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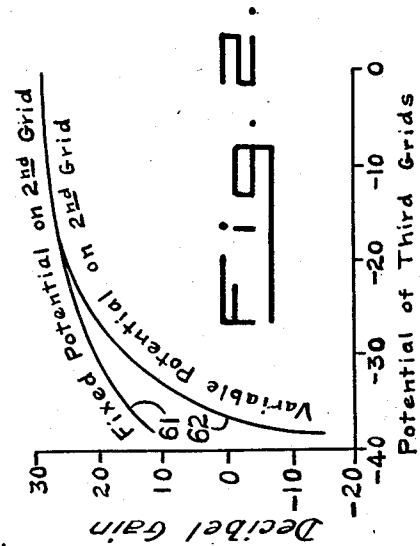
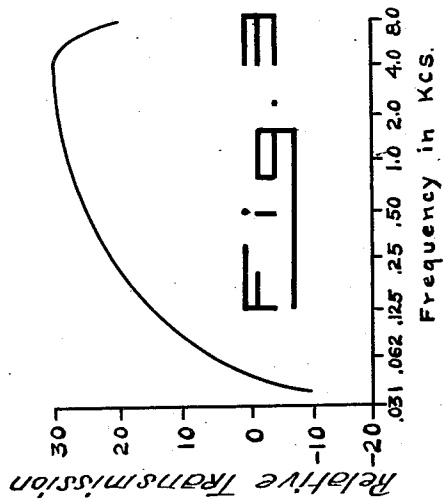
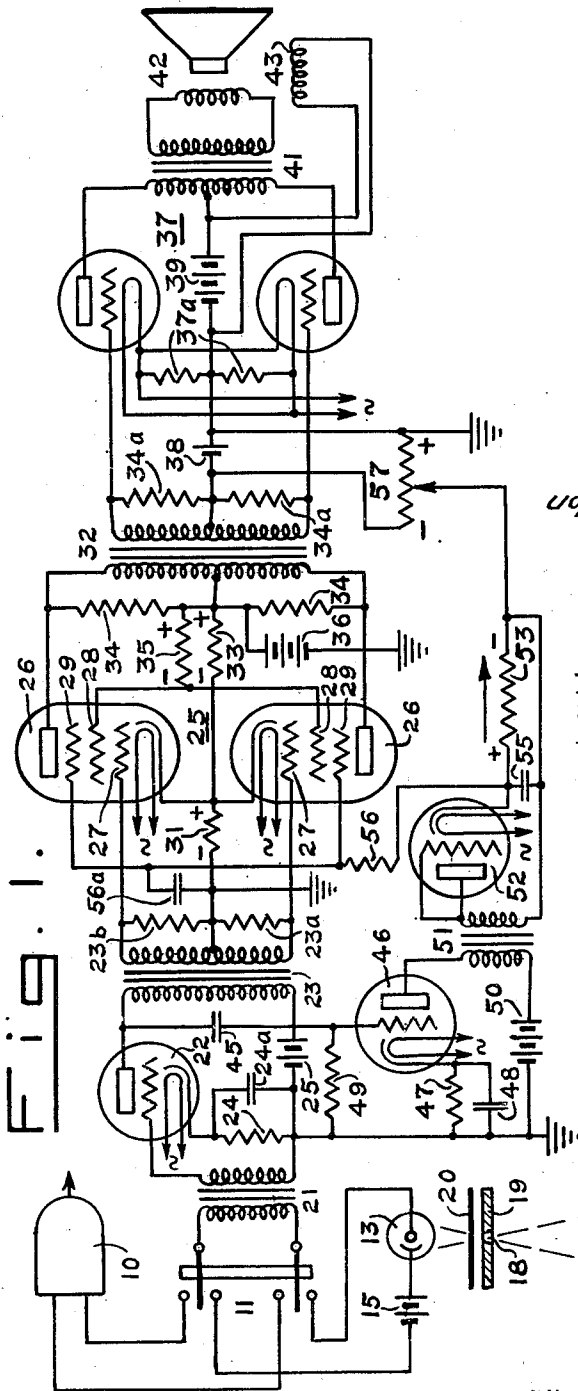
E. S. PURINGTON

2,096,759

DYNAMIC MULTIPLIER

Filed April 3, 1936

2 Sheets-Sheet 1



INVENTOR
Ellison S. Purington.

BY *N. Fleck*
ATTORNEY

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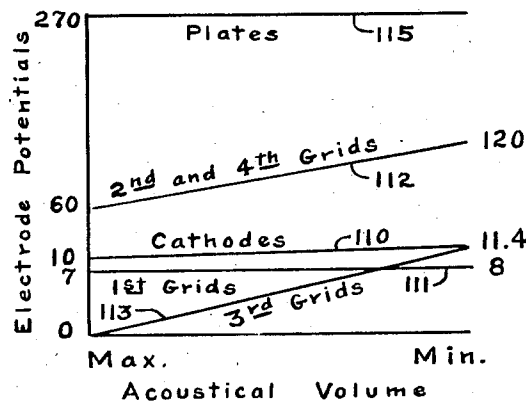
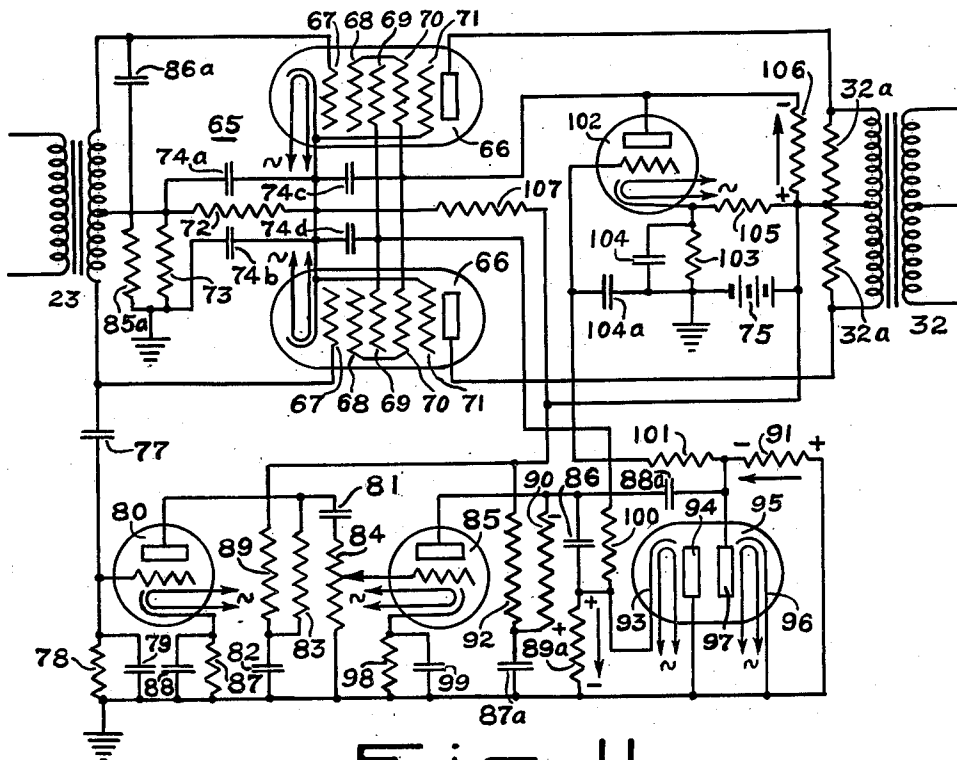
E. S. PURINGTON

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DYNAMIC MULTIPLIER

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2 Sheets-Sheet 2



INVENTOR

Ellison S. Purington.

B Y

A. Leek
ATTORNEY

UNITED STATES PATENT OFFICE

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DYNAMIC MULTIPLIER

Ellison S. Purington, Gloucester, Mass., assignor
to John Hays Hammond, Jr., Gloucester, Mass.

Application April 3, 1936, Serial No. 72,519

19 Claims. (Cl. 179—171)

This invention relates to sound reproducing systems, and more particularly to an improved system for automatically expanding the dynamic range of sound energy.

5 An object of this invention is to provide an improved method of controlling the volume expansion in dynamic multipliers.

Another object is to improve the sharpness of cut-off at low volume and to obtain the desired amount of expansion without critical adjustments.

Various other objects and advantages will be apparent as the nature of the invention is more fully disclosed.

15 A feature of the invention consists in the use of amplifier tubes having a plurality of electrodes, at least one of which is positively biased, and two of which are negatively biased. The control voltage is impressed on both the positively biased electrode and a negatively biased electrode.

20 In one embodiment of the invention, the control voltage is impressed on the positively biased electrode by coupling from an electrode located between said first electrode and the anode. As applied to a triple grid tube, the signal is impressed upon the first grid, the control voltage upon the third grid and the change in space current to the second grid caused by variations in voltage on the third grid is used to control the bias of the second grid in such manner that the control effects of the second and third grids are additive.

In another embodiment as applied to a pentagrid tube, the negative bias of the third grid is decreased and the positive bias of the second and fourth grids is increased in accordance with an increase in control voltage and vice versa. In this way the control effect of all of the grids is utilized.

40 Although the novel features which are believed to be characteristic of this invention will be more particularly pointed out in the claims appended hereto, the invention itself, as to its objects and advantages, the mode of its operation and the manner of its organization may be better understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof, in which,

50 Fig. 1 illustrates diagrammatically the system as applied to the reproduction of sound from the sound record of a talking, moving picture and phonograph;

Fig. 2 is a series of curves illustrating the expansion characteristics of the system;

Fig. 3 is a curve illustrating the selectivity characteristics of the control circuit;

Fig. 4 shows a modified circuit arrangement using pentagrid tubes; and

Fig. 5 is a series of curves showing the change of potential of the electrodes occurring during the operation of the system of Fig. 4.

In the following description and in the claims various parts will be identified by specific names for convenience, but they are intended to be as generic in their application to similar parts as the art will permit.

Referring to the accompanying drawings, and more particularly to Fig. 1, a phonograph pick-up 10 is shown which is connected to two contacts of a double pole double throw switch 11, the other contacts of which are connected to the circuit of a photoelectric cell 13 including battery 15. Light from a lamp 16 is focused by means of a lens 17 through an aperture 18 in an aperture plate 19 upon the sound record of a moving photographic film 20. The light which passes through this film impinges upon the photo-electric cell 13.

The blades of the switch 11 are connected to the primary of an input transformer 21, one terminal of the secondary of which is connected to ground and the other terminal of which is connected to the grid of a triode space discharge amplifier tube 22 of the separate heater type. Between the cathode of the tube 22 and ground are connected in parallel a cathode bias resistor 24 and a bias resistor by-pass condenser 24a. The plate of tube 22 is connected to one terminal of the primary of coupling transformer 23, the other terminal of which is connected to the positive side of plate battery 25, the negative side of which is grounded.

The terminals of the secondary of transformer 23 are connected to the first grids 27 of two triple-grid amplifier tubes 26 of the separate heater type. These tubes may be of the type commonly used in radio frequency amplifiers, and in addition to the usual heater, cathode and anode have three grid structures, 27, 28, and 29. Although in radio frequency amplifiers these grids are usually termed signal, screen and suppressor grids, they are here termed for audio amplifier purposes, first, second and third grids. The center tap of secondary of transformer 23 is grounded, and ballasting resistors 23a and 23b are bridged from each terminal to the center tap.

The third grids 29 of tubes 26 are joined together and connected to one end of resistor 56. The potentials of these third grids are normally

negative with respect to ground, but are variably negative in accordance with the signal energy impressed upon tube 22 in a manner to be described later. A by-pass timing and filtering condenser 56a is connected between these third grids and ground.

Plate currents for tubes 26 are supplied by plate battery 36, the negative end of which is grounded, and the positive end of which is connected to center tap of the primary of coupling transformer 32. The terminals of this primary are connected to the plates of tubes 26. Bridged across from plates of tubes 26 to the center tap of primary of transformer 32 are two terminating resistors 34. These are of the same order of magnitude as the internal output impedance of the tubes which transformer 32 is designed to match, and are desirable because of the very high internal output impedance characteristic of triple grid tubes such as would usually be used in this arrangement. Battery 36 also serves other purposes than supplying plate power. Between the positive terminal of this battery and ground are connected in series, bleeder resistor 33 and cathode bias resistor 31, to the junction of which are connected the cathodes of tubes 26. These two resistors are so chosen that during the operation of the system with variable space currents within the tubes to the cathodes, the voltage across resistor 31 does not change by more than 25 to 50 per cent. The cathode is maintained positive with respect to the grid by the amount of the voltage drop through the resistance 31. Hence the first grids 27, which are at ground potential, and the third grids 29, which are negative with respect to ground, are both negative with respect to the cathodes. The second grids 28 of tubes 26 are connected together, and to one end of a coupling resistor 35, the other end of which is connected to the positive terminal of battery 36. The second grids 28 are thus positively biased by the potential of the battery 36, minus the voltage drop in the resistance 35 due to the current drawn by said grids. The constants of the various parts are so chosen that with the third grids of tube 26 shorted to the cathodes for test purposes, the potentials of and currents to the various electrodes will be substantially those values for which the tube is designed to give best amplification.

The secondary terminals of transformer 32 are connected to the grids of two triode-type power amplifier tubes 37. The filaments of these tubes are connected in parallel, and bridged across the filaments is a center tapped resistor 37a, the center tap of which is grounded. The center tap of the secondary of transformer 32 is connected to the negative terminal of grid bias battery 38, the positive terminal of which is grounded. From terminals to center tap of the secondary are bridged resistors 34a which cooperate with primary resistors 34 in producing satisfactory tonal transfer.

The plates of tubes 37 are connected to the primary terminals of output transformer 41, the center tap of which is connected to the positive side of plate battery 39, the negative side of which is grounded. The secondary winding of transformer 41 is connected to the voice coil of a loud speaker 42, the field winding 43 of which is connected across battery 39.

A condenser 56a is connected between the third grids of the tubes 26 and ground.

For controlling and varying the voltage across condenser 56a, blocking, coupling and filtering condenser 45 is connected between the plate of

tube 22 and the grid of a triode amplifier tube 46 of the separate heater type. Between the grid and ground of this tube is connected a filtering and grid bias fixing resistor 49. Between the cathode of tube 46 and ground are connected in parallel a cathode bias resistor 47 and a bias resistor by-pass condenser 48. The plate of the tube 46 is connected to one terminal of the primary of the filtering coupling transformer 51, the other terminal of which is connected to the positive terminal of battery 50, the negative terminal of which is grounded.

One terminal of the secondary of transformer 51 is connected to the plate and grid of a triode rectifier tube 52 of the separate heater type. The other terminal of the secondary of transformer 51 is connected to the adjustable contact of a potentiometer 57 which is connected across battery 38. Between the cathode of tube 52 and the adjustable contact of potentiometer 57 in parallel are connected rectifier output resistor 53 and first filter condenser 55. Between the cathode of tube 52 and the third grids of tubes 26 is a filtering and timing resistor 56, and as above described between the third grids of tubes 26 and ground is condenser 56a which serves as a second rectifier filter and timing condenser.

In the operation of the embodiment of the invention shown in Fig. 1, the energy received by the transformer 21 from either the phonograph pick-up 10 or the photo-electric cell 13, passes to the amplifier 22 where it is amplified and the major portion is fed through the transformer 23 to the push-pull amplifier tubes 26. Here the energy is reproduced in the plate circuit, amplified to a more or less degree depending upon the potentials of the various grids with respect to the cathodes. Thereupon it is impressed through transformer 32 upon the grids of push-pull power amplifier tubes 37, where it is further amplified and impressed upon loud speaker 42 which produces sound vibrations in accordance with the electrical energy impressed thereupon.

For producing control voltage across condenser 56a, some of the energy amplified by tube 22 is transferred from the plate of tube 22 through the filtering coupler 45 and 49, which discriminates against the low frequency tones, to amplifier 46, where it is amplified and impressed through transformer 51 upon the rectifier 52. In addition to the filtering actions of elements 45 and 49, the transformer 51 and the bias devices 47 and 48 are also of such characteristics as to aid in the selection of tones for operating the rectifier by discriminating against lowest and highest frequency tones. As a result the energy impressed upon rectifier 52 more nearly represents the acoustical volume level of the sound record than the electrical volume level.

The potentiometer 57 is so adjusted that in the absence of tonal signal there is a large negative bias due to battery 38 impressed upon the third grids of tubes 26, there being substantially no currents in the resistors 53 and 56. With signals impressed upon the rectifier, rectified current is produced in the resistor 53 in the direction of the arrow, decreasing the negative bias on the third grids. In case the signal is so strong that the third grids become positive with respect to the cathodes, current passes from these third grids to the cathodes within the tubes, and direct current flows upwardly through resistor 56 thereby limiting the ability of rectified current to further increase the third grid potential.

The effects of the decrease of negative bias of

the third grids, which may also be considered as an increase of the electrical potential, are twofold. It increases the ability of the first grid to control the plate current, thereby increasing the first grid to plate conductance and increasing the gain ratio of the amplifier stage for the tonal signals. Also it causes the current to the second grids to change, due to the resistance coupling action of resistor 35 supplied with current from battery 36 as will be later described. By the balanced push-pull arrangement this current through resistor 35 follows fluctuations in the control voltage impressed upon the third grids, and not the fluctuations due to the signal voltage impressed in a balanced manner upon the first grids. The effect of this resistance coupling for the control voltage is to make the normally positive second grid more positive as the third grid becomes less negative as explained below. The absolute potentials of the third grids and second grids become algebraically greater or less in unison, in accordance with greater or less energy impressed upon the rectifier. In general, in a multi-grid tube, with electronic induction, an increase of absolute potential of one electrode only increases the space current to the plate or to any other positively biased electrode between it and the plate, but on the other hand decreases the current to any positively biased electrode between it and the cathode. As a result, in the present instance increased absolute potential of the third grid due to increased signal, and therefore, decreased negative bias, causes increased current to the plate, but decreased current to the positively biased second grid. Decreased current to the second grid in turn causes less drop through the coupling resistor 35 and increases the potential of the second grid. As a result of this increased potential of the second grid, the first grid is caused to exercise increased control of the plate current, thereby increasing the gain of the amplifier stage over and above the increase of gain due to the control by the third grids alone.

For purposes of illustration, Fig. 2 shows the decibel gain of the amplifier stage from grids of tubes 26 to grids of tubes 37 of a typical circuit constructed in accordance with this invention, as a function of the potential of the third grids 29. Curve 61 relates to the gain with the second grids maintained at a fixed potential in accordance with the previous art. Curve 62 relates to the gain with the second grids caused to vary in synchronism and in phase with the third grids in accordance with the present invention. In both cases the potential of the second grids is the same with the third grid at ground potential. The much greater control effect of the third grid upon the gain of the amplifier stage due to the cooperative action of the second grid is clearly evident, as well as the increased sharpness of cut-off of transmission at the lower volumes. This not only permits a wide range of volume expansion to be achieved in a single amplifier stage, but also permits smooth expansion characteristics to be obtained.

For illustration also, in Fig. 3 is shown a transmission curve relating the rectified voltage developed across resistor 53 to the frequency of voltage impressed upon the grid of amplifier tube 22. This curve is approximately correct for converting electrical volume level to acoustical volume level.

In the modified circuit arrangements of Fig. 4, the dynamic multiplier circuits only are shown. It will be understood that the primary of trans-

former 23 is connected to and driven from a source of sound and a preamplifier such as the phonograph pick-up 10, photoelectric cell 13, amplifier tube 22 of Fig. 1, and that the secondary of transformer 32 is connected to a power amplifier and loud speaker such as afforded by tubes 37 and loud speaker 42 of Fig. 1.

In Fig. 4, the secondary terminals of transformer 23 are connected in a balanced fashion to the first grids of a pentagrid mixer tube of the separate heater type, which serve as the expander tubes of a dynamic multiplier. These tubes contain a plurality of grid structures 67, 68, 69, 70, and 71, between the cathodes and plates, designated as first, second, third, fourth and fifth grids. Within the tube the fifth grids 71 are connected to the cathode and the second and fourth grids 68 and 70 are connected together. The plates of these tubes are connected to the terminals of the primary of a coupling transformer 32, the center tap of which is connected to the positive terminal of supply battery 75, the negative side of which is grounded. Input resistors 32a are connected between the terminals of the primary of transformer 32 and the center tap. Three resistors 107, 72 and 73 are connected in series between the positive side of battery 75 and ground. The cathodes, and therefore also the fifth grids 71 of tubes 66, are connected together and to the junction of resistors 107 and 72. Hence they are maintained positive with respect to ground by the voltage drop in resistances 72 and 73. The center tap of the secondary of transformer 23 is connected to the junction of resistors 72 and 73 to bias the first or signal grids 67 negative with respect to the cathodes by the amount of the voltage drop in the resistance 72. The third grids 69 are connected together, and between them and ground are connected the resistors 100 and 89a in series. When no current is drawn, these grids are at ground potential and are thus negative with respect to the cathodes. The second and fourth grids of both tubes are connected together and to the plate of triode control repeater tube 102 of the separate heater type, which in turn is connected to one end of resistor 106, the other end of which is connected to the positive end of the battery 75. These grids are thus positive by the potential of the battery 75 minus the voltage drop in resistance 106. Between the positive end of the battery and ground are connected in series a bleeder resistor 105 and a cathode bias resistor 103, to the junction of which is connected the cathode of the tube 102. The circuit is so arranged that the potential of the cathode does not change more than 25 to 50 per cent during the operation of the tube. Between the grid of tube 102 and ground are connected in series resistors 101 and 91. Bypass condenser 74a is connected from cathodes of tubes 66 to the center tap of the secondary of transformer 23, bypass condenser 74b from cathodes of tubes 66 to ground; and bypass condenser 104 from the cathode of tube 102 to ground. Smoothing and timing condensers 74c, 74d and 104a are connected between second and fourth grids and cathodes of tubes 66, between third grids and cathodes of tubes 66, and between grid of tube 102 and ground, respectively.

For controlling the potentials of the third grids of tubes 66 and the grid of tube 102, between one terminal of the secondary winding of transformer 23 and ground are connected a coupling, blocking and filtering condenser 77, and a filtering and bias fixing resistor 78, the junction of

which is connected to the grid of a triode amplifier tube 80 of the separate heater type. In parallel with resistor 78 is high audio frequency bypass condenser 79. Between the other terminal of the secondary of transformer 23 and ground are connected in series a balancing condenser 86a and resistor 85a. Between the cathode of tube 80 and ground are connected in parallel a cathode bias resistor 87 and high audio frequency bypass condenser 88. Between the plate of tube 80 and the positive terminal of battery 75 are connected in series a coupling resistor 83 and a feed resistor 89, between the junction of which and ground is connected a high audio frequency bypass condenser 82. Between the plate of tube 80 and ground are connected in series a D. C. and low frequency blocking condenser 81 and gain control potentiometer 84, the adjustable contact of which is connected to the grid of a triode amplifier tube 85 of the separate heater type. Between the cathode of tube 85 and ground are connected in parallel a cathode bias resistor 98 and high frequency bypassing condenser 99. Between the plate of tube 85 and the positive side of battery 75 are connected in series a coupling resistor 90 and a feed resistor 92, between the junctions of which and ground is connected a high frequency by-passing condenser 87a. Between the plate of tube 85 and ground are connected in series a high frequency coupling condenser 86 and a rectifier discharge resistor 89a, and also between the plate of the tube 85 and ground are connected in series a high frequency coupling condenser 88a and a rectifier discharge resistor 91. The junction between condenser 86 and resistor 89a is connected to the first cathode 93 of a dual rectifier tube 95, and to one end of a filtering and timing resistor 100 the other end of which is connected to the third grids of tubes 66. The junction between condenser 88a and resistor 91 is connected to the second plate 97 of tube 95, and to one end of a filtering and timing resistor 101, the other end of which is connected to the grid of tube 102. The first plate 94 and the second cathode 96 of tube 95 are connected to ground.

The filaments of all tubes are heated by means not shown, preferably from a secondary winding of a power transformer, the center tap of which is connected to ground or to the cathode of the tube which it heats.

In the operation of the circuit of Fig. 4, signals from a sound record, pick-up, and preamplifier are impressed through transformer 23 upon the first grids of tubes 66 in a balanced fashion. Here the signals are amplified in a degree depending upon the potentials of the second, third and fourth grids with respect to ground, and are impressed through transformer 32 upon the grids of power amplifier tubes which in turn operate a loud speaker to produce tonal signals corresponding to the electrical signals impressed thereupon.

Some of the energy delivered through transformer 23 is diverted to the grid or amplifier tube 80, where it is amplified and impressed upon the grid of tube 85 to a degree depending upon the setting of the potentiometer 84. Here again the energy is amplified and impressed through condensers 86 and 88a upon the first and second plate-cathode branches of the rectifier tube 95. The constants of the circuits between transformer 23 and the rectifier 95 are so chosen that the energy impressed upon the rectifier represents the acoustical level instead of the electrical level of the signal impressed upon the first grids of tubes

66. The energy impressed upon rectifier 95 produces rectified current in resistors 89a and 91 in the direction of the arrows, causing control voltages which are smoothed out by resistors 100 and 101, and the condensers 74d and 104a. The voltage impressed upon the third grids of tubes 66 due to the rectifier 95 increases its potential in an algebraic sense, that is reduces its negative bias, and increases the ability of the first grid to control the plate current. As a consequence increased rectified energy causes increased gain of the amplifier stage of which tubes 66 form a part. The increased potential upon the third grid increases the space current to the positively biased fourth grid which is between the third grid and the plate, but at the same time decreases the space current to the positively biased second grid which is between the third grid and the cathodes. As a result the third grid potential produces little or no effect upon the current through resistor 106, and therefore upon the positive potential of the second and fourth grids. However, the current through resistor 106 is controlled by the rectified voltage across resistor 91, which produces increased bias upon the grid of the tube 102. The cathode resistor 103 and bleeder resistor 105 having been originally chosen so that a relatively large current passes through resistor 106 to the plate of tube 102 and to the second and fourth grids of tubes 66, it is clearly evident that increased bias upon the grid of tube 102 due to increased rectifier energy reduces the current flow through resistor 106, and increases the positive potential upon the second and fourth grids of tubes 66. As a result, through the agency of two rectifiers, and the auxiliary tube 102, the positive bias potential of the second and fourth grids are increased simultaneously with increase of potential of the third grids which decreases their negative bias, and produces an increased control effect upon the gain ratio of the amplifier stage.

For purposes of illustration, in Fig. 5 is shown how the potentials of various electrodes change in accordance with the acoustical volume. The main control upon the third grids causes a potential change from 0 to +11.4 volts, while the control upon the second and fourth grids due to operation of tube 102 causes a potential change from 60 to 120 volts. The potential of the plates changes negligibly, while the potentials of the cathodes and first grids increase slightly. The increase of the first grid bias with respect to the cathode is small, producing small control effect, and at any rate no greater effect than if the control were only upon the third grid.

The effect of the second, third and fourth grids is additive in controlling the mutual conductance and impedance of the tubes 66 and produces a control similar to that obtained in the tubes 26 described in connection with Fig. 1. In Fig. 4, however, the control on the second and fourth grids is direct, whereas in Fig. 1 the control is obtained indirectly by electronic coupling from the negative control grid.

Although certain specific embodiments of the invention have been set forth in detail for purposes of illustration, it is obvious that various changes and modifications may be made therein as will appear to a person skilled in the art. The invention is only to be limited in accordance with the following claims when interpreted in view of the prior art.

What is claimed is:

1. In a sound reproducing system, an amplifier

stage comprising an amplifier tube having a cathode and a plurality of other electrodes, at least one of said other electrodes being biased positively with respect to the cathode and at least two of said other electrodes being biased negatively with respect to the cathode, an audio frequency circuit connected to impress audio frequency energy upon one of said negatively biased electrodes, means deriving sub-audio frequency control energy from said audio frequency energy, means impressing said control energy upon another of said negatively biased electrodes and means for changing the potential of said positively biased electrode in phase with the change of potential of said last mentioned negatively biased electrode to produce a control effect in the same sense.

2. In a sound reproducing system, an amplifier stage comprising an amplifier tube having a cathode and a plurality of grids, at least one of said grids being biased positively with respect to the cathode and at least two of said grids being biased negatively with respect to the cathode, an audio frequency circuit connected to impress audio frequency energy upon one of said negatively biased grids, means deriving sub-audio frequency control energy from said audio frequency energy, means impressing said control energy upon another of said negatively biased grids and means for changing the potential of said positively biased grid in phase with the change of potential of said last mentioned negatively biased grid to produce a control effect in the same sense.

3. In a sound reproducing and recording system, an amplifier stage comprising an amplifier tube having a cathode, at least one power consuming electrode and at least two non-power consuming electrodes, an audio frequency circuit connected to impress audio frequency energy upon one of said non-power consuming electrodes, means deriving sub-audio frequency control energy from said audio frequency energy, means impressing said control energy upon another of said non-power consuming electrodes and means for changing the potential of said power consuming electrode in phase with the change of potential of said last mentioned non-power consuming electrode to produce a control effect in the same sense.

4. In a sound reproducing and recording system, an amplifier stage comprising an amplifier tube having a cathode, at least one power consuming electrode and at least two non-power consuming electrodes, an audio frequency circuit connected to impress audio frequency energy upon one of said non-power consuming electrodes, means deriving sub-audio frequency control energy from said audio frequency energy, means impressing said control energy upon another of said non-power consuming electrodes and means responsive to the change in space current to the power consuming electrode produced by change in potential of the last mentioned non-power consuming electrode to vary the bias of said power consuming electrode.

5. In a sound reproducing system, an amplifier stage comprising an amplifier tube having a cathode and a plurality of other electrodes, at least one of said other electrodes being biased positively with respect to the cathode and at least two of said other electrodes being biased negatively with respect to the cathode, an audio frequency circuit connected to impress audio frequency energy upon one of said negatively biased electrodes, means deriving sub-audio frequency

control energy from said audio frequency energy, means impressing said control energy upon another of said negatively biased electrodes, a resistor in the lead from the source of positive bias to said positively biased electrode and means utilizing the potential drop across said resistor, produced by a change in space current to said last mentioned electrode, to change the positive bias thereof so as to produce a control effect in the same sense as that produced by the last mentioned negatively biased electrode.

6. In a sound recording and reproducing system an amplifier stage comprising an amplifier tube having a cathode and a plurality of grids, said grids being connected to constitute a negatively biased signal grid, a negatively biased control grid and a positively biased control grid, means applying signal energy to said signal grid, means deriving control energy from said signal energy and applying said control energy to said negatively biased control grid and means changing the potential of said positive control grid in phase with the change in potential of said negative control grid to produce a control effect in the same sense.

7. In a sound recording and reproducing system, an amplifier stage comprising an amplifier tube having a cathode and a plurality of grids, said grids being respectively connected to operate as a signal grid, a positively biased control grid and a negatively biased control grid respectively, said positively biased control grid being disposed in the space current path between said negatively biased control grid and said cathode, whereby a reduction in the negative bias of said negatively biased control grid will decrease the space current drawn by the positively biased control grid, means applying signal energy to said signal grid, means applying control energy derived from said signal energy to said negatively biased control grid and means utilizing the change in space current to the positively biased control grid thus produced for changing the bias thereof in phase with the change in bias of said negatively biased control grid.

8. In a sound recording and reproducing system, an amplifier stage comprising an amplifier tube having a cathode and a plurality of grids, said grids being respectively connected to operate as a signal grid, a positively biased control grid and a negatively biased control grid, said positively biased control grid being disposed in the space current path between said negatively biased control grid and said cathode whereby a reduction in the negative bias of said negatively biased control grid will decrease the space current drawn by the positively biased control grid, means applying signal energy to said signal grid, means applying control energy derived from said signal energy to said negatively biased control grid, a resistor connected in the lead from the source of positive bias to the positively biased control grid, and means utilizing the potential drop in said resistor produced by a change in space current drawn by said last grid to variably oppose the positive bias of said grid so as to produce a change in bias in phase with the change in bias of said negatively biased control grid so as to effect a control in the same sense.

9. In a sound recording and reproducing system an amplifier stage comprising a pair of amplifier tubes connected in push-pull relationship, each of said tubes having a cathode and a plurality of grids connected respectively to constitute a signal grid, a positively biased control

grid and a negatively biased control grid, means applying signal energy to said signal grids, a control channel, means applying a portion of the signal energy to said control channel, a rectifier in said control channel adapted to rectify said control energy so as to produce a control voltage proportional to the moving average of the signal energy, means applying said control voltage to said negatively biased control grids for controlling the amplification characteristics of said tubes and means operable by electronic coupling of said positively biased control grids to produce a change in the bias thereof in phase with the change in bias of said negatively biased control grids.

10. In a sound recording and reproducing system, an amplifier stage comprising a pair of amplifier tubes connected in push-pull relationship, each of said tubes having a cathode and a plurality of grids connected respectively to constitute a signal grid, a positively biased control grid and a negatively biased control grid, means applying signal energy to said signal grids, a control channel, means applying a portion of the signal energy to said control channel, a rectifier in said control channel adapted to rectify said control energy so as to produce a control voltage proportional to the moving average of the signal energy, means applying said control voltage to said negatively biased control grids for controlling the amplification characteristics of said tubes, a resistor connected in the lead from the source of positive bias to said positively biased control grids and means utilizing the change in potential drop across said resistor produced by change in power drawn by said last grids for varying the bias thereof in phase with the bias change of said negatively biased control grids.

11. In a sound recording and reproducing system, an amplifier stage comprising a pair of amplifier tubes connected in push-pull relationship, each of said tubes having a cathode and a plurality of grids connected respectively to constitute a signal grid, a positively biased control grid and a negatively biased control grid, said positively biased control grids being disposed in the space current path between said negatively biased control grids and the cathodes whereby a decrease in the negative bias of said negatively biased control grids causes the space current of said positively biased control grids to decrease, means applying signal energy to said signal grids, a control channel, means applying a portion of the signal energy to said control channel, a rectifier in said control channel adapted to rectify said control energy so as to produce a control voltage proportional to the moving average of the signal energy, means applying said control voltage to said negatively biased control grids for controlling the amplification characteristics of said tubes, a resistor connected in the lead from the source of positive bias to said positively biased control grids and means utilizing the change in potential drop across said resistor produced by change in power drawn by said last grids for varying the bias thereof in phase with the bias change of said negatively biased control grids.

12. In a sound recording and reproducing system, an amplifier stage comprising an amplifier tube having a cathode and a plurality of grids, said grids being connected to constitute a negatively biased signal grid, a negatively biased control grid and a positively biased control grid, means applying signal energy to said signal grid, a control channel comprising a control amplifier and a rectifier circuit fed thereby, a resistance

coupling supplying signal energy to said control amplifier, means associated with said rectifier to produce a control potential proportional to the average signal energy, means applying said potential to control the negative bias of said negatively biased control grid and means utilizing the mutual conductance effect of the negatively biased control grid upon the space current drawn by the positively biased control grid for changing the positive bias of said last grid in phase with the change in bias produced on said negatively biased control grid.

13. In a sound recording or reproducing system an amplifier stage comprising an amplifier tube having a cathode and a plurality of grids connected respectively to constitute a negatively biased signal grid, a negatively biased control grid and a pair of positively biased control grids, said last mentioned grids being disposed on opposite sides of said negatively biased control grid with respect to the space current path, means applying signal energy to said signal grid, a control channel actuated by said signal energy, said control channel having means to produce a control voltage varying in accordance with the average signal energy, means applying said control voltage to vary the negative bias of said negatively biased control grid and additional means applying said control voltage to said positively biased signal grids so as to produce a change in bias thereof in phase with the change in bias of said negatively biased control grid.

14. In a sound recording or reproducing system an amplifier stage comprising an amplifier tube having a cathode and a plurality of grids connected to constitute a negatively biased signal grid, a negatively biased control grid and a pair of positively biased control grids, said last mentioned grids being disposed on opposite sides of said negatively biased control grid with respect to the space current path, means applying signal energy to said signal grid, a control channel actuated by said signal energy, said control channel having means to produce a control voltage varying in accordance with the average signal energy, means applying said control voltage to vary the negative bias of said negatively biased control grid and an additional control channel applying said control voltage to both of said positively biased control grids to produce a change in bias thereof in phase with the change in bias of said negatively biased control grid.

15. In a sound recording or reproducing system, having an amplifier stage comprising an amplifier tube having a plurality of grids, at least two of which are negatively biased and at least one of which is positively biased, the method of automatically varying the characteristics of said stage which comprises impressing signal energy upon one of said negatively biased grids, and impressing control energy upon another of said negatively biased grids and upon said positively biased grid so as to produce a control effect in the same sense by both of said last grids.

16. In a sound recording or reproducing system, having an amplifier stage comprising an amplifier tube having a plurality of grids, at least two of which are negatively biased and at least one of which is positively biased, the method of automatically varying the characteristics of said stage which comprises impressing signal energy upon one of said negatively biased grids, impressing control energy upon another of said negatively biased grids, and utilizing the change in current drawn by said positively biased grid pro-

duced by electronic coupling with said last mentioned negatively biased grid for varying the bias of said positively biased grid in phase with the bias change of said negatively biased grid.

5 17. In a sound recording or reproducing system having an amplifier stage comprising an amplifier tube having a plurality of grids, the method of automatically varying the characteristics of said stage which comprises applying signal energy to the first grid, impressing a variable
10 negative bias on the third grid which varies in accordance with a control voltage, applying a positive bias to the second grid, and utilizing the electronic coupling between said second grid and
15 said third grid to vary the positive bias in phase with the change in bias of said third grid.

18. In a sound recording or reproducing system having an amplifier stage comprising an amplifier tube having a plurality of grids, the
20 method of automatically varying the characteristics of said stage which comprises applying signal energy to the first grid, impressing a variable

negative bias on the third grid which varies in accordance with a control voltage, applying a positive bias to the second grid and utilizing the change in current drawn by said second grid in response to variations in the bias of said third
5 grid for changing the bias of said second grid in phase therewith, so as to produce a control in the same sense.

19. In a sound recording or reproducing system having an amplifier stage comprising an amplifier tube having a plurality of grids, the method
10 of automatically varying the characteristics of said stage which comprises applying signal energy to the first grid, impressing a variable negative bias on the third grid which varies in accordance
15 with a control voltage, impressing a positive bias upon the second and fourth grids, and varying said positive bias in accordance with the control voltage and in phase with the change in bias of
20 said third grid.

ELLISON S. PURINGTON.