Jan. 15, 1946. E. B. PASSOW 2,393,184

TONE CONTROL

Filed Oct. 14, 1944

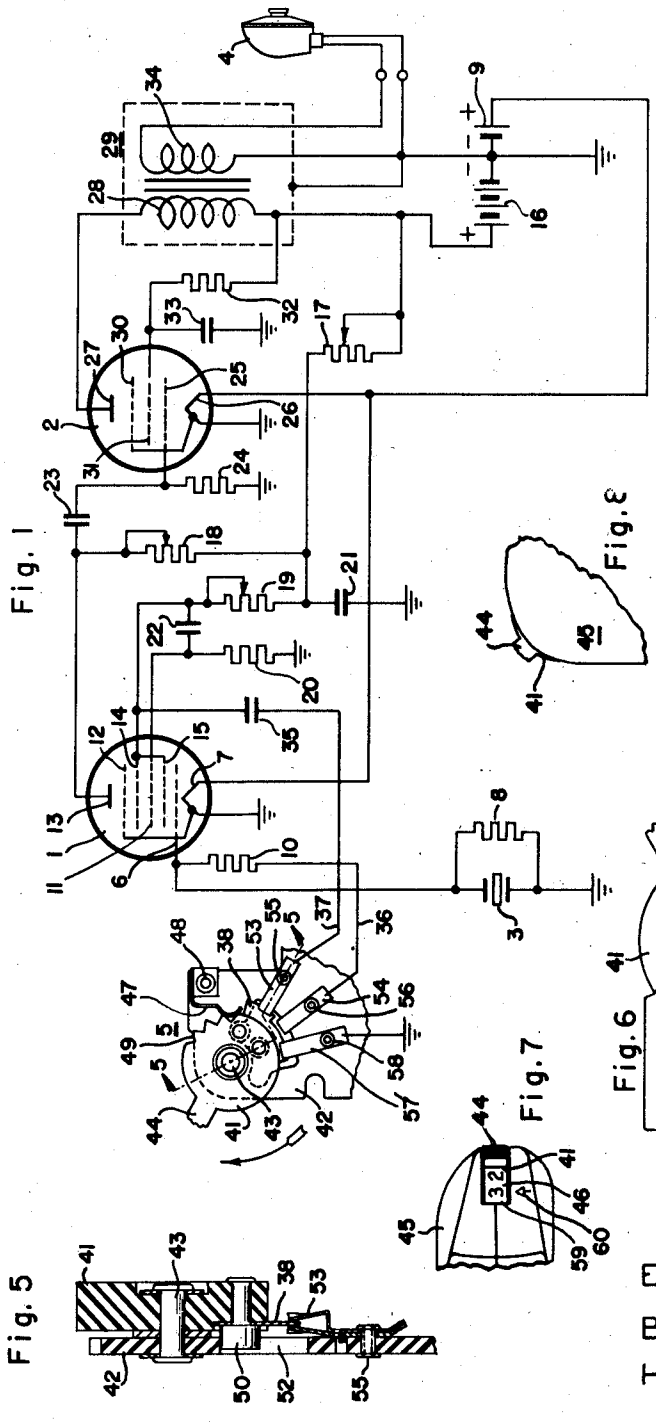


Fig. 1

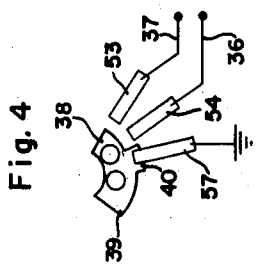


Fig. 4

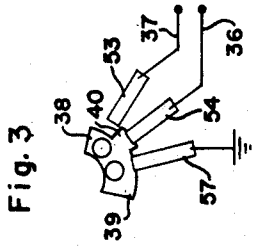


Fig. 3

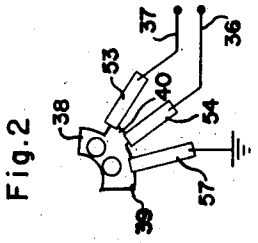


Fig. 2

Fig. 8

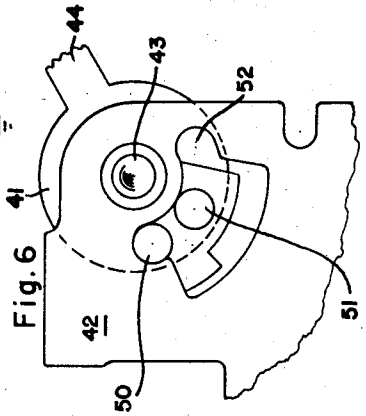


Fig. 6

Fig. 7

Fig. 5

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TONE CONTROL

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Application October 14, 1944, Serial No. 558,723

9 Claims. (Cl. 179—1)

This invention relates to tone control arrangements of the type particularly useful in hearing aid or other portable hearing apparatus.

In hearing aid or other small portable hearing apparatus it is advantageous to have incorporated in such apparatus a single control element readily movable by the wearer to one of a plurality of operating positions corresponding to the particular character of tone desired from such apparatus. This advantage in a tone control arrangement should be obtained by using as few electrical and mechanical elements as possible; otherwise, the cost of the component parts is expensive, the apparatus is needlesly heavy and bulky and it may not be so readily carried or concealed on the person of the user.

It is, therefore, an object of the present invention to provide an improved tone control arrangement which is inexpensive to manufacture, readily operable by the user and which does not add materially to the weight or bulkiness of the apparatus with which it co-acts to produce different characters of tone.

A further object of the present invention is to provide an improved inexpensive switch construction having a minimum number of parts and allowing mass production in a relatively short time.

Still another object of the present invention is to provide a simple improved tone control arrangement especially useful in small portable hearing apparatus.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The present invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing in which:

Fig. 1 shows an improved hearing aid circuit incorporating an improved tone control arrangement in accordance with the present invention;

Figs. 2 through 4 show certain elements of the switch shown in Fig. 5 in different operating positions thereof;

Fig. 5 shows a sectional view taken substantially on line 5—5 of Fig. 1;

Fig. 6 shows, in enlarged form, the other side of the switch construction shown in Fig. 1;

Figs. 7 and 8 show respectively plan and elevational views of a portion of a portable case having incorporated therein a tone control in accordance with the present invention.

In Fig. 1 there is illustrated an improved hearing aid circuit, incorporating a high gain amplifier including electron discharge device 1 and a second amplifier including electron discharge device 2. The two amplifiers successively amplify signals from microphone 3 and impress such amplified signals on sound reproducing device 4 in linearly amplified form. A switch 5, described in detail hereinafter, for effecting tone control is interconnected with device 1.

Sound waves impinging on microphone 3 are transformed into electrical variations in the main control electrode circuit of discharge device 1. The microphone 3 is preferably of the piezo-electric type as illustrated. The device 1 greatly amplifies electrical variations produced by microphone 3 and the amplified electrical variations are further amplified by electron discharge device 2 before being applied to the sound reproducing device 4.

Microphone 3, which produces electrical variations in response to sound waves impinging thereon, is connected between the main control grid 6 and the grounded filamentary cathode 7 of discharge device 1; and a grid leak resistance 8 is connected in parallel circuit relationship with microphone 3 to bypass continuous current flowing around microphone 3 between control grid 6 and the cathode 7. Substantially no grid current flows through resistance 8, because the grid 6 is at a negative potential with respect to the cathode 7, such negative bias potential being provided by connecting grid 6 through resistance 8 to the grounded negative terminal of voltage source 9 across which are connected the opposite terminals of the filamentary cathode 7. It is to be understood, of course, that other conventional means may be used to establish a suitable continuous operating potential between grid 6 and cathode 7 and such means may be a battery or a voltage drop produced by space current flowing through discharge device 1. Resistance 10, much smaller than resistance 8, is also connected in parallel to microphone 3 through switch 5 for a different purpose than resistance 8 as is described hereinafter.

Electron discharge device 1 is of the pentagrid type in commercial use and may, for example, be of the type commonly known as the 1R5. The particular elements of this device 1 are connected in a linear high gain amplifier circuit. This invention is not limited to the use of a discharge device of the type commonly known as the 1R5, but within the scope of the present invention any discharge device which performs equiva-

lent functions is suitable. Large gain is realized when device 1 is connected in the manner hereinafter described and such large gain is substantially independent of signals applied between the main control grid 6 and cathode of discharge device 1.

In general, device 1 is connected so as to be effectively two amplifiers in cascade with regeneration between the two amplifiers. In addition to the main control grid 6, discharge device 10 has what is termed a second control grid 11, a suppressor grid 12 connected to the cathode 7, a main anode 13, and a pair of screen electrodes 14 and 15 on opposite sides of the second control grid 11.

Operating continuous potentials for device 1 are supplied from a voltage source 16 whose negative terminal is grounded and whose positive terminal is connected to the main anode 13 of discharge device 1 through a series circuit including adjustable voltage dropping resistance 17 and output coupling resistance 18. The electrodes 14 and 15 are connected together and are maintained positive with respect to the cathode 7 by connection to the positive terminal of voltage source 16 through the series circuit including voltage dropping resistance 17 and coupling resistance 19. The continuous operating potential of the second control grid 11 is stabilized by connecting it to ground and the cathode 7 through resistance 20, which also serves as a coupling resistance for audio frequency current as described hereinafter.

When alternating current signals are impressed between the main control grid 6 and cathode 7 substantially all of the alternating output voltage appears across output coupling resistance 18, a bypass capacitance 21 of low reactance being connected between the grounded cathode of discharge device 1 and the lower terminal of resistance 18 removed from the main anode 13. Potential variations on electrodes 14 and 15 due to an alternating voltage applied between main control grid 6 and cathode 7 are impressed on the second control grid 11 through a coupling capacitance 22 connected between grids 14 and 15 and grid 11.

Therefore, alternating voltages applied directly to control grid 6 and indirectly to control grid 11 cause alternating output signals to appear across resistance 18, which output signals are then applied to the grid circuit of another linearly amplifying discharge device 2. Coupling capacitance 23 and input resistance 24 are connected in series and the series circuit formed thereby is connected in parallel circuit relationship to the series circuit formed by output coupling resistance 18 and low reactance bypass capacitance 21. Capacitance 23 is of relatively low reactance and serves essentially as a means for blocking the flow of continuous current from source 16 to resistance 24. The alternating voltage developed across resistance 24 through condenser 23 is applied between the first or control grid 25 and cathode 26 of discharge device 2 so as to control the space current therein, which current normally flows due to the fact that voltage source 16 is connected between the anode 27 of device 2 through the primary winding 28 of an output transformer 29.

Discharge device 2 is preferably of the pentode type having its suppressor grid 30 connected to the cathode 26 and with the voltage source 16 connected between its screen grid 31 and cathode 26 through a voltage dropping resistance 32. The screen grid 31 is maintained at constant potential in the presence of signals of frequency corresponding to audio frequency by means of low reactance bypass capacitance 33 which is connected between the screen grid 31 and cathode 26.

Alternating voltages developed across input resistance 24 are amplified linearly by discharge device 2, and appear across the secondary winding 34 of transformer 29 which is connected to impress those amplified voltages on the sound reproducing device 4 which is connected across the terminals of secondary winding 34.

The filamentary cathodes of discharge device 1 and 2 are preferably heated by current flowing therethrough, as shown in Fig. 1, in such case the cathodes 7 and 26 are connected in parallel circuit relationship to voltage source 9.

The circuit thus far described is especially useful as a hearing aid circuit and, because of the high gain obtained by the use of discharge device 1, only two discharge devices requiring small space current are necessary for good performance, even though a tone control arrangement in accordance with the present invention is provided. Because of the high gain obtained from the use of discharge device 1, a highly efficient and useful hearing aid circuit is provided which requires a small current drain from voltage source 9. This is particularly true when, as in this instance, resistances 17, 18 and 19 are relatively large.

The volume of signals reproduced by speaker 4 may be controlled by adjusting volume control resistance 17. An adjustment of resistance 17 causes no substantial non-linearity between the intensity of input signals applied to grid 6 and the intensity of signals developed across resistance 18 over a large range of input signals.

The tone of signals reproduced on sound reproducing device 4 may be controlled by connecting resistance 10 and capacitance 35 in the hearing aid circuit thus far described. In general, resistance 10 which may be connected in parallel circuit relationship to piezoelectric microphone 3 serves to reduce the intensity of low frequency signal components, and capacitance 35 which may be connected between the electrode 14 and cathode 7 of discharge device 1 serves to reduce the intensity of high frequency signal components. For this purpose, switch 5 serves to connect the lead 36 of resistance 10 to ground and also serves to connect the lead 37 of condenser 35 to ground. Different types of tone may be produced corresponding to the four positions of the tone control switch member 38 shown in Figs. 1–4. That is, switch member or metallic short circuiting bar 38 having an inwardly disposed body portion 39 and an outwardly extending projecting body 40 is of such shape that in its clockwise movement, bar 38 assumes positions whereby: (1) as in Fig. 1 the capacitance 35 alone is connected in the hearing aid circuit and high frequencies only are suppressed, and (2) as in Fig. 2 when both resistance 10 and capacitance 35 are connected in the hearing aid circuit, both some of the high and some of the low frequencies are suppressed, and (3) as in Fig. 3 when resistance 10 alone is connected in the hearing aid circuit only some of the low frequencies are suppressed, and (4) as in Fig. 4 when neither the resistance 10 nor the capacitance 35 is connected in the hearing aid circuit, neither the high notes nor the low notes are affected. The resistance 17, when its

lead 36 grounded causes no attenuation in the ordinary sense of the word, but its function is to present a different degree of mismatch as a function of frequency to the crystal microphone 3 whose equivalent circuit may be represented by a voltage source in series with the equivalent condenser. The resistance 10 serves as a better match for the equivalent condenser at the higher frequencies than at the lower frequencies. Accordingly, more energy is transferred to the resistance 10 at higher frequencies than at lower frequencies.

As mentioned previously, discharge device 1 operates as two amplifying stages combined in the envelope of one discharge device with regeneration between the two amplifying stages. The first stage may be considered to comprise a triode section including the cathode 7, main control grid 6 and electrode 15, which electrode operates as the anode of a conventional triode. The second amplifying stage operates as a pentode and includes control electrode 11, screen electrode 14, suppressor electrode 12 and anode 13.

The overall gain of discharge device 1 is preferably adjusted by adjusting the amount of regeneration in discharge device 1. It is desirable to make the amount of regeneration such that linear operation of the stage including device 1 is assured consistent with as high gain as possible. For purposes of analysis, the two stages may be considered to be equivalent to two separate discharge devices, a triode and a pentode, connected in cascade, wherein the regeneration may be viewed as a negative resistance of the dynatron type connected across the anode load of the triode.

The regeneration which comes into being is believed to be due to negative transconductance from second control grid 11 to the screen electrodes 14 and 15. This negative transconductance effect is produced in accordance with the following constructions: the total cathode space current of device 1 is substantially independent of the voltage applied to the second control grid 11, which controls the distribution of current between electrode 15 on one side and electrode 14 and anode 13 on the other side. Since the two electrodes 14 and 15 are connected together, substantially equal and opposite effects are produced on the electrode 15 and on electrode 14 and anode 13 by a change of the voltage on the second control grid 11. That is, if electrode 11 is made more negative, more space current tends to flow to electrode 15 and less to electrode 14 and anode 13. But the decrease in current to electrode 14, which shares its current with anode 13, is less than the increase in current to electrode 15. Therefore, the total current to electrodes 14 and 15 increases with a more negative potential on electrode 11 and current to anode 13 decreases. Accordingly, the transconductance between second control grid 11 and anode 13 is positive, and the transconductance between second control grid 11 and connected electrodes 14 and 15 is negative. When, as in the illustrated circuit, the current flowing to connected electrodes 14 and 15 produces a varying voltage drop across external resistance 19 in response to voltage variations impressed on main control grid 6 and at least a portion of that voltage drop is fed back to the second control grid 11, through coupling capacitance 22 for further controlling the electron stream in discharge device 1 regeneratively by voltage on electrode 11. That is, in Fig. 1, it appears as though a negative resistance effect, which causes regeneration for signals of audio frequencies, occurs between connected electrodes 14 and 15, second control grid 11 and the cathode 7, considered as a group, since coupling condenser 22 is of low reactance for signals of audio frequency.

In the particular amplifier circuit shown in Fig. 1, when properly adjusted, the increase in triode gain in discharge device 1 due to regeneration is about 70%. It is possible, however, to increase the regeneration to such an extent that a gain of about 2000 is obtained in the triode section alone. This condition is not satisfactorily stable.

In general, any means that causes a change in transconductance between the control electrode 11 and anode 13 may be used to control negative transconductance between control grid 11 and connected electrodes 14 and 15 so that the amount of regeneration in discharge device 1 is also changed. That is, when the positive transconductance between grid 11 and anode 13 is high, the negative transconductance between control grid 11 and grids 14 and 15 is also high. For that reason, the amount of regeneration is adjusted by adjusting the anode output resistance 18. When anode resistance 18 is decreased below a critical resistance, the transconductance between the control grid 11 and anode 13 is increased so that device 1 breaks into oscillation, due to the corresponding increase in negative transconductance between control grid 11 and connected grids 14 and 15. The signal voltage developed across resistance 18 is, of course, equal to the signal current flowing therethrough, multiplied by the ohmic magnitude of resistance 18. By making resistance 18 high in magnitude the transconductance of the device is lowered but the voltage developed across resistance 18 tends to remain constant.

Characteristics and operating features of device 1 are further set forth in the co-pending application of John G. Prentiss, filed October 4, 1943, Serial Number 504,958, and assigned to the same assignee as the present invention.

Tone control is produced by adjusting the position of the manually operated movable element 41 which is rotatably mounted on insulating support 42 by means of pin 43 (Fig. 5). Movable element 41 has an integrally formed projection 44 which extends out from the housing or hearing aid case 45 for convenient manipulation by the finger of an operator and also has suitable indicia 46 for indicating to the operator the operating position of movable element 41. Movable element 41 may be held in any one of the four positions by means of a resilient finger 47, having one of its ends fastened to support member 42 by means of rivet 48 and its free end arranged to enter into one of a series of four equally spaced notches 49 on the periphery of rotatably mounted element 41.

Rotational movement of element 41 is limited substantially to the angular distance corresponding to the overall spacing of the four notches 49 by means of the heads of rivets 50 and 51, respectively engaging the opposite sides of the walls defining aperture 52 in support member 42. Rivets 50 and 51 not only serve to limit rotational movement of element 41 but also serve to fasten the metallic short circuiting bar 38 to element 41, preferably of insulating material, whereby bar 38 is moved simultaneously with element 41.

As seen in Figs. 1–4, short circuiting bar 38

extends beyond the periphery of element 41 where such bar has a width corresponding substantially to the angular distance through which element 41 may be rotated. Bar 38 comprises an inwardly disposed body portion 39 and a projecting portion 40 which extends outwardly from the axis of element rotation so as to engage contact members 53 and/or 54 respectively, fixedly mounted on insulating support 42 by means of rivets 55 and 56. A third contact member 57 fixed on insulating support 42 by means of rivet 58 extends further inwardly than the other two contact members 53 and 54 so as to engage the body portion 39 of bar 38 in all positions of element 41. Contact members 53, 54 and 57 are preferably equally spaced in that order at the periphery of element 41 with the overall distance from contact member 53 to contact member 57 being of the order of the permissible angular movement of element 41 and with contact member 57 extending further inwardly in a radial direction than the other two contact members 53 and 54 such that contact member 57 continuously engages bar portion 39 and contact members 53 and 54 engage only bar portion 40 when it is in predetermined positions determined by the position of resilient finger 47 in a particular notch 49. Bar projection 40 has a width substantially equal to the spacing between contact members 53 and 54 and so disposed as to short circuit those members 53 and 54 in one predetermined position of contact member 41 as shown in Fig. 2 and to engage respectively only one of the two contact members 53 and 54 in other predetermined positions of element 41 (Figs. 1 and 3). In the fourth predetermined position shown in Fig. 4 neither the contact member 53 nor the contact member 54 is engaged by bar portion 40.

As shown in Fig. 1, contact member 53 is connected through lead 37 to one terminal of condenser 35, contact member 54 is connected through lead 36 to one terminal of resistance 10, and contact member 58 is grounded so as to continuously maintain the short circuit bar 38 at ground potential for effecting the tone control previously described by manipulating control element 41.

Control element 41 is rotatably mounted not only to be easily operated by the finger of the operator but also such as to be placed at the corner of a hearing aid case 45 where it is readily accessible to the operator and does not distract from the general appearance of the case. The case 45 is preferably made with rounded corners so as to reduce noises produced by rubbing of the operator's garments on the housing. As shown in Fig. 7, even though the tone control element 41 is mounted at a corner of the housing, the element 41 is so shaped and so moved and positioned in its different operating positions that the benefits of a rounded corner are obtained together with an easily accessible and easily operated tone control.

In Fig. 7, the edge 59 of the hearing aid case 45 serves to obscure certain indicia on control element 41 depending upon its particular position. The arrow 60 engraved on the hearing aid case points to the particular predetermined position of the tone control element 41 and the position 3 shown in Fig. 1 corresponds to the position of element 38 shown in Fig. 2.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from this invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. In combination, a support, a movable element rotatably mounted on said support, means for limiting the rotatable movement of said element with respect to said support to a relatively small arc of a circle, said element having spaced notches therein along a length thereof corresponding to said arc, three spaced insulated contact members mounted on said support and arranged along said arc of said circle, a metallic short circuiting bar carried on the periphery of said rotatable element and arranged to make contact with said contact members in different predetermined positions of said element, said bar having a width corresponding to the length of said arc, resilient means mounted on said support and biased into said notches for maintaining said movable element in any one of a plurality of predetermined positions wherein said bar is positioned differently relative to said contact members, said bar having an inwardly disposed body portion and a projecting portion, said projecting portion extending outwardly from the axis of rotation of said element and having a width at least as great as the distance between two adjacent ones of said contact members, the other one of said contact members extending radially inwardly a distance sufficient to engage said body portion in all positions of said element, said notches having such spacing that in one position of said element said projecting portion engages only one of said two adjacent contact members, in a second predetermined position both of said adjacent contact members are engaged by said projecting portion and in a third predetermined position only the other one of said adjacent contact members is engaged by said projecting portion.

2. In combination, a support, a movable element rotatably mounted on said support, said support having an aperture, said element having spaced notches therein along a length thereof, three spaced insulated contact members mounted on said support and arranged near the periphery of said element, a metallic short circuiting bar, means for fastening said bar on the periphery of said rotatable element whereby said bar makes contact with said contact members in different predetermined positions of said element, said fastening means having a head thereon arranged to engage the walls defining said aperture of said support whereby the rotatable movement of said element with respect to said support is limited to a relatively small arc of a circle, said bar having a width corresponding to the length of said arc, resilient means mounted on said support and biased into said notches for maintaining said movable element in any one of a plurality of predetermined positions wherein said bar is positioned relative to said members, said bar having an inwardly disposed body portion and a projecting portion, said projecting portion extending outwardly from the axis of rotation of said element and having a width at least as great as the distance between two adjacent ones of said contact members, the other one of said contact members extending radially inwardly a distance sufficient to engage said body portion in all positions of said element, said notches having such spac-

ing that in one position of said element said projecting portion engages only one of said two adjacent contact members, in a second predetermined position both of said adjacent contact members are engaged by said projecting portion and in a third predetermined position only the other one of said adjacent contact members is engaged by said projecting portion.

3. In combination, an electron discharge device having a first and second electrode, separate means including a control grid for providing in said device an electron discharge stream modulated in intensity at frequencies within a predetermined band of frequencies, said first electrode being so arranged with respect to said stream as to develop an alternating potential in response to the intensity modulation of said stream, said second electrode being arranged to affect said electron stream in response to potentials impressed on said second electrode after said stream affects said first electrode, means for impressing substantially all of said alternating potential developed by said stream on said first electrode upon said second electrode, whereby potentials impressed on said second electrode after being developed on said first electrode increase the effect on said first electrode of intensity modulation of the electron stream beyond the effect which would exist without the impression of such alternating potential upon said second electrode, an electroacoustical transducer connected to said control grid, a first frequency selective impedance element for transferring selectively certain frequency components of signals from the transducer to said control grid, a second impedance element for altering the degree to which signals of different frequencies are amplified in said discharge device, and means for operatively connecting said first and second mentioned impedances respectively to said transducer and/or said first electrode.

4. In combination, an electron discharge device having a first and second electrode, separate means for producing in said device an electron discharge stream modulated in intensity at frequencies within a predetermined band of frequencies, means for impressing a positive average potential on said first electrode whereby said stream develops an alternating potential on said first electrode in response to the intensity modulation of said stream, said second electrode being arranged to affect said electron stream in response to potential impressed on said second electrode after said stream affects said first electrode, means for impressing substantially all of said alternating potential developed by said stream on said first electrode upon said second electrode, whereby potentials impressed on said second electrode after being developed on said first electrode increase the effect on said first electrode of intensity modulation of the electron stream beyond the effect which would exist without the impression of such alternating potential upon said second electrode, an impedance element for altering the degree to which signals of different frequencies are amplified in said discharge device, and means for selectively connecting said impedance element to said first electrode.

5. In combination, an electron discharge device having a first and second electrode, separate means for producing in said device an electron discharge stream modulated in intensity at frequencies within a predetermined band of frequencies, means for impressing an average positive potential on said first electrode whereby said stream develops an alternating potential on said first electrode in response to the intensity modulation of said stream, means for impressing a smaller average potential on said second electrode, said second electrode being arranged to affect said electron stream in response to alternating potentials impressed on said second electrode after said stream affects said first electrode, means for impressing substantially all of said alternating potential developed by said stream on said first electrode upon said second electrode, whereby potentials impressed on such second electrode after being developed on said first electrode increase the effect on said first electrode of intensity modulation of the electron stream beyond the effect which would exist without the impression of such alternating potential upon said second electrode, an impedance element for altering the degree to which signals of different frequencies are amplified in said discharge device, and means for selectively connecting said impedance element to said first electrode.

6. In combination, an electron discharge device having a cathode, a control electrode and two anode electrodes, means for producing a regenerative effect on one of said anode electrodes to increase the intensity of signals impressed on said control electrode and appearing on the other of said anode electrodes, means for impressing a signal having frequencies within a predetermined band of frequencies on said control electrode, an impedance, and means for selectively connecting said impedance between said cathode and one of said electrodes to alter the relative amount of amplification of signals in said discharge device over said band of frequencies.

7. In combination, an electron discharge device having a cathode, a control electrode and two anodes, means for producing a regenerative effect on one of said anodes to increase the intensity of signals impressed on said control electrode and appearing on the other of said anodes, means for impressing a signal having frequencies within a predetermined band of frequencies on said control electrode, two unlike impedances, and means for selectively connecting one of said impedances between said cathode and said control electrode, the other of said impedances between said cathode and one of said anodes, both of said impedances between said cathode and respectively said control electrode and said one anode simultaneously, and for disconnecting both of said impedances whereby the relative amount of amplification of signals in said discharge device of said band frequencies is correspondingly altered.

8. In combination, a support, a movable element rotatably mounted on said support, means limiting the rotatable movement of said element with respect to said support to a relatively small arc of a circle, said element having at least one positioning member thereon to hold said element in at least one predetermined adjusted position intermediate the extremities of said arc along a length thereof corresponding to said arc, three spaced insulated contact members mounted on said support and arranged along said arc of said circle, a metallic shortcircuiting bar carried on the periphery of said rotatable element and arranged to make contact with said contact members in different predetermined positions of said element, said bar having a width corresponding to the length of said arc, at least one cooperating positioning member mounted on said

support and cooperating with said first mentioned positioning member to hold said element in said one predetermined adjusted position such that said bar may be positioned differently relative to said contact members, said bar having an inwardly disposed body portion and a projecting portion, said projecting portion extending outwardly from the axis of rotation of said element and having a width at least as great as the distance between two adjacent ones of said contact members, the other one of said contact members extending radially inwardly a distance sufficient to engage said body portion in all adjusted positions of said element, said cooperating positioning members being spaced such that in one position of said element said projecting portion engages only one of said adjacent contact members, in a second predetermined position both of said adjacent contact members are engaged by said projecting portion, and in a third predetermined position only the other one of said adjacent contact members is engaged by said projecting portion.

9. In combination, a support, a movable element rotatably mounted on said support, means limiting the rotatable movement of said element with respect to said support to a relatively small arc of a circle, said element having at least one positioning member thereon to hold said element in at least one predetermined adjusted position intermediate the extremities of said arc, three spaced insulated contact members arranged along said arc of said circle, a metallic shortcircuiting bar arranged to make contact with said contact members in different predetermined positions of said element, movement of said movable element producing relative movement between said three insulated contact members and said shortcircuiting bar, said bar having a width corresponding to the length of said arc, at least one cooperating positioning member mounted on said support and cooperating with said first mentioned positioning member to hold said element in said at least one predetermined adjusted position, and arranged such that said bar may be positioned differently relative to said contact members, said bar having an inwardly disposed body portion and a projecting portion, said projecting portion extending outwardly from the axis of rotation of said element and having a width at least as great as the distance between two adjacent ones of said contact members, the other one of said contact members extending radially inwardly a distance sufficient to engage said body portion in all positions of said element, said cooperating positioning members being arranged such that in one adjusted position of said element said projecting portion engages only one of said two adjacent contact members, in a second predetermined adjusted position both of said adjacent contact members are engaged by said projecting portion, and in a third predetermined adjusted position only the other one of said adjacent contact members is engaged by said projecting portion.

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