Feb. 11, 1936. M. L. DULL 2,030,573

ELECTRIC CONTROL

Filed April 30, 1932 2 Sheets-Sheet 1

FIG. 1.

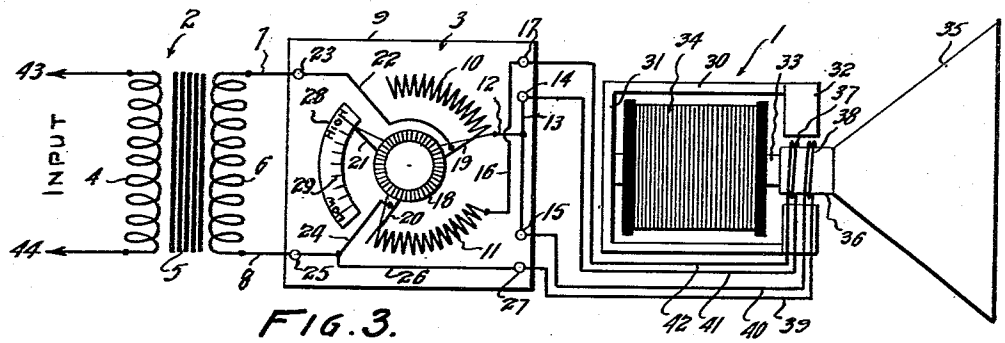


FIG. 3.

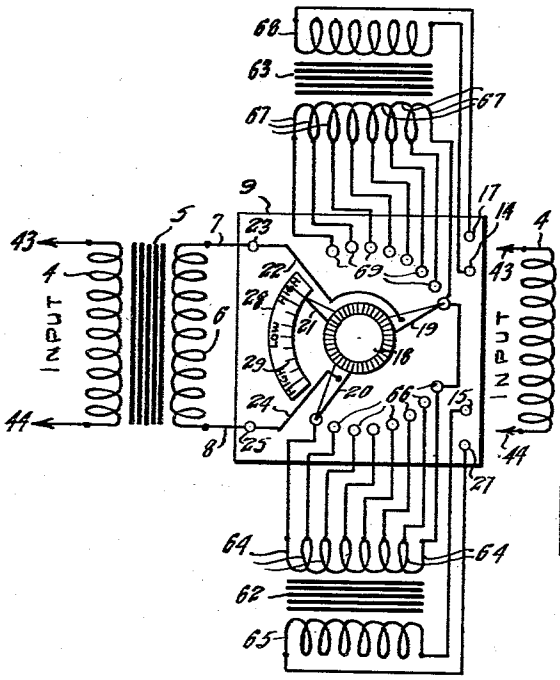
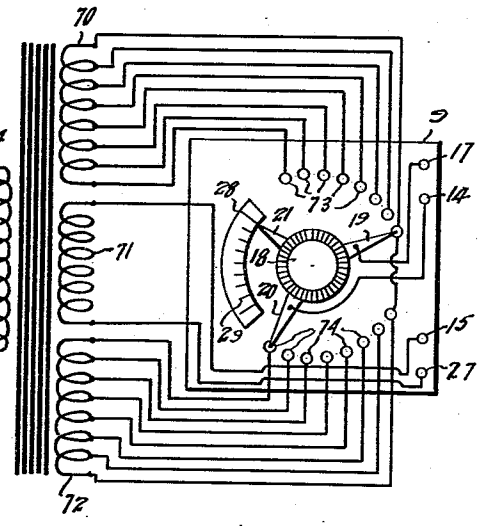


FIG. 4.



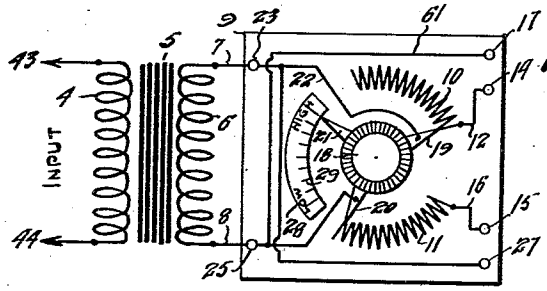


FIG. 5.

Inventor

M. LYTTON DULL

By Semmes & Semmes

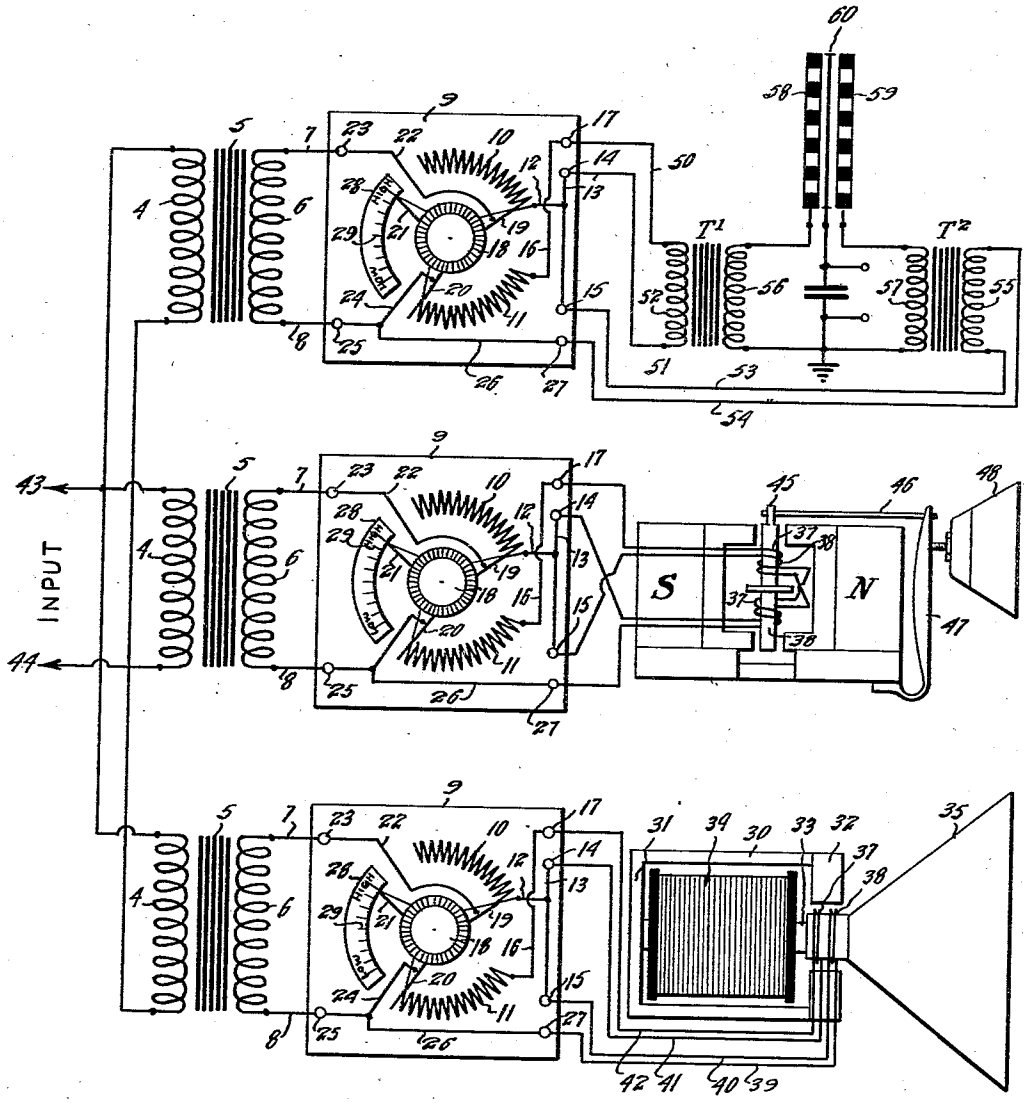
Attorneys

Feb. 11, 1936. M. L. DULL 2,030,573

ELECTRIC CONTROL

Filed April 30, 1932 2 Sheets-Sheet 2

FIG. 2.



Inventor

M. LYTTON DULL

By Semmes & Semmes

Attorneys

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UNITED STATES PATENT OFFICE

2,030,573

ELECTRIC CONTROL

Marshall Lytton Dull, Catonsville, Md., assignor to Dull Radio Laboratories, Inc., Baltimore, Md., a corporation of Maryland

Application April 30, 1932, Serial No. 608,504

5 Claims. (Cl. 179—1)

This invention relates to a method of controlling electrical outputs and more particularly to a method of controlling the volume of an electrical reproducer.

The desirability of controlling the volume of sound emitted from a radio reproducer was recognized at an early date and a number of methods of controlling such volume have been developed. These, generally considered, involve the diminution of reproduced sound by modifying the operating conditions of the receiver. A typical method of control, for example, consists of the introduction of a suitable control in the associated equipment to alter the energy amplified at the source, or while passing through such equipment. While prior devices have served to control the volume, this has been done at the expense of the quality of reproduction.

An object of the present invention is to provide an improved method of electrical control.

Another object is to provide an improved method of controlling the electrical reproduction of sound.

Another object is to provide a method of controlling the volume of reproduced sound while maintaining the full quality of sound to be reproduced.

Yet another object is to improve the effectiveness of a radio receiving system.

A further object is to devise an improved sound reproducer.

The present invention is based upon a concept quite different from that involved in prior volume control and is effectuated in a method which is not only different in its operating principle but which accomplishes results inherently impossible of achievement in prior devices.

The present invention is conceived to ramify more widely than the radio receiving art, but insofar as it pertains to the art of reproduction of sound the present invention comprehends the concept of controlling the volume of reproduced sounds, as for example in a loud speaker, not by a reduction or distortion of the electrical source but by maintaining the effective maximum energy of the source and controlling its ultimate effect by opposing such maximum energy with a predetermined controllable quantum of energy which is identical in character with the energy source, actuating the reproducer.

With the given concept it will be appreciated that improved results may be achieved. For example, in prior devices, operating upon the principle of cutting down the electrical input to the reproducer system, as the volume of the reproduced sound was progressively diminished the relative volume of extraneous sound, such as hum, tube noises and so forth, progressively increased. In the present system in which the receiving set is operated at maximum energy output, these extraneous sounds, such as tube noises and hum, are always maintained at a low value relative to the maintained high intensity of the sound signals to be reproduced. Under actual operating conditions the relative value of such extraneous sounds is so low as to be insignificant and indistinguishable in the loud speaker. When the present invention is embodied in a radio receiver, therefore, there is achieved a great reduction in the effect of foreign energy on the controlled output of the desired energy.

In addition to this, utilization of the present improvement achieves a truer response to the sound signals received due to the relatively great energy being used for the reproduction of the sounds than that which is represented in the output, when that output has been controlled to a low value.

Similarly, the present improvement insures an increased sensitivity of the controlled output due to the fact that even feeble impulses received in the system are impressed in their full relative value upon the loud speaker. The present system also insures a great reduction in the persistence of vibration of those parts of the equipment which are associated with the output arrangement.

The present invention also insures an optimum quality of reproduction. For example, the timbre or color of the musical notes to be reproduced are faithfully secured in the reproducer. Since the present invention insures the operation of the receiving system at its maximum power efficiency, there is secured a great reduction in alteration of set voltages, under all conditions, resulting in improved selectivity and reduction of first and second power line harmonic modulation of the radio frequency energy, thereby reducing distortion and cross talk.

As noted hereinbefore, the present invention is susceptible of embodiment in a number of specific electrical apparatus, but in order to clearly explain the underlying principles there is shown in the accompanying drawings a preferred embodiment of it in the reproducer or loud speaker art.

Fig. 1 is a diagrammatic illustration of the improved system of control applied to a typical dynamic speaker.

Fig. 2 is an illustration of the system utilizing different types of reproducer units.

Fig. 3 is a diagrammatic illustration of a modification of the volume control unit.

Fig. 4 is a further modification of the device shown in Fig. 3.

Fig. 5 illustrates an additional modification of the resistive type of control shown in Fig. 2.

In the ordinary receiving set now employed the loud speaker comprises essentially a single movable coil which is conductively connected to the secondary of a coupling transformer. In such prior sets there is no provision for controlling the volume in the reproducer or loud speaker, but such control is obtained by means included in the first stages of the receiving circuit and are operative to vary the energy output of the transformer.

As noted hereinbefore, the present system operates on a different principle and involves as major features the establishment and maintenance of the effective maximum energy output of the coupling transformer and the opposition to this maximum output of a variable quantum of energy which has the precise electrical characteristics of the output energy. The energy which operates the speaker, therefore, is the residual or differential energy.

The different devices illustrated in the drawings which operate upon the stated principle, though structurally different are substantially functionally equivalent. These are, however, not to be considered as the exclusive apparatus available for effectuating the underlying principles but are merely illustrative or typical embodiments. Similarly it will be appreciated that while in these structures variations in electrical input are transmuted into sound by means of an air-displacing body, the fundamental ideas may be incorporated in a similar or different apparatus to obtain other results. Thus the present system is peculiarly adapted to the orthophonic recording of sound upon a suitable medium. If such a result is desired it may readily be achieved by attaching a cutting instrument to the movable coil or armature in place of the cone of the speaker. All other such ramifications and adaptations are intended to be comprehended within the spirit and scope of the present disclosure.

As shown in the drawings, the major principles of the invention may be embodied in any desired type of reproducer and may utilize different specific means of control. In Fig. 1 is shown a unit which comprises a movable coil reproducer 1, associated with any desired type of receiving circuit through the coupling transformer 2 and a variable control unit 3.

The coupling transformer is of special design to more effectively operate under the conditions of the present improvement. It comprises the primary winding 4, the core 5, and secondary winding 6. This unit should be of a size sufficiently ample to accommodate the maximum watt rating of the reproducer. The primary winding 4 is designed to match the impedance in the associated receiving system. The impedance of the secondary winding 6 matches that of one of the coils of the double wire coil assembly (to be described).

The leads 7 and 8 from the secondary of the transformer are conductively connected to a volume control unit. For the sake of simplifying the drawings this is shown as a separate element provided with binding posts for connections to the reproducer at one end and to the coupling transformer at the other. However, it will be appreciated that the variable control element may be made up in a single unit with the loud speaker. In one typical form, as shown in Fig. 1, the control unit may comprise a special variable resistance. This is designed in a novel manner to adapt it to the requirements of the improved unit.

This variable resistance may take the form of a suitable casing 9 in which are mounted the resistors 10 and 11. These resistor units should be of sufficient size to efficiently handle the watt rating of the reproducer employed. The resistor 10 is conductively connected through the leads 12 and 13 with the binding post 14. The lead 13 is connected at its other end to the binding post 15. The resistor unit 11 is connected through lead 16 to the binding post 17 thereby making resistor 10 common to the two voice coils 37 and 38. Therefore the two coils are equally effected by any variation in the resistor 10.

Suitably mounted on a rotative shaft is the control knob 18 which carries the conductive arms 19 and 20 and the index or pointer 21. The arm 19 is adapted to make contact with and slide over resistor unit 10 and is conductively connected through the lead 22 to the binding post 23. Similarly, the arm 20 which slides over and makes electrical contact with resistor 11 is connected through lead 24 to binding post 25. The arm 20 is likewise connected through the lead 26 to the terminal binding post 27.

The resistance element 11 should be of the square-jaw type having a total resistance of approximately five times the impedance of one coil of the double voice coil assembly of the reproducer 1. The resistor 10 should be of the proper resistance value and taper so as to maintain the terminals 23 and 25 of the volume control unit at a constant impedance regardless of the position of the control knob 18. It will be understood that these stated values for the resistance elements will vary considerably depending upon the size and mechanical shape of the reproducer and upon the impedance of the voice coils.

There is also suitably associated with the control knob 18 and pointer 21 of the volume control unit a dial 28 provided with graduations 29. The dial is divided into degrees, represented by the graduations, and the control units so calibrated that these graduations represent fixed quantities or increments of volume.

The electro dynamic reproducer 1 is of special construction in respect of the voice coil assembly. It may comprise a cylindrical case 30 of suitable magnetic material having an integral wall 31 forming a closure at one end and an annular pole piece 32 at the other end. A central core 33 of soft iron or other suitable magnetic material is attached to the end wall 31 by any desired means (not shown). The free end of the core, as shown, extends into the circular opening or gap in the pole piece 32. A field coil 34 of any approved design encloses the core 33 and is connected by leads (not shown) to a suitable source of unidirectional current, such for example as rectified and filtered alternating current.

A cone 35 is mounted adjacent the core 33 by means of a cylindrical extension 36. The cone and mounting cylinder are supported in their operative position by a spider or other suitable means (not shown) in the manner known to those skilled in the art. Upon the cylindrical extension are mounted the two voice coils 37 and

38. Preferably these coils are made up by convoluting two wires of exact dimensions and exact electrical constants on the revolving coil support. These coils are wound in parallel and the winding operation is so conducted that the parallel wires remain in the same cylindrical plane throughout each layer. Each layer of wire is insulated from the preceding layer and after completion of the winding the entire unit is impregnated with a suitable embedment compound so that the entire double coil assembly constitutes a solid unit mass. After the winding operation each end of each wire, constituting the double coil, protrudes and these form termini for the attachment of flexible leads 39, 40, 41, and 42 for the purpose of conductively connecting the coil assembly to the volume control unit. This method of mounting, therefore, insures a unitary coil assembly comprising two coils of the same electrical constants.

The electrical energy to be reproduced enters the system at the input terminals 43 and 44 entering the primary 4 of the transformer. The corresponding value of induced current then passes by way of the volume control unit to the voice coils. In this circuit it is, so to speak, divided or dissociated into two components of current, the values of which depend on the position of the control knob. These current components by way of suitable leads are fed to the coils 37 and 38 where they oppose each other. The difference between the components then becomes the available operating current energy for the cone 35.

In the position of the parts shown in Fig. 1 the pointer 21 is at one end of the dial 26. This is the high or maximum volume position. In such an adjustment energy from the secondary 6 enters by way of terminal 23 and lead 22 to conducting arm 19. This arm is at the extreme high end of resistor 10 and hence the entire resistor is cut out. The maximum current, therefore, traverses lead 12 and terminal 15 and then through the lead 40 to voice coil 38. The circuit of this coil is completed through lead 39, binding post 27, leads 26 and 8, to the other end of the secondary.

Tracing the circuit of coil 37 it will be seen that in the position of parts shown in Fig. 1 current entering the volume control mechanism by way of binding post 23 and lead 22 passes directly through arm 19 and lead 12 to binding post 14, since the resistance 10 is cut out. Current in this line is, therefore, conducted through lead 41 to the second coil 37. On the other side of the coil 37, it will be noted however, the lead 8 from the secondary is connected by lead 24 to the arm 20. In the maximum value position, current from lead 8 and lead 24 passes through the entire resistance 11. Therefore, in view of the fact that the resistor 11 is in the circuit connecting coil 37 with the secondary of the transformer, the energy coil 37 is at a minimum. In the preferred embodiment this is about 16.6%.

The voice coils 37 and 38 are thus so connected to the energy source that the energy in coil 37 cancels out or nullifies its value from the coil 38. As noted above, even in the extreme high position of the volume control knob, a small quantity of energy (approximately 16.6%) is impressed on coil 37. This is done to increase the faithfulness of the vibration of the cone 35 to the alternations of the input electric energy by operating, so to speak, as an electrical buffer, thus preventing overriding of the cone and insuring a more precise response to the input.

It will be appreciated that as the knob 18 is turned and the pointer 21 traverses the dial 28 from the extreme high to the extreme low position, the energy passing through coil 37 approaches in value that passing through coil 38. When the device is adjusted to the extreme low position coils 37 and 38 will contain the same amount of energy and, in view of their cancelling or nullifying effect, there will be no movement of the cone 35. In this extreme low position of the volume control, the resistor 10 is brought into the circuit common to both the coils 37 and 38. This is done for the purpose of maintaining a constant impedance across the terminals 23 and 25.

The mechanical operation of the cone itself will be appreciated by those skilled in the art. Due to the establishment of a strong magnetic flux between the outer end of pole piece 33 and the front plate 32, the residual or available alternating energy in coil 38 effects an inward and outward movement of the coil support 36 which, due to its connection, imparts a corresponding movement to the cone. When the source of energy at the input of the transformer is within the audible range, sound will be produced by the movement of the cone.

While the principles of the present invention have been explained as embodied in an electro-dynamic speaker, it will be apparent that these may similarly be incorporated in any other desired type of speaker. Examples of such embodiments are shown in Fig. 2 where, for purposes of simplicity, three typical types of reproducers, namely electro-dynamic, electro-magnetic and electrostatic, are shown connected to the one input through the terminals 43 and 44. For the purpose of description these three units may be considered either as connected up to the one input or considered as separate units adaptable for use with any improved radio receiving set. The input end of each one of these units including the volume control casings are similar and may take the form of that shown in Fig. 1, each having the elements and parts corresponding to the unit shown in Fig. 1 down to and including the output terminal binding posts 14, 15, 17, and 27. The electro-dynamic unit shown at the bottom of Fig. 2, whether used alone or conjointly with one or more electrical producers, is identical with that shown in Fig. 1.

The fundamental principles of the invention may be embodied in any approved electro-magnetic speaker. Such device is shown in Fig. 2 which comprises a balanced armature unit. This is provided with a fixed magnet within which is mounted an armature 45 connected through links 46 and 47 with a cone 48. Associated with the armature are the two coils 37 and 38, identical sections of each coil being mounted on opposite sides of the center of oscillation of the armature. As in the construction shown in Fig. 1, the coil 37 is connected through suitable leads to the terminals 14 and 17 and the coils 38 are connected to the terminals 15 and 27. These coils are so associated with the armature that they operate in identically the same manner as the similar coils in Fig. 1, namely the adjustable quantity of energy passing through coils 37 is adapted to balance out or nullify its corresponding quantity of energy from coils 38, leaving the residual energy in coils 38 as the operating energy for the armature 45. When this type of structure is associated

with an electro-magnetic speaker, the improved results hereinbefore described are achieved.

Similarly, the improvements herein considered are equally applicable to an electrostatic speaker. This improvement may be incorporated in an electrostatic speaker when used alone or conjointly with an electro-magnetic and/or electrodynamic reproducer as shown. In an installation wherein the present improvements are included in an electrostatic speaker, a slightly different mechanical structure is of course employed. Terminals 14 and 17 are connected through the leads 50 and 51 to the primary 52 of a transformer T_1. The terminals 15 and 27 are similarly connected through the leads 53 and 54 to the primary 55 of transformer T_2. The transformers T_1 and T_2 therefore in a sense correspond to the voice coils 37 and 38 respectively of the electrodynamic and electromagnetic units. The induced currents from the transformer T_1 and T_2 are taken off from the secondaries 56 and 57 respectively, which are suitably connected to the condenser plates 58 and 59. These plates 58 and 59 constitute the fixed plates of the condenser and are positioned on opposite sides of the movable plate 60. These plates 58 and 59 are shown conventionally as comprising the typical lattice structure employed in electrostatic speakers so as to impart impulses to the flexible plate 60 at spaced points over its entire area.

It will be seen from this description that the elements 52, 56, and 58 functionally correspond to the coil 37 shown in the other device, while elements 55, 57, and 59 functionally correspond to the voice coil 38. These are the functional equivalents because in operation of the electrostatic speaker they subserve the same purpose. By varying the control knob the current passing to the primary and hence the induced current set up in the respective secondary circuits, may be varied and the electrostatic effects in the condenser units are hence precisely and proportionately changed. In these circumstances the effects set up in the plate 58 balance out or nullify its value from the plate 59 and the differential or residual energy value in 59 constitutes the operating force for the displaceable element 60.

While these three types of speakers have been shown as connected up to a single input, it will be appreciated that any combination of two or more of these may be employed and that, if desired, the control of two or more of these different reproducers may be achieved by the one volume control knob by suitable circuit arrangements.

As intimated hereinbefore, the invention in its broader aspects comprises the concept of controlling the operation of the loud speaker by utilizing as the operative force of the speaker electrical energy which is the resultant of two opposing energies of identical electrical characteristics. While the objects of the invention have been described as obtainable by using a system of variable resistances, it will be appreciated that types of variable resistances, other than that shown in Figs. 1 and 2, may be employed. Furthermore, other electrical characteristics may be varied to achieve the desired results. Thus, in Fig. 5 is shown a resistive type of variable element which differs somewhat from the types shown in Figs. 1 and 2. In this unit the coupling transformer may be substantially similar to that previously described comprising the primary 4, core 5 and secondary 6. This unit, like the units shown in Figs. 1 and 2, includes also the resistors 10 and 11 and the conducting arms 19 and 20. To maintain a constant impedance, across the terminals 23 and 25, a different circuit arrangement is utilized. One end of the secondary 6 is connected through the binding post 23 and lead 22 to the conducting arm 19. This arm is connected through the lead 12 to the binding post 14. The other end of the secondary 6 is connected through the binding post 25 and lead to conducting arm 20. This arm is connected through the resistor 11 and lead 16 to binding post 15. Binding post 23 is conductively connected to binding post 27, and binding post 25 is conductively connected to binding post 17.

By referring to Fig. 5 it will be seen that, as the pointer 21 is moved toward the low end of scale 28, resistance is added to the circuit between binding posts 23 and 14, and at the same time resistance is decreased in the circuit between binding posts 25 and 15.

If the above movement of pointer 21 is carried far enough, the energy available at binding posts 14 and 17 will exactly equal that available at binding posts 15 and 27. Since these two latter pairs of binding posts are destined to be conductively connected to coils 37 and 38 of the reproducer, the output of the reproducer under the above adjustment will be at a minimum.

The terminals 23 and 25 are maintained at a constant impedance at all times, due to the fact that the addition of resistance in one circuit of the variable element is exactly balanced by the decrease of resistance in the other, thus maintaining the sum of the two substantially the same at all times.

It will be seen that in electrical operation, this device is functionally equivalent to the system depicted in Fig. 1 and under the different positions of the control knob 18, the same control of the volume of reproduction is achieved.

In lieu of utilizing as the controlling unit a variable resistance, other forms of variable elements may be employed, typical examples of which are shown in Figs. 3 and 4. In Fig. 3 there is shown one type of inductive form of variable element. In this unit a coupling transformer comprising the primary 4, core 5 and secondary 6 may be similar to that previously described. The secondary of the coupling transformer is connected through the binding posts 23 and 25, leads 22 and 24 to the conductive arms 19 and 20 respectively. These arms, instead of traversing a resistance element as in the units previously described, are adapted to cooperate with the phase changing transformers 62 and 63, which are exactly alike. The transformer 62 includes the primary winding 64 and the secondary 65. The primary is divided into seven portions which are brought out to the taps 66. As will be noted on the drawings, these taps are adapted to cooperate with the rotating arm 20 so as to progressively cut out an increasing section of the primary. The general design is such that the impedance of any seven consecutive portions of the circuit comprising the connected primaries 64 and 67 of the transformers 62 and 63 and spanned by the conductive arms 19 and 20, will equal the impedance of the secondary 6 of the coupling transformer.

Similarly, the transformer 63 includes the plural winding primary 67 and the secondary 68. The sections of the primary winding 67 are connected to the taps 69 which latter are adapted to make electrical contact with the traversing arm 19. The secondary winding of the phase changing transformer 63 is connected through suitable

leads to the binding posts 14 and 17; likewise the secondary of the transformer 62 is connected to the binding posts 15 and 27. The binding posts 17—14 and 15—27 are connected, as in the device in Fig. 1, to the voice coils 37 and 38 respectively.

This type of volume control operates in the same manner as that previously described. As the control knob 18 is adjusted from high to low position the amount of energy passing through coil 37 progressively increases, thus progressively diminishing the residual or effective operating energy in coil 38. As in the device previously described, the output of the radio receiving set is operated at maximum energy and the improved results flowing from such an operation inhere in this inductive type of volume control. In this type of control it will be noted that the low position is at the center of the dial and the high position may be at either end.

Other modifications of the inductive type of control may be employed, a typical additional illustrative embodiment being shown in Fig. 4. This device includes the primary 4 of the input coupling transformer and a plurality of secondaries indicated at 70, 71, and 72. These secondaries are exactly alike and of the same electrical constants. It is of particular importance that the secondary winding 71 be designed to match the load connected across its terminal binding posts 15 and 27 which, as noted hereinbefore, is the voice coil 38. The phase changing secondaries 70 and 72 are the functional equivalents of the secondaries 64 and 67 in Fig. 3 and operate in an equivalent manner. The sections of secondary 70 are brought out to the taps 73 which are adapted to be contacted by the conductive arm 19. Similarly the sections of the secondary 72 are brought out to taps 74, with which taps the arm 20 makes contact.

In the operation of this device as in the others previously described, the circuit spanned by the rotating arms 19 and 20 will match the load connected across the terminals 17 and 14, which will be the coil 37. As in the other structures, the binding posts 14 and 17 are connected through suitable leads to the voice coil 37, while the binding posts 15 and 27 are conductively connected to the voice coil 38. As the knob 18 is rotated so as to adjust the volume control from the high to the low position, the value of current flowing by way of the terminals 14 and 17 through the voice coil 37 progressively increases and neutralizes its corresponding energy value in the voice coil 38.

These specific embodiments of the invention have been described in detail in an explanatory but not in a limiting sense. It will be appreciated that other and different specific structures which function similarly for obtaining the volume control may be utilized, and all such functional equivalents are intended to be comprehended herein.

It will now be seen that the present improvements achieve many novel results. Such an installation insures a great reduction in the effect of hum, tube noises and foreign or extraneous energies generally. The system also insures a truer response to the received signals due to the fact that actually greater energy is being used for reproduction than that represented in the output of the reproducer, when it is controlled to any value lower than maximum.

An additional accomplishment achieved by the present system is the very great diminution of the persistence of vibrations of the diaphragm and associated parts of the reproducer, due to their mechanical inertia. Such inertia is represented in older reproducers by distortion; for such inertia causes an electrical current to be "generated" in the voice coil assembly, which current is the electrical equivalent of the mechanical distortion of the parts. In the present system, however, due to the reverse phase connections of the two coils comprising the voice coil assembly, such "generated" current is, in effect, short circuited, thus largely obviating the mechanical distortion. Hence the vibrations of the diaphragm of the present reproducer more accurately and faithfully correspond to the electrical voice currents.

As noted hereinbefore, a salient improved feature of the present system is the high sensitivity of the reproducer to even feeble impulses in the source of energy.

The constant impedance load characteristic of the present system also permits a wide ramification of possible uses. Thus it readily permits the use of two or more reproducers on the same amplifier line without however having one materially affect the other. Such a combination finds peculiar utility in a "talkie" reproducer system in which it is sometimes desirable to adjust the reproducer system to accommodate different acoustic conditions in particular theaters.

It will be appreciated that the principles described herein are not limited to the particular structures shown. Thus, while reproducers have been shown and described which comprise a double coil, it is obvious that the improved control unit including the double coil may be associated within reproducers which are themselves provided with a coil or coils which perform useful functions, such for example, as neutralized coils of fixed value which are utilized to counteract the effect of induced currents in the telephone or voice coil emanating from the field coil, such effects being caused by the varying amplitude characteristics of the uni-directional currents in this field coil that may exist under certain operating conditions.

Similarly also it will be realized that the present system is not inherently or necessarily limited for use in a reproducer of the kind described. Such system on the contrary may be utilized where similar problems are encountered or comparable results are sought. This system, as noted hereinbefore, may be utilized in the electrical reproduction of sound. So also, as typifying its ramifications and scope, the improvement may be utilized for reducing "hunting" and other causes of alteration in the speed of electric motors. A familiar example demanding constancy of speed and phase is the driving motor of a television disc. So also the system is available generally for the amplification of electrical energies; for the stabilization of the frequency of alternating current generators, and so forth. It is also obvious that my invention may be applied to electrical instruments, particularly those intended for measurements of alternating or rapidly fluctuating currents. Therefore, while preferred embodiments have been described, these are given merely for the purpose of illustrating the principles of the invention and not for limiting them to any particular apparatus or use beyond such limitations as are clearly imposed by the spirit and terminology of the appended claims.

I claim:

1. A method of increasing the sensitivity and response, and controlling the volume of a radio receiving set which includes a receiving circuit and a reproducer circuit which comprises operat-

ing the receiving circuit at the maximum efficient energy output, dividing such output energy into two respectively opposing components, feeding such components to two opposing coils associated with the cone of the reproducer and simultaneously varying each component to increase or decrease the differential energy and utilizing such differential energy as the effective operating energy of the reproducer.

2. An electrical reproducer circuit comprising a transformer, the primary of which is adapted to be connected with a receiving circuit, a reproducer in the receiving circuit, a secondary for the transformer, means to divide the current from the secondary into two components, said means comprising two coils, each connected to the secondary of the transformer, the respective values of the energy in each of which may be varied but the sum of which remains substantially equal, means to impress such currents upon the reproducer in such a manner that one component directly opposes the other and the difference between the said components constitutes the effective operating current for the reproducer.

3. An electro-dynamic speaker unit comprising a coupling transformer, an electro-dynamic speaker, resistors connected to each end of the secondary of the transformer, a coil connected to each resistor and mounted in the air gap of the speaker, and means to respectively inversely vary the value of the energy in the said coils by adjusting the said resistors.

4. An electrodynamic speaker unit comprising a coupling transformer, an electrodynamic speaker, two coils associated with the diaphragm of the speaker in such a manner that the energy in one opposes that in the other, means to connect the coils to the transformer and means to vary the energy in the coils.

5. In an electromagnetic sound reproducer comprising a core and a magnet spaced from the core to form an air gap, a coil unit mounted within the gap, said coil unit comprising at least two oppositely acting coils, means to connect the coils to the same source of energy and means to vary the quantity of energy passing from the source to one of such coils without diminishing the energy at the said source.

M. LYTTON DULL.