Nov. 10, 1942. J. B. GEHMAN 2,301,268

SOUND RECORDING APPARATUS

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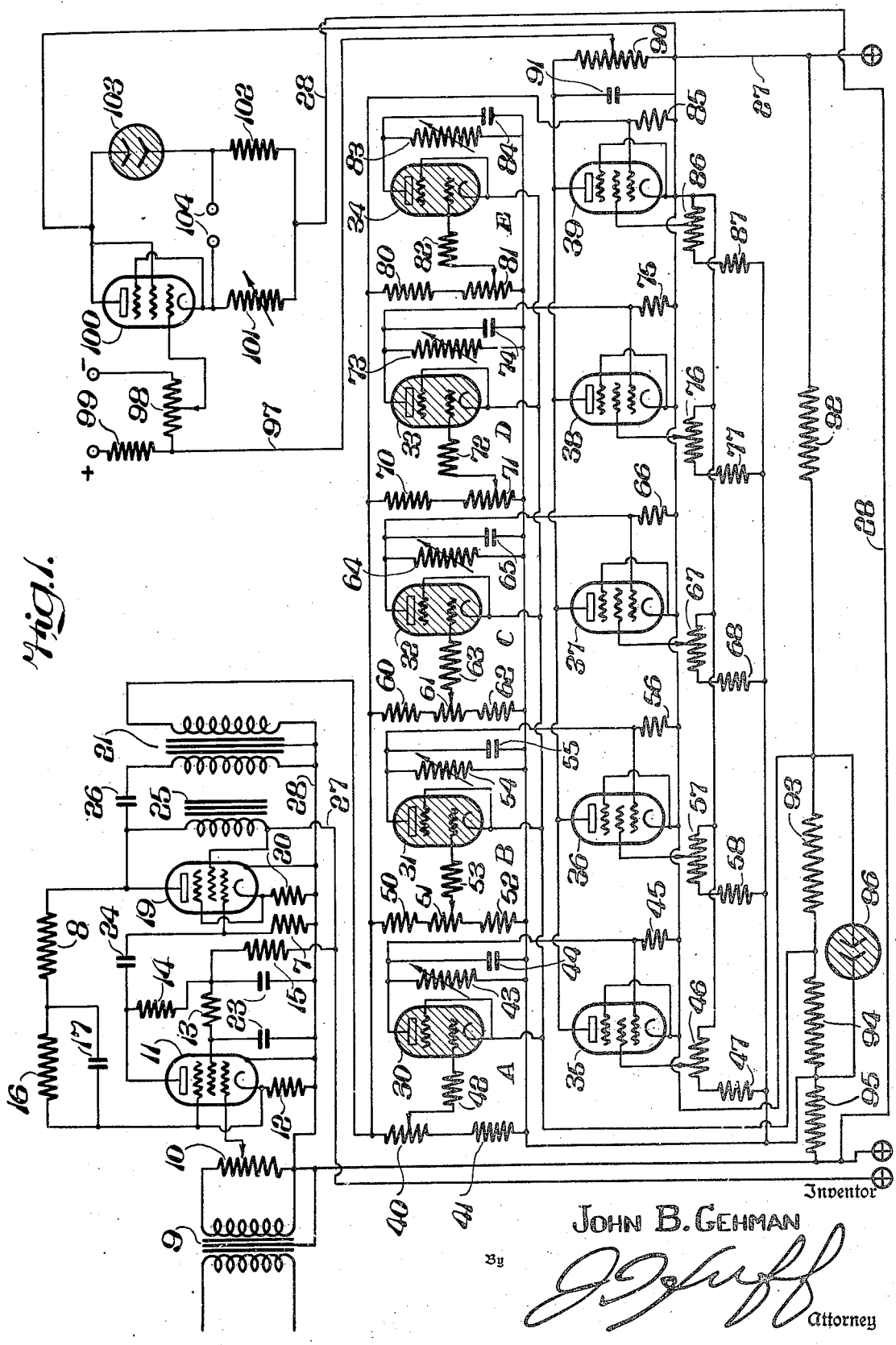


Fig. 1.

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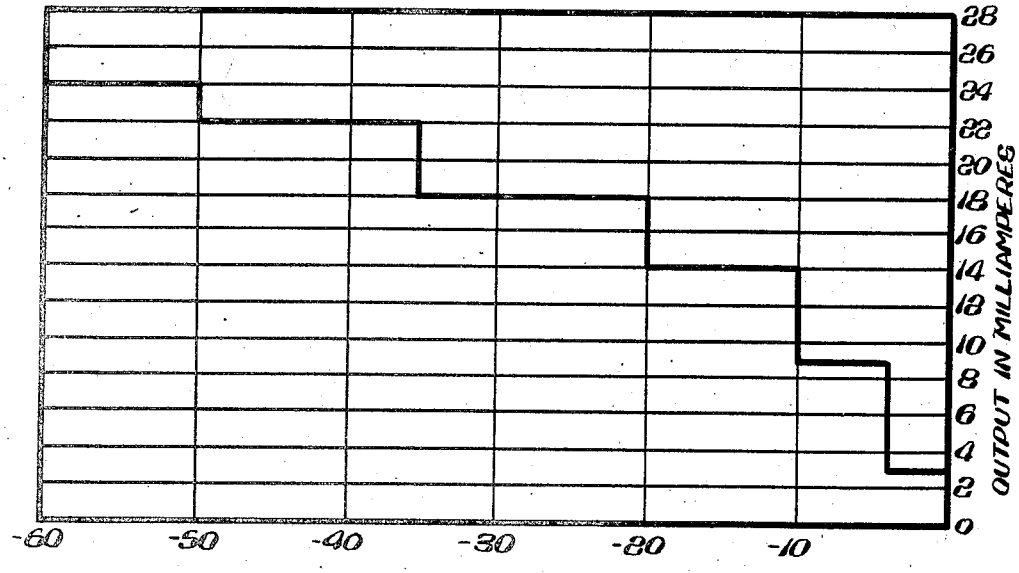
Attorney

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SOUND RECORDING APPARATUS

Filed Aug. 29, 1941 2 Sheets-Sheet 2

Fig. 2.



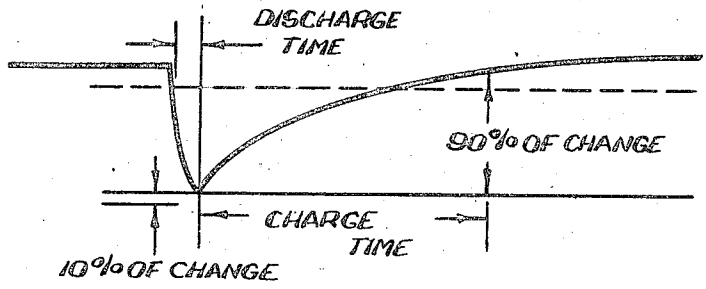


Fig. 3.

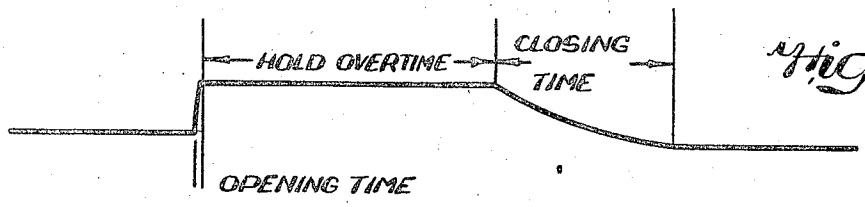


Fig. 4.

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UNITED STATES PATENT OFFICE

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SOUND RECORDING APPARATUS

John B. Gehman, Indianapolis, Ind., assignor to Radio Corporation of America, a corporation of Delaware

Application August 29, 1941, Serial No. 408,866

6 Claims. (Cl. 179—100.3)

This invention relates to sound recording apparatus and more particularly to a ground noise reduction amplifier for use in recording sound on film and is an improvement on the amplifier of my application No. 362,581, filed October 24, 1940. It has heretofore been proposed, as for example in McDowell Reissue Patent 21,389, to reduce the ground noise produced by the transmission of light through the transparent portion of a sound record film by rendering that transparent portion opaque over an area corresponding to the envelope of the recorded sound waves. This is ordinarily done as described in the said McDowell patent by interposing a shutter in the recording light beam and causing the shutter to follow the envelope of the sound waves being recorded so as to leave a corresponding transparent area on the negative. This sound record which when printed onto the sound record produces a corresponding opaque area. In the recording of variable density sound records a corresponding procedure has been used by varying the opening of the light valve or intensity of the glow lamp as the case may be, so that at low sound intensities the average light transmitted to the negative is comparatively little, increasing with the sound amplitude and thereby increasing the average density of the negative sound record with amplitude and conversely reducing the average density and light transmission of the positive sound record at low amplitudes.

The amplifier shown in the McDowell patent was reasonably satisfactory for the purpose but improvements in the standards of quality of sound recording and reproduction have been so great that improvement in the ground noise reduction amplifier has been continually required. One deficiency of early types of amplifiers has been that they tended to follow the wave form of the sounds being recorded too closely. Another disadvantage has been that when a sound consisted of a series of peaks spaced at intervals large in proportion to the timing of the peaks the amplifier tended to clip the peaks. Another disadvantage has been that with the more usual types of amplifiers it has been difficult to provide a device which would open rapidly and close slowly. In an ideal type of amplifier the amplifier should open as rapidly as required without producing thump and should maintain to opening level for a predetermined time after cessation of the signal before starting to close as described in my application Serial No. 362,581, filed October 24, 1940.

The present amplifier is an improvement on that of my earlier application in that, on the application of a signal within predetermined limits, the ground noise reduction device is opened by a predetermined amount and stays at that opening for a predetermined time unless a signal of greater amplitude should follow within that time and cause further opening, as in the earlier application, but the limits and holding time are both adjustable.

This is accomplished by the use of a series of gas tubes which operate at different potentials. The use of gas tubes operating at different potentials to secure a step by step control is broadly shown in Strieby Patents Nos. 1,776,821 and 1,776,822, issued September 30, 1930. In those patents, however, neon tubes are used for the purpose which require the application of high voltages to secure their operation, and the currents passed through the tubes are used to actuate the controlled mechanism.

In this apparatus, I provide an arrangement of gas filled hot cathode tetrodes which are used to control the vacuum tube amplifiers supplying operating current to the ground noise reduction shutter. With this arrangement, the gas tubes may control the timing independently of the amplitude of the currents controlled and they may be set to operate at much lower voltages than required by the tubes of the Strieby patents so that a much greater range of volume may be controlled. The amplifier tubes connected to the successive gas tubes are arranged to control an improved type of direct current amplifier which actuates the ground noise reduction apparatus.

One object of the invention is to provide an improved type of ground noise reduction timing circuit.

Another object of the invention is to provide an improved control circuit which is capable of any required adjustment as to time constants.

Another object of the invention is to provide an improved amplifier having an A.-C. input and a D.-C. output.

Another object of the invention is to provide such an amplifier which will have greater stability than that described in my prior application.

Another object of the invention is to provide such an amplifier which will be simpler than that described in my prior application.

Another object of the invention is to provide such an amplifier in which the holding time of the several steps is separately adjustable.

Other and incidental objects of the invention will be apparent to those skilled in the art from a reading of the following specification and an

inspection of the accompanying drawings in which:

Figure 1 is a schematic wiring diagram of the improved amplifier,

Figure 2 is a curve showing the output of the amplifier in milliamperes plotted against the relative input in decibels,

Figure 3 is a curve showing the capacitor charging time plotted against charging voltage, and

Figure 4 is a curve showing output current plotted against output time.

The speech amplifier is illustrated in the upper left portion of the figure and is of more or less conventional type, but is designed to give a maximum output voltage of approximately 300 at maximum input corresponding to 100 percent modulation of the sound track. In this amplifier, the speech input is applied through the transformer 9 across the 100,000 ohm potentiometer 10, which determines the portion of the input signal applied to the control grid of the tube 11 which is preferably of the commercial type known as the 6J7. This tube is provided with a cathode resistor 12 having a value of approximately 470 ohms and with a screen dropping resistor 13 of 1,200,000 ohms bypassed by the capacitors 23 and 23' of .5 and 2 mfd. respectively. The 220 volt positive potential is supplied to the screen and plate through the 15,000 ohm resistor 15 and is fed to the plate through the 220,000 ohm resistor 14. The output from the tube 11 is applied to the tube 19 through the 0.1 mfd. condenser 24, grid bias being applied through the 390,000 ohm resistor 7.

The tube 19, which is preferably of the type known as the 6F6, is provided with the usual cathode biasing resistor 20 of 680 ohms. Degeneration is provided by feedback from the plate of the tube 19 through the resistor 8 having a resistance of 100,000 ohms and the filter composed of the resistor 16 of 180,000 ohms and the capacitor 17 having a value of .025 mfd. The output of the tube 19 is fed to the transformer 21 through the 1.0 mfd. capacitor 26, and thence to the input of the step amplifier. Direct current at a potential of 220 volts is supplied through the power supply terminals 27 and 28 and is fed to the plate of the tube 19 through the reactor 25 having an inductance of 40 henrys at 18 m. a. D. C. The output from the speech amplifier is applied across the five potentiometers 40, 51, 61, 71 and 81 in the five stages of the step amplifier. It will be apparent to those skilled in the art that a greater or lesser number of stages may be used according to the number of steps required.

Between the potentiometers and the gas tubes 30, 31, 32, 33, 34 there are provided 1 megohm protective resistors 42, 53, 63, 72, 82 so that unusually high signals will not injure the tubes and so that a maximum signal will not injure the tube adjusted to respond to the minimum signal.

The tubes 30, 31, 32, 33, 34 are preferably gas tetrodes of the type commonly known as the RCA 2051, although the RCA 2050 tubes may be used. These tubes in the circuit shown will trigger at a voltage of approximately two volts on the grid, and the potentiometers are so adjusted in the successive stages that this voltage is applied at the appropriate volume level in the recording apparatus. The second grid of each of these tubes is connected to the cathode as shown.

Potential is applied to the plate of the tubes 30, 31 32, 33, 34 through the resistors 45, 56, 66, 75 and 85, each of 330,000 ohms.

The present circuit differs from that of my earlier application, among other things, in the timing circuit. In the circuit of my earlier application the timing was controlled entirely by the resistors corresponding to 45, 56, etc. In the present circuit I provide a resistor connected between the plate and grid return of each of the gas tubes in shunt to the timing capacitors and this resistor may be made adjustable to control the timing of the individual stages.

The stage marked A will first be described in detail. In this stage the potentiometer 40 has a resistance of 250,000 ohms while the fixed resistor 41 has a resistance of 220,000 ohms, the resistor 42 having a resistance of one megohm as above described. The capacitor 44 has a capacitance of .025 mfd. and the resistor 43, which may be variable, has a resistance of 6.8 megohms. When the tube 30 is triggered the capacitor 44 discharges through the resistor 94 of 2200 ohms which determines the discharge time, which, in the present instance, is approximately 120 microseconds, to ten percent of charge at which point the resistor 45 causes such a voltage drop that the necessary drop of 14 volts across the tube 30 cannot be maintained and the tube then becomes non-conductive. After the discharge the capacitor 44 starts to charge through the resistor 45 but if between this time and full charge another impulse is received it will again discharge the capacitor 44 down to 14 volts. This arrangement causes a sawtooth wave to be applied to the grid of the tube 30 as shown in Fig. 3 of the drawings.

Due to the fact that the tube 30 being a gas tube is either conductive or non-conductive, the wave shape produced by the output of the tube 30 and therefore by the output of the tube 35 is that shown in Fig. 4. It will be apparent that if a second impulse occurs during the hold-over time indicated in Fig. 4 it will move the beginning of the closing time to the right in that figure without affecting the amplitude of the opening on that particular stage.

The timing of the tube 30 is determined by two different factors, the charging time of the capacitor 44 is determined by the resistors 43 and 45 acting as if they were in parallel and variation of the capacitor 43 will correspondingly affect the charging time. In addition to this effect the resistor 43 changes the grid bias on the tube 30. Decreasing the value of the resistance will increase the bias, making the operating point nearer cut-off and increasing the holding time while at the same time, as pointed out above, the decrease in the value of this resistor will decrease the charging time.

Although the opening time of the individual stage is approximately 120 microseconds as described above, the opening time applied to the ground noise reduction apparatus is determined by the filter circuit 90, 91 described in more detail hereinafter.

When no signal is applied to the apparatus the potential in the capacitor 44 is built up to its maximum and the tube 35 is biased to its normal current by a negative grid bias of five volts. When a signal is applied sufficient to trigger the tube, the tube 30 immediately becomes highly conductive and the capacitor 44 discharges through the tube 30, as described above. This promptly raises the negative grid potential on the tube 35 considerably beyond the cut-off of the tube 35 and causes the corresponding open-

ing of the ground noise reduction shutter or other device through the D. C. amplifier 100.

As pointed out above, each of the tubes 35, etc., is biased considerably above cut-off when the corresponding tube 30 is triggered. Due to this increased bias, the tube 35 does not begin to conduct until the charge on the corresponding capacitor 44 has built up to an appropriate value through the resistor 45. The tube 35 will then gradually become conductive following an exponential curve determined by the charging rate of the condenser 44 through the resistors 43 and 45 effectively in parallel. Due to this arrangement, the output curve of a single stage will remain flat for a length of time determined by the time required for the capacitor 44 to reach the cut-off potential of the tube 35 from the relatively greater negative potential applied to the grid of tube 35 and, after reaching this point, the tube 35 will follow an exponential curve in becoming conductive. The timing of the exponential curve may be varied by changing the capacitor 44 or the resistor 43 or 45 or either of them, while, with any given timing for this time circuit, the length of time during which the tube remains non-conductive after cessation of a signal is determined by the excess of negative voltage applied to the grid of the tube 35. With this arrangement, if the shutter is opened to a given amount and the signal suddenly decreases and thereafter immediately increases to its original value within the time of constant level, the shutter will not change in its position.

When the capacitor 44 has discharged to a potential corresponding to the minimum plate voltage on the tube 30 which is approximately 14 volts the potential on the grid of the tube 30 again takes control and the tube becomes non-conductive. Potential then builds up on the capacitor 44 through the resistor 45 until either the capacitor 44 is charged to maximum potential or a subsequent signal has again triggered the tube. It will be apparent from this that each stage, including the tubes corresponding to the tube 30 and the tube 35, constitutes a separate sawtooth oscillator triggered by the input signal and having a periodicity determined approximately by the capacitor 44 in the resistors 43 and 45.

In this circuit, as in most sawtooth oscillators, the frequency is varied to a certain extent by the frequency of the applied signal. If a signal of slightly varying level approximating the level for which any one stage is set were applied, there would be a tendency for that stage to turn on and off irregularly, and this is prevented by the portion of the circuit next described.

The power supply of 220 volts is applied at the terminals indicated.

The stages B, C, D and E differ slightly from the stage A. In stage B the resistor 50 has a value of 330,000 ohms, the potentiometer 51 has a resistance of 100,000 ohms, and the resistor 52 has a resistance of 56,000 ohms. The resistor 53 has a value of one megohm, resistor 54 6.8 megohms, and the capacitor 55 .025 mfd. as in stage A. In the stages C, D and E the resistors 63, 72 and 82 likewise have a value of one megohm and the variable resistors 64, 73 and 83 each have a value of 6.8 megohms maximum. The capacitors 63, 74 and 84 likewise have a value of .025 mfd. In stage C the resistor 60 has a value of 470,000 ohms, the potentiometer 61 a resistance of 50,000 ohms, and the resistor 62 a resistance of 10,000 ohms. In the stage D the resistor 70 has a value of 470,000 ohms, while the potentiometer 72 has a resistance of 10,000 ohms and in stage E the resistor 80 has a resistance of 470,000 ohms and the potentiometer 81 a resistance of 5,000 ohms.

It will be apparent from the foregoing that the voltage dividers for applying potential to the grids are chosen according to the signal level to which the several stages are to respond. In the arrangement shown, satisfactory triggering levels and ranges for the successive stages on the basis of a maximum level of zero db. (6 m. w. ref.) and a minimum level of −60 db. may be:

Level	Range
−50 db. for stage A,	−54 db. to −46 db.
−35 db. for stage B,	−42 db. to −33 db.
−20 db. for stage C,	−33 db. to −14 db.
−10 db. for stage D,	−16 db. to max. level
−4 db. for stage E.	−8 db. to max. level

The opening time may be 10 to 12 milliseconds and the closing time 40 to 45 milliseconds.

The foregoing levels plotted as input in decibels against output of the D.-C. amplifier in milliamperes is shown in Figure 2.

The tube 96 is preferably of the type known as an RCA VR-105/30, which is a unidirectionally conducting tube establishing a voltage drop of 105 volts, and limits the potential between the midpoint of the resistors 93 and 94 and the lead to the cathodes of the tubes 35, 36, 37, 38, 39 to 105 volts, leaving the balance of potential of 230 volts or 70 volts distributed between the 10 ohm resistor 95 and the 22,000 ohm resistor 92. Due to this arrangement, when one of the gas tubes becomes conducting and plate current starts to flow, since the potential difference between the resistor 95 and the cathode lead of the tube 35 is maintained constant at 105 volts, an increase in the drop amounting to approximately ½ volt occurs across the resistor 95 for each stage triggered, thereby decreasing the grid bias applied to the tubes 30, 31, etc., by a corresponding amount and causing the tubes 30, etc., to remain conductive as long as the input signal does not fall more than one-half volt below the signal which originally turned on that particular stage. Conversely, when the input signal drops more than one-half volt below that which originally turned on the stage, that stage becomes inoperative and remains so until the signal reaches the original trigger level.

The resistor 95 which controls the lock-in voltage would not have a proportionate value in excess of that above assigned to it and it may well on occasion have a lower value. If the lock-in voltage produced by the resistor 95 is too high, it will produce an appreciable difference between the instantaneous and the continuous peak voltage to which the higher stages will respond.

Since each of the stages of the step amplifier is, as pointed out above, substantially a sawtooth oscillator, there is a tendency for the device to produce a buzz which is applied across the resistor 94 and thereby applied to the untriggered stages through the condensers 44, 53, etc., of each of them. The untriggered stages transmit the buzz to the ground noise reduction apparatus. This buzz may be eliminated from the output by the provision of a bypass condenser 91. This condenser should have a capacity of not less than 1 mfd.

The output from the step amplifier is fed to the shutter amplifier illustrated in the upper right hand portion of the figure. Although this is called a shutter amplifier, it will be understood that it can be used to operate either a ground noise reduction shutter such as referred to above

or a shutter such as commercially used in variable density recording, or the output may be applied in an appropriate manner to any other type of ground noise reduction apparatus, volume compressor, volume expander or any equivalent device. Although the output from the step amplifier might be sufficient to operate the shutter or other device, the shutter amplifier is necessary in order to isolate the output circuit, as otherwise the inductance, etc., of the output circuit might form a resonant circuit with the capacitor 91 of the thump filter.

The output from the step amplifier is applied across the potentiometer 90 which is bypassed by the 1.0 mfd. capacitor 91. This potentiometer preferably has a resistance of approximately 3,000 ohms and with the capacitor 91 constitutes a thump filter. As pointed out above, the several step amplifier stages open very rapidly—practically at radio frequency. In the application of the output of the step amplifier to ground noise reduction apparatus, it is necessary to slow this action down to an inaudible frequency, as otherwise the step action of the amplifier will be reproduced as a click or thump. The particular filter arrangement shown permits an opening time of approximately 10 to 12 milliseconds, which is below the normal frequency range transmitted by present theater amplifiers or reproduced by the present commercial types of speakers. Since the output from the step amplifier is direct current and at a fairly high positive potential, it is necessary to provide an appropriate potential across the resistors 98 and 99 between the contact to the potentiometer 90 and the grid of the tube 100. The potential applied to the control grid of the tube 100 is determined by the potentiometer 98. The tube 100 is preferably RCA type 6F6 and may be provided with an adjustable cathode bias resistor 101 of 1500 ohms resistance. The resistor 56 may have a resistance of approximately 10,000 ohms and the tube 103 is preferably the RCA type known as the VR–150/30 which provides a drop of 150 volts. It will be apparent that the tube 100, the tube 103, the resistor 101 and the resistor 102 form a bridge circuit and the ground noise reduction apparatus is connected across this bridge circuit at 104. In the particular arrangement shown, an increase in speech input across the transformer 8 causes a decrease in potential drop across the resistor 99, thereby decreasing the bias on the tube 100 and increasing its plate current.

In current commercial practice, the load resistance of a ground noise reduction shutter such as connected at 104 is approximately 700 ohms and it requires a maximum current of 30 milliamperes. When the apparatus is properly adjusted, the resistor 101 is so adjusted that there is at least 30 milliamperes current through the load when the tube 53 is biased to cut-off. There is 150 volts drop across the tube 103 with a current of 35 milliamperes through it and 5 milliamperes of current passing through the resistor 102 to keep the tube 103 in operation. With a supply current of 220 volts there is a 70 volt drop across the resistor 102 and a 21 volt drop across the 700 ohm load at 104. The voltage drop across the tube 100 is then 171 volts and that across the resistor 101 is 49 volts. When the circuit is thus connected, the control grid of the tube 100 becomes more positive on increase in output from the speech amplifier and draws current since the voltage across the tube 103 remains constant at 150 volts. As the current drawn by the tube 100 increases, that permitted to pass through the load at 104 may decrease to zero.

If it is desired to use this circuit to operate a variable density shutter wherein the shutter current is required to increase with increase in signal current, the shutter may be inserted in place of the resistor 101 and the tube 103 is removed. In this arrangement, the increase in current through the tube 100 causes a corresponding increase in current through the load.

It will be apparent to those skilled in the art that the invention is not limited to the exact construction before described but that the construction and characteristics of the apparatus may be greatly varied within the scope of the invention. In the apparatus above described, if a gradually increasing signal is applied to the speech amplifier, the step amplifier will increase its output step by step as the signal gradually increases until the maximum output is reached. If the signal is then completely removed all the timing circuits which are similar will cause the output of the several stages of the step amplifier to decrease simultaneously, and the output will drop to zero at the time determined by any one of the timing circuits. If the signal decreases gradually, the output will decrease step by step at the end of the closing time determined by the timing circuit of each step.

The characteristics of the opening timing circuit 90, 91 may be varied as desired according to the characteristics of the apparatus with which the amplifier is to be used, but it should be kept in mind in making any such variation that the ground noise reduction apparatus should open as rapidly as possible without producing any audible thump.

I claim as my invention:

1. In a trigger type amplifier, a gas type trigger tube including a control grid, a vacuum type amplifier tube, means for applying a plate potential to said trigger tube and a grid potential to said amplifier tube, a timing circuit including a capacitor shunted by a resistor connected between the plate and cathode of said trigger tube, means for applying a grid bias to said trigger tube, and means for applying a signal to the grid of said trigger tube.

2. In a trigger type amplifier, a gas type trigger tube including a control grid, a vacuum type amplifier tube, means for applying a plate potential to said trigger tube and a grid potential to said amplifier tube, a timing circuit including a capacitor shunted by a resistor connected between the plate and cathode of said trigger tube, means for applying a grid bias to said trigger tube, means for applying a signal to the grid of said trigger tube, and means for decreasing said grid bias on the triggering of said tube.

3. In a trigger type step amplifier, a plurality of step stages in parallel, each including a gas type trigger tube including a control grid, a vacuum type amplifier tube, means for applying a plate potential to said trigger tube and a grid potential to said amplifier tube, and a timing circuit including a capacitor shunted by a resistor connected between the plate and cathode of said trigger tube.

4. In a trigger type step amplifier, a plurality of step stages in parallel, each including a gas type trigger tube including a control grid, a vacuum type amplifier tube, means for applying a plate potential to said trigger tube and

a grid potential to said amplifier tube, a timing circuit including a capacitor shunted by a resistor connected between the plate and cathode of said trigger tube, means for applying a grid bias to said trigger tube, and means for applying a signal of different amplitude to the grid of each of said trigger tubes.

5. In a trigger type step amplifier, a plurality of step stages in parallel, each including a gas type trigger tube including a control grid, a vacuum type amplifier tube, means for applying a plate potential to said trigger tube and a grid potential to said amplifier tube, a timing circuit including a capacitor shunted by a resistor connected between the plate and cathode of said trigger tube, means for applying a grid bias to said trigger tube, means for applying a signal of different amplitude to the grid of each of said trigger tubes, and means for decreasing said grid bias on the triggering of each of said tubes.

6. In a trigger type step amplifier, a plurality of step stages in parallel, each including a gas type trigger tube including a control grid, a vacuum type amplifier tube, means for applying a plate potential to said trigger tube and a grid potential to said amplifier tube, a timing circuit including a capacitor shunted by a resistor connected between the plate and cathode of said trigger tube, means for applying a grid bias to said trigger tube, means for applying a signal of different amplitude to the grid of each of said trigger tubes, and means for decreasing said grid bias on the triggering of each of said tubes, said bias-decreasing means including a voltage divider having in sequence vacuum tube plate voltage, trigger tube plate voltage and trigger tube grid voltage sections, the cathodes of the vacuum tubes being connected to the positive end of the trigger tube plate voltage section, and a constant voltage device connected across the trigger tube plate voltage and trigger tube grid voltage portions of said divider only.

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