential as the plate of tube VT₅, the over-all potential of the filter system is reduced for the plates of these tubes by a resistance R₃', to arrive at a second potential connection B'+ to which the plate electrodes of the three tubes are connected. Since any hum producing disturbances in tube VT₄ are subject to amplification in tube VT₅, it may be found in practice that the smoothing out of the rectified current by condenser K is not sufficient for this first audio frequency tube VT₄, so that an additional condenser K' may be added at the point of taking off the plate potential for this tube.

A resistance R₁' common to the grid circuits of these three like amplifying tubes provides for creating the desired grid biasing potential for all of them, while the resistance R₂' and condenser C' provide for the hum neutralizing connection for all of these tubes, this being in accordance with the arrangement of Fig. 3 for handling a plurality of like tubes. A potentiometer P is connected across the filament supply circuit common to these three tubes; and the grid bias resistance and hum elimination connection are connected to this potentiometer just as in the case of tube VT₅. The connection Y provides for the usual practice of grounding the negative or B- side of the system.

Since detector tube VT₃ usually requires a still smaller plate energizing potential, provision is made for further reducing the potential available across terminals B'+ and B- by a suitable resistance R₃'' to arrive at a new terminal connection B''+ to which the plate electrode of the detector tube is connected. Since any hum disturbances in the detector tube are subject to double amplification in tubes VT₄ and VT₅, it may be desirable to add for the benefit of the detector tube another condenser K₃''. A resistance R₁'' provides for securing the desired grid bias for the detector tube, if such be used, and a resistance R₂'' and condenser C'' provide for the hum neutralizing connection for use in the manner described in connection with Fig. 1. Since this detector tube is shown to include an indirectly heated cathode f' electrically independent of the raw alternating current heating supply, the grid biasing resistance and hum neutralizing connec-

tion are shown connected to this cathode in lieu of the potentiometer arrangements of the amplifying tubes.

While I have referred to providing additional condensers K₃' and K₃'' because of the first audio frequency tube and detector tube being followed by steps of amplification, I have found that this is a refinement that may be eliminated in practice without introducing any detrimental degree of hum production, and particularly if other procedure for eliminating residual hum effects is resorted to. For example, I find that if the arrangement does not completely neutralize all hum producing conditions in the circuits of tube VT₅, a little residual hum in the circuits of tube VT₄ may be utilized to advantage for neutralizing the residual hum in the circuits of tube VT₅ by introducing this residual hum from tube VT₄ in the grid circuit of tube VT₅ in such phase that the two effects neutralize. The production of the hum effects in tube VT₄ of the correct phase and degree can be controlled by proper adjustment of resistance R₁' and neutralizing circuit elements R₂' and C', as previously explained in connection with Fig. 1. Also slight adjustments of the contacts on potentiometers P and P₁ provide for producing residual hum effects for neutralizing purposes from one stage to the other. This process of neutralizing from stage to stage may be extended to include these effects as between detector tube VT₃ and the succeeding audio frequency tubes, and may be even further extended to include effects as between the detector and audio frequency portion of the system and the radio frequency portion of the system. While the radio frequency transformers of the radio frequency portion of the system do not permit of transferring directly from stage to stage the low frequency hum effects, yet the energizing of these tubes from an alternating current source causes modulation of the radio frequency carrier currents to some extent as the amplifying abilities of the tubes are varied by the alternating current energizing. This modulating effect provides for hum effects being carried through the radio frequency portion of the system to the detector where, by detection, they are sifted out as low frequency effects, and can be passed forward with amplification. It is therefore very desirable in a combination system of many tubes as illustrated in Fig. 4 to utilize the possibility of what might be termed a clean-up of residual hum by means of this stage-to-stage bucking or neutralizing effect. To this end, it may be undesirable to eliminate completely all of the hum in output tube VT₅ and circuits, but rather to create therein some hum effects of proper degree and phase to neutralize those that may come forward from tube VT₄.

The effectiveness of this stage-to-stage

bucking is made most apparent by a simple test. For example, I have adjusted a system substantially in all respects like that of Fig. 4 so that no hum could be heard in the loud speaker, and then short circuited the primary winding of transformer T_s to eliminate transfer of all low frequency currents from tube VT_4 , with the result that a most substantial hum was created in the loud speaker. This is a clear indication that the final adjustment provided for an over-adjusting in tube VT_5 and circuits to neutralize the hum effects coming forward from tube VT_4 and its circuits, and which effects may include those originating even in advance of tube VT_4 .

I have even removed the neutralizing connections R'_2 and C' for the amplifying tubes and R_2'' and C'' for the detector tube, resulting in passing considerable hum energy forward through transformer T_s , and neutralized this large amount of hum energy by adjusting the neutralizing connection of tube VT_5 to give a substantial fluctuating current of correct phase to oppose this incoming hum current. In fact, I have found the procedure so effective as to be entirely satisfactory and well within the standards of commercial requirements for alternating current operated broadcast receivers.

While I have illustrated and described my invention in specific ways, I have done so merely for the purpose of explanation. Its application in many ways other than those illustrated and described will be immediately obvious to those skilled in the art and no limitations are intended by reason of the applications chosen merely for explanatory purposes.

Having fully described my invention, I claim:

1. In a system including a three electrode vacuum tube having grid, filament and plate electrodes, the combination of a source of current having a fluctuating component, means for energizing the grid electrode of said tube for operation including an energy consuming element through which said current is passed to derive a potential for said electrode, connections for passing said current through said tube by way of said filament and plate electrodes, and reactive-resistive means for diverting a desired portion of the fluctuating component only of said current from the path through said tube.

2. In a system including a three electrode vacuum tube having grid, filament and plate electrodes, the combination of a source of current having a fluctuating component for energizing for operation the grid and plate electrodes of said tube, means for energizing said electrodes oppositely in polarity by the current energy of said source, and reactive-resistive means for diverting from said plate

electrode a desired portion of the fluctuating energy component only of said current.

3. In a system including a three electrode vacuum tube having grid, filament and plate electrodes, a source of current having a fluctuating component for energizing said grid and plate electrodes for operation, and reactive-resistive means for diverting a desired portion of the fluctuating component only of the energy of said source from said plate electrode whereby the fluctuating energy components on said electrodes are more completely neutralized in their effects on the operation of said tube.

4. In a system including a three electrode vacuum tube having grid, filament and plate electrodes, a source of current having a fluctuating component for energizing said grid and plate electrodes negatively and positively respectively for operation, means for dividing the average value of the potential of said source into two average values of potential required by said electrodes for the operation of said tube in a predetermined manner, and means for dividing differently the values of the fluctuating component of the potential of said source applied to the respective said electrodes.

5. In a system including a three electrode vacuum tube having grid, filament and plate electrodes, a source of current having a fluctuating component connected negatively to said grid electrode and positively to said plate electrode, a resistance connected between the negative terminal of said source and said filament whereby current flowing through said tube from filament to plate electrodes passes through said resistance to create a negative fluctuating potential on said grid, and a reactive-resistive connection for diverting from said filament-to-plate path a portion of the fluctuating component only of the current energy flowing through said resistance.

6. In a system including a three electrode vacuum tube amplifier having grid, filament and plate electrodes, input and output circuits, the combination of a source of current having a fluctuating component for energizing said grid and plate electrodes negatively and positively respectively for operation, and connected thereto by way of said input and output circuits, a resistance connected between a point in said input circuit and said filament of such value that the fluctuating current from said source flowing there-through develops on said grid an average value of negative potential required for operating said tube in a predetermined manner, and a connection between said filament and output circuit including in series a condenser and a resistance having a value of the order of the value of said resistance between input circuit and filament multiplied by the amplification factor of said tube.

7. In a system including a three electrode vacuum tube having input and output electrodes and circuits and a filament, a source of current having a fluctuating component for energizing said input and output electrodes negatively and positively respectively connected thereto through said circuits, a resistance connected between said input circuit and filament, and a connection between said filament and said output circuit including a resistance and a condenser in series, the reactance of said condenser in ohms to the fluctuating component of said current being less than the resistance in ohms of said series resistance.

8. In a system including a three electrode vacuum tube amplifier having input and output electrodes and a filament, high frequency input and output circuits connected to said electrodes, a source of low frequency fluctuating current for energizing said input and output electrodes negatively and positively respectively through said circuits whereby said tube acts as an amplifier of high frequency currents, a resistance connected between a point in said input circuit and said filament, a resistance and condenser in a series connection between said filament and a point in said output circuit, and low capacity high frequency by-pass condensers in shunt to said resistances.

9. In a system including a plurality of three electrode vacuum tubes of like characteristics having grid, filament and plate electrodes, and connected in cascade for amplified repeating, a single source of current having a fluctuating component for energizing the grid and plate electrodes of said tubes negatively and positively respectively for operation as amplifiers, means for connecting all of said grid electrodes in parallel to the negative terminal of said source, means for connecting all of said plate electrodes in parallel to the positive terminal of said source, a connection common to the filaments of all of said tubes, a resistance connected between said common filament connection and the negative terminal of said source, and a resistance and condenser connected in series between said common filament connection and the positive terminal of said source.

10. In a system including a plurality of three electrode vacuum tubes of like characteristics having grid, filament and plate electrodes, and connected in cascade for amplified repeating, a single source of current having a fluctuating component for energizing the grid and plate electrodes of all of said tubes negatively and positively respectively for operation as amplifiers, means common to all of said tubes for deriving from said source a negative potential for all of said grid electrodes, and means including a reactive-resistive element for passing fluctuating current components only common

to all of said tubes controlling the neutralizing of the fluctuating energy component of said source as between said grid and plate electrodes in each of said tubes.

11. In a system including a plurality of three electrode vacuum tubes for performing different functions or the same functions in different degrees, and having grid, filament and plate electrodes, a single source of current having a fluctuating component for energizing the grid and plate electrodes of said tubes negatively and positively respectively for operation in their respective functions, a plurality of means for deriving from said source a plurality of negative potentials for the grid electrodes of said tubes, and a plurality of means including reactive-resistive elements for the passage of fluctuating current components only associated with several of said tubes for controlling the neutralizing of the fluctuating energy components of said source as between the grid and plate electrodes of said plurality of tubes.

12. In a system including a plurality of three electrode vacuum tubes having grid, filament and plate electrodes, said grid and plate electrodes requiring different degrees of energizing potential in different tubes for operating the system as a whole in a desired manner, a single source of current having a fluctuating component for energizing the grid and plate electrodes of all of said tubes, means for dividing the potential of said source as many times as there are tubes to be differently energized, a plurality of means for deriving from said source different negative potentials for said grid electrodes, a plurality of connections for applying the positive divided potentials of said source to different ones of said plate electrodes, and a plurality of means for controlling the neutralizing of the fluctuating energy components of said source as between the grid and plate electrodes of the several differently energized tubes.

13. In a system including a plurality of three electrode vacuum tubes having grid, filament and plate electrodes, said tubes being connected in cascade, the combination of a single source of current having a fluctuating component for energizing the grid and plate electrodes of all of said tubes, means for deriving from said source negative potentials for said grid electrodes, means for deriving from said source positive potentials for said plate electrodes, and means associated with one of said tubes and its circuits for neutralizing the fluctuating components of said energizing source together with the fluctuating components introduced into said tube and circuits from other tubes and circuits of said cascade arrangement.

14. In a system including a plurality of three electrode vacuum tubes having grid filament and plate electrodes, said tubes be-

ing connected in cascade for stage-to-stage operation, a single source of current having a fluctuating component for energizing the grid and plate electrodes of all of said tubes, means associated with the last tube and circuits of the series for controllably producing hum currents therein, and connections between said last tube and the preceding tubes for transferring from the preceding tubes hum currents to the last tube, whereby the combined residual hum in the last tube of the system is controllably neutralized.

15. In a system including a plurality of three electrode vacuum tubes, having grid, filament and plate electrodes, said tubes being connected in cascade with circuits to successively amplify high frequency modulated currents, detect the modulations in said current, and amplify the resulting low frequency currents, a single source of current having a fluctuating component for energizing the grid and plate electrodes of all of said tubes, a plurality of means for deriving from said source different negative potentials for the grid electrodes of said tubes so functioning that different potentials are required, and means associated with the last tube of the series for controlling the hum currents arising therein from said energizing source and transferred thereto from preceding tubes energized from the same source.

16. The method of energizing the grid and plates electrodes of a three electrode vacuum tube for operation from a source of current having a fluctuating component which consists of so distributing the energizing current that the ratio of the average value to the fluctuating component of the derived grid potential is different from the ratio of the average value to the fluctuating component of the derived plate potential.

17. The method of energizing the grid and plate electrodes of a three electrode vacuum tube for operation from a source of current having a fluctuating component which consists of so distributing the energizing current that the ratio of the average value to the fluctuating component of the derived grid potential is less than the ratio of the average value to the fluctuating component of the derived plate potential.

18. In a system including a three electrode vacuum tube, the method of energizing the grid and the plate electrodes thereof for operation from a source of current having a fluctuating component and neutralizing fluctuating effects which includes developing the required grid potential from said source, dividing said current into a plurality of parts with the fluctuating components thereof in aiding phase and one of them flowing through said tube, and opposing the fluctuating component of said part flowing through said tube by the action of the fluctuating component

of said grid potential through the amplifying action of said tube.

19. In an amplifier system, the combination of a thermionic tube having a grid, filament and plate, a source of unidirectional current of fluctuating voltage, the high potential terminal of said source being connected to said plate, a resistance connected between the low potential terminal of said source and said filament, the grid-filament circuit of said tube including a portion of said resistance whereby a biasing potential of a value dependent upon the space current of said tube is impressed upon said grid, and means for impressing through a resistively influenced reactance a desired fluctuating voltage from said source across said resistance while maintaining the current flow through said resistance substantially equal to the space current of said tube.

20. In an amplifier system, the combination of a thermionic tube having a grid, filament and plate, a source of unidirectional current of fluctuating voltage, the high potential terminal of said source being connected to said plate, a resistance connected between the low potential terminal of said source and said filament, the grid-filament circuit of said tube including a portion of said resistance whereby a biasing potential of a value dependent upon the space current of said tube is impressed upon said grid, and means for impressing a desired amount of fluctuating voltage from said source across said resistance while maintaining the current flow through said resistance substantially equal to the space current of said tube, said means consisting of a condenser and a second resistance series related and connected between the high potential terminal of said source and the filament of said tube.

21. In an amplifier system, the combination of a thermionic tube having a grid, filament and plate, a source of unidirectional current of fluctuating voltage, the high potential terminal of said source being connected to said plate, a resistance connected between the low potential terminal of said source and said filament, the grid-filament circuit of said tube including a portion of said resistance whereby a biasing potential of a value dependent upon the space current of said tube is impressed upon said grid, and means for impressing a desired amount of fluctuating voltage from said source across said resistance while maintaining the current flow through said resistance substantially equal to the space current of said tube, said means consisting of a condenser and a second resistance series related and connected between the high potential terminal of said source and the filament of said tube, the reactance of said condenser to the current flowing therethrough being substantially less than the ohmic resistance of said second resistance.

22. In an amplifier system, the combina-

tion of a thermionic tube having a grid, filament and plate, a source of unidirectional current of fluctuating voltage, the high potential terminal of said source being connected to said plate, a resistance connected between the low potential terminal of said source and said filament, the grid-filament circuit of said tube including a portion of said resistance whereby a biasing potential of a value dependent upon the space current of said tube is impressed upon said grid, and means for impressing a desired amount of fluctuating voltage from said source across said resistance while maintaining the current flow through said resistance substantially equal to the space current of said tube, said means consisting of a condenser and a second resistance series related and connected between the high potential terminal of said source and the filament of said tube, said second resistance having a value of substantially the amplification constant of said tube times the first mentioned resistance.

23. In an amplifier system, the combination of a thermionic tube having a grid, filament and plate, a source of fluctuating voltage, the high potential terminal of said source being connected to said plate, a resistance connected between the low potential terminal of said source and said filament, input and output devices for radio frequency signal current, the grid-filament circuit of said tube including said input device and a portion of said resistance whereby a biasing potential of a value dependent upon the space current of said tube is impressed upon said grid, means for impressing through a resistively influenced reactance a desired fluctuating voltage from said source across said resistance while maintaining the current flow through said resistance substantially equal to the space current of said tube, and means for by-passing radio-frequency currents around said resistance and said last mentioned means without effecting the value of the fluctuating current flowing therein.

24. In an amplifier system, the combination of a thermionic tube having a grid, filament and plate, a source of fluctuating voltage, the high potential terminal of said source being connected to said plate, a resistance connected between the low potential terminal of said source and said filament, input and output devices for radio frequency signal current, the grid-filament circuit of said tube including said input device and a portion of said resistance whereby a biasing potential of a value dependent upon the space current of said tube is impressed upon said grid, means for impressing a desired amount of fluctuating voltage from said source across said resistance while maintaining the current flow through said resistance substantially equal to the space current of said tube, said means consisting of a condenser and a second re-

sistance series related and connected between the high potential terminal of said source and the filament of said tube and condensers shunting said first named resistance and said series related condenser and second resistance.

In testimony whereof I hereunto affix my signature.

BENJAMIN F. MIESSNER.