Feb. 19, 1935. D. O. WHELAN 1,992,021

VOLUME CONTROL SYSTEM

Filed Sept. 15, 1931 2 Sheets-Sheet 1

Fig. 1.

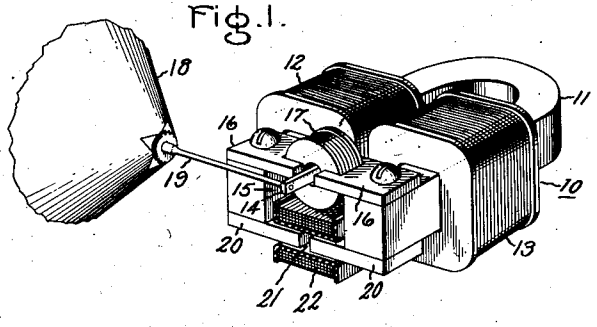


Fig. 2.

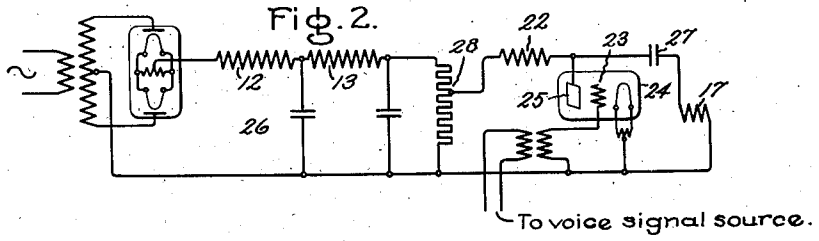


Fig. 3.

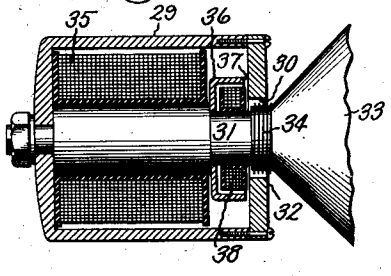
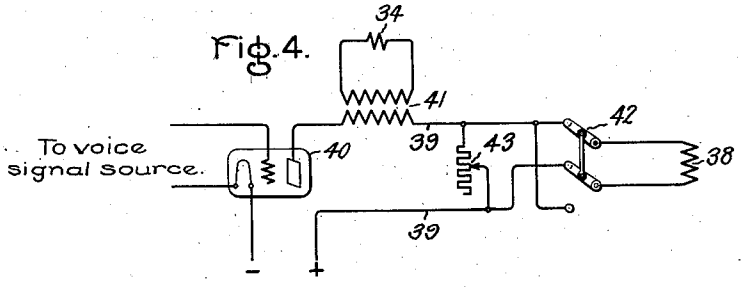


Fig. 4.



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Fig. 5.

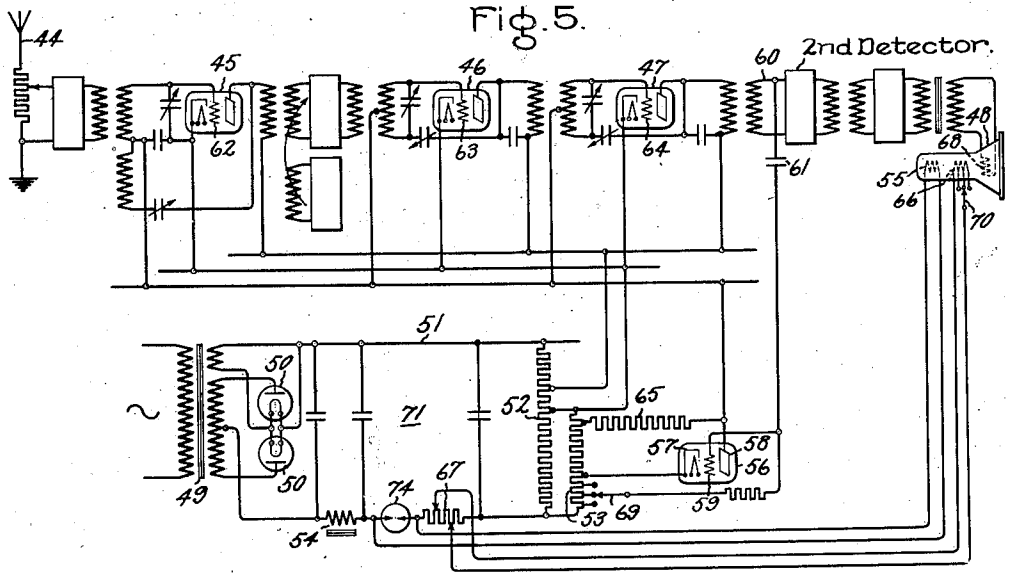


Fig. 6.

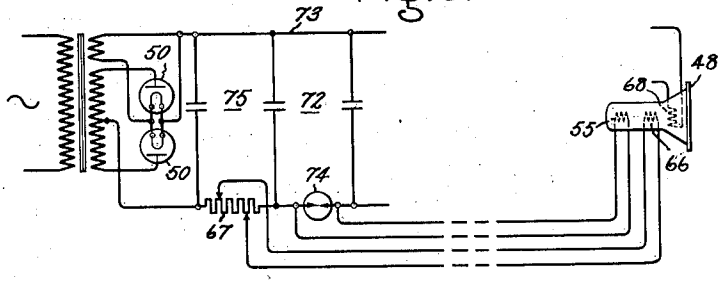
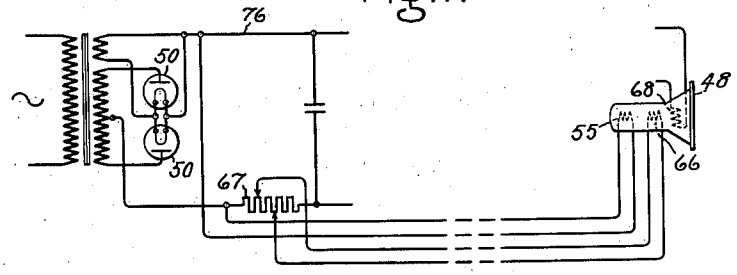


Fig. 7.



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1,992,021

UNITED STATES PATENT OFFICE

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VOLUME CONTROL SYSTEM

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Application September 15, 1931, Serial No. 562,961

18 Claims. (Cl. 250—20)

My invention relates to signal receiving systems, particularly to means for controlling the intensity of the signal emitted by the loudspeaker or other signal indicating device of a radio or other signal receiving system, and has for its object the provision of an improved volume control arrangement for such systems.

In the operation of radio receivers it is necessary that means be provided for the control of the intensity of sound waves emitted by the loudspeaker in order to permit the operator to obtain a desired level of sound volume, and in order also to maintain the level of the sound volume at the predetermined desired value over wide ranges of variation in the intensity of signals impressed on the receiving system, such as occur in case the signals are subjected to the phenomenon known as fading, or as occur when tuning the receiving system from station to station and thereby causing sounds of undesirably loud volume to be produced due to signals from nearby, powerful stations.

Manual control means have been employed for all of the above purposes but by reason of the inconvenience involved in the repeated readjustment of the volume control necessary to compensate for fading, and by reason of the difficulties encountered in so coordinating manually the adjustment of the tuning control and volume control as to prevent undesirable sound volume when tuning from station to station, it is usual practice to provide automatic volume control means to maintain substantially constant the level of sound volume determined manually by the operator.

Various systems of volume control for the purposes above described have been proposed in the past. In certain of these systems means have been provided for varying the bias voltage impressed on the control electrodes of amplifier devices incorporated in the receiver system, or to vary the anode voltage of the amplifier devices, thereby varying correspondingly the intensity of the signal impulses transmitted to the loudspeaker. These and similar means for volume control in radio receivers and the like have not been found altogether satisfactory, however, when employed as manual or other volume control means for causing extreme changes in the intensity of the sound emitted by the loudspeaker, by reason of the tendency to distortion of the signals transmitted through the electronic amplifiers utilized as part of the volume control means.

In accordance with my invention these difficulties are overcome by the provision in a radio or other signal receiving system of volume control means operating on the field flux of the reproducer unit or loudspeaker. This volume control means preferably comprises a leakage path or magnetic shunt forming an auxiliary gap in the loudspeaker magnet structure, and an auxiliary winding associated with the shunt to vary the flux in this auxiliary gap, the winding being connected to a unidirectional current circuit forming part of the signal receiving system.

In a modification of my invention the volume control means operating on the field flux of the reproducer unit comprises means including a main field winding of this unit for varying the total field flux. In this modification the control of sound volume is accomplished by connecting the main field winding to a unidirectional current circuit and by shunting or reversing a portion of the field winding, or otherwise arranging the winding to vary the field flux.

The volume control system in accordance with my invention may be so arranged that the intensity of the signal impulses impressed on the loudspeaker is varied in accordance with current changes in the unidirectional current circuit, to which the winding of the reproducer unit is connected, to compensate for the effects of fading or to prevent the excessively loud sound response above described when tuning from station to station, the system thereby providing automatic volume control without distortion over a wide range in the intensity of the signals impressed on the receiving system. The volume control system in accordance with my invention may be arranged to provide also, in combination with an automatic volume control means, a semi-automatic volume control in which the desired levels of sound signals which are maintained constant by the automatic means are obtained manually by the above mentioned means operating on the field flux of the reproducer. Further, the volume control system comprising the above mentioned means may be so arranged that the sensitivity of the loudspeaker is increased under certain operating conditions, as may be desirable when receiving signals from distant broadcasting stations.

My invention will be better understood from the following description when considered in connection with the accompanying drawings and its scope will be pointed out in the appended claims.

Referring to the drawings, Fig. 1 is a perspective view of a loudspeaker of the electromagnetic type embodying my invention; Fig. 2 is a circuit diagram of a receiving system incorporat-

ing the loudspeaker shown in Fig. 1 and including an automatic volume control arrangement in accordance with my invention; Fig. 3 is a sectional view of a loudspeaker of the electro-dynamic type embodying my invention; Fig. 4 is a circuit diagram of a receiving system incorporating the loudspeaker shown in Fig. 2 and including an automatic volume control and a sensitivity control in accordance with my invention; Fig. 5 is a circuit diagram of a radio receiving system including a semi-automatic volume control system having a manually operated volume control means in accordance with my invention combined with an automatic volume control means; and Figs. 6 and 7 are modifications of the system shown in Fig. 5.

In Fig. 1 is shown a loudspeaker comprising an electromagnetic driver unit 10 including a magnet core 11 having field coils 12, 13 mounted thereon, and an armature 14 arranged to vibrate in a main air gap 15 formed by a pair of pole pieces 16 between which and surrounding the armature 14 is mounted an actuating or voice coil 17. The armature 14 is connected to a diaphragm 18 by a drive rod 19. In accordance with my invention, the electromagnetic driver 10 further includes a second pair of pole pieces 20 forming an auxiliary air gap 21, and on these latter pole pieces is mounted a differential or shunt coil 22 adapted to vary the flux in the auxiliary flux path formed by the pole pieces 20 and air gap 21.

The operation of a volume control system comprising the driving unit 10 will be clear by reference to the circuit diagram of Fig. 2.

In Fig. 2 signals of voice frequency are impressed from any suitable source (not shown) on the control electrode 23 of an amplifier including an anode 25. Current for the anode circuit is supplied preferably from an alternating current source (not shown) and rectified, the resulting unidirectional current passing through a filter 26, certain filter reactors of which are preferably constituted by the field coils 12, 13 of the loud speaker driver 10 shown in Fig. 1.

The output circuit of amplifier 24 which represents the audio frequency amplifier stage immediately preceding the loudspeaker, or the last audio frequency amplifier stage if more than one stage are employed, is of the type characterized by an output condenser and an output choke or output reactor. In the system illustrated in Fig. 2 the alternating component of the amplifier output is, therefore, impressed on the voice coil 17, represented diagrammatically in Fig. 2 and in perspective in Fig. 1, through an output condenser 27 in the usual manner.

In accordance with my invention, however, the output choke or reactor through which the direct component of the amplifier anode current flows is constituted by the auxiliary winding 22 of magnet core 11, above described in connection with Fig. 1. This winding, shown in perspective in Fig. 1, is illustrated diagrammatically in Fig. 2 as connected between the anode 25 and a voltage divider resistor 28 connected to the filter 26.

Assuming that the intensity of signals impressed on the control electrode circuit of amplifier 24 varies undesirably by reason of fading or by reason of tuning the receiver from station to station, the signal oscillations impressed on voice coil 17 of driver 10 from the output circuit of amplifier 24 tend to vary in amplitude, with a corresponding variation in the intensity of sound waves emitted by the loudspeaker. As the anode current of amplifier 24 varies, however, changes occur in the flux in the magnetic shunt or leakage path, constituted by the auxiliary pole pieces 20 and air gap 21, on which is mounted the auxiliary winding 22 constituting the output reactor of the amplifier. The winding 22 is so arranged that as the current therein increases, due to increase in the intensity of the signals impressed on amplifier 24, the flux in the auxiliary air gap 21 increases correspondingly, a portion of the flux in the main air gap 15 being shunted therefrom through the auxiliary air gap 21. The consequent reduction in the flux density in main air gap 15 is accompanied by a reduction in the amplitude of vibration of armature 14 mounted in the main air gap. In the same manner a decrease in the current in auxiliary winding 22 is accompanied by a decrease in the flux shunted through auxiliary gap 21 from main air gap 15, the amplitude of vibration of the armature then increasing correspondingly.

By the provision, therefore, of the magnetic shunt or leakage path and of the auxiliary winding associated therewith and connected in the output circuit of amplifier 24, the volume of sound waves emitted by the loudspeaker tends to remain automatically at proper levels during periods of undesired variation in the intensity of signals impressed on the receiving system.

In the embodiment of the invention illustrated in Figs. 3 and 4, a loudspeaker of the electro-dynamic type is shown in Fig. 3 including a usual magnet structure 29 having a main air gap 30 formed therein between a core 31 and a pole piece 32 having a central aperture. A diaphragm 33 is arranged to be driven in the usual manner by a voice coil 34 mounted to vibrate in the main air gap and a field coil 35 is mounted on the core 31. In accordance with my invention a magnetic shunt or leakage path is formed in the magnet structure by means of an auxiliary pole piece 36 interposed between core 31 and pole piece 32 and arranged to form therebetween an auxiliary air gap 37. Associated with the magnetic shunt or leakage path formed by the auxiliary pole piece 36 and air gap 37 is a winding 38 corresponding to the auxiliary winding 22 above described in connection with the embodiment of the invention shown in Figs. 1 and 2.

As shown in the circuit diagram of Fig. 4, the output circuit 39 of a voice frequency amplifier 40, corresponding to amplifier 24 of Fig. 2, is connected through an output transformer 41 to the voice coil 34, and auxiliary winding 38 of the speaker shown in Fig. 3 is connected in series with the output circuit 39 through a reversing switch 42. Manual volume control means is provided comprising a variable resistor 43 connected across the output circuit 39.

The operation of the form of the invention shown in Figs. 3 and 4 is in general the same as that of the form shown in Figs. 1 and 2, the auxiliary winding 38, through which flows the output current of amplifier 40, operating to change the distribution of the flux through the main air gap 30 and the auxiliary air gap 37, the system then functioning, as above described in connection with Figs. 1 and 2, as an automatic volume control to compensate for changes in the intensity of impressed signals.

In case, however, the system shown in Figs. 3 and 4 is used for the reception of signals from distant stations, necessitating the highest degree of sensitivity in the receiving system, the direction of the output current of amplifier 40 through winding 38 may be reversed by means of switch

42, whereby as the relatively weak signals are impressed on the receiver a decrease instead of an increase of the flux in the auxiliary gap 37 occurs and a corresponding increase in the intensity of sound emitted by the loudspeaker, by reason of the increased flux in main air gap 30 in which is mounted voice coil 34. It will be evident that means such as switch 42 for increasing the sensitivity of the loudspeaker during reception of weak signals may be incorporated without difficulty in the volume control system shown in Figs. 1 and 2.

The loudspeakers illustrated in Figs. 1 and 3 have been described as incorporating magnet cores having field coils mounted thereon. It will be understood, however, that the field structure of the loudspeakers may be of the permanent magnet type.

In the embodiment of the invention illustrated diagrammatically in Fig. 5 the signal receiving system in which a semi-automatic volume control is incorporated is shown for purposes of illustration as a radio broadcast receiving apparatus of the superheterodyne type with which is operatively combined a socket power unit for supplying direct voltages to the electronic devices of the receiving apparatus from an alternating current source. The receiver portion of the system includes an antenna 44 coupled to a radio frequency amplifier 45, a 1st detector, an oscillator, two intermediate radio frequency amplifiers 46 and 47, a 2nd detector, a power or output amplifier, and a reproducer unit or loudspeaker 48 which is preferably of the electrodynamic type. The power unit portion of the receiving system includes a transformer, only a part of which, 49, is shown in the figure, connected to an alternating current source, rectifying tubes 50, a filter 51, voltage divider resistors 52 and 53, and filter reactors 54 and 55 one of which as 55 is preferably constituted by a field coil of the loudspeaker 48 similar to the field coil 35 of the reproducer unit shown in Fig. 3. The above apparatus illustrated in Fig. 5 is of well known construction and need not be described further.

In order to enable the operator of the receiving system illustrated in Fig. 5 to obtain desired volume of sound from the reproducer unit 48, and, at the same time, in order to maintain the level of volume of sound at any predetermined desired value over a range of variations in the intensity of the signals impressed on the antenna 44, the semi-automatic volume control system which is provided comprises a manually operated control portion and an automatic portion.

Of this semi-automatic volume control system the automatic portion may be of any well known form but comprises preferably an automatic volume control or pilot tube 56 having a cathode 57, an anode 58 and a control electrode or grid 59. This tube maintains the predetermined level of sound volume constant in a usual manner by controlling the intensity of the transmitted signal at some point or points of the receiver preceding the output or power amplifier stage. In this form of automatic volume control the signal voltages impressed on the input circuit 60 of the 2nd detector are also impressed through a condenser 61 on the grid 59 of the pilot tube 56, thereby influencing the current in the anode circuit of this tube. Since the bias potential impressed on the control electrodes or grids 62 to 64 of amplifiers 45 to 47 is constituted by the voltage drop across a resistor 65 in the anode circuit of pilot tube 56 a strong signal impressed on the grid 59 of the pilot tube, ordinarily producing a loud sound from the reproducing unit 48, causes an increase in anode current in this tube and therefore an increased bias voltage on the amplifier grids 62 to 64 due to the increased voltage drop in anode resistor 65. This increased bias voltage on grids 62 to 64 tends to decrease the signal transmitted to the 2nd detector and therefore the sound output of the reproducer unit. In the same manner, a weak transmitted signal tends to be increased by the action of the pilot tube. This tube, therefore, operates to maintain the intensity of the signal impressed on the reproducing unit 48, and the volume of sound emitted therefrom, at a predetermined level.

In semi-automatic volume control systems employed heretofore incorporating a volume control or pilot tube, as tube 56 shown in Fig. 5, the manual adjustment of the receiver for a predetermined level of sound volume has been accomplished by varying the bias voltage impressed on the grid of this pilot tube, for example by connecting its grid through manually operated switch means to a continuously variable resistor connected to the filter of the alternating current supply means. In accordance with my invention, however, the pilot tube, associated as above described with the grids of the amplifiers 45 to 47 and with the input circuit 60 of the 2nd detector, is relieved from the work of determining by manual operation the desired level of sound volume. In the embodiment of the invention illustrated in Fig. 5 this part of the semi-automatic control of sound volume is accomplished by means similar in general to the volume control system, including means operating on the flux in the magnet system of the reproducer unit, above described in connection with the embodiments of the invention illustrated in Figs. 1 to 4. In the latter volume control systems a winding, as coil 22 of Figs. 1 and 2, and coil 38 of Figs. 3 and 4, is described as connected to a unidirectional current circuit of the receiving system, the current in which varies in accordance with the variations in the intensity of the signals impressed on the system, the winding operating on the field flux in a manner to maintain predetermined levels of sound volume automatically.

The volume control means in the system illustrated in Fig. 5, however, including a winding, as 66, operating on the field flux of the reproducer unit 48 is provided for the purpose of permitting manual adjustment of the level of sound volume and not for the purpose of maintaining this level automatically. The winding 66 of reproducer unit 48, associated preferably with a magnetic shunt or leakage path in the same manner as described in connection with the auxiliary winding 38 shown in Fig. 3, is, therefore, arranged to constitute a filter reactor in the filter 51, the current in that portion of the filter to which the winding 66 is connected being substantially constant, or varying only to a slight degree with variations in the intensity of signals impressed on the system of which the filter forms a part.

In order to vary manually the current flowing in winding 66 the latter is connected to a continuously variable resistor 67 connected in the filter 51, adjustment of the variable resistor, to vary the amount of filter load current flowing through coil 66, operating to vary the effective flux in the magnet of the reproducer 48 and consequently the level of the sound volume. When this level has been established by the described manual adjustment of the filter load current

flowing in coil 66, the level is then maintained constant by the action hereinbefore explained of the automatic portion of the semi-automatic control system, this latter portion comprising pilot tube 56.

It will be noted that the semi-automatic volume control system illustrated in Fig. 5 and above described has the marked advantage over the usual semi-automatic system employing an automatic volume control tube or pilot tube whose control electrode voltage is manually varied that a much wider control range is covered without distortion and without the necessity of employing highly specialized tubes for the control of sound volume. To produce this beneficial result, in the system shown in Fig. 5 the manual control of the sound volume level, which after being set manually at a desired value is maintained constant by the pilot tube, is effected by means operating not on the bias voltages of the amplifier tubes but only on the field flux of the reproducer unit, thus permitting all of these amplifier tubes, controlled by the pilot tube, to operate on that bias voltage which produces maximum quality of sound reproduction. This higher quality of reproduction is attained, by this means, even when the pilot tube operates over narrow limits of volume variation.

In the above description of operation of the volume control systems illustrated in Figs. 1 to 5, I have set forth that the control of the field flux in the reproducer unit is accomplished by means comprising a magnetic shunt and an auxiliary field winding cooperating therewith to vary the distribution of flux between the main air gap and an auxiliary air gap. It will be readily understood however that instead of employing a magnetic shunt and an auxiliary winding to vary the field flux the total field flux may be controlled, and the intensity of sound emitted by the reproducer unit correspondingly varied, by connecting a main field coil or coils, as field coils 12 and 35 of Figs. 1 and 3 respectively, to a unidirectional current circuit forming part of the signal receiving system as shown for example in Figs. 2 and 5, and by providing suitable switch means, as required for manual control of the sound volume level, to connect the field coil in any suitable manner to the unidirectional current circuit, for example to shunt or reverse a portion of the coil, thereby varying the total field flux in the main air gap in which the vibrating armature 14 of Fig. 1 or the voice coil 30 of Fig. 3 is mounted.

Since in the semi-automatic volume control system illustrated in Fig. 5 the control or pilot tube 56 is not operated as a means for manual adjustment of the level of sound volume but only for automatic maintenance of this level, the grid circuit of this tube does not require the continuously variable resistor means provided heretofore for effecting the manual adjustment. Therefore, in the form of the invention illustrated in Fig. 5 the grid 59 of pilot tube 56 is connected to the voltage divider resistor 53 by means of a tapped switch 69, whereby preliminary adjustment of the automatic volume control or pilot tube is accomplished by simple switch means, this form of switch permitting the use of relatively high resistance values between adjacent control points of the switch, not obtainable in a switch means comprising a volume control resistor which is continuously variable.

In order to provide for the larger variations in the sensitivity of the reproducing unit 48 the field windings of the reproducer unit may be connected to the current source through tapped switches, as switch 70 connected to the field winding 66, or the field windings may be arranged for series parallel tapping for this purpose. It will be readily understood, further, that for the purpose of increasing the sensitivity of the reproducer when receiving weak signals, means may be provided for reversing the direction of current through the field winding 66 in the same manner as described in connection with the winding 38 and switch 42 shown in Fig. 3.

The modification of my invention illustrated in Fig. 6 is in all respects the same as that illustrated in Fig. 5 except that, whereas in Fig. 5 the main field winding 55 and auxiliary winding 66 of reproducer unit 48 are connected in the same section 71 of filter 51, in Fig. 6 these windings are connected each in a different section of a filter. In Fig. 6 main winding 55 is connected in one section 72 of the filter 73, across a field protective short-circuiting switch 74 as in Fig. 5, and auxiliary winding 66 is variably connected to the resistor 67 in another section 75 of the filter 73.

The modification of my invention illustrated in Fig. 7 is similar in construction and operation to the modifications illustrated in Figs. 5 and 6. The modification shown in Fig. 7, however, differs from those of Figs. 5 and 6 in that at least one of the field windings 55, 66 of the reproducer unit 48 is connected to the current source filter in parallel with the load. Whereas in the modifications shown in Figs. 5 and 6 both windings are in series with the load connected to the filter, in Fig. 7 the auxiliary winding 66 only is connected in series with the load in filter 76, the main winding 55 being connected across the filter in parallel with the load therein.

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

1. The combination with a signal system comprising a unidirectional current circuit and a signal indicating device including means providing a magnetic circuit having an air gap, a movable element mounted in said gap, and means to actuate said element in accordance with signal current in said system, of means to provide distortionless control over a wide frequency range of the intensity of the signal produced by said signal indicating device, said means including a winding connected to said unidirectional circuit and associated with said magnetic circuit to vary the flux in said gap, said last-named means remaining fixed in position with relation to said signal indicating device during variation of said flux.

2. The combination with a signal receiving system comprising a signal indicating device including a magnet having a main air gap and a signal current coil associated therewith, and a unidirectional current circuit associated with said system, of means to provide distortionless control over a wide frequency range of the intensity of the signal produced by said signal indicating device, said means including a winding associated with said magnet and connected to said unidirectional circuit to vary the flux in said gap, said means remaining fixed in position with relation to said magnet during variation of the intensity of said signals.

3. In a signal receiving system, an input circuit, a unidirectional current circuit, the current in said unidirectional current circuit varying in accordance with the intensity of signals impressed on said input circuit, a sound producing device

including a magnet having an air gap and an element adapted to vibrate therein, and means to provide distortionless control over a wide frequency range of the volume of sound emitted by said sound producing device, said means including a winding connected to said unidirectional current circuit and associated with said magnet to vary automatically in accordance with the intensity of said signals impressed on said input circuit the intensity of sound waves produced by said sound device, said means remaining fixed in position with relation to said magnet during variation of the intensity of said signals.

4. In a signal receiving system, an input circuit, a unidirectional current circuit, the current in said unidirectional circuit varying in accordance with the intensity of signals impressed on said input circuit, a sound producing device including a magnet having an air gap and a vibrating element mounted therein, means providing a leakage path for the flux in said magnet, and means to provide distortionless control over a wide frequency range of the volume of sound emitted by said sound producing device, said means including a winding connected to said unidirectional current circuit and associated with said magnet to vary automatically the flux in said leakage path in a predetermined manner in accordance with the current in said unidirectional current circuit, said means providing a leakage path remaining fixed in position with relation to said magnet during variation of the flux in said leakage path, whereby the intensity of sound waves emitted by said sound device is varied in accordance with the intensity of said impressed signals.

5. In a signal receiving system, an input circuit, a sound producing device including a magnet having an air gap and a vibrating element mounted therein, and means to provide distortionless control over a wide frequency range of the volume of sound emitted by said sound emitting device, said means including a winding associated with said magnet and in which flows current varying in accordance with the intensity of signals impressed on said input circuit to vary automatically the flux in said magnet, said winding being so arranged that the intensity of the sound waves emitted by said sound device varies automatically inversely as the intensity of said impressed signals, whereby the intensity of said emitted sound waves tends to remain substantially constant with varying intensity of said impressed signals, said means including said winding remaining fixed in position with relation to said magnet during variation of the flux in said magnet.

6. In a signal receiving system, an amplifier including an input circuit and an output circuit, a sound producing device operatively associated with said amplifier and including a magnet having an air gap and a vibrating element mounted therein, and means to provide distortionless control over a wide frequency range of the volume of sound emitted by said sound emitting device, said means including a winding connected to said output circuit to vary the flux in said magnet, whereby the intensity of sound waves emitted by said sound device tends to vary automatically in accordance with the intensity of signals impressed on said input circuit, said means including said winding remaining fixed in position with relation to said magnet during variation of the flux in said magnet.

7. In a signal receiving system, an amplifier including an input circuit and an output circuit, a sound producing device adapted to be operated by said amplifier and including a magnet having an air gap and a vibrating element mounted therein, means to provide distortionless control over a wide frequency range of the volume of sound emitted by said sound emitting device, said means including a winding connected to said output circuit to vary the flux in said magnet and switch means in operative relation with said winding to cause said flux to change in a predetermined manner, whereby the intensity of sound waves emitted by said sound device tends to increase in one position of said switch and to diminish in another position thereof in accordance with the intensity of signals impressed on said input circuit, said means including said winding remaining fixed in position with relation to said magnet during variation of the flux in said magnet.

8. The combination with an electric system comprising a unidirectional current circuit and a signal indicating device including means providing a magnetic circuit having an air gap and a movable element mounted in said gap, of means to provide distortionless control over a wide frequency range of the intensity of the signal produced by said signal indicating device, said means providing a magnetic leakage path in said magnetic circuit, and means including a winding connected to said unidirectional current circuit and associated with said magnetic leakage path to vary the flux in said gap, said means providing a leakage path remaining fixed in position with relation to said signal indicating device during variation of the flux in said gap.

9. The combination with an electric system comprising a unidirectional current circuit and a signal indicating device including a magnet structure having a main air gap and an element adapted to vibrate in said gap, of means to provide distortionless control over a wide frequency range of the intensity of the signal produced by said signal indicating device, said means including an auxiliary air gap in said magnet structure, and means including a winding connected to said unidirectional current circuit and associated with said auxiliary air gap to vary the flux in said main air gap, said auxiliary air gap remaining of fixed length during variation of the flux in said main air gap.

10. The combination with an electric system comprising a unidirectional current circuit and a signal indicating device including a magnet structure having a main air gap and an element adapted to vibrate in said gap, of means to provide distortionless control over a wide frequency range of the intensity of the signal produced by said signal indicating device, said means including an auxiliary air gap in said magnet structure, and means including a winding connected to said unidirectional current circuit to shift flux from said main air gap to said auxiliary air gap, said auxiliary air gap remaining of fixed length during variation of the amount of flux shifted from the main air gap to the auxiliary air gap.

11. In a signal receiving system, an amplifier including input and output circuits, a source of unidirectional current, a sound producing device arranged to be operated by said amplifier and including a magnet structure having an air gap and a vibrating element mounted therein, and means to provide distortionless control over a wide frequency range of the sound emitted by said sound producing device, said means including a magnetic shunt in said magnet struc-

ture and means including a winding associated with said shunt to vary the flux therein said source of unidirectional current being connected to said output circuit through said winding, said magnetic shunt remaining fixed in position with relation to said magnet structure during variation of the flux in said shunt.

12. In a signal receiving system, an amplifier including an input circuit and an output circuit, a source of unidirectional current, a sound producing device including a magnet structure having an air gap and a vibrating element mounted therein, means including a capacitance to connect said sound device to said output circuit, and means to provide distortionless control over a wide frequency range of the sound emitted by said sound producing device, said last-named means including a magnetic shunt in said magnet structure and means including a winding associated with said magnetic shunt to vary the flux therein, said winding being connected between said current source and said output circuit and constituting the output choke of said amplifier, said magnetic shunt remaining fixed in position with relation to said magnet structure during variation of the flux in said shunt.

13. The combination with a signal system adapted to receive signals of varying intensity and comprising an amplifier of frequencies above audibility, a unidirectional current circuit, and a sound producing device including a field magnet having poles forming an air gap and a vibratable member mounted therein, of means to maintain the intensity of sound waves emitted by said sound device at predetermined levels, said means comprising volume control means connected with said amplifier and operating in accordance with current therein to maintain automatically the intensity of signals impressed on said sound device substantially constant during periods of variation in the intensity of signals received by said system, and means to control manually without distortion over a wide frequency range the intensity of said emitted sound waves including a winding connected to said unidirectional circuit and arranged to vary the flux in said air gap, said last-named means remaining fixed in position with relation to said field magnet during variation of the flux in said air gap.

14. The combination with a signal system adapted to receive signals of varying intensity and comprising an amplifier of frequencies above audibility having a control electrode, a detector having an input circuit, a sound producing device including a field magnet having poles forming an air gap and a member adapted to vibrate therein, and a unidirectional current circuit, of means to maintain the intensity of sound waves emitted by said sound device at predetermined levels, said means comprising an electronic device arranged to vary the bias voltage of said control electrode of said amplifier in accordance with the voltage in said input circuit of said detector to maintain automatically the intensity of of signals impressed on said sound device substantially constant during periods of variation in the intensity of signals received by said system, and means to control manually without distortion over a wide frequency range the intensity of said emitted sound waves including a winding connected to said unidirectional circuit and arranged to vary the flux in said air gap, said last-named means remaining fixed in position with relation to said field magnet during variation of the flux in said air gap.

15. The combination with a signal receiving system comprising an amplifier device having a plurality of electrodes, a detector, a sound producing device including a field magnet, means to impress signals on said sound device from said detector, and means including a current source and a filter for supplying current to the output circuits of said amplifier and detector, of means to control the intensity of sound waves emitted by said sound producing device, said last-named means comprising volume control means connected with one of said amplifier electrodes and with the input circuit of said detector and operating in accordance with current in said amplifier to maintain automatically at a predetermined value the signal energy transmitted from said amplifier to said detector, and means to vary manually independently of said automatic means the intensity of said emitted sound waves without distortion over a wide frequency range comprising a winding connected to said filter and constituting a filter reactor therein, said winding being associated with said field magnet for varying the flux therein, said manually variable means remaining fixed in position with relation to said field magnet during variation of the flux in said magnet.

16. The combination with a signal receiving system comprising a plurality of amplifiers each having a control electrode and an output circuit, a detector having input and output circuits, a loudspeaker including a field magnet, means to impress signals on said loudspeaker from said detector output circuit, and means including a current source and a filter for supplying current to said output circuits, of means to control semi-automatically the intensity of sound waves emitted by said loudspeaker, said last-named means comprising an electronic device to vary automatically the bias voltage of said control electrode in accordance with the voltage in said detector input circuit, and means to vary manually without distortion over a wide frequency range the intensity of said emitted sound waves comprising a magnetic shunt in said field magnet and a winding associated with said shunt for varying the flux in said field magnet and constituting a filter reactor of said filter, said manually variable means remaining fixed in position with relation to said field magnet during variation of the flux in said magnet.

17. In a signal receiving system, a plurality of amplifiers each having a control electrode and an output circuit, a detector having input and output circuits, a loudspeaker including a field magnet, means to impress signals on said loudspeaker from said detector output circuit, means including a current source and a filter for supplying current to said output circuits, and volume control means for said system comprising means including an electronic device having a control electrode to vary automatically the bias voltage of said control electrodes of said amplifiers in accordance with the voltage in said detector input circuit, means including a tapped resistor associated with said filter for supplying potentials to said control electrode of said electronic device, and means to vary manually without distortion over a wide frequency range the intensity of sound waves emitted by said loudspeaker including means providing a magnetic shunt in said magnet and a tapped winding associated with said shunt and constituting a choke coil to vary the flux in said shunt, said means providing a magnetic shunt remaining fixed in position with

relation to said field magnet during variation of the flux in said shunt.

18. In a signal receiving system, a plurality of amplifiers each having a control electrode and an output circuit, a detector having input and output circuits, a sound producing device including a field magnet having poles forming an air gap and a vibratable member mounted therein, means including a current source and a filter for supplying current to said output circuits, and volume control means for said system comprising means including an electronic device having a control electrode to vary automatically the bias voltage of said control electrodes of said amplifiers in accordance with the voltage in said detector input circuit, means including a resistor associated with said filter for supplying potentials to said control electrode of said electronic device, which means including taps in said resistor adapted to be connected to said electrode for preliminary adjustment of said electronic device, means to control manually without distortion over a wide frequency range, the intensity of sound waves emitted by said sound device including a winding associated with said field magnet and arranged to vary the flux in said air gap, said last-named means remaining fixed in position with relation to said field magnet during variation of the flux in said air gap, and means to supply current to said winding including a continuously variable resistor connected to said filter for fine adjustment of the current in said winding and switch means comprising taps in said winding for preliminary coarse adjustment of said current in said winding.

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