

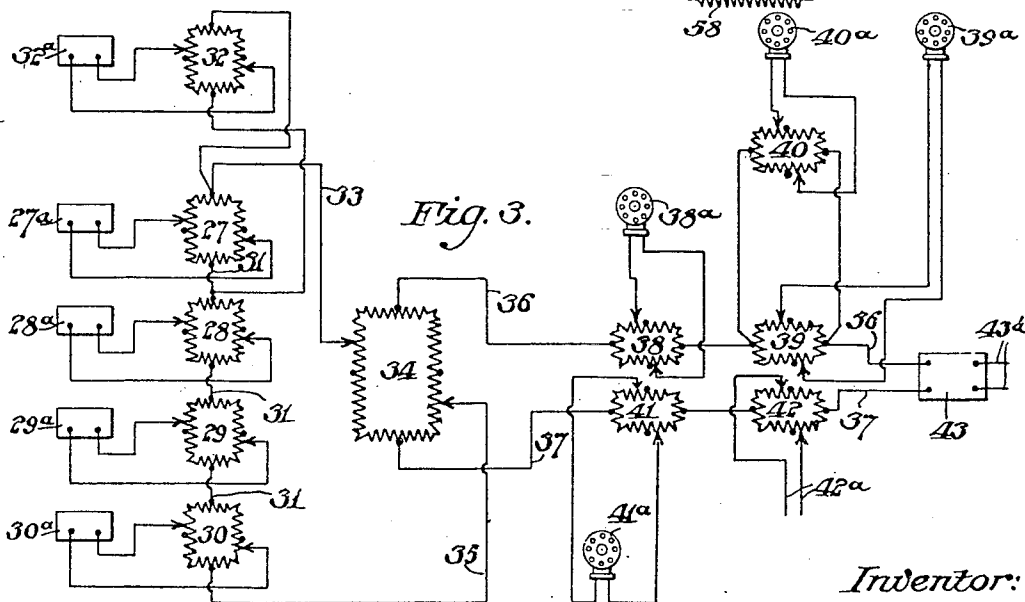
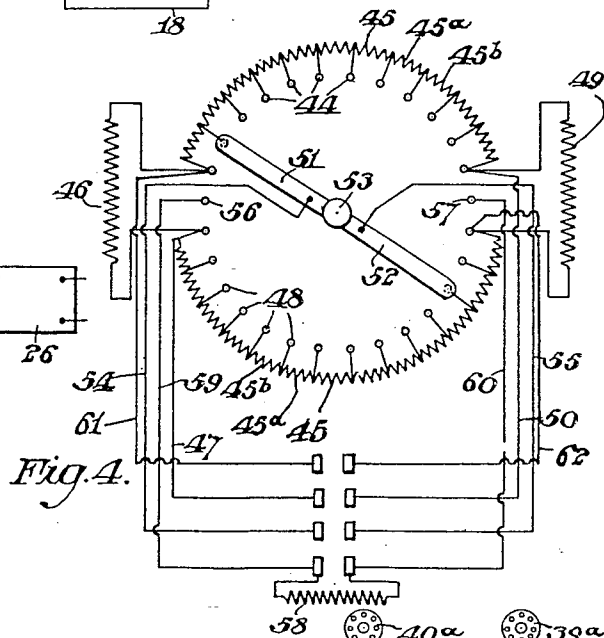
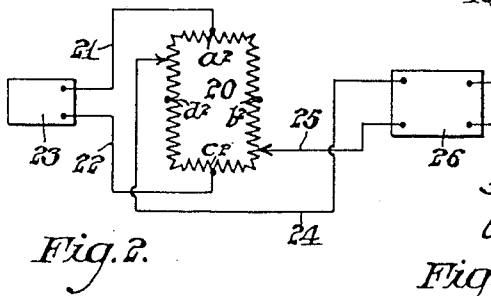
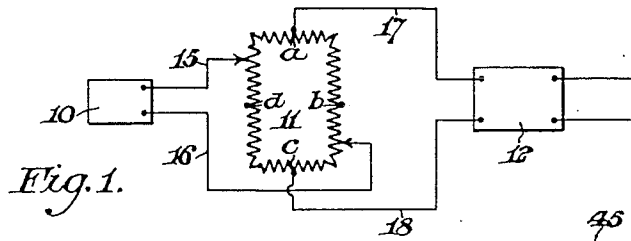
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VARIABLE ATTENUATION OR GAIN CONTROL SYSTEM

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VARIABLE ATTENUATION OR GAIN
CONTROL SYSTEM

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This invention relates to a variable attenuation or gain control system and more particularly to a system of this character by which voltages in the audio spectrum may be advantageously controlled.

In voice transmission systems there are two methods of control or mixing generally known, these being referred to as "high level" and "low level". These terms are used with reference to the relative magnitudes of the normal operating voltages appearing across the faders or attenuators. In "high level" control systems, it is necessary to employ a "pre-amplifier" or preliminary stage of amplification between the microphone and the fader or mixing system while in "low level" control or mixing systems the microphone is connected directly to the fader or mixing system.

With either method, spurious contact voltages which effect disturbances in the form of noise frequently develop in the fader switches and these disturbances are, of course, very objectionable from the viewpoint of the clarity of transmission delivered from the systems, whether these systems are utilized for broadcasting, sound motion pictures, public address, or the like. If it be assumed that the spurious contact voltages that develop in the fader switches of either system, whether high level or low level, are equal, the relative disturbance is more of a factor in the low level system and this disturbance becomes increasingly objectionable as the program level is reduced.

From the standpoint of economy of apparatus and circuit simplicity, the low level system is very much to be preferred. The critical nature of the usual type of low level mixing heretofore available, with its potential troubles, has resulted in low level mixing not being generally employed. For this reason, practically all of the broadcasting apparatus at present in use is constructed for operation with high level systems.

The present invention surmounts the usual difficulties encountered in low level mixing and makes its use entirely feasible.

Satisfactory low level mixing is accomplished in accordance with the present invention with ordinary attenuator switches and with resultant contact disturbances well below the "shot effect" and "thermal agitation" levels.

It is an object of the present invention to provide an improved method of and apparatus for the control or mixing of voltages in the audio range.

It is also an object of the present invention to

provide an improved low level control or mixing system.

It is also an object of the invention to provide a fader or mixer system which will be substantially lossless, thereby allowing the use of a large number of faders or attenuators to be connected into the system without the necessity as in the systems heretofore employed of providing additional amplification which was rendered necessary in order to make up for the loss in a mixing system where each attenuator offers a loss.

It is also an object of this invention to provide a variable attenuator that offers the same input impedance termination regardless of the positions of the variable arms.

It is also an object of this invention to provide means for entirely disconnecting the input and the output of a variable attenuator without destroying the impedance relations and at the same time eliminating the possibility of "cross-talk" or interference from other attenuators or other circuits.

It is a further object of this invention to provide a mixer system wherein the separate attenuators act entirely independent of all others so that the motion of any one offers no influence, with respect to level changes or otherwise, over any of the others.

It is also one of the purposes of this invention to provide a system for minimizing the losses of any variable attenuator or combination of variable attenuators by providing adequate terminal impedance conditions (for the attenuator input system) by means of the unit itself or the unit in combination with an additional impedance and at the same time connecting the combination into a high impedance input of a following or succeeding device, the high impedance being of an order such that the terminal impedance of its previous circuit is not substantially or critically altered.

It is a further object of the present invention to provide a low level control system which will have a wide range of use in connection with voltages in the audio range, for radio broadcasting station apparatus, sound motion picture systems, loud speaker systems and the like.

The nature and characteristic features of the invention will be more readily understood from the following description, taken in connection with the accompanying drawing forming part hereof, in which:

Figure 1 is a diagrammatic view of a circuit arrangement illustrative of and embodying the main features of the present invention;

Fig. 2 is a diagrammatic view showing a different circuit arrangement embodying certain features of the present invention.

Fig. 3 is a diagrammatic view showing another and composite circuit arrangement illustrative of the main features of the present invention; and

Fig. 4 is a diagrammatic view of one form of dual potentiometer or bridge unit which may be employed in connection with the circuit arrangements shown in Figs. 1, 2 and 3.

It will, of course, be understood that the description and drawing herein contained are illustrative merely, and that various modifications and changes may be made in the structure disclosed without departing from the spirit of the invention.

Referring more particularly to Fig. 1 of the drawing in which one embodiment of the present invention is illustrated, there is provided, in connection with a voltage source 10 such as a low impedance microphone, a bridge unit 11. The bridge unit 11 preferably comprises two arms of fixed value and two opposite arms, the effective value of which may be varied as hereinafter pointed out. The end points of the arms are connected, the points of connection being designated respectively as *a*, *b*, *c* and *d*. The two arms of fixed value are shown at *a—b* and *c—d* and the two variable arms at *a—d* and *b—c*. The four arms, *a—b*, *c—d*, *a—d*, and *b—c*, of the bridge unit 11 are made up of impedance units. In some types of installations the units will be resistance units and in others combinations of resistance or capacitance or inductance units will be employed in the arms of the bridge, in accordance with the requirements to effect the proper electrical balance of the bridge.

The foregoing portion of the system is connected into a circuit 12, which preferably is a relatively high impedance circuit, such as the input of an amplifier, as in Fig. 1, or which may be a grid input, a transformer input or other suitable input. The circuit 12 may also be another bridge attenuator (see Fig. 3).

As shown in Fig. 1 the circuit of the control system includes the voltage source 10 which may be of low impedance, the bridge 11, which matches this impedance and the circuit 12, which may be an amplifier with a relatively high impedance, although the invention is not restricted to a high impedance at this point. Suitable conductors 15 and 16 are provided preferably between the output of the source 10 and the bridge unit 11, so that these conductors have their end portions for contact as desired at points along the branches *a—d* and *b—c*. Suitable conductors 17 and 18 are also preferably provided between the bridge unit 11 and the high impedance circuit 12 and these are connected to the end points *a* and *c*.

In Fig. 2 there is illustrated a modified form of the circuit shown in Fig. 1, the bridge 20 being composed of four arms, the two arms of fixed value being shown at *a₁—b₁*, and *c₁—d₁*, and the two variable arms at *b₁—c₂* and *a₂—d₂*. The conductors 21 and 22 which connect a voltage source 23 to the bridge 20 are respectively connected to the end points *a₁* and *c₁*, and the conductors 24 and 26 which connect the bridge 20 to the high impedance input 26 are adapted to contact as desired at points along the arms *a₂—d₂* and *b₂—c₂*.

In Fig. 3 there is illustrated a circuit in which the inputs from a number of sources such as

microphones, or other circuits of comparable levels, are brought together through a plurality of bridge units connected in various ways.

As shown in Fig. 3, a plurality of bridge units 27, 28, 29 and 30 are connected together in series by means of conductors 31, each of these bridge units having variably connected to opposed arms thereof a plurality of suitable inputs from sources 27_a, 28_a, 29_a and 30_a, respectively. One of the bridges of this group in series, the bridge unit 27 being taken as illustrative, may have connected thereto in parallel a bridge unit 32, a voltage source 32_a being variably connected to opposed arms of the bridge unit 32.

One end point of the bridge unit 27 may be variably connected by a conductor 33 to one arm of a bridge unit 34, a conductor 35 being variably connected between an end point of the bridge unit 30 and an arm of the bridge unit 34 opposite to that to which the conductor 33 is connected.

It will be seen that the circuit up to and including the bridge unit 34 permits the mixing or modulating of voltages from the separate sources 27_a, 28_a, 29_a, 30_a and 32_a, so as to provide, in conductors 36 and 37 which lead from the bridge unit 34, a resultant controlled output.

The line 36 may have therein bridge units 38 and 39 connected in series, the bridge unit 38 having variably connected to opposed arms thereof a microphone 38_a, and the bridge unit 39 may have variably connected to opposed arms thereof another microphone 39_a. The bridge unit 39 may have, connected in parallel, a bridge unit 40, a microphone 40_a being variably connected to opposed arms of the bridge unit 40.

The line 37 may have in series therein bridge units 41 and 42, the bridge unit 41 having variably connected thereto a microphone 41_a, and the bridge unit 42 having variably connected thereto conductors 42_a which may be connected to telephone lines, for example, over which a program of suitable level is being transmitted.

The ends of the conductors 36 and 37 may be connected to an amplifier 43 from which suitable leads 43_a are provided.

The circuit shown in Fig. 3 permits of mixing or modulating voltages from a variety of separate sources and permits of individualized control of each of the sources so that its effect on the input of the amplifier may be controlled as desired.

In Fig. 4 there is illustrated schematically a form of bridge unit for use in the circuits heretofore referred to. This bridge unit includes a plurality of contact points 44, arranged in a semi-circle for illustrative purposes, with each of the points having therebetween impedances 45, 45_a, 45_b, of predetermined optional values. The contacts 44 and 48 may be disposed on the circumferences of concentric circles of different diameters. Each pair of opposed contacts that are assigned to the same attenuation value will then be on a common radius rather than being situated diametrically opposite as shown in Fig. 4. One of the end contact points of the plurality of points 44 is connected to one end of a fixed value impedance 46. The other end of the impedance 46 may have a conductor 47 connected thereto and is connected to an end contact point of another semicircularly disposed plurality of contact points 48 each having therebetween impedances 45, 45_a, 45_b. The other end contact point of the plurality of contact points 48 is connected to one end of another fixed value impedance 49. The other end of the impedance 49 is connected to an end contact point of the group of contact points 44

and may have connected thereto a conductor 50. The point of connection between the impedance 46 and the end contact point of the contacts 44 may have a suitable conductor 61 connected thereto and the point of connection between the impedance 49 and the end contact point of the contact points 48 may have a suitable conductor 62 connected thereto. The two respective groups of contact points 44 and 48 are diametrically opposed, and concurrently movable electrically insulated contact arms 51 and 52 are provided, the end portions of which contact opposed pairs of the contact points 44 and 48. The arms 51 and 52 are rotatably mounted for actuation by a knob 53. The two contact arms 51 and 52 have connected thereto conductors 54 and 55, respectively. The terminals of the conductors 47 and 50 or 61 and 62, and of the conductors 54 and 55 may be suitably connected into the circuits illustrated in Figs. 1, 2 and 3.

Two additional contact points 56 and 57, which can be referred to as null points, are provided, for engagement as desired by the contact arms 51 and 52, a substitution resistor 58 which may be of any value being connected therebetween by suitable conductors 59 and 60.

Reference may now be had to the principles of the operation of the system in accordance with the foregoing description. The use of the Wheatstone bridge principle employed in the variable attenuator herein set forth makes it possible to vary the gain of a microphone circuit or other circuit in accordance with a predetermined attenuation characteristic. Full attenuation will obtain at the bridge balance or null points; zero attenuation obtains when the swinger arms are rotated to the opposite ends of the variable elements.

Instead of having the full "off" condition with the switch arms on the balance or null points, it is more expedient to assign the "off" position to the first contact point of each potentiometer unit, these two contact points as at 56 and 57 being independent or entirely disconnected from the bridge proper. Infinite attenuation and complete isolation is thereby assured. A substitution resistor, as at 58, which may be of a value equivalent to the impedance or resistance of the bridge unit is connected between the isolated switch points 56 and 57. Thus the proper terminal impedance relations will always obtain. The separate switch points referred to make it possible to have either the input or the output circuit entirely separated from the bridge unit depending upon whether the switch arms are connected to the input or to the output of the unit respectively.

While the present invention is intended for use in either high level or low level control systems, its full value is not realized unless the switch arms, such as 51 and 52, are connected to the source or input circuit as shown in Fig. 1 which is the preferred form for low level control.

By thus connecting the switch arms, the contact transients are nullified to a degree dependent on the position of the switch arms. The nearer the switch arms are to the null points, the greater will be the attenuation of the contact voltages or disturbances; at the null point a contact transient will not appear in the output of the bridge circuit due to its cancellation within the bridge.

As heretofore indicated, a contact noise condition becomes more and more critical as the switch arms approach the full attenuation position of any type of fader or attenuator; this being so be-

cause the magnitude of a spurious disturbance becomes more and more comparable in level with the desired signal or program level. The ideal condition obtains therefore when the transient suppression increases in proportion to the attenuation of the signal. This rigorous condition is accomplished by the present invention.

Or stated in another way, in low level systems, employing circuits heretofore referred to and with an output at the microphone of the order of minus 70 decibels, any contact noises developed will keep the same magnitude ratio with respect to the microphone circuit level irrespective of the particular contact location selected on the bridge arms. The noise will be balanced out by the bridge and while the balancing out decreases as the attenuation is decreased the simultaneous increase in program level permits of more noise without objectionable interference.

Reference may also be had to the lossless feature of the invention.

There is no necessity, with the system heretofore referred to, to insert additional resistance to preserve proper impedance relationships because the bridge has the same impedance at every position of the switch arms.

Ordinarily an attenuator, specified as having a certain impedance, must be terminated with this certain impedance value so that the device ahead of the attenuator is properly terminated and so that the attenuator itself develops the prescribed attenuation characteristic.

The variable attenuator of the present invention, is preferably designed so that the attenuator unit itself is, for all practical purposes, the terminating device of the previous microphone or other circuit. When a group of attenuators is to be controlled by another such type of variable attenuator the latter is preferably of higher impedance than the combined impedance of the group.

With the switch arms as at 51 and 52 in the full on or in the zero attenuation position, the full voltage of the microphone or other voltage source appears across the attenuator.

Now when the output of this attenuator is connected across a relatively high impedance, which may be the input of an amplifier, the full microphone voltage also appears across this impedance and no microphone terminal impedance change has been effected.

It will be clear therefore that no insertion loss will result due to the attenuator.

Further, when a plurality of such attenuators is connected in series, and the combination is connected to such a high impedance input, the additional units will offer no insertion losses because the voltage drop across each or all of the additional units is insignificant in comparison with the voltage drop across the high impedance.

For all practical purposes, therefore, the full voltage of any of the microphones will appear across the input of the amplifier and such a system may be considered as lossless.

While the system herein described has been referred to as a variable attenuation or gain control system it will be understood that it can also be referred to as a variable fader, a variable bridge attenuator, a mixer, or a volume control.

I claim:

1. A gain control system including an input circuit, an output circuit, a bridge device interposed between said input and said output circuits, said bridge device having four major arms and having at least two of said arms oppositely

disposed, and means for variably connecting one of said circuits to said oppositely disposed arms for varying the effect of said arms.

2. A gain control system including an input circuit, an output circuit, a bridge device interposed between said input and said output circuits, said bridge device having four major arms and having at least two of said arms oppositely disposed, and means for variably connecting said input circuit to said oppositely disposed arms.

3. A gain control system including an input circuit, an output circuit, a bridge device interposed between said input and said output circuits, said bridge device having four major arms and having at least two of said arms oppositely disposed, and means for variably connecting said output circuit to said oppositely disposed arms.

4. A gain control system including a bridge device having four arms connected at their ends, two of said arms being fixed impedances oppositely disposed in the bridge device and the other two of said arms also being oppositely disposed, means for connecting an input source to said bridge, means for connecting an output circuit to said bridge, and means for varying the position of one of said connecting means along said other two of said arms.

5. A gain control system including an input circuit, a variable attenuator connected to said input circuit, and a high impedance output circuit to which said attenuator is connected.

6. A gain control system including an input circuit and an output circuit, and a bridge device having four impedance arms connected together, two of said arms being oppositely disposed, means for variably connecting said input circuit to said oppositely disposed arms, and means for connecting portions of said bridge to said output circuit.

7. A gain control system including an input circuit and an output circuit, and a bridge having four impedance arms connected together, said arms including two arms oppositely disposed in said bridge, means for variably connecting said input circuit to said two arms, means for connecting portions of said bridge to said output circuit, and means for substituting an impedance for said bridge.

8. A gain control system including an input circuit and an output circuit, a bridge device interposed between said input and said output circuits, said bridge having two pairs of oppositely disposed arms, taps on each arm of one of said pairs of arms for varying the effect of the arms on the bridge device output, and means for substituting an impedance for said bridge.

9. An attenuator comprising two impedances each provided with a plurality of taps, two fixed impedances, the ends of one of said fixed impedances being connected to ends of said first mentioned impedances, and the ends of the other of said fixed impedances being connected to the other ends of said first mentioned impedances, and a pair of arms for simultaneously contacting diagonally oppositely disposed pairs of said taps.

10. An attenuator comprising two impedances of equal value each provided with a plurality of taps, two fixed impedances of equal value, the ends of one of said fixed impedances being connected to ends of one of said first mentioned impedance, and the ends of the other of said fixed

impedances being connected to the other ends of the other of said fixed impedances, and a pair of arms for simultaneously contacting pairs of said taps.

11. An attenuator consisting of four impedances all of equal value, two of said impedances being provided with a plurality of taps, the ends of one of said impedances being connected to ends of said tapped impedances and the ends of another of said impedances being connected to other ends of said tapped impedances, and a pair of arms for simultaneously contacting pairs of said taps.

12. An attenuator comprising two impedances each provided with a plurality of taps, two fixed impedances, the ends of one of said fixed impedances being connected to ends of said first mentioned impedances and the ends of the other of said fixed impedances being connected to other ends of said first mentioned impedances, a pair of arms for simultaneously contacting pairs of said taps, additional taps for contact by said arms, and a substitution impedance connected to said additional taps.

13. An attenuator comprising an impedance provided with a plurality of taps, fixed impedances connected to each end of said first impedance and another impedance connected to the other ends of said fixed impedances, said other impedance being provided with a plurality of taps, and arms for simultaneously contacting one tap of each of said plurality of taps.

14. An attenuator comprising an impedance provided with a plurality of taps, fixed impedances connected to each end of said first impedance and another impedance connected to the other ends of said fixed impedances, said other impedance being provided with a plurality of taps, and arms for simultaneously contacting one tap of each of said plurality of taps, additional taps between the ends of said other taps for contact by said arms, and a substitution impedance connected to said additional taps.

15. A gain control system comprising an amplifier and an input circuit therefor, said input circuit including a plurality of bridge attenuator devices connected in series and input circuits connected to each of said attenuator devices, and bridge attenuator devices in parallel with certain of said other bridge attenuator devices.

16. A gain control system comprising an amplifier and an input circuit therefor, said input circuit including a plurality of bridge attenuator devices connected in series and input circuits connected to each of said attenuator devices, and another bridge attenuator for controlling the output of said plurality of attenuator devices.

17. A low level gain control system directly connected to an amplifier and including an input circuit, said input circuit including a plurality of bridge attenuator devices, and bridge attenuator devices in parallel with certain of said other bridge attenuator devices.

18. A low level gain control system directly connected to an amplifier and including an input circuit, said input circuit including a plurality of bridge attenuator devices and input circuits connected to each of said attenuator devices, and bridge attenuator devices in parallel with certain of said other bridge attenuator devices.

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