

Jan. 20, 1931.

S. Y. WHITE

1,789,664

ELECTRICAL AMPLIFIER SYSTEM

Filed Aug. 8, 1927

Fig. 1.

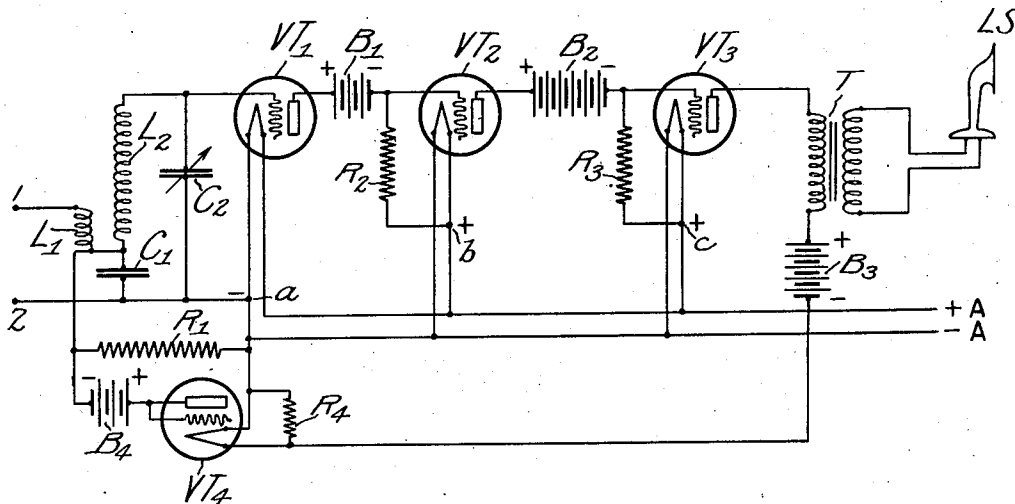
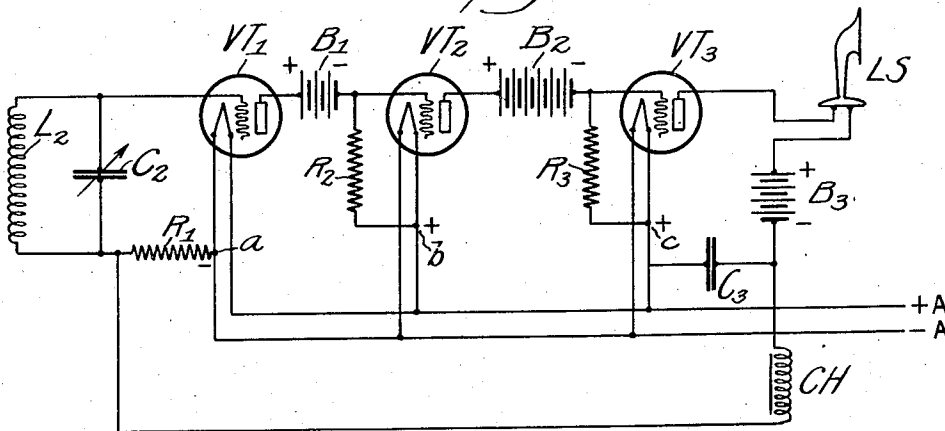


Fig. 2.



WITNESS

Oliver N. Holmes

INVENTOR
SIDNEY Y. WHITE
BY *G. A. Hapton*
ATTORNEY

UNITED STATES PATENT OFFICE

SIDNEY Y. WHITE, OF NEW YORK, N. Y., ASSIGNOR TO EDWARD H. LOFTIN, AS TRUSTEE

ELECTRICAL AMPLIFIER SYSTEM

Application filed August 8, 1927. Serial No. 211,292.

My invention relates generally to electrical amplifier systems, and has for a particular object the efficient amplification of electrical energy irrespective of its character of movement.

Another object is to provide an amplifying system substantially devoid of natural periodicities within the limits of the frequencies of alternating currents generally encountered in practice, including the very high frequencies of so-called "short wave" radio signaling, and thereby eliminate distortion due to circuit discrimination in favor of one frequency over other frequencies in broad band amplifying, as is required in line and radio telephony and like practices.

A further object is to provide a system that in large part requires no interchanging of apparatus in shifting its use as an amplifier from a range of frequencies of one order to a range of frequencies of entirely different order, and at the same time employing apparatus that is simple, inexpensive and permanent.

A particular object is the preservation of tonal quality in the amplification of sound conveying currents for sound reproduction now so extensively in use in numerous ways.

Numerous uses and advantages will be apparent from the description to follow in connection with the accompanying drawings.

Fig. 1 diagrammatically illustrates a complete amplifying system including connections rendering it suitable for use in connection with a radio broadcast receiver or like use. Fig. 2 illustrates the system in modified form as to one of the control elements. Like reference characters represent like elements in the two systems so far as possible.

The figures show three electrode vacuum tubes VT_1 , VT_2 and VT_3 connected in tandem, the filaments being heated from a common circuit energized in a well known manner from a source indicated as $+A$, $-A$.

Tubes VT_1 and VT_2 preferably have very high amplifying ability, but may be of low power with respect to tube VT_3 at the output end of the system. For example, I have had unusually good results in my system with tubes having an amplification constant in the

neighborhood of 30 in the positions of VT_1 and VT_2 , and so-called power tubes having amplification constants in the neighborhood of 3 to 8 in the position of VT_3 . On the other hand, with tubes having amplification constants in the neighborhood of 8 and below in the positions of VT_1 and VT_2 the results have been relatively less satisfactory.

Tube VT_3 is shown to have its plate circuit energized in a normal manner from a source B_2 indicated for convenience as a battery, and I preferably employ the normal rated plate potential of the particular type of tube at this point. Tubes VT_1 and VT_2 are shown to have the unusual arrangement of plates connected directly to grids of succeeding tubes through sources of potential, indicated for convenience as batteries, B_1 and B_2 respectively, the positive terminals of the batteries being connected plate-wise. High resistances R_2 and R_3 connect the negative terminals of these batteries to the positive side of the filament heating current system as indicated at the points b and c respectively.

The potentials of sources B_1 and B_2 , and the values of resistances R_2 and R_3 , are determined largely by the nature of the succeeding tube in the series and more particularly with respect to its grid bias or initial grid potential characteristic for normal operation. For example, with a tube requiring a normal grid bias of about -40 volts in position VT_3 I employ a potential at B_2 in the neighborhood of 67 volts and a resistance at R_3 in the neighborhood of 1-4 megohm, while with a tube requiring a grid bias of about -1 volt in position VT_2 I employ a potential B_1 of about 4 volts, and a resistance at R_2 in the neighborhood of 1 megohm. However, I can alter the values of these resistances over a wide range without correspondingly altering the potentials of the batteries, but find it desirable to maintain the ratio of the resistance values substantially constant in making such variations. In operation the current drawn from the sources B_2 and B_3 is so small that dry batteries can be used with an operating life substantially equal to shelf life.

It is well to note at this point that the high

amplification tubes I have mentioned as preferably employed in positions VT_1 and VT_2 do not begin to give any noticeable amplification when cascaded in the usual manner in well-known systems until the plate energizing potential reaches the neighborhood of 100 volts, and in fact are rated for normal operation at 180 plate volts; so that the very low potentials I use would render these tubes totally inoperative as amplifiers in such other systems. In fact, I have obtained very good results without the use of any source at B_1 , but relying entirely upon the potential derived from connecting resistance R_2 to the positive side of the filament system, as at point b .

For normal operation the filament-plate impedance of the high amplification tubes I use in positions VT_1 and VT_2 is extremely high; that is, of the order of several hundred thousand ohms. At the very small plate currents in my mode of operation this impedance increases to megohms.

Inspection of the figures shows as a matter of fact that not all of the abnormally low potentials of sources B_1 and B_2 is applied between the filament and plate electrodes of VT_1 and VT_2 respectively. Because of the presence of resistances R_2 and R_3 , which have values of the order of the filament-plate impedances of their respective tubes, the total applied potentials are divided about equally between the filament-plate impedances and the associated resistances; or in other words, the potentials on the plate of a preceding tube and grid of a succeeding tube are near equality and about one-half of the total applied potential. This accounts for the preceding mentioned requirement that the potential of B_2 greatly exceed the normal required grid bias potential of VT_3 .

The input circuit of tube VT_1 is shown to include a variable circuit L_2C_2 through which the tube can be selectively energized with currents to be amplified, the currents being derived as shown in Fig. 1, from any source through connections 1 and 2, and being transferred to the variable circuit through the combined electromagnetic-electrostatic coupling including the inductive relation between coils L_1 and L_2 and the capacitive relation through coupling condenser C_1 . The currents may for instance be those of radio signals, in which case the connection 1 may lead to the elevated portion of an antenna and the connection 2 to ground; or the connections may well be the output of an ordinary radio frequency amplifier whose input is connected to an antenna.

The grid of tube VT_1 is connected for an initial negative bias to point a on the negative side of the filament circuit. The functions of resistance R_1 , battery B_1 , and tube VT_1 in Fig. 1, and resistance R_1 , condenser

C_1 , and choke coil CH in Fig. 2 will be discussed later.

The output circuit of VT_1 is shown connected to a loud speaker or translating device LS through a transformer T in Fig. 1, the transformer being for the purpose of protecting the loud speaker winding from the direct current component in the plate circuit, though with a proper design of winding the loud speaker may be connected directly in the plate circuit as shown in Fig. 2.

The operation will be understood from the following discussion: In the usual form of connection for cascaded amplifiers a permanent change in grid bias or initial potential of the grid of the first tube will not affect the steady or permanent current flow in the plate circuit of the last tube, but merely change the steady or permanent current flow in the plate circuit of the tube whose grid bias is modified. In my system a permanent modification of the grid bias of tube VT_1 will carry through the system and permanently modify the plate current of tube VT_3 , which may be accounted for as follows: With the grid bias of tube VT_1 made so highly negative that no space current flows, with the result that the plate impedance is practically infinite, no current can flow from battery B_1 through resistance R_2 to alter the grid bias of tube VT_2 . The grid of tube VT_2 is positively biased through the connection of resistance R_2 to the positive side of the filament, as at point b , so that space current flows in tube VT_2 under the potential of battery B_2 . This current flows through resistance R_3 to create a negative difference of potential overcoming the positive bias on the grid of VT_3 , which bias is derived from the connection of resistance R_3 to the positive side of the filament, as at point c . This negative bias thus produced on the grid of tube VT_3 holds down the current flow in the plate circuit of this tube, and if the values of the resistances and the potentials of the batteries are properly chosen, current flow in the plate circuit of VT_3 can be substantially eliminated by reason of a bias on the grid of tube VT_1 .

By lessening the degree of negative bias of tube VT_1 , current is caused to flow in the plate circuit of tube VT_3 in accordance with the degree of lessening of the negative bias, and I have found that such a small change in this grid bias potential is necessary to change the current flow in the plate circuit of tube VT_3 from zero to 20 milliamperes that there results a power amplification in the system of extremely high order. It will be recognized that this is direct current amplification through the over-all system, for so long as the new bias on tube VT_1 is maintained the current in the plate circuit of VT_3 continues to flow.

It is apparent however that if the bias of tube VT_1 be set to maintain a given current flow in the plate circuit of VT_3 , then any alteration of this bias, no matter how slow or fast, will correspondingly amplifiedly alter the current flow in the plate circuit of VT_3 , so that the system, in addition to being an amplifier of direct current, is equally well an amplifier of alternating current or varying current of any character. Since the system is substantially devoid of inductance and capacity other than that of the distributed type contained in the necessary wiring and connections, which for practical purposes is negligible, it is to all intents and purposes an aperiodic system, even for the highest of frequencies in practical use.

In operating the system as an amplifier of alternating currents it is desirable to initially bias the grid of tube VT_1 to such degree that the plate current flow of tube VT_3 is maintained at about the middle of the plate current characteristic curve of the particular tube, this in order that alternating variations will occur on the substantially straight portion of the curve extending both ways from this middle point.

In operating the system as an amplifier in a radio receiver, as shown in Fig. 1, the high frequency modulated radio signals are selectively impressed upon tube VT_1 by means of tunable circuit L_2C_2 . It is well to bring out at this point that the system is an efficient rectifier in addition to its ability as an amplifier, with the result that a continuous wave, modulated or unmodulated, impressed upon tube VT_1 is rectified and has the effect of permanently altering the initial bias of VT_1 in proportion to the strength of the incoming continuous wave. In view of this fact it may be that if the system is so initially biased as to bring the plate current flow of tube VT_3 to the middle of the plate current characteristic, the additional bias due to an incoming continuous wave will change this point of operation to some removed point with respect to the middle of the characteristic curve, and it is quite likely to happen in the case of nearby powerful stations that this point is moved so far as to cause the alternating current variations to operate in the region of one or the other of the bends of the characteristic curve, which results in distortion in a well known manner.

In view of these conditions it is desirable to be able to alter the initial bias of tube VT_1 to permit of bringing the point of operation on the characteristic curve at about the middle for any intensity of incoming signal. It is a simple matter to provide the grid circuit of tube VT_1 with a battery and potentiometer to permit of adjusting the initial grid bias to a proper value for combination with the incoming continuous wave, and

gauge the result by means of a milliammeter inserted in the plate circuit of tube VT_3 . This of course would be a manual operation requiring readjustment by the operator for the different stations to which he might care to listen.

Since manual adjustments, particularly for unskilled operators, are undesirable, I have provided means for automatically overcoming this difficulty, shown in one form in Fig. 1 and in another form in Fig. 2. In Fig. 1, I provide a vacuum tube VT_4 having its filament in series with the plate circuit of tube VT_3 , and choose a vacuum tube VT_4 of such filament heating characteristics that the filament just commences to be sufficiently hot to emit electrons at about the plate current value of VT_3 which represents operation at the middle of the characteristic curve. However, by means of a resistance R_1 in shunt to the filament of tube VT_4 , I can adapt commercial tubes not having precisely the exact filament heating characteristics to satisfy the requirements for satisfactory performance.

In series with the plate and filament connection I place a source of potential B_1 and a resistance R_1 , and connect these elements as shown so that any change in current flow through the resistance R_1 , due to electron emission in tube VT_4 , altering the over-all resistance of the combination will result in changing the initial bias on tube VT_1 . Thus if the plate current of tube VT_3 tends to permanently increase for any reason the filament of tube VT_4 will heat up to emit electrons, thereby increasing the conductivity between filament and plate to permit more or less current to flow from battery B_1 through resistance R_1 , and thus increase the negative bias on tube VT_1 , which negative bias will immediately cause the plate current of VT_3 to subside, and in this way to remain at some predetermined fixed value irrespective of the strength of the incoming signal or other cause tending to increase the plate current.

It is to be noted that this arrangement will not prevent the plate current of tube VT_3 momentarily increasing to represent signal effects, because such signal effects take place at such high frequency that there is no possibility of the temperature of the filament of tube VT_4 responding. It does, however, most effectively prevent any effect tending to produce a permanent change in the plate current from accomplishing the undesired result.

I show tube VT_4 as a three electrode tube converted into a two electrode tube in effect by connecting the grid directly to the plate. It so happens that there is available a commercial type of three electrode tube having very nearly the desired filament heating characteristics to be operated in conjunction with

a commercially available type of power tube suitable for the position VT₁. In fact, the particular tube VT₁ should be operated with a plate current of approximately 20 milliamperes. The particular tube VT₁ requires a filament current of approximately 60 milliamperes for normal operation as an amplifier, but begins to emit electrons at about the 20 milliamperes mentioned.

The auxiliary device of Fig. 2 for maintaining constant operation comprises a resistance R₁ in the grid circuit of tube VT₂, so connected that the plate current of tube VT₂ must pass therethrough. The value of this resistance is so chosen that when the desired plate current of tube VT₂ is had the difference of potential across the resistance will be correct for combining with any other difference of potential to give the proper grid bias to tube VT₁. If the plate current of tube VT₂ tends to increase for any reason, the difference of potential across resistance R₁ will increase and thereby offset the effect. To prevent resistance R₁ from producing the same limiting effect on signal variations a by-pass condenser C₂ is connected between the filament and the plate circuit as shown, and a choke coil CH is inserted in series with the plate circuit, thus shunting signal variations from the resistance R₁.

The objection to this arrangement of Fig. 2 is that the use of condenser C₂ and choke coil CH introduces elements having frequency characteristics into the system, which procedure tends to destroy to some extent the aperiodic character of the system.

The amplified high frequency modulated currents arrive at audio frequency transformer T in Fig. 1 in rectified form, and this transformer acts to filter the low frequency modulations from the rectified high frequency current for delivery to the loud speaker LS. It is obvious that the transformer T and loud speaker LS have frequency characteristics and serve to lessen the aperiodic character of the system, but since these are the only elements in the system so acting the frequency discriminating characteristics are extremely small compared to existing systems employing a large number of such transformers. However, loud speakers are now available having such construction that it is not necessary to prevent the steady direct current of the plate circuit from flowing through the winding, so that it is possible to insert such loud speakers directly in the output circuit as shown in Fig. 2, and thus do away with another element tending to lessen the aperiodic character of the system.

In employing the system for amplifying high frequency modulated currents as described it is not necessary that the rectifying characteristic of the system be utilized for detecting the modulations. The transformer

T of Fig. 1 may be of high frequency character, tuned or not, to transfer high frequency currents to a succeeding rectifying or other detecting device. Further amplification at low frequency after detection may be carried out utilizing the type of system herein described or other well known audio frequency amplifying systems. Where the highest standard of tonal quality is demanded I prefer the herein described type of amplification throughout.

I claim:

1. An electric amplifier system including a plurality of three electrode vacuum tubes connected in cascade, means for applying a biasing potential to the grid electrode of the first tube of the series, means for creating a substantial current flow in the plate circuit of the last tube of the series, means linking said tubes and cooperating therewith whereby the effect of said biasing potential is transferred from tube to tube in the series with alternately reversed effects to produce a plate current flow in said last tube responsive to said biasing potential, and means for maintaining the biasing potential to the grid electrode of the first tube of the series of such polarity and magnitude that the steady component of the plate current flow in the output circuit of said last tube is maintained at substantially the midpoint of its plate current characteristic curve.

2. An electrical amplifier system including a plurality of three electrode vacuum tubes connected in cascade, means for applying a biasing potential to the grid electrode of the first tube of the series, means linking said tubes and cooperating therewith to transfer the effect of said biasing potential to the grid of the last tube of the series to produce a plate current flow in said last tube responsive to said biasing potential, and means responsive to said plate current flow for determining the degree of said biasing potential.

3. An electrical amplifier system including a plurality of three electrode vacuum tubes connected in cascade, means linking said tubes whereby a potential bias on the grid electrode of the first tube of the series controls the degree of plate current flow in the last tube of the series, and means responsive to said plate current flow for determining the degree of said biasing potential.

4. An electrical amplifier system including a plurality of three electrode vacuum tubes connected in cascade, means for impressing a fixed biasing potential on the grid electrode of the first tube of the series, means linking said tubes whereby a potential bias on said grid electrode controls the degree of plate current flow in the last tube of the series, and means responsive to said plate current flow for altering the degree of said biasing potential.

5. An electrical system including a plural-

ity of three electrode vacuum tubes, means for creating a plate current flow in one of said tubes, and means for creating a grid biasing potential for another of said tubes including a heated cathode electron discharge device having its cathode energized by said plate current flow and means for making a potential derived from the resulting current flow in said electron discharge device effective on the grid of said other tube.

6. An electrical amplifier system including a plurality of three electrode vacuum tubes connected in cascade, means for creating a plate current flow in the plate circuit of the last tube of the series, means for creating a biasing potential on the grid electrode of the first tube of the series, means linking said tubes and cooperating therewith to transfer the effect of said grid biasing potential through the system whereby said plate current flow is responsive thereto, means for impressing a modulated carrier current potential on the grid of said first tube, and means for limiting the effect of rectification in the system of said carrier current on said biasing potential and plate current flow including means operated by said plate current flow for altering said biasing potential.

7. An electrical amplifier system including a pair of three electrode vacuum tubes connected in cascade by means including a direct connection between the plate of the preceding tube and the grid of the succeeding tube, and a source of direct current potential connected to be negatively impressed on the grid of said succeeding tube with respect to its cathode by way of the filament-to-plate impedance of said preceding tube and said direct connection, the potential of said source being of the order of double that required as a grid biasing potential in the normal operation of said succeeding tube as an amplifier.

8. An electrical amplifier system including a pair of three electrode vacuum tubes connected in cascade by means including a direct connection between the plate of the preceding tube and the grid of the succeeding tube, a source of direct current potential connected to be negatively impressed on the grid of said succeeding tube with respect to its cathode by way of the filament-to-plate impedance of said preceding tube and said direct connection, the potential of said source being of the order of double that required as a grid biasing potential in the normal operation of said succeeding tube as an amplifier, and a high resistance directly connecting the grid of said succeeding tube to its cathode.

9. An electrical amplifier system including a pair of three electrode vacuum tubes connected in cascade by means including a conductive connection between the plate of the preceding tube and the grid of the succeeding tube, a source of direct current potential connected to be negatively impressed on the grid

of said succeeding tube with respect to its cathode by way of the filament-to-plate impedance of said preceding tube and said conductive connection, the potential of said source being of the order of 150 per cent of that required as a grid biasing potential in the normal operation of said succeeding tube as an amplifier, and a high resistance connecting the grid of said succeeding tube to a point of positive potential of lesser magnitude than said first potential.

10. An electrical amplifier system including a plurality of three electrode vacuum tubes connected in cascade including conductive connections between the plates of preceding tubes and the grids of succeeding tubes, one or more of said tubes requiring for normal operation as amplifiers grid biasing potentials different from one or more of the other of said tubes, means for supplying negatively to the grids of succeeding tubes a direct current potential of the order required for biasing the grids of said succeeding tubes for said normal operation as amplifiers by way of the filament-to-plate impedance of and the conductive connection to the plates of succeeding tubes, and high resistances connecting the grids of said tubes to their respective cathodes.

11. An electrical amplifier system including a pair of three electrode vacuum tubes and means connecting said tubes in cascade relation, said means including a source of direct current potential and conductive connections for energizing the plate electrode of the preceding tube and the grid electrode of the succeeding tube therefrom, the potential of said source being of the order of double that normally required for energizing the grid electrode of said succeeding tube for operation as an amplifier.

12. An electrical amplifier system including a pair of three electrode vacuum tubes and means connecting said tubes in cascade relation, said means including a source of direct current potential and conductive connections for energizing the plate electrode of the preceding tube and the grid electrode of the succeeding tube therefrom, the potential of said source being so low that its application to the plate electrode of said preceding tube produces operation on the plate current characteristic curve of said tube below the lower bend thereof.

13. An electrical amplifier system including a plurality of three electrode vacuum tubes connected for cascade amplification through conductive connections between the plate electrodes of preceding tubes and the grid electrodes of succeeding tubes, direct current means capable of energizing the plate electrode of the last tube of the series for operation at substantially the mid point of the plate current characteristic curve of said tube, direct current means for energizing the grid

electrodes of said tubes, said means being connected to said electrodes by way of said conductive connections and in series with the filament-to-plate impedances of preceding tubes, the potentials of said means being incapable of operating said preceding tubes beyond the lower bend of the plate current characteristic curves thereof, and means impressing a grid biasing potential on the grid electrode of the first tube of the series of such polarity and value as to fix the steady current flow of the plate circuit of said last tube at about the mid point of the plate current characteristic curve thereof.

14. In a direct coupled amplifier system, the combination of a source of energy, a plurality of electron tubes, impedance output and input circuits coupling said tubes in cascade, and means for energizing electrodes of said tubes so that the cathode-plate impedance of each preceding tube is of the same order as the impedance input to the next succeeding tube of said cascade.

15. In a direct coupled amplifier system, the combination of a source of energy, a plurality of electron tubes, impedance output and input circuits coupling said tubes in cascade, and means for energizing electrodes of said tubes so that the cathode-plate impedance of each preceding tube is of the same order as the impedance input to the next succeeding tube of said cascade, the cathode-plate impedance of each preceding tube and the input impedance to the succeeding tube being determined as functions approaching as a limit, in-so-far as practicable, the cathode-grid impedance of the succeeding tube.

16. In a direct coupled amplifier system, the combination of a source of energy, a plurality of electron tubes, impedance output and input circuits coupling said tubes in cascade, means for energizing the electrodes of said tubes so that the cathode-plate impedance of each preceding tube is of the same order as the impedance input to the next succeeding tube of said cascade, and means series related between the space current path of the last tube of said cascade and said source for determining the grid bias of one or more tubes of said cascade.

17. In a direct coupled amplifier system, the combination of a source of energy, a plurality of electron tubes, impedance output and input circuits coupling said tubes in cascade, means for energizing electrodes of said tubes so that the cathode-plate impedance of each preceding tube is of the same order as the impedance input to the next succeeding tube of said cascade, and means series related between the space current path of the last tube of said cascade and said source for determining the grid bias of all of said tubes.

18. In a direct coupled amplifier system, the combination of a source of energy, a plurality of electron tubes having interconnected

cathodes, impedance output and input circuits coupling said tubes in cascade, and means for energizing electrodes of said tubes so that the cathode-plate impedance of each preceding tube is of the same order as the impedance input to the next succeeding tube of said cascade, said means including connections between the grids of all but the first of said tubes and a potential point in said inter-cathode connection more positive than the connection of the negative terminal of the cathode of the respective tube thereto.

19. In a direct coupled amplifier system, the combination of a source of energy, a plurality of electron tubes, impedance output and input circuit coupling said tubes in cascade, means for energizing electrodes of said tubes so that the cathode-plate impedance of each preceding tube is of the same order as the impedance input to the next succeeding tube of said cascade, and means series related between the space current path of the last tube of said cascade and said source for determining the grid bias of one or more tubes of said cascade, said means being substantially non-responsive to signal current energy flowing therethrough.

20. In a direct coupled amplifier system, the combination of a source of energy, a plurality of electron tubes, impedance output and input circuits coupling said tubes in cascade, means for energizing electrodes of said tubes so that the cathode-plate impedance of each preceding tube is of the same order as the impedance input to the next succeeding tube of said cascade, and means series related between the space current path of the last tube of said cascade and said source for determining the grid bias of one or more tubes of said cascade, said means consisting of a discharge tube having a plurality of electrodes, the cathode of which is series related between the space current path of said last tube and said source, another electrode being connected directly to the grid of one of the tubes of said cascade, and means for producing a potential across the space discharge path of said discharge tube.

21. In a direct coupled amplifier system, the combination of a source of energy, a plurality of electron tubes, impedance output and input circuits coupling said tubes in cascade, means for energizing electrodes of said tubes so that the cathode-plate impedance of each preceding tube is of the same order as the impedance input to the next succeeding tube of said cascade, and means series related between the space current path of the last tube of said cascade and said source for determining the grid bias of one or more tubes of said cascade, said means consisting of a discharge tube having a plurality of electrodes, the cathode of which is series related between the space current path of said last tube and said source, another electrode being connected di-

rectly to the grid of the first tube of said cascade, and means for producing a potential across the space discharge path of said discharge tube.

5 22. The method of energizing an amplifier system including an output tube and an amplifier tube, which consists in controlling the average intensity of the space current of the output tube by the intensity of the space current of the amplifier tube, and controlling
10 the average intensity of the space current of the amplifier tube by the average intensity of the space current of the output tube.

15 23. The method of energizing an amplifier system including an odd number of tubes including an output tube and a plurality of amplifier tubes arranged in cascade, which consists in producing a rise in the average space current of the output tube by a rise in
20 the space current of any odd numbered tube of said cascade, and producing a decrease in the average space current of said odd numbered tube by the rise in the space current of said output tube.

25 24. The method of energizing an amplifier system including an odd number of tubes including an output tube and a plurality of amplifier tubes arranged in cascade, which consists in producing a rise in the average space current of the output tube by a rise in the
30 space current of any odd numbered tube of said cascade, and producing a rise in the average space current of any even numbered tube of said cascade by the rise in the space current of said output tube.

35 25. The method of energizing an amplifier system including an odd number of tubes including an output tube and a plurality of amplifier tubes arranged in cascade, which consists in producing a decrease in the average space current of the output tube by a decrease in the average space current of any
40 odd numbered tube of said cascade, and producing a rise in the space current of said odd numbered tube by the decrease in the space current of said output tube.

45 26. The method of energizing an amplifier system including an output tube and an amplifier tube arranged in cascade, which consists in producing a decrease in the average space current of the output tube by a rise in the average space current of said amplifier tube, and producing a decrease in the average space current of said amplifier tube by said
50 decrease in the average space current of said output tube.

55 In testimony whereof I affix my signature.
SIDNEY Y. WHITE.

DISCLAIMER

1,789,664.—*Sidney Y. White*, New York, N. Y. ELECTRICAL AMPLIFIER SYSTEM. Patent dated January 20, 1931. Disclaimer filed February 19, 1935, by the assignee, *Radio Corporation of America*.

Hereby disclaims that part of the specification of said patent which consists of claims 2, 3, 4, 10, 22, 23, 24, 25, and 26, which are in the following words:

"2. An electrical amplifier system including a plurality of three electrode vacuum tubes connected in cascade, means for applying a biasing potential to the grid electrode of the first tube of the series, means linking said tubes and cooperating therewith to transfer the effect of said biasing potential to the grid of the last tube of the series to produce a plate current flow in said last tube responsive to said biasing potential, and means responsive to said plate current flow for determining the degree of said biasing potential.

"3. An electrical amplifier system including a plurality of three electrode vacuum tubes connected in cascade, means linking said tubes whereby a potential bias on the grid electrode of the first tube of the series controls the degree of plate current flow in the last tube of the series, and means responsive to said plate current flow for determining the degree of said biasing potential.

"4. An electrical amplifier system including a plurality of three electrode vacuum tubes connected in cascade, means for impressing a fixed biasing potential on the grid electrode of the first tube of the series, means linking said tubes whereby a potential bias on said grid electrode controls the degree of plate current flow in the last tube of the series, and means responsive to said plate current flow for altering the degree of said biasing potential."

"10. An electrical amplifier system including a plurality of three electrode vacuum tubes connected in cascade including conductive connections between the plates of preceding tubes and the grids of succeeding tubes, one or more of said tubes requiring for normal operation as amplifiers grid biasing potentials different from one or more of the other of said tubes, means for supplying negatively to the grids of succeeding tubes a direct current potential of the order required for biasing the grids of said succeeding tubes for said normal operation as amplifiers by way of the filament-to-plate impedance of and the conductive connection to the plates of succeeding tubes, and high resistances connecting the grids of said tubes to their respective cathodes."

"22. The method of energizing an amplifier system including an output tube and an amplifier tube, which consists in controlling the average intensity of the space current of the output tube by the intensity of the space current of the amplifier tube, and controlling the average intensity of the space current of the amplifier tube by the average intensity of the space current of the output tube.

"23. The method of energizing an amplifier system including an odd number of tubes including an output tube and a plurality of amplifier tubes arranged in cascade, which consists in producing a rise in the average space current of the output tube by a rise in the space current of any odd numbered tube of said cascade, and producing a decrease in the average space current of said odd numbered tube by the rise in the space current of said output tube.

"24. The method of energizing an amplifier system including an odd number of tubes including an output tube and a plurality of amplifier tubes arranged in cascade, which consists in producing a rise in the average space current of the output tube by a rise in the space current of any odd-numbered tube of said cascade, and producing a rise in the average space current of any even numbered tube of said cascade by the rise in the space current of said output tube.

"25. The method of energizing an amplifier system including an odd number of tubes including an output tube and a plurality of amplifier tubes arranged in cascade, which consists in producing a decrease in the average space current of the output tube by a decrease in the average space current of any odd numbered tube of said cascade, and producing a rise in the space current of said odd numbered tube by the decrease in the space current of said output tube.

"26. The method of energizing an amplifier system including an output tube and an amplifier tube arranged in cascade, which consists in producing a decrease in the average space current of the output tube by a rise in the average space current of said amplifier tube, and producing a decrease in the average space current of said amplifier tube by said decrease in the average space current of said output tube."

[*Official Gazette March 19, 1935.*]