Dec. 23, 1941. F. E. SUMMERS 2,267,053

AMPLIFIER

Filed Jan. 27, 1930

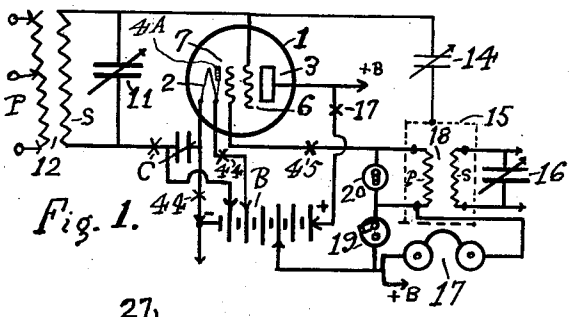

Fig. 1.

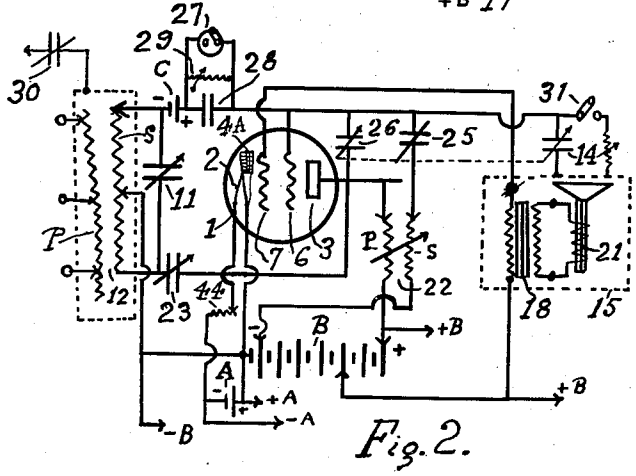

Fig. 2.

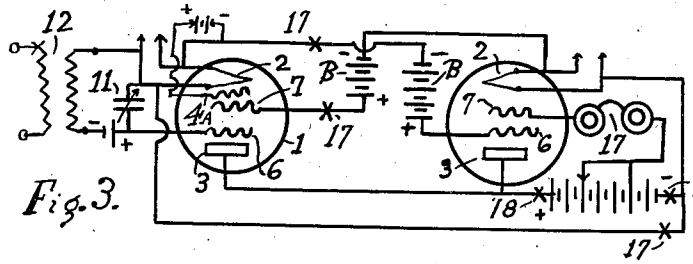

Fig. 3.

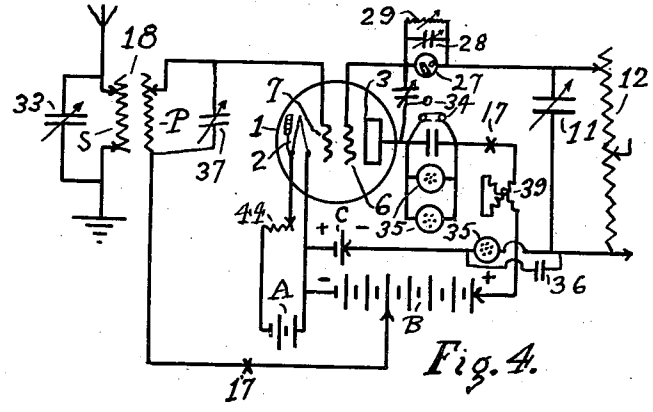

Fig. 4.

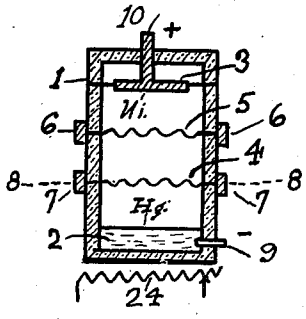

Fig. 5.

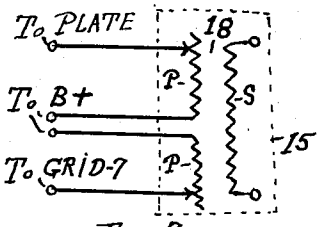

Fig. 7.

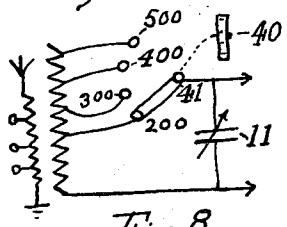

Fig. 8.

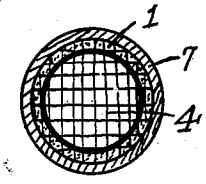

Fig. 6.

Frank E. Summers.

Inventor

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UNITED STATES PATENT OFFICE

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AMPLIFIER

Frank E. Summers, Sedgwick, Kans., assignor to Radio Corporation of America, New York, N. Y., a corporation of Delaware

Application January 27, 1930, Serial No. 423,737

37 Claims. (Cl. 179—171)

My invention relates to improvements in radio and wire communication and is readily adapted to either transmitting or receiving apparatus.

The primary object is to increase the amplifying factor of an electron tube.

Another object is to use the inner grid electrode of electron tubes as the output electrode. Whereas, in conventional circuits now in use the anode or plate electrode of electron tubes is used as the output electrode and the inner grid electrode as the control electrode, it is one object of my invention to use said electrodes virtually for opposite purposes. When I used the inner grid electrode in the output circuit and the plate or outer grid electrode as the control element, far greater efficiency was obtained. Furthermore this new arrangement of circuits makes possible many functions and results heretofore unobtainable.

Another object is to provide means whereby the inner grid is directly connected to the cathode.

Another object is to provide means whereby the outer grid electrode is connected direct to said cathode.

Another object is to provide means whereby the middle grid is directly connected to said cathode.

Another object is to provide means whereby a grid electrode is connected direct to said cathode for greatly increasing the internal capacity of vacuum tubes. This is especially desirable for short waves, for amplification, and for improving the tonal qualities of speech and music.

Another object is to provide means whereby all electrodes of an electron tube, except the cathode electrode, have and operate with a positive charge or bias.

Another object is to provide means to increase greatly the efficiency of electron tubes by connecting the inner grid directly to the cathode electrode, or the cathode to one of the grid electrodes.

With these and other objects of my invention in view which will appear as the disclosure of this specification proceeds, with and in reference to the accompanying drawing, my invention resides in the novel construction, proportion and relative arrangement of apparatus and circuits as claimed.

In the accompanying drawing, Figure 1 shows a simple one tube set using my invention, which may be used as a detector stage or as a stage of radio frequency amplification.

Figure 2 shows my invention in use in a regenerative detector stage or a stage of radio frequency amplification, and positive means to control the degree of regeneration.

Figure 3 shows a plurality of direct coupled electron tubes using my invention.

Figure 4 shows one method of how the inner grid electrode can be used as the output electrode or circuit in a radio transmitter.

Figure 5 shows a novel mercury cathode tube which can be used in lieu of the filamentary cathode electrodes shown in the preceding figures.

Figure 6 shows a cross section of said mercury cathode tube at the dotted line 8.

Figure 7 shows how I have used the inner grid electrode and the plate electrode both as output electrodes or circuits.

Figure 8 shows a novel way in which I have increased the efficiency of radio sets for constant amplification over all the regular broadcast band, by using a dial control, to operate the secondary inductance in steps of 100 meters.

This invention was largely disclosed in my prior applications Serial No. 608,999 filed Dec. 26, 1922; Serial No. 672,130 filed Nov. 1, 1923, and Serial No. 156,890, filed Dec. 24, 1926. Also this invention is a continuation-in-part of applications Serial No. 684,545 filed Jan. 5, 1924 and Serial No. 352,668 filed Apr. 5, 1929.

Referring to the drawing, Figure 1 discloses my invention for use as an electron tube detector or radio-frequency amplification stage. The transformer 12 which may be connected to an aerial or to the output circuit of a preceding vacuum tube stage has a primary winding P and a secondary winding S. The secondary winding is shunted by condenser 11 which is variable. The input circuit includes the outer grid electrode of tube 1, the cathode 2 and grid 4A and the said secondary winding. The control grid 6 return may be biased for the purpose intended. The plate 3 and cathode 2 circuit acts somewhat as a trigger when connected to the positive side of the B battery. The output circuit of my invention includes the inner grid electrode 7, the primary winding of transformer 18 or the telephone receiver 17, the portion of B battery and cathode 2 and grid 4A. Connecting the cathode directly to one of the grid electrodes increases the internal capacity and conductivity of electron tubes, and hence the amplification and efficiency. In one modification of this invention, I have used 180 volts of B battery on the plate 3 and 90 volts on inner grid 7. In another modification I used 135 volts on plate electrode 3, and 67.5 volts on the inner grid 7 when operating as a detector or an amplifier of radio-frequencies.

In using this modification as a radio detector with telephone receivers, a transformer 18 should be used having a primary to virtually equal the resistance of the tube between the inner grid and cathode electrodes, and a secondary winding of about 2,000 ohms. The telephone receiver 17 is shown connected serially with said secondary winding. If desired a loudspeaker may be used in lieu of the telephone receiver. It will be noted in Figure 1 that all contacts on the B battery source are variable, including the left leg of the cathode contact, making it possible to provide any positive, or positive to negative voltage relation for the electrodes of said tube.

This invention provides means whereby there is a more uniform amplification of wave lengths from 200 to 550 meters. One reason for this is that the outer grid is used as a control electrode which is arranged between the inner grid electrode and the plate electrode. Since the latter two electrodes have far more internal capacity than the inner grid electrode and the filamentary electrode, amplification is more constant and uniform over a wider wave band, and also the ratio of amplification of a given signal is increased. For a further disclosure of this principle see my application filed April 5, 1929 Serial No. 352,668. By connecting the inner grid, or one of the grids directly to the cathode electrode, the internal capacity is greatly increased which likewise increases amplification. Also in increasing the internal capacity of electron tubes the tuning is broader which is very desirable in tuning short waves.

The switch 20 short-circuits the primary winding of transformer 18, so that telephone receivers may be used. The switch 19 short-circuits the telephone receivers so that the primary winding of transformer 18 may be used.

It is obvious that any of the grid electrodes may be connected to the cathode, to shunt some of the undesirable energy around the electron flow, and for increasing internal capacity. Also it is to be understood that the outer grid in some modifications is connected direct to the cathode, the middle grid being the output circuit, and the inner grid being the input circuit. These connections are manifestly alternate connections of my inventions.

The transformer 18 may be wound for audio-frequencies and preferably with an iron or nickel alloy core. The secondary is connected direct to telephone receivers as above stated or said secondary winding may be connected to a succeeding electron tube.

In using the transformer 18 to connect a plurality of electron tubes in cascade for radio-frequency amplification I have used many different windings from one turn up to several hundred in the primary winding. For instance in one modification I used the same number of turns in the primary winding as there were in the secondary winding which were about 45 on an insulating tube of 3 inches in diameter. As near as I could tell this primary winding had a natural wave length of 190 to 200 meters, depending on the amount of space allowed between windings. I wound this right on and over the secondary winding. See my application Serial No. 87,599 filed Feb. 11, 1926. I also used in this manner a primary winding having a natural wave length of 300, 400, 500, 600 and more meters, as the inherent capacity of the electron tube electrodes used tunes the primary winding to a fixed wave length. In using the longer wave lengths of primary windings and conventional condensers shunting the secondary windings to tune from 200 to 550 meters, virtually the same or far more constant amplification was obtained on the short and long wave lengths. This is because the primary winding becomes resonant, or near resonant, on the longer wave lengths, thus to a certain extent compensating for the loss of conventional .00035 mmfd. condensers when tuned to 550 meters or less.

As one means to aid in controlling regeneration and neutralizing cascade radio-frequency amplification I show a radio or audio frequency metallic shield 15, connected direct to the control grid 6, by the variable condenser 14, which is preferably of relatively small capacity. In lieu of this condenser in many modifications I have obtained better results with a variable resistance as shown in Fig. 2. This resistance is preferably several thousand ohms, and non-inductive. This provides means whereby I have obtained far more constant and uniform amplification over the broadcast band of frequencies.

The modification shown in Figure 2 is also a detector or radio-frequency stage, similar to Figure 1, only more controls are used to neutralize or control regeneration. I show added here certain means that I have used with good results, such as enclosing the audio-frequency transformer 18 and loudspeaker 21, all in a metallic shield 15. I use shield 15 in the form of a metallic screen copper wire at the part opposite to the cone or horn to let out the sound and at the same time to effectually shield same.

I might also add that I have used this shield connected in the same manner to one side of the A battery, with very good results in certain instances.

The transformer 22 connected in the plate and outer grid circuits, consists of two windings, one acting as a primary winding and the other a secondary winding. Both of these windings preferably have the same number of turns of wire and of the same diameter. I have used this transformer with each winding wound to 175, 200, 300, 400, 500, 570 and more meters. These windings are wound in opposite directions or with connections made so that if the windings are wound in the same direction, the effect obtained will be the same. The coupling of this transformer is variable, and its function is to impart an opposed potential so as to decrease natural reaction, whereby the cathode may be used at a much higher temperature before natural reaction sets in. The degree of opposing this retroaction is obtained by the variable condenser 25 and the coupling of transformer 22.

The degree of regeneration is controlled by variable condensers 23, 26 and 14, these condensers being preferably of small capacity.

The switch 31 cuts in or out the condenser 14 or the variable resistance.

Figure 3 shows a circuit arrangement wherein a plurality of electron tubes are directly coupled together without using intermediate transformers. It will be noted here that the cathode and anode electrode of each tube is connected in parallel, while the input circuit 11 is connected to grid 6 of the first tube. It will also be noted that the cathode 2 and inner grid electrode 7 of the first tube and the cathode 2 and outer grid electrode 6 of the second tube are serially connected. The telephone receivers 17 are connected serially in the output circuit which comprises the cathode and inner grid electrode of

the second tube. These tubes all have a positive potential for their electrodes, except of course the cathode electrodes. I have obtained good results with this device as a repeater or amplifier of radio frequencies, and also as a repeater and amplifier of audio frequencies, and to those versed in the art it is clear that it can be used in radio and wire circuits for transmitting or receiving, or both.

I have shown in Figure 4 circuit means to generate a relatively high amperage of relatively low voltage, which I have found causes a different mode of operation in travelling through the natural or artificial media, especially in the very short waves. In transmitting below 80 meters the skip distance from a vertical antenna increases with the frequency, and I also have found it to increase with the voltage used in transmission. Therefore reducing the voltage used even though a higher frequency is used than 80 meters, also reduces the skip distance. I have found that the laws of conduction through the natural media are different. Therefore means that will send out relatively heavy currents of a low voltage is greatly desired. In this device shown in this Figure 4 I have provided one way that this is accomplished. The plate 3 has a relatively high plate potential from battery B, and the outer grid electrode 6 may have either a positive or negative bias, each producing a different mode of operation. The grid 6 circuit is tuned by the transformer 12 and condenser 11, while the plate circuit is tuned by the variometer 39. When the plate circuit and the input circuit (the latter including the grid 6) are in resonance and the filament is operating at the required temperature, oscillations set in. This in turn causes like pulsations of radio frequencies in the output circuit which includes the cathode, inner grid electrode 7, and primary winding P of R. F. transformer 18. Sustained oscillations are then induced in the secondary winding S of the transformer, which is connected to the aerial and ground, and then radiated through the air. The voltage induced in the secondary winding 18 is controlled by the return wire from the inner grid electrode 7 by variable contact with the B battery. I have used and generated in this manner high frequency oscillations having a potential of only one volt. The conduction of low voltage and high frequency currents through the natural or artificial media are surprising. I have also modulated these oscillations by microphones 35 either in the plate circuit or in the control or outer grid circuit. Of course this device may be modified to use crystal control for constant oscillation. It will be noted that I have provided a self contained means for radio transmission, and provided radio waves that have a different mode of conduction through the natural or artificial media. Also there has been provided radio waves which have a great application in the medical sciences as well as other branches of science, especially chemistry.

The device I have shown in Figure 5 provides a hot mercury or mercury alloy or amalgam electrode as a cathode, and nickel as an anode electrode, and with nickel grid electrodes disposed in between. When experimenting with tubes of this class several years ago, using a Delco light plant as the source of potential, I discovered that in heavy vapor discharge tubes the glass conducted a lot of current, especially near the center of same, and grids fused through the glass wall I increased the efficiency of control of vapor tubes. I used this mercury with iron and cerium. Also I have discovered at about this time that an alloy of Ni, Fe and Ce makes a material that can be used as very efficient cathodes in vacuum tubes. I used a relatively small percent of Ce, probably less than 3%. However the proportion of these elements did not seem to be critical for the purpose of electron emission. I used mercury amalgams because of the fluid nature of mercury. I was experimenting to develop a tube that could be used with Delco light systems. This I succeeded in doing, since it would take quite a temperature before the liquid state was reached. In some modifications the heat I used in heater 24 would not cause the cathode to reach a liquid state.

Figure 6 shows a cross section of the electron tube disclosed in Figure 5 at the dotted line marked 8—8. This is largely self explanatory, and shows the grid 4 extending through the glass wall to the metal ring or electrode 7.

Figure 7 shows means whereby the altered energy in the input inner grid circuit and the plate circuit may be used in unison, or opposed windings may be used to control or decrease natural reaction.

Figure 8 discloses a secondary winding wound to 500 meters and taps 100 meters apart, so that natural radio-frequency loss is greatly decreased. The dial 40 being connected to switch taps 200, 300, 400 and 500 meters, respectively. This is better disclosed in my copending application Serial No. 409,847, filed in November, 1929.

It is to be understood that as many stages of radio-frequency amplification may be used as desired. Also it is to be understood that as many detector stages may be used as desired, connected either direct or in cascade.

It is to be understood that the outer grid in some modifications may be connected to the cathode direct, the input circuit then being connected to the inner grid. Also in some of my inventions the middle grid is preferably connected to the cathode direct.

I have discovered that the efficiency of cascade radio-frequency amplification is increased when relatively low voltage is used in the primary windings of cascade transformers. Also I have discovered that regeneration, neutralization or retroaction is more easily controlled. I prefer to use primary windings that have as many, or more, turns of wire than the secondary windings; this also reduces the voltage or potential induced in the secondary windings. It is obvious that I have provided means to use a potential of a very few volts in the output circuits.

It is to be understood that tubes using 4, 5 or more electrodes may be used with my invention. Also my electron tube disclosed in Serial No. 352,668, filed April 5, 1929, I have used in this invention, which in effect is a four element device. In open air modifications of this tube I used the capacitive plate or element 4A as the inner grid electrode, and the element 3 as the outer grid electrode. I have also used this extra element 4A, in four element double screen grid modifications, the element 4A shielding the cathode and increasing the internal capacity of electron tubes, thus greatly decreasing the plate to cathode impedance of conventional 3, 4, 5 or more electrode tubes.

In the claims not specific to four electrodes, the outer grid is the middle grid electrode in five element tubes. I am herein claiming Fig. 1.

What I claim as new and desire to secure by

Letters Patent of the United States of America in this application, is:

1. An amplifier comprising an electron tube having a cathode electrode and an anode electrode and inner and outer grid electrodes disposed between said cathode electrode and said anode electrode, an input circuit including said cathode electrode and said outer grid electrode, an output circuit including said cathode electrode and said inner grid electrode, and means to impress a positive potential upon each of said inner and outer grid electrode and said anode electrode.

2. An amplifier comprising an electron tube having a cathode electrode and an anode electrode, and inner and outer grid electrodes disposed between said electrodes, a transformer having primary and secondary windings, a metallic shield for said transformer, an input circuit including said cathode electrode and said outer grid electrode, an output circuit including said cathode electrode, said inner grid electrode and the primary winding of said transformer, and means to electrically connect said metallic shield to said outer grid electrode.

3. An amplifier comprising an electron tube having a cathode electrode and an anode electrode, and inner and outer grid electrodes disposed between said electrodes, a transformer having primary and secondary windings, a metallic shield for said transformer, an input circuit including said cathode electrode and said outer grid electrode, an output circuit including said cathode electrode, said inner grid electrode and the primary winding of said transformer, and condenser means to electrically connect said metallic shield to said outer grid electrode.

4. An amplifier comprising an electron tube having a cathode electrode and an anode electrode, and inner and outer grid electrodes disposed between said electrodes, a transformer having primary and secondary windings, a metallic shield for said transformer, an input circuit including said cathode electrode and said outer grid electrode, an output circuit including said cathode electrode, said inner grid electrode and the primary winding of said transformer, and variable condenser means to electrically connect said metallic shield to said outer grid electrode.

5. A stage of radio-frequency amplification comprising an electron tube having input and output circuits, a transformer, a conducting shield for said transformer, means to connect electrically said transformer to said output circuit, and means to electrically connect said conducting shield for said transformer to said input circuit, and a source of electrical energy connected serially in said output circuit.

6. A stage of radio-frequency amplification comprising an electron tube having a cathode electrode and an anode electrode, and inner and outer grid electrodes disposed between said electrodes, a radio-frequency transformer having primary and secondary windings, a metallic shield disposed around said transformer, an input circuit including said cathode electrode and said outer grid electrode, an output circuit including said cathode electrode and said inner grid electrode and the primary winding of said transformer, and means to electrically connect said metallic shield to said outer grid electrode, and means to impress a relative high positive electrical potential upon said anode electrode and means to impress a relatively low positive electrical potential upon said inner grid electrode.

7. An amplifier comprising an electron tube having a cathode electrode, an anode electrode and a plurality of grid electrodes, an input circuit including said cathode electrode and one of said grid electrodes, an output circuit including said cathode electrode and one of said grid electrodes, and means to impress a positive potential upon each of said grid and anode electrodes.

8. An amplifier comprising an electron tube having a cathode electrode, an anode electrode and two grid electrodes, an input circuit including said cathode electrode and one of said grid electrodes, an output circuit including said cathode electrode and the other said grid electrode, and means to impress a positive potential upon said anode electrode and each of said grid electrodes.

9. A stage of radio frequency amplification comprising an electron tube having input and output circuits, a transformer, a conducting shield for said transformer, means to electrically connect said transformer to said output circuit, means to electrically connect said conducting shield for said transformer by a condenser to the input electrode of said input circuit and by a condenser to the cathode electrode of said input circuit.

10. An amplifier comprising an electron tube having input and output circuits, a transformer, a conducting shield for said transformer, means to electrically connect said transformer to said output circuit, means to electrically connect said conducting shield for said transformer by a variable condenser to the input electrode of said input circuit and by a variable condenser to the cathode electrode of said input circuit.

11. An amplifier comprising an electron tube having a cathode electrode, an anode electrode and inner and outer grid electrodes disposed between said cathode and anode electrodes, a radio-frequency transformer having primary and secondary windings, a metallic shield disposed around said transformer, an input circuit including said cathode electrode and said outer grid electrode, an output circuit including said cathode electrode and said inner grid electrode and the primary winding of said transformer, and means to electrically connect said metallic shield by capacity to said outer grid electrode and to said cathode electrode.

12. An electric system comprising an electron tube having a cathode electrode, a control electrode, and a grid electrode disposed between said electrodes, an input circuit including said cathode electrode and said control electrode, and an output circuit including said cathode electrode, a telephone receiver and said grid electrode, and means to impress a continuous positive potential upon said grid electrode and said anode electrode and said control electrode.

13. An electric system comprising an electron tube having a cathode electrode, a control electrode, and a grid electrode disposed between said electrodes, an input circuit including said cathode electrode and said control electrode, and an output circuit including said cathode electrode and said grid electrode, and means to impress a positive electrical potential upon said control electrode and a greater positive potential upon said grid electrode.

14. An amplifier comprising an electron tube having a cathode electrode, an anode electrode, and inner and outer grid electrodes disposed between said cathode electrode and said anode electrode, a transformer having a primary winding and a secondary winding, a conducting shield for

said transformer, an input circuit including said cathode electrode and said outer grid electrode, an output circuit including said cathode electrode and said inner grid electrode and the primary winding of said transformer, and means to electrically connect said conducting shield by variable capacity to said outer grid electrode and by capacity to said inner grid electrode.

15. An amplifier comprising an electron tube having a cathode electrode, an anode electrode, and inner and outer grid electrodes disposed between said cathode electrode and said anode electrode, a transformer having primary and secondary windings, a conducting shield for said transformer, an input circuit including said cathode electrode and one of said grid electrodes, an output circuit including said cathode electrode, the remaining grid electrode, and the primary winding of said transformer, and means to electrically connect said conducting shield by variable capacity to two of said electrodes working 180 degrees out of phase.

16. An electric system comprising an electron tube having a cathode electrode, a control electrode and a grid electrode disposed between said electrodes, an input circuit including said cathode electrode and said control electrode, an output circuit including said cathode electrode and said grid electrode, a second grid electrode disposed between said cathode electrode and said grid electrode, and said second grid electrode connected direct to said cathode electrode, and means to impress a positive electrical potential upon said first mentioned grid electrode.

17. An electric system comprising an electron tube having a cathode electrode, a control electrode, and a grid electrode disposed between said electrodes, an input circuit including said cathode electrode and said control electrode, an output circuit including said cathode electrode and said grid electrode, a second grid electrode disposed between said cathode electrode and said grid electrode, and said second grid electrode connected direct to said cathode electrode, and means to impress a positive electrical potential upon said first mentioned grid electrode, and an electrical positive potential upon said control electrode.

18. A stage of radio frequency amplification comprising a four electrode tube having a cathode electrode, an anode electrode and two grid electrodes disposed in succession between said cathode and anode electrodes, a radio frequency transformer having primary and secondary windings, the primary winding of said radio-frequency transformer having a natural fixed wave length of substantially two hundred meters, an output circuit including said cathode electrode said inner grid electrode and the primary winding of said radio-frequency transformer, an input circuit including said cathode and the said remaining grid electrode, an anode circuit including said cathode, said anode electrode and a radio-frequency winding having a natural fixed wave length of substantially four-hundred meters, and means to impress electrical potentials upon said anode and grid electrodes.

19. A stage of radio frequency amplification comprising a four electrode tube having a cathode electrode, an anode electrode and two grid electrodes disposed between said cathode and said anode electrodes, a radio-frequency transformer having primary and secondary windings, the primary winding of said radio-frequency transformer having a natural fixed wave length of substantially two-hundred meters, an input circuit including said cathode electrode and one of said grid electrodes and the primary winding of said radio frequency transformer, an input circuit including the remaining said grid electrode, an anode circuit including said cathode, said anode electrode and a radio frequency winding having a natural fixed wave length of substantially four-hundred meters, and means to impress electrical potentials upon said anode and grid electrodes.

20. A stage of radio frequency amplification comprising a four electrode tube having a cathode electrode, an anode electrode and two grid electrodes disposed between said cathode and anode electrodes, a radio-frequency transformer having primary and secondary windings, the primary winding of said radio-frequency transformer having a natural fixed wave length of substantially between five hundred and fifty and two-hundred meters, an input circuit including said cathode electrode and one of said grid electrodes, an output circuit including said cathode electrode, the said remaining grid electrode, and the primary winding of said radio-frequency transformer, an anode circuit including said cathode, said anode electrode and a radio frequency winding having a natural fixed wave length of substantially between five hundred and fifty and two hundred meters, and means to impress electrical potentials upon said anode and grid electrodes, and said radio frequency windings having different fixed wave lengths.

21. In combination, an electron tube stage of radio-frequency amplification including a four electrode tube having a cathode electrode, an anode electrode, and two grid electrodes disposed in succession between said electrodes; a radio-frequency transformer having primary and secondary windings, the primary winding of said radio-frequency transformer having a natural fixed wave length of between 200 and 550 meters; an input circuit including said cathode electrode, and said outer grid electrode; an output circuit including said cathode electrode, said inner grid electrode and the primary winding of said radio-frequency transformer; an anode circuit including said cathode, said anode electrode, and a radio-frequency winding having a natural fixed wave length of between 200 and 550 meters, said natural fixed wave lengths being substantially different whereby efficient amplification is obtained over a broad band of wave lengths.

22. An amplifying system comprising in combination an electron tube having a cathode electrode, an anode electrode, and three grid electrodes disposed in succession between said cathode and anode electrodes; an input circuit having said outer grid, an inductance, and said cathode serially connected therein; an anode circuit having said anode, said cathode and a source of electrical energy connected serially therein, the positive side being connected to said anode; an output circuit having said cathode, said middle grid, a telephone receiver, and a source of electrical energy connected serially therein, the positive side being connected to the said middle grid; and a direct non-inductive connection between said cathode and the grid that is disposed nearest to said cathode.

23. A radio-frequency amplifying system comprising in combination an electron tube having a cathode electrode, an anode electrode, and three grid electrodes disposed in succession between said cathode and anode electrodes; a radio-frequency transformer having a primary winding

and a secondary winding; an input circuit having said outer grid, an inductance, and said cathode electrode serially connected therein; an anode circuit having said anode, said cathode, and a source of electrical energy connected serially therein, the positive side being connected to said anode electrode; an output circuit having said cathode, said middle grid electrode, the primary winding of said radio-frequency transformer, and a source of electrical energy connected serially therein, the positive side being connected to said middle grid electrode; and a direct non-inductive connection between said cathode and the grid that is disposed nearest to the said cathode electrode.

24. A radio-frequency amplifying system comprising in combination an electron tube having a cathode electrode, an anode electrode, and three grid electrodes disposed in succession between said cathode and anode electrodes; a radio-frequency transformer having a primary winding and a secondary winding; an input circuit having said outer grid, a grid leak resistance, a condenser shunting said grid leak resistance, an inductance, a tuning condenser shunting said inductance, and said cathode electrode serially connected therein; an anode circuit having said anode electrode, said cathode electrode, and a source of electrical energy connected serially therein, the positive side being connected to said anode electrode; an output circuit having said cathode, said middle grid, the primary winding of said radio-frequency transformer, and a source of electrical energy connected serially therein, the positive side being connected to said middle grid; the secondary winding of said radio-frequency transformer shunted by a tuning condenser; and the grid that is disposed nearest to said cathode electrode being connected direct to said cathode electrode.

25. An electric system comprising in combination an electron tube having a cathode electrode, an anode electrode, and two grid electrodes disposed in succession between said electrodes; a radio-frequency transformer having two primary windings and a secondary winding; a metallic shield for said transformer; an input circuit having said cathode electrode, said outer grid electrode, and a variable tuning inductance connected serially therein; a second circuit having said cathode, said inner grid electrode, one of the primary windings of said transformer, and a source of electrical energy connected therein, the positive side being connected to said inner grid electrode; and a third circuit having said cathode electrode, said anode electrode, the other primary winding of said transformer, and a source of electrical energy connected serially therein, the positive side being connected direct to said anode electrode; a tuning condenser shunting the secondary winding of said transformer; and said metallic shield connected directly to said outer grid electrode.

26. In combination, a stage of radio-frequency amplification including an electron tube having input and output electrodes; input and output circuits associated with said input and output electrodes; a radio-frequency transformer connected serially in said output circuit and a condenser like shield disposed in capacitive relation to said transformer; and said condenser like shield connected directly to said input electrode for the purpose of feeding radio-frequency current direct to said input electrode from said radio-frequency transformer.

27. In combination, a stage of radio-frequency amplification including an electron tube having input and output electrodes; input and output circuits associated with said input and output electrodes; a radio-frequency transformer connected serially in said output circuit and a condenser like shield disposed in capacitive relation to said transformer; and said shield connected by capacity directly to said input electrode, for the purpose of feeding radio-frequency currents direct to said input electrode from said radio-frequency transformer.

28. In combination a stage of radio-frequency detection including an electron tube having input and output electrodes; input and output circuits associated with said input and output circuits; an audio-frequency transformer connected serially in said output circuit and a condenser like shield disposed in capacitive relation but not touching said audio-frequency transformer; and means to connect said condenser like shield directly to the said input electrode for the purpose of feeding radio-frequency currents direct to said input electrode from said audio-frequency transformer.

29. A stage of amplification comprising in combination a five electrode tube having a cathode electrode, an anode electrode, and three grid electrodes disposed in succession between said electrodes; an input circuit having said cathode, an inductance, and said outer grid electrode serially connected therein; an output circuit having said cathode, said middle grid, a source of electrical energy, and a telephone receiver connected serially therein; an anode circuit having said anode electrode, and a source of electrical energy connected serially therein; and the grid that is disposed nearest to said cathode being connected directly to said cathode electrode.

30. A stage of radio-frequency amplification comprising in combination a five electrode tube having a cathode electrode, an anode electrode, and three grid electrodes disposed in succession between said electrodes; a middle grid circuit having said cathode, a source of electrical energy, said middle grid, and the primary winding of a radio-frequency transformer connected serially therein; an input circuit having an inductance tunable over a wide wave band, one of the remaining grid electrodes, and said cathode electrode connected serially therein; the remaining grid electrode being connected direct to said cathode electrode; and an anode circuit having said anode electrode, said cathode electrode and a source of electrical energy connected serially therein.

31. A stage of radio-frequency amplification comprising in combination a five electrode tube having a cathode electrode, an anode electrode, and three grid electrodes disposed in succession between said cathode electrode and said anode electrode; a radio-frequency transformer having a primary winding and a secondary winding; an input circuit having said cathode electrode, said outer grid electrode, and an inductance tunable over a wide wave band connected serially therein; a middle grid circuit having said cathode electrode, said middle grid electrode, the primary winding of said radio-frequency transformer, and a source of electrical energy connected serially therein; said secondary winding of said radio-frequency transformer being shunted by a tuning condenser; an anode circuit having said anode, said cathode, and a source of electrical energy connected serially therein; and said inner grid

electrode connected directly to said cathode electrode.

32. A stage of radio-frequency amplification comprising in combination a five electrode tube having a double terminal cathode, an anode electrode, and three grid electrodes disposed in succession between said electrodes; a radio-frequency transformer having a primary winding and a secondary winding; an input circuit having said cathode, said outer grid, and an inductance tunable over a wide wave band connected serially therein; a middle grid circuit having said cathode, said middle grid, the primary winding of said radio-frequency transformer, and a source of electrical energy connected serially therein; said secondary winding of said radio-frequency transformer being shunted by a tuning condenser; an anode circuit having said anode, said cathode, and a source of electrical energy connected serially therein; and said inner grid electrode connected direct to the negative side of said cathode.

33. The combination with an electron discharge device having an electron emitting cathode, an anode, and three grids interposed between cathode and anode, of an input circuit connected to the grid nearest the anode, an output circuit which includes a source of potential having its positive terminal connected to the anode through a load, an electrical connection from the cathode to the grid nearest said cathode, said connection including means for maintaining said grid positive with respect to said cathode, and a connection from a positive terminal of a second source of potential to the grid intermediate the first and second grids through a low impedance path.

34. An electron discharge amplifying device having an electron emitting cathode, an anode, and three grids interposed between said cathode and said anode, means for connecting both the anode and the intermediate grid to a source of positive potential at points having different potentials, a direct connection between the said cathode and the grid disposed nearest said cathode through a path of negligible impedance, and an input circuit connected in series with said cathode-grid and said outer grid.

35. A stage of radio-frequency amplification comprising in combination a five electrode tube having a cathode electrode, an anode electrode, and three grid electrodes disposed in succession between said cathode electrode and said anode electrode; of a radio-frequency transformer having a primary winding and a secondary winding; a middle grid circuit having said middle grid, said cathode and a source of positive potential connected serially therein; an input circuit having a radio-frequency winding, said cathode and one of said other grids connected serially therein; an output anode circuit having said anode, said cathode, said primary winding of said radio-frequency transformer, and said source of said potential connected serially therein, and said cathode electrode connected direct to the remaining grid electrode through a path of negligible impedance.

36. A stage of radio frequency amplification comprising in combination a five electrode tube having a cathode electrode, an anode electrode, and three grid electrodes disposed in succession between said cathode electrode and said anode electrode; of a radio-frequency transformer having primary and secondary windings; a middle grid circuit having said middle grid, said cathode and a source of positive potential connected serially therein; an input circuit having said outer grid, a radio-frequency winding, and said cathode connected serially therein; an output circuit having said anode, said primary winding of said radio-frequency transformer, and said source of positive potential connected serially therein; and said inner grid electrode connected direct to said cathode through a path of negligible impedance.

37. The combination with an electron discharge device having an electron emitting cathode, an anode, and three grids interposed between said cathode and said anode, of an input circuit connected to the grid nearest the anode, an output circuit which includes a source of potential having its positive terminal connected to the middle grid through an inductive load, a second ouput circuit which includes said source of potential having its positive terminal connected through an inductive load to said anode electrode, a direct electrical connection of said inner grid to said cathode electrode.

FRANK E. SUMMERS.