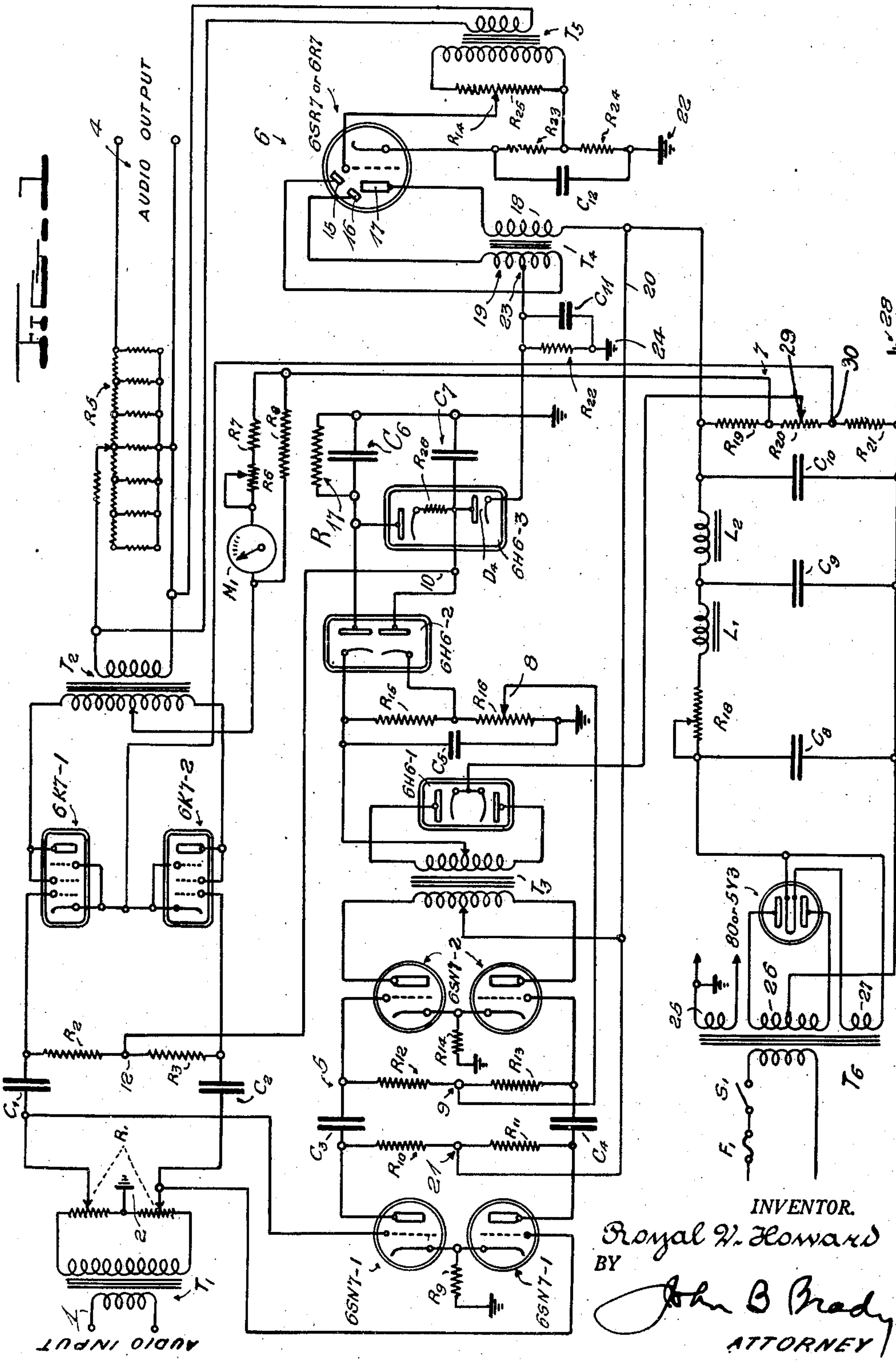
Jan. 8, 1946. R. V. HOWARD 2,392,384

AUTOMATIC REGULATING SYSTEM

Filed July 19, 1944 2 Sheets-Sheet 1



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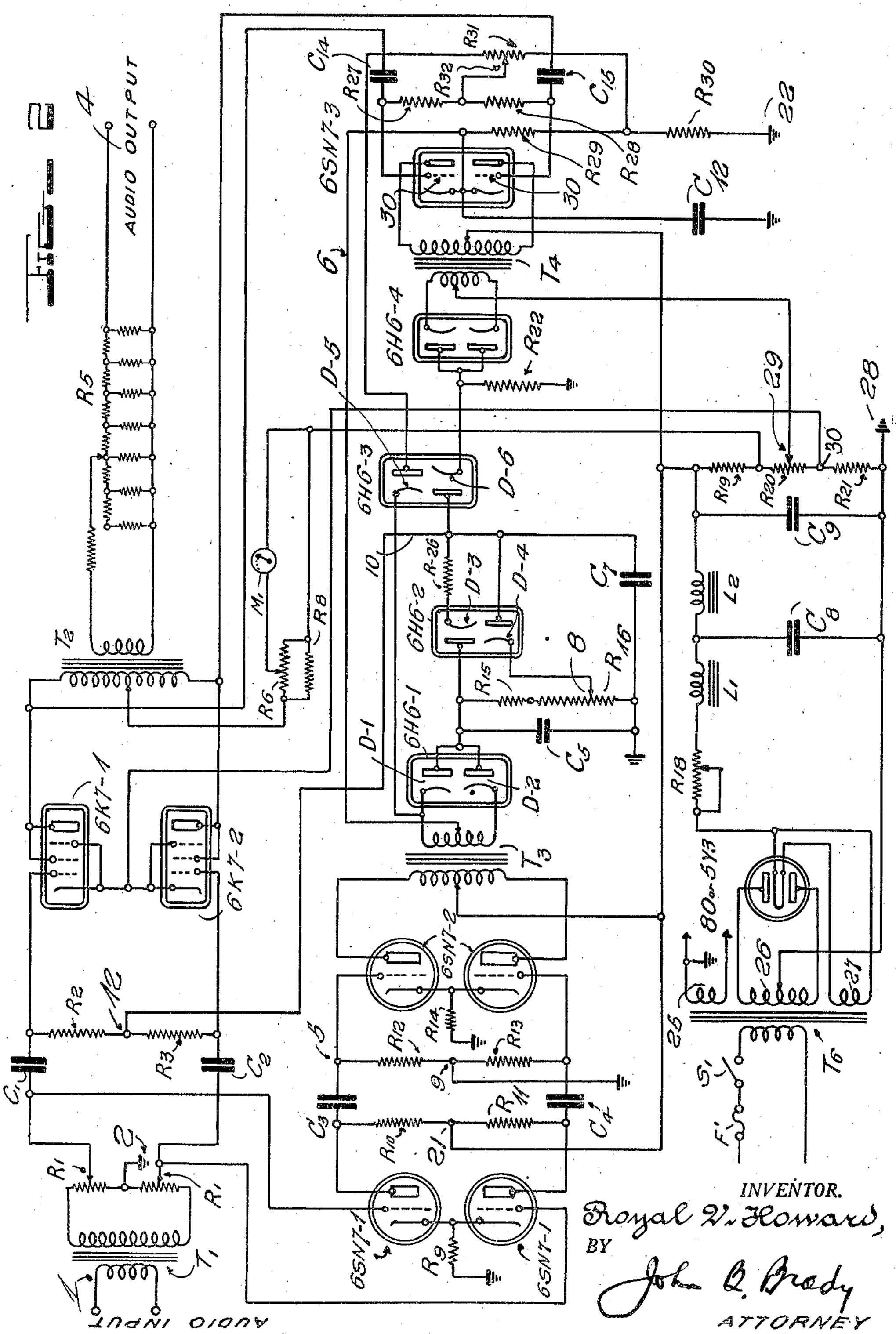

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AUTOMATIC REGULATING SYSTEM

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9 Claims. (Cl. 179—171)

My invention relates broadly to amplification systems and more particularly to an automatic gain control circuit for amplification systems.

One of the objects of my invention is to provide a circuit arrangement for an amplifier system in which changes in condition of the signaling energy at the input circuit of the amplifier system may be employed to automatically control the operating characteristics of the amplifier system for maintaining the level at the output circuit of the amplifier system substantially constant.

Another object of my invention is to provide a system of level control in which the amplifier circuit has the input thereof connected to the input circuit of a gain control amplifier and the output circuit thereof connected to a limiter circuit with a differential circuit associated with the composite output thereof for restoring the operating condition of the amplifier to counteract changing conditions in the input circuit for maintaining the output level in the output circuit substantially constant.

A further object of my invention is to provide an electronically controlled compensation system for amplifier circuits whereby changes in the condition of level of the input have minimum effect upon the level of output.

Other and further objects of my invention reside in the circuit arrangement for the automatic control system for audio frequency amplifier channels as set forth more fully in the specification hereinafter following by reference to the accompanying drawings in which:

Figure 1 diagrammatically illustrates one circuit arrangement embodying my invention and Fig. 2 diagrammatically illustrates a modified circuit arrangement of my invention.

The advantages in the use of the circuit of my invention will be apparent from the more detailed description hereinafter following. I may employ the circuit as a guardian or control system for microphone and voice amplifier circuits for connection to a telephone line, an electric phonograph, a recording system, a radio transmitter of frequency modulated, amplitude modulated, or other modulated types, an audio frequency channel of a television system or for use in talking motion picture systems wherein substantially constant level output is highly important. No matter how skilled or trained operating personnel may be, it is impossible to obtain maximum utilization of available facilities, be they recording, line transmission, or radio transmission, by manual operation of volume. No matter how judicious and adept the personnel may be, individual errors occur due to the operators's interpretation of the volume level indicating devices. Nor is it possible for the personnel to judge whether the positive peaks or negative peaks are causing the indications he is receiving, nor can the operator control them if he is able to differentiate or correct these peaks. It is also apparent, to one skilled in the art, that the multiplicity of errors, that readily occur under manual regulation, are not apparent to those less familiar, for there is involved a very complex and constantly changing wave form and energy content that the personnel is unable to integrate or anticipate. Therefore, it becomes readily manifest that the ideal solution is some device of a purely electronic nature that will control and regulate the program to a finer degree than that obtained by manual operation. Such a device permits a maximum utilization of the facilities and provides a more uniform output, eliminates human error to a great extent, and, further, effects economy in manpower.

This desirable objective is not as easily obtained as might be apparently indicated, for one of the things that any device of this nature must not do is destroy the dynamic range of program content. Early experiment proved that it was not feasible or practical to put into use just a slow operating volume control device, for this had a constant rate of decay and, no matter how the constants were selected the desired results could not be obtained. It was noted, from observation over long periods of time, that what was needed was a device that, once regulated in its control, would not deviate in its gain regulation until a certain period of time had elapsed. Then, if the program material was low, the device would seek slowly, at first, to recover the deficiency. However, it is obvious that, once the lost gain has been restored by the instrument, it must be on the qui vive for any sudden applications of normal or excessive level. The device must also have the property of being able to reduce any abnormally high audio level to the proper value. Therefore, any instrument to be used for this purpose must regulate the long term audio output over a specified range while being unaffected by normal program dynamic ranges and yet able to correct instantly on high peak applications.

It was determined by extended research and measurements in standard broadcast practice that very rarely do program levels vary over a ±10 db. Practical applications indicate that such a device in a radio transmitter should be placed in a circuit before the normal peak limiting amplifier, for this enables the constant use of the limiting amplifier at its maximum efficiency. It is of course possible and practical to incorporate the peak limiter into the automatic device.

The amplifier system that is arranged between the input and output circuits of the audio frequency channel has the gain control or guardian circuit of my invention connected substantially in parallel therewith so that the audio frequency variations which are supplied to the amplifier channel are also supplied to the input of the gain control circuit. The gain control circuit has the output thereof connected to the bias control circuit of the tubes of the main amplifier system and also to a resistance capacity network having a time constant which is determinative of the gain rate of the main amplifier. I also provide a limiter circuit having its input connected with the output of the main amplifier system and connected to the resistance capacity network for the purpose of restoring the normal condition in the resistance capacity network for counterbalancing the opposite effects produced therein by program failure or gain reduction. That is to say, the resistance capacity network operates as a differential circuit controlled in one condition according to the input program level and in another condition according to the output program level. By the coaction of the gain control amplifier with the main channel amplifier and with the resistance capacity network and the limiter I am enabled to control with great precision the program level supplied to the audio output circuit.

The system of my invention operates in such a manner as to maintain essentially a constant audio output regardless of variations to the input level between certain desired limits. This control may be accomplished by utilizing the average level of rectified input signal as the control voltage on an input stage containing variable MU tubes, as shown on the diagram. In the particular amplifier employed in the embodiment of my invention disclosed herein, a 6SN7—1 tube amplifies the input signal to such a level that, when it is applied to the diode tube labeled 6H6—1, the resulting D. C. potential is sufficient to control the variable MU 6K7—1—2 stage. The tubes marked 6H6—2 and 6H6—3 are utilized to obtain a differential potential which charges condensers labeled C_7 and C_6 at different potentials. Condenser C_6 receives the higher potential by means of the voltage divider made up of the 0.5 and 1.0 megohm resistors R_{15} and R_{16} located between 6H6—1 and 6H6—2. Now as long as the potential on C_6 exceeds that on C_7, the amplifier gain cannot be increased as condenser C_7, not having a bleeder circuit, holds the charge. If, however, the average input signal level to the 6H6—3 decreases, the charge on C_6 will leak off through its bleeder (3.0 megohm) resistor R_{17}. When this potential is reduced to a value below that of C_7, diode 6H6—3 conducts the charge accumulated on C_7 through the 3.0 megohm resistor R_{17} shunted across C_6. This action reduces the bias on the gain control 6K7—1—2 tubes, and thereby increases their gain.

Now, if the average input level increases, the charge on C_7 will increase and the gain will decrease. This arrangement, therefore, would cause an increase or decrease in gain. However, if the input signal ceases for any desired period of time, approximately 10 seconds, the gain will remain unchanged as it requires this interval of time for the charge on condenser C_6 to leak off to a value equal to the charge on condenser C_7. If, however, the input signal ceases or is reduced for a period exceeding 10 seconds, the gain in the amplifier will be slowly restored toward a maximum. Since the control device is essentially a slow-time device (the time can be adjusted to any desired amount by the proper selection of values) due to the large size condensers, restoration of signal would naturally result in an excessive output level for an appreciable period. The deleterious effect is overcome in the automatic system of my invention by the use of a fast-time control, or limiter device. This consists of the tube, in this particular case marked 6SR7 or 6R7, coupled to the output of the main amplifier or output stage. The diodes of this 6SR7 or 6R7 tube system are biased at such a level that it contributes no output during normal level operation. This limiter action therefore is to prevent excessive output levels. Its action applies voltage back through 6H6—2—3 until such a time as the input control can build up to its proper operating potential.

An adjustable arm marked 8 is provided on resistor R_{16} which is used to adjust the bias voltage which is connected at point 9 to the tubes 6SN7—2. If the level is too high or too low, the negative bias may be regulated by adjustment of tap 8 on resistor R_{16}.

Meter M_1, shown in the circuit, is used as an indicating device that is calibrated to show the amount of regulation of gain that has taken place at any given time. I provide a resistance network in series and shunt with meter M_1 as shown at R_6, R_7 and R_8 as required.

The upper section shown in the diagram comprises the main amplifier. It is represented as a single push-pull stage using tubes of the 6K7 variety as heretofore explained with the screens and plates thereof connected together to form triode connection with medium impedance output. In the apparatus illustrated herein, the normal input level is intended to be about 20 db. below standard reference level of 1 milli-watt in 600 ohms. The minimum input level at which it will operate is approximately 25 db. The highest input level permissible will depend on the attenuation range of R_1.

Normally the amplifier operates 10 db. below its maximum possible gain so as to permit an automatic increase of 10 db. when the input level should drop that amount. In the opposite direction the output remains essentially constant with an increase of 10 db. above the normal input level resulting in a control of ± 10 db. or total range of 20 db. At the normal operating point there is a slight overall gain providing attenuator R_5 is set for minimum attenuation. The amplifier has exceedingly low distortion and very low noise level. The audio input to the system is connected at 1 leading through transformer T_1 to the potentiometer system R_1 grounded at 2 and then to the coupling system comprising condensers C_1 and C_2 and resistors R_2 and R_3 to the input circuits of tubes 6K7—1 and 6K7—2. The cathode circuits of the tubes 6K7—1 and 6K7—2 are connected to the voltage divider of the power supply system between the potentiometer resistors R_{20} and R_{21}. The output of the main amplifier connects through transformer T_2 to the adjustable attenuator R_5 leading to output circuit 4 of the system.

The center left section shown at 5, consisting of a two stage amplifier followed by diodes 6H6—1, 6H6—2 and 6H6—3 is the program level control circuit. The two stage amplifier 5 constitutes the gain control amplifier formed by pairs of tubes which may be of the types represented at 6SN7—1 and 6SN7—2. The coupling between the tube stages is of the resistance capacity type constituted by resistors R_{10}, R_{11}, R_{12} and R_{13} interconnected by condensers C_3 and C_4 as shown.

The tubes of the first stage have their cathodes connected to ground through resistor R_9 while the tubes of the second stage have their cathodes connected to ground through resistor R_{14}. The output of the second stage of amplification connects to the transformer T_3, the secondary of which connects to the double diodes represented at 6H6—1, 6H6—2 and 6H6—3. The output of the double diode 6H6—1 is coupled to the succeeding diodes 6H6—2 and 6H6—3 through the potentiometer system R_{15}—R_{16} shunted by condenser C_5. An adjustable tap 8 is provided on potentiometer section R_{16} and leads to a midpoint connection 9 between the coupling resistors R_{12} and R_{13} in the input circuit of the second stage of amplification of gain control amplifier 5 for thus regulating the bias potential thereof. Potentiometer section R_{15} connects to the cathodes of the double diode 6H6—2 as shown. The anodes of this double diode connect to the anode and cathode of one section of the double diode 6H6—3 as shown, the cathode thereof having a resistor R_{26} in series therewith as shown. The other section of the double diode 6H6—3 represented at D_4 connects to the resistance-capacity network which includes condenser C_7 and condenser C_6 shunted by resistor R_{17}. A tap 10 is taken from a point in the circuit between diodes 6H6—2 and 6H6—3 to the midpoint 12 between resistors R_2 and R_3 in the coupling circuit of the main amplifier system. The program level control circuit 5 provides the variable bias for the control grids of the 6K7 tubes. It is important that condenser C_7 has no leakage as it must hold its charge until the voltage on condenser C_6 leaks down to a value equal to that on condenser C_7, at which time the gain increase rate of the amplifier is determined by the time constant of condenser C_6 and resistor R_{17}. This action occurs approximately 10 seconds after program failure. During the 10 second period no gain change takes place.

The center right section shown at 6 is the limiter circuit. This is necessary to hold the peaks down to normal level until the slow time control circuit has had sufficient time to seek its normal operating level. This limiter acts only for two or three seconds at the beginning of program. The limiter includes input transformer T_5 which connects to the audio output system on the secondary side of transformer T_2. The output of transformer T_5 has a potentiometer R_{25} thereacross connected through adjustable tap 14 to the input of the limiter tube 6SR7 or 6R7. This particular tube contains output electrodes 15, 16 and 17 connected with the windings 18 and 19 of transformer T_4 as shown. The transformer system T_4 has the primary winding 18 thereof connected to the positive side of power supply system represented at 7. A lead 20 extends from the same connection to supply positive potential to the plate electrodes for the tubes of the gain control amplifier. The cathode circuit of the limiter tube includes series connected resistors R_{23} and R_{24} by-passed by condenser C_{12} to ground 22. The secondary winding 19 of the transformer system T_4 connects from tap 23 to the diode D_4 leading to the resistance capacity network for restoring the charge to the condensers C_6 and C_7. The current through this circuit is regulated by resistance R_{22} shunted by condenser C_{11} connected to ground represented at 24.

The power supply 7 comprises well filtered source of plate potential. Adjustable resistor R_{18} is provided for adjusting the output to 250 volts when the entire system is operating normally. The power supply system includes transformer T_6 connected to suitable source of power such as 110 volt 60 cycle alternating current through fuse F_1 and S_1. Transformer T_6 includes secondary windings 25, 26 and 27. Winding 26 supplies heating current for all of the heaters of the heater type tubes. Winding 27 supplies heating current for the cathode of the double rectifier tube indicated at 80 or 5Y3. The anodes of the double rectifier tube are connected to opposite ends of secondary winding 26. The output of the double rectifier connects to the transformer circuit including condensers C_8, C_9 and C_{10}, and adjustable resistor R_{18} and inductances L_1 and L_2. The potential divider across the output of the power supply system contains resistors R_{19}, R_{20} and R_{21} connected in its positive end to the anode supply circuits in the gain control amplifier and limiter and at its negative end to ground indicated at 28. The adjustable tap 29 on the potential divider R_{20} connects to the circuit of double diode 6H6—1. The intermediate point 30 between potential divider resistors R_{20} and R_{21} connects to the circuits of tubes 6K7—1 and 6K7—2.

Adjustment procedure

It is assumed that all tubes are operating properly. Set R_1 about 16 db. below maximum gain. Set R_{25} for zero input. Potential divider R_{21} is selected of a value for obtaining maximum positive potential on the 6H6—1 cathode through adjustable tap 29 on potential divider R_{20}. Now adjust R_6 until M_1 reads full scale. If this cannot be accomplished the value of R_8 should be altered. Now feed a 400 cycle audio signal into the amplifier input at a level of about −20 db. below standard reference. Now reduce the positive bias on tube 6H6—1 by means of adjustable tap 29 on potential divider R_{20} until M_1 just begins to show a current reduction. Now increase the gain 10 db. by means of R_1. M_1 should now show approximately mid scale. The adjustment of R_{16} can only be made approximate by means of a steady tone. A volume indicator should be connected across the output before the ladder attenuator as the level is rather low. Now increase the audio oscillator output of the volume indicator about 10 db. and observe the output level. R_{16} should be adjusted until the output level shows a reduction of approximately 3 db. If it were not for the action of this negative bias on 6SN7—2, the amplifier would be over controlled. The proper adjustment of this bias can only be made with actual program material feeding in as will be explained later. There remains the adjustment of R_{25}. Feed an audio signal in just sufficient to start current reduction on M_1. Now remove 6H6—1 from socket. Increase the signal input 4 db. Now adjust R_{25} until M_1 just begins to show current reduction again. This will be the proper adjustment.

Now for actual adjustment under program conditions. An attenuator capable of 20 db. range should be inserted in the input to the amplifier and some program material connected to the input to the attenuator. Set the attenuator for 20 db. loss and adjust R_1 until M_1 just begins to show current reduction on program peaks. Observe the output level on the volume indicator now by means of the external attenuator, increase input level 10 db. After several seconds M_1 should show about mid scale and the output level should show the same level as previously noted. Now increase the input level another 10 db. and after several seconds note the output level. If the level is too high provide less negative bias for 6SN7—2 by means of R_{16}. If the level is too low, increase this bias. It may be necessary to make further adjustments of R_{21} and repeat the above procedure in order to secure a linear dynamic control characteristic which shows constant output with a total input variation of 20 db. The 6H6 tubes are preferably glass in order to reduce leakage.

I have listed hereinafter the values for the several circuit components which I have found most efficient for carrying out my invention in the circuit of Fig. 1:

R_1 Dual, approximately 120,000 ohm, built from 9 position two pole tap switch and fixed resistors to give an attenuation of 2 db. per step
R_2, R_3 One meg., ½ watt
R_4 250 ohm, 1 watt
R_5 Ladder attenuator, built from 9 position single pole tap switch and fixed resistors to give 2 db. per step
R_6 2500 ohm wire wound rheostat
R_7 5000 ohm, ½ watt
R_8 Approximately 200 ohm, depends on meter used
R_9 1500 ohm, 1 watt
R_{10} 10,000 ohm, 1 watt
R_{11} 10,000 ohm, 1 watt
R_{12} 500,000 ohm, ½ watt
R_{13} 500,000 ohm, ½ watt
R_{14} 1000 ohm, 1 watt
R_{15} 500,000 ohm, ½ watt
R_{16} 125,000 ohm (regular volume control)
R_{17} 3 megs., ½ watt
R_{18} 2000 ohm wire wound 20 watts, slide wire
R_{19} 5000 ohm wire wound 20 watts
R_{20} 5000 ohm wire wound, slide wire, 10 watts
R_{21} 100 ohm wire wound
R_{22} 250,000 ohm, ½ watt
R_{23} 1500 ohm, 1 watt
R_{24} 75,000 ohm, 1 watt
R_{25} 1 meg. (regular volume control)
R_{26} ½ meg., ½ watt
C_1 .01 mf. mica condenser
C_2 .01 mf. mica condenser
C_3 .05 mf. paper condenser, 600 volt
C_4 .05 mf. paper condenser, 600 volt
C_5 2 mf. paper condenser, 400 volt
C_6 2 mf. paper condenser, 400 volt
C_7 ½ mf. Pyranol, 600 volt
C_8 4 mf. paper, 600 volt or equivalent electrolytic condenser
C_9 4 mf. paper, 600 volt or equivalent electrolytic condenser
C_{10} 4 mf. paper, 600 volt or equivalent electrolytic condenser
C_{11} .1 mf., 400 volt paper condenser
C_{12} 25 mv., 150 volt electrolytic condenser
T_1 Well shielded input transformer, line to grid, good quality
T_2 Output transformer, approximately 10,000 ohm primary to 500 ohm secondary
T_3 Approximately 20,000 ohm primary, one to one ratio overall
T_4 Approximately 10,000 ohm primary, ratio primary to one-half secondary one to one
T_5 Input transformer, line to grid, 500 ohm to 100,000 ohm. Medium quality, extra magnetic shielding not necessary
T_6 Power transformer, 600 volt C. T., 6.3 volt, and 5 volt
M_1 Preferably a regular 500 micro amps., VU meter. However any 1 ma. meter will suffice
S_1 "On-off" switch
F_1 3 amp. fuse

Referring to Fig. 2 of the drawings it will be seen that the voltage from transformer T—3 is fed to the tube labeled 6H6—1. The rectified output of tube 6H6—1 is impressed across condenser C_5 which has shunted across it resistors R_{15} and R_{16}. The voltage from 6H6—1 plates which is connected to C_5 and R_{15} is impressed upon the plate constituting one-half of 6H6—2. The cathode of this section of tube 6H6—2 shown at D—3 is connected to a one-half megohm resistor identified as R_{26} to the control line 10, connecting to point 12 intermediate resistors R_2 and R_3. The other cathode of 6H6—2 is connected at point 8 of R_{16} which is adjustable. The other plate of tube 6H6—2 shown at D—4 is connected to the control circuit 10 which is connected to ground via a one-half microfarad condenser identified as C_7. The limiter circuit derives its voltage from 6K7—1 and 6K7—2 which is applied through suitable blocking condensers to the grids of tube 6SN7—3 whose plates are coupled to an output transformer labeled T_4 whose secondary is coupled to tube 6H6—4. The output of this circuit is connected to a stabilizing resistor R_{22} to diode D—6 of tube 6H6—3 in the arrangement shown in Fig. 2, whose plate is connected to control circuit 10.

A connection is made at the cathode of tube 6H6—1 of diode D—1 which connects with the cathode of diode D—5 of tube 6H6—3. The plate of diode D—5 is connected through resistors R_{31} and R_{29} to the cathode of tube 6SN7—3.

Voltage is received from the output of tube 6H6—1 which charges condenser C_5 which has connected across it resistors R_{15} and R_{16}. Voltage is picked up from the adjustable divider at connection 8 on R_{16} which is impressed upon the cathode of D—4 of tube 6H6—2 which is then passed on via the plate of diode section D—4 which charges condenser C_7 and the voltage is therefore increased on control circuit 10 which is applied back at point 12 to the control tubes 6K7—1 and 6K7—2. As the voltage impressed upon C_5 is reduced by the action of the shunting resistors R_{15} and R_{16} to a point where its voltage is less than that of C_7 of control circuit 10, then diode D—3 of tube 6H6—2 conducts and the voltage across C_7 is reduced by the resistance of D—3 and the other circuits and the decay characteristics of this voltage are determined by resistors R_{26}, R_{16} and the resistance of diode D—3 of tube 6H6—2. By such action the voltage on control circuit 10 connected to the control tubes is further reduced and the gain of the controlled amplifier is increased. With no signal impressed on the output of the diodes of tube 6H6—1 the bias is obtained by the voltage drop occurring across resistors R_{29} and R_{30}. Upon application of signal through the capacity coupling provided by condensers C_{14} and C_{15}, the bias on tube 6H6—1 is reduced due to the increase of bias applied to the grids 30 of tube 6SN7—3 through diode D—5 of tube 6H6—3 and resistors R_{31}, R_{27} and R_{28} whose voltage is adjusted on R_{31} by variable connection R_{32} therefore increasing the rate of control through control circuit 10.

The center right section shown at 6 is a limiter circuit. This is necessary to hold the peaks down to normal level until the slow-time control circuit has had sufficient time to seek its normal operating level. This limiter acts for approximately only two or three seconds at the beginning of program. When normal operating level is reached the limiter control tube 6SN7—3 is made inoperative by the bias developed across resistor R_{31}. However until it is made inoperative, voltage is developed in the output circuit of tube 6SN7—3 which is fed to the cathodes of tube 6H6—4 through transformer T_4 through the load of the terminating resistor R_{22} to diode D—6 of tube 6H6—3. The output of diode D—6 is connected to control circuit 10. This voltage is then used to charge condenser C_7 a small portion of which may aid in charging condenser C_5 and the instantaneous voltage thus supplied by diode D—6 also reduces the voltage on the grids of tube 6K7—1—2. The fixed bias on diodes 6H6—4 is supplied by tap 29 of potentiometer R_{20}. This bias regulates the point at which the operation of diodes of tubes 6H6—4 will come into operation.

The peak limiter is definitely made inactive until slow-time control becomes inactive. The circuit of Fig. 2 has a finer limit of control. On this instrument the output voltage becomes linear after the control section has reached saturation.

The components of the circuit of Fig. 2 are substantially the same as set forth in Figure 1 with the addition of the components illustrated in Fig. 2 which have values as follows:

R_{27}	½ meg., ½ watt
R_{28}	½ meg., ½ watt
R_{29}	1000 ohms, 1 watt
R_{30}	5000 ohms, 1 watt
R_{31}	1 meg., 1 watt
C_{14}	.05 mf. mica condenser
C_{15}	.05 mf. mica condenser

For certain circuits I have found it desirable to increase the capacity of condensers C_1 and C_2 to .05 mf. and reduce the values of resistors R_2 and R_3 to ½ meg. It will be understood, however, that I have made reference herein to values merely for the purpose of explaining certain preferred embodiments of my invention and that I have no desire to restrict the components to the particular values shown. As heretofore noted the control system of Fig. 2 is in certain installations more effective than the control system of Fig. 1 as the circuit of Fig. 2 exerts a broader range of control. Both embodiments of my invention, however, have proven highly successful in operation.

While I have set forth certain preferred embodiments of my invention and designated certain particular types of tubes and certain values for the elements employed in the equipment, I desire that it be understood, as heretofore noted, that all of the designations referred to are intended in the illustrative sense and not in the limiting sense. I realize that modifications may be made in the circuit arrangement and values and types of the circuit components and I intend no limitations upon my invention other than may be imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. In a system for controlling amplification level in audio frequency amplifiers in combination an audio frequency amplifier channel including an input circuit, an output circuit and a bias control circuit, a gain control amplifier having its input circuit connected with the input circuit of the aforesaid audio frequency amplifier channel, pairs of diodes connected with the output circuit of said gain control amplifier, a condenser connected with the output of one of said diodes, a condenser shunted by a resistor connected with the output of the other of said diodes, a limiter circuit having its input connected with the output of said audio frequency amplifier channel, a connection between the output of said limiter circuit and said condensers, and means interconnecting one of said condensers and said bias control circuit for correcting the bias condition of said audio frequency amplifier system to compensate for variations in level of the program incident upon the input circuit of said audio frequency amplifier system.

2. In a system for controlling amplification level in audio frequency amplifiers in combination an audio frequency amplifier channel including an input circuit, an output circuit and a bias control circuit, a gain control amplifier having its input circuit connected with the input circuit of the aforesaid audio frequency amplifier channel, a condenser circuit having a substantial time delay discharge rate connected with the output circuit of said gain control amplifier, a charge accelerating circuit connected between said condenser circuit and the output circuit of said audio frequency amplifier, and a connection between said condenser circuit and said bias control circuit for controlling the bias potential thereon in proportion to the discharge and charging rate of said condenser circuit by the conjoint action of said gain control amplifier and said charge accelerating circuit.

3. A control system for amplifiers comprising in combination with a main amplifier including a bias control circuit therefore, a gain control amplifier, means for simultaneously feeding both said main amplifier and said gain control amplifier, a multiplicity of isolating diodes connected with the output of said gain control amplifier, a resistance shunted by a condenser connected with one of said diodes, a condenser connected with the other of said diodes, a limiter circuit connected with the output of said main amplifier, and circuit connections between said diodes, said condensers, said limiter circuit and between said condensers and said bias control circuit for impressing bias potential upon the bias control circuit of said main amplifier proportional to changes in the operating conditions in the output circuit of said main amplifier.

4. A control system for amplifiers comprising in combination with a main amplifier including a bias control circuit therefore, a gain control amplifier having a bias control circuit, means for simultaneously feeding both said main amplifier and said gain control amplifier, a multiplicity of isolating diodes connected with the output of said gain control amplifier, resistance capacity networks connected with each of said diodes, a connection between one of said networks and the bias control circuit of said gain control amplifier, a connection between another of said networks and the bias control circuit of said main amplifier, and a limiter circuit interconnecting said last mentioned network and the bias control circuit of said main amplifier.

5. A control system comprising an amplifier having an input circuit, a bias control circuit and an output circuit, a gain control amplifier having input, bias control and output circuits, a parallel feed circuit for each of said input circuits, a differential control circuit connected with the output circuit of said gain control amplifier, a limiter circuit connected between the output of said main amplifier and said differential circuit, and connections between said differential circuit and the bias control circuits of said main amplifier and said gain control amplifier for determining the

bias potential on said main amplifier by the conjoint action of said gain control amplifier and said limiter circuit upon said differential circuit.

6. A control system comprising an amplifier having an input circuit, a bias control circuit and an output circuit, a gain control amplifier having input, bias control and output circuits, a parallel feed circuit for each of said input circuits, a capacitative circuit connected with the output circuit of said gain control amplifier and operative to be discharged thereby according to decay in the current supplied to said input circuits, a connection from said capacitative circuit to the bias control circuit of said gain control amplifier, a connection from said capacitative circuit to the bias control circuit of said first mentioned amplifier, and means interconnecting said capacitative circuit with the output circuit of said first mentioned amplifier for restoring the charged condition of said capacitative circuit and maintaining predetermined biased condition of the bias circuit of said first mentioned amplifier.

7. A control system comprising an amplifier having an input circuit, a bias control circuit and an output circuit, a gain control amplifier having input, bias control and output circuits, a parallel feed circuit for each of said input circuits, a capacitative circuit connected with the output circuit of said gain control amplifier and operative to be discharged thereby according to decay in the current supplied to said input circuits, a connection from said capacitative circuit to the bias control circuit of said gain control amplifier, a connection from said capacitative circuit to the bias control circuit of said first mentioned amplifier, a limiter circuit comprising a resistance network connected with the output of said first mentioned amplifier, and an accelerating amplifier connected with said resistance network with the output thereof connected to said bias control circuit for accelerating the restoration of said bias control circuit to a predetermined normal operating condition.

8. A control system comprising an amplifier having an input circuit, a bias control circuit and an output circuit, a gain control amplifier having input, bias control and output circuits, a parallel feed circuit for each of said input circuits, a capacitative circuit connected with the output circuit of said gain control amplifier and operative to be discharged thereby according to decay in the current supplied to said input circuits, a connection from said capacitative circuit to the bias control circuit of said gain control amplifier, a connection from said capacitative circuit to the bias control circuit of said first mentioned amplifier, a resistance network, means for capacitatively connecting said resistance network to the output circuit of said first mentioned amplifier, and an accelerating amplifier connected with said resistance network and connected with said bias control circuit for restoring said bias control circuit to a predetermined bias control condition.

9. A control system for amplifiers comprising in combination with a main amplifier including a bias control circuit therefore, a gain control amplifier having a bias control circuit, means for simultaneously feeding both said main amplifier and said gain control amplifier, a multiplicity of isolating diodes connected with the output of said gain control amplifier, resistance capacity networks connected with each of said diodes, a connection between one of said networks and the bias control circuit of said gain control amplifier, a connection between another of said networks and the bias control circuit of said main amplifier, a resistance network, means for capacitatively connecting said resistance network with the output of said first mentioned amplifier, an electron tube accelerating circuit connected with said resistance network and connections from said electron tube accelerating circuit to said bias control circuit for expediting the restoration of the bias value to normal operating condition.

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