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AUDIO VOLUME EXPANDER CIRCUIT

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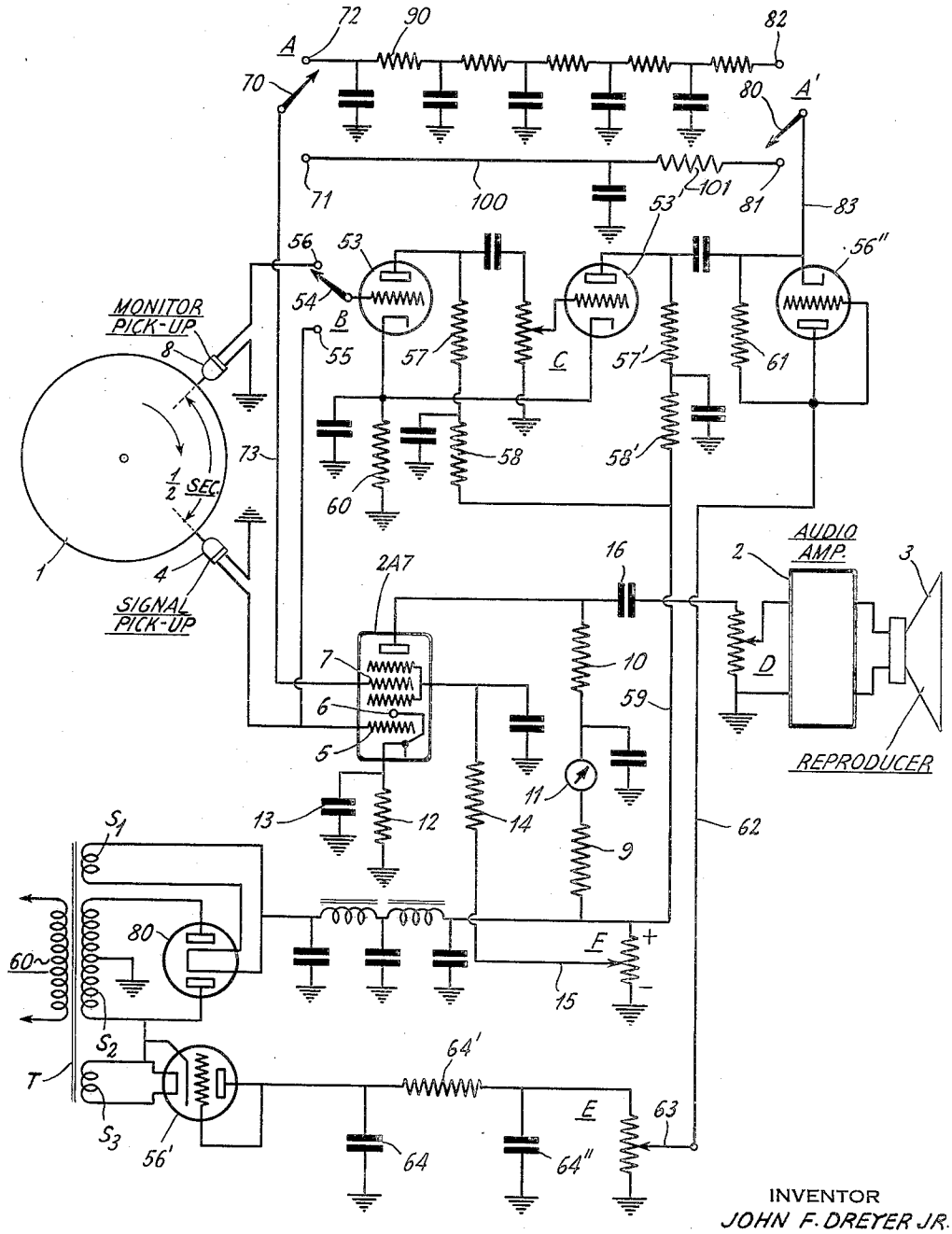

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AUDIO VOLUME EXPANDER CIRCUIT

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My present invention relates to automatic volume control circuits, and more particularly to automatic volume expander circuits for audio frequency amplifier systems.

One of the main objects of my present invention is generally to provide an improvement in automatic volume expander networks for audio frequency amplifiers, the improved volume expander utilizing in combination with the audio frequency amplifier and reproducer, an expander tube which is provided with a pair of control electrodes, one of which electrodes is adapted to have impressed upon it the audio frequency signal to be reproduced, and the other electrode having impressed upon it a control voltage for automatically regulating the audio output of the reproducer in response to variations in the audio envelope of the signal to be reproduced.

Another important object of the invention may be stated to reside in the provision of a volume expander network for an audio amplifier system of sound records, which expander operates to amplify loud audio signals to a greater extent than weak signals, and the regulation being accomplished by the utilization of an electron discharge device which includes a special expansion control electrode, and the control voltage being applied to the latter through a network having a long time constant.

Other objects of the invention are to improve generally the simplicity and efficiency of volume expansion systems for audio amplifiers, and more especially to provide a volume expander network for a sound record reproducer system which will not only be reliable and efficient in operation, but economically manufactured and assembled.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawing in which I have indicated diagrammatically a circuit organization whereby my invention may be carried into effect.

Referring now to the accompanying drawing, wherein is shown a circuit diagram of an embodiment utilizing my present invention, it is first pointed out that, in general, the sound record reproduction system comprises the usual sound record 1, the audio amplifier 2 and reproducer 3. The sound record 1 may be of any desired type, and, as well known, may have a period of revolution of 1.2 seconds. The audio amplifier 2 may include one, or more, stages of audio frequency amplification, the input thereof including a variable potentiometer D which functions as a manual volume control to regulate the input energy to the audio amplifier. The reproducer 3 may be of any desired type, and, since those skilled in the art are fully aware of the different types of reproducers which may be utilized, further explanation is not thought necessary.

Between the audio frequency signal pick-up device 4 and the variable potentiometer D there is disposed an electron discharge tube of the 2A7 type. This type of tube is very well known to those skilled in the art at the present time, and is graphically shown in the drawing; it comprises a cathode, a plate, and a signal input grid 5, an auxiliary electrode 6, which is for the purpose of the present invention tied back to the cathode; an additional auxiliary electrode 7, the latter being disposed between a pair of positively biased screen grid electrodes.

The electrode 7 functions as the gain control electrode of the 2A7 type tube. Signal energy for providing gain control voltage for electrode 7 may be derived from the monitor pick-up device 8 or the pick-up 4. The pick-ups 4 and 8 may be of any conventional type well known to those skilled in the art, and for this reason the construction thereof need not be shown in any further detail.

The direct current energizing voltages are provided for the 2A7 tube from a power supply source which comprises an 80 type alternating current rectifier. The primary winding of the transformer T is connected to the usual 60 cycle alternating current source, and the secondary winding is divided into three sections; the section S_1 being connected to the cathode of the tube 80; the section S_2 having its opposite ends connected to the anodes of the tube; and the section S_3 being connected to the heater element of a tube 56'. The usual multi-section filter is disposed in the output of the alternating current rectifier 80, and the bleeder resistor F is connected across the output of the power filter network. The bleeder resistor may have a magnitude of approximately 30,000 ohms, and the positive side thereof is connected to the plate of the 2A7 tube through a pair of resistors 9 and 10, the junction of which resistors is connected to ground through a condenser, and each of which resistors may have a magnitude of approximately 50,000 ohms. A milliammeter 11 may be disposed between resistors 9 and 10 to indicate the ampli-

tude of the plate current of the 2A7 type tube. The normal operating negative bias for the signal input grid 5 is provided by the usual cathode resistor 12, suitably by-passed by condenser 13, and the resistor 12 may have a magnitude of some 300 ohms.

Proper positive voltage for the screen electrodes of the 2A7 type tube is provided through the path including resistor 14 and lead 15, the latter lead being connected to any desired point on the bleeder resistor F by means of an adjustable tap. The cathode side of bleeder resistor F may have a magnitude of approximately +300 volts. The ungrounded side of the resistor element of the manual volume control device D is connected to the plate of the 2A7 type tube through a coupling condenser 16, and, as stated before, adjustment of the variable element of the control D varies the audio input amplitude to the audio amplifier 2.

The monitoring network comprises an electron discharge tube 53 having its control grid connected to an adjustable switch element 54 of switch B. The switch B is provided with contacts 55 and 56. The contact 56 is connected to the ungrounded terminal of the pick-up 8, and the contact 55 is connected to the signal grid 5 of the 2A7 tube. The plate of tube 53 is connected to the positive ungrounded side of bleeder resistor F through a path which includes resistor 57 having a magnitude of about 50,000 ohms, resistor 58 having a magnitude of about 20,000 ohms, and lead 59. The junction of resistors 57 and 58 is connected to ground through a by-pass condenser.

The tube 53' has its control grid connected by an adjustable lead to a point on the resistor of potentiometer C, the resistor having a magnitude of about 500,000 ohms. One side of resistor C is connected to the plate of tube 53 through a coupling condenser, and the other side of the resistor is grounded. The cathode of tube 53' is connected to the cathode of tube 53, and the usual condenser by-passed resistor 60 provides a grid bias for tubes 53 and 53', it being pointed out that the resistor 60 has a magnitude of about 500 ohms. The lead 59 is further connected to the plate of tube 53' through resistor elements 58' and 57', and these resistors may have magnitudes similar to those of resistors 58 and 57.

The amplified output of tube 53' is impressed upon a 56 type tube which has its grid and plate strapped together so as to provide a diode device. The diode 56'' has its cold output electrode connected to the cathode thereof through a resistor 61, having a magnitude of about 500,000 ohms; the cathode side of resistor 61 being connected to the plate of tube 53' through a condenser having a magnitude of about 0.01 mfd. The cold output electrode of diode 56'' is connected by lead 62 to a bleeder resistor E, which has a magnitude of about 20,000 ohms. The lead 62 terminates in an adjustable tap 63, and the ungrounded side of bleeder resistor E has a voltage magnitude of approximately −100 volts.

The alternating current rectifier 56' has its cathode connected to the heater element of the tube, and also to the anodes of rectifier 80. The grid and plate of tube 56' are strapped together, and the filter network 64—64'—64'' is disposed between the bleeder resistor E and the output electrode of rectifier 56', the resistor 64' having a magnitude of approximately 20,000 ohms. The separate rectifier 56' functions to provide the initial negative bias for the gain control grid 7 of the expander tube. While the bleeder F could be used for this purpose, the separate bleeder E prevents audio instability and "motor-boating" effects.

Switches A and A' are provided in order to permit selection of a desired time constant network for the control network. Thus, switch A comprises an adjustable switch element 70 and a pair of contacts 71 and 72. The adjustable element 70 is connected by lead 73 to the gain control electrode 7 of the 2A7 tube. The selector switch A' comprises an adjustable element 80 and contact elements 81 and 82, the adjustable element 80 being connected by lead 83 to the cathode of diode 56''. When adjustable elements 70 and 80 are connected to contacts 72 and 82 respectively, the short time constant network comprising the plurality of series resistors and shunt condensers is connected in circuit. This short time constant network is generally designated by the numeral 90, and each of the series resistors may have a magnitude of approximately 0.5 megohm; each of the shunt condensers may have a magnitude of approximately 0.02 mfd. The long time constant network, generally designated by the numeral 100, comprises a series resistor 101 having a magnitude of approximately two megohms and a shunt condenser having a magnitude of approximately 0.25 mfd.

Considering now the operation of the volume expander system shown in the drawing, and described in detail above, it will be observed that the monitoring pick-up 8 is only in use when the adjustable element 54 of switch B is connected to contact 56. When the element 54 is connected to contact 55 the signal input to the monitoring network 53—53'—56'' is from the signal pick-up 4. Again, when the switches A—A' have their adjustable elements 70 and 80 connected to contacts 71 and 81 respectively then the long time constant circuit is in use. The delay of the long time constant network may be of the order of 1.2 seconds.

However, when the elements 70 and 80 are connected to contacts 72 and 82 respectively, then the short time constant circuit is connected between the gain control diode 56'' and the gain control electrode 7. When the adjustable element 54 of switch B is connected to contact 55, and elements 70 and 80 are connected to contacts 71 and 81, then the usual signal pick-up device 4 is utilized with a long time constant. The short time constant network is preferably used when the sound record 1 has been made with a compressor circuit having similar short time constant.

Assuming, by way of illustration, that the signal pickup device 4 is being utilized, and that the long time constant network is used, then when loud signals are impressed upon the grid 5, such signals will be amplified by the gain control amplifiers 53 and 53', and thus the cathode side of resistor 61 will be increased in positive potential. This results in a reduction in the normal negative bias of the gain control electrode 7 of the 2A7 tube. In fact, with loud signals greater increments of positive potentials are produced at contacts 81 and 71 than with weak signals. The result is greater amplification of the loud signals than with the weak ones with consequent volume expansion. Of course, during recording the reverse action (compression) has taken place.

When it is desired to utilize the monitoring pick-up 8 it is merely necessary to throw the adjustable element 54 into connection with contact 56, and a similar action will take place. When it is de-

sired to utilize the short time constant circuit **90**, it is merely necessary to throw the adjustable elements **70** and **80** into connection with contacts **72** and **82**. The pick-up **8**, when used, will receive signals from the record grooves and produce an increasing direct voltage at A at the transition point between soft and loud passages. However, this will be delayed by approximately the time constant of network **100**. Hence, the pick-up **8** is spaced from pick-up **4** on record **1** a distance corresponding to 1.2 seconds in period of revolution, this being the time constant value.

It is to be understood that the system is capable of use with but pick-up **4** connected to the gain control circuit. If the monitor pick-up is to be used, then it should be displaced by the angular distance noted. A6L7 type tube may be used in place of the 2A7 tube; whereas in the former the signal grid **5** is of the variable mu type and the grid **7** is not, in the latter the reverse is true. The indicator **11** is used to secure the initial adjustment of expander tube 2A7. Varying tap **63**, or tap **15**, will adjust the minimum operation point of the 2A7 tube; at this point with no signal input there is a slight flow of plate current. The tap of potentiometer C may be used to secure the maximum adjustment setting of the expander tube, and the indicator **11** can be used to indicate such operation.

It is also pointed out that the time constant network **100**, when in circuit, performs an additional function. It limits the bias of grid **7** to zero bias when the voltage applied to it from diode **56''** becomes sufficiently positive to overcome the normal negative bias. This occurs by virtue of grid current flow through the series resistor of network **100** as the grid **7** swings positive. Thus, distortion and other undesirable effects are effectively prevented.

While I have indicated and described a system for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In combination with an electron discharge tube provided with a cathode, signal input electrode, gain control electrode, and an output electrode, means for impressing upon the signal input electrode an audio signal to be amplified in said tube, means for normally biasing the gain control electrode negatively with respect to the cathode, a reproducer, a signal transmission network coupling the reproducer to the output electrode of said tube, audio volume range expander means responsive to an increase in amplitude of said audio signal for automatically varying the bias of the gain control electrode of said tube in a positive potential sense to reduce said normal negative bias, said last means having a time constant which is relatively long.

2. In combination with an electron discharge tube provided with a cathode, signal input electrode, a normally negatively biased grid and an output electrode, means for impressing upon the signal input electrode a signal to be amplified in said tube, a reproducer, a signal transmission network coupling the reproducer to the output electrode of said tube, means having a relatively long time constant responsive to an increase in amplitude of said signal for automatically reducing the bias of said grid and increasing the gain of said tube, said source of signals comprising a sound record, said signal input electrode of the gain regulated tube being connected to the sound record through a signal pick-up device.

3. In combination with an electron discharge tube provided with a cathode, signal input electrode and an output electrode, means for impressing upon the signal input electrode an audio signal to be amplified in said tube, a reproducer, a signal transmission network coupling the reproducer to the output electrode of said tube, a special negatively biased gain control grid in said tube means responsive to an increase in amplitude of said signal for automatically reducing the bias of the grid and increasing the gain of said tube, additional means for varying at will the time constant of the regulating means from short to long, and said gain regulating means including a signal rectifier connected to said audio source.

4. In combination with an audio frequency amplifier tube which includes a cathode, a plate, signal grid and at least one negatively biased auxiliary control electrode, a source of audio frequency signals connected to the signal grid, audio volume range expansion means responsive to an increase in the amplitude of said audio frequency signals for varying the potential of said auxiliary electrode in a positive potential sense to reduce the bias thereof with respect to the cathode, and means for reproducing the audio signals coupled to the plate of said audio amplifier tube.

5. In combination with an audio frequency amplifier tube which includes a cathode, a plate, signal grid, at least one auxiliary control electrode, and means surrounding the latter with a positive potential field, a source of audio frequency signals connected to the signal grid, audio volume range expansion means responsive to an increase in the amplitude of said audio frequency signals for varying the potential of said auxiliary electrode in a positive potential sense with respect to the cathode to increase the amplifier gain, means for reproducing the audio signals coupled to the plate of said audio amplifier tube, a time constant network, and means for connecting said time constant network between said auxiliary electrode and said gain regulation means.

6. In combination with an audio frequency amplifier tube which includes a cathode, a plate, signal grid and at least one negatively biased auxiliary control electrode, a source of audio frequency signals connected to the signal grid, expander means responsive to an increase in the amplitude of said audio frequency signals for varying the potential of said auxiliary electrode in a positive potential sense with respect to the cathode, means for reproducing the audio signals, said gain regulation means including a rectifier of the diode type, the diode electrodes being connected through a resistor, and the cathode side of said diode resistor being connected through a long time constant network to the said auxiliary electrode of said amplifier tube.

7. In combination with an audio frequency amplifier tube which includes a cathode, a plate, signal grid and at least one auxiliary control electrode, a source of audio frequency signals connected to the signal grid, means responsive to an increase in the amplitude of said audio frequency signals for varying the potential of said auxiliary electrode in a positive potential sense with respect to the cathode, means for repro-

ducing the audio signals, means for energizing the electrodes of said amplifier tube with direct current voltages of predetermined operating magnitudes, and a second source of negative direct current voltage independent of said energizing means connected between the cathode and auxiliary electrode of the amplifier to normally bias the control electrode thereby preventing audio instability.

8. In combination with an audio frequency amplifier, a tube which includes a cathode, a plate, signal grid and at least one negatively biased auxiliary control electrode, a source of audio frequency signals connected to the signal grid, means responsive to an increase in the amplitude of said audio frequency signals for varying the potential of said auxiliary electrode in a positive potential sense to reduce said bias with respect to the cathode, means for reproducing the audio signals coupled to the amplifier, said audio frequency signal source comprising a sound record, a signal pick-up device, and said signal pick-up device being connected to the signal grid of said tube and the first means.

9. In combination in an audio amplifier network, a sound record, a signal pick-up device, an electron discharge tube amplifier of a type including a signal grid, and a negatively biased auxiliary gain control grid having a variable mu construction, both grids being separated by a positive screening field, an audio amplifier network connected to the output electrode of said first named tube, a monitor circuit comprising at least one amplifier having its input electrode adapted for selective connection to said pick-up device, a diode rectifier connected to said monitor amplifier, a time constant network, means for connecting the monitor rectifier to said time constant network, and means for connecting said gain control electrode of a potential point of said amplifier tube to said time constant network such that its bias is reduced with audio signal increase.

10. In combination with an audio frequency amplifier tube which includes a cathode, a plate, signal grid and at least one negatively biased auxiliary control electrode, a source of audio frequency signals connected to the signal grid, audio volume range expansion means responsive to an increase in the amplitude of said audio frequency signals for varying the potential of said auxiliary electrode in a positive potential sense to reduce the bias thereof with respect to the cathode, a positive screen grid electrode positioned within the amplifier tube between said signal grid and control electrode, and means for reproducing the audio signals coupled to the plate of said audio amplifier tube.

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