United States Patent

Komatsu

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[54] SINGLE CONTROL DEVICE FOR PLURAL VARIABLE RESISTORS

[72] Inventor: **Hiroaki Komatsu,** Tokyo, Japan

[73] Assignee: **Alps Electric Co., Ltd.,** Tokyo, Japan

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[52] **U.S. Cl.** **338/90,** 338/128

[51] **Int. Cl.** **H01c 9/02**

[58] **Field of Search** ..... 338/90, 128, 130, 122, 123, 338/124, 125; 200/6 A, 17 R, 18; 74/471

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Primary Examiner—Lewis H. Myers
Assistant Examiner—D. A. Tone
Attorney—James and Franklin

[57] **ABSTRACT**

A control device for use in volume adjustment of a multi-speaker sound system utilizes a floating carrier adapted to move within a housing enclosure in two dimensions. The carrier is provided with a plurality of electrical contacts adapted to slidingly engage respectively a plurality of resistive elements on a substrate. The carrier is moved by a control member extending through a window in the housing. The shape of the window and the resistive patterns of the plurality of resistive elements is such that the operative resistances may be simultaneously varied to adjust the sound volume of a plurality of speakers in correlation with the position of the control member within the housing window.

24 Claims, 10 Drawing Figures

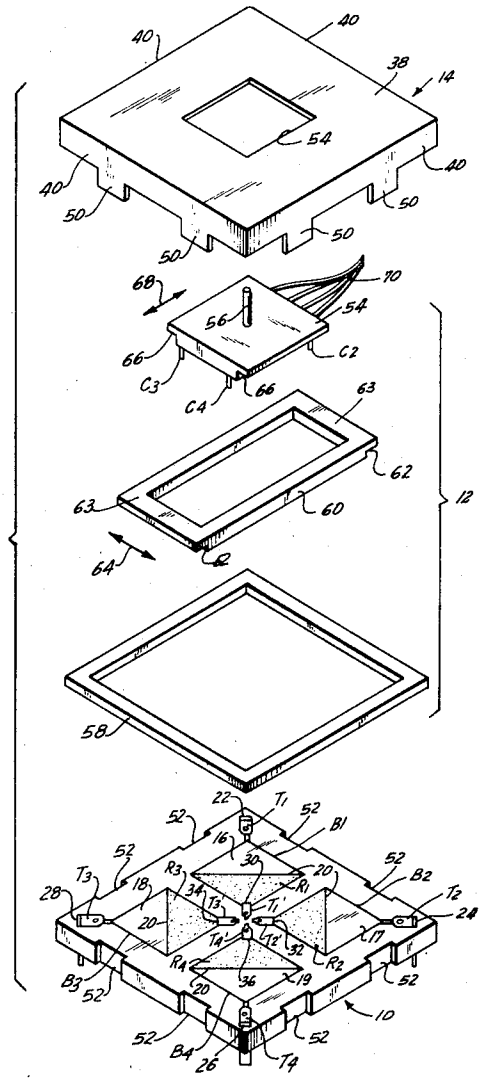


FIG. 1

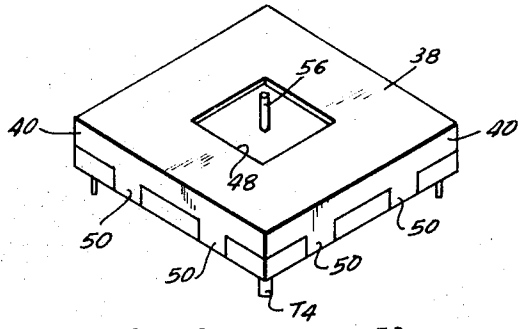


FIG. 8

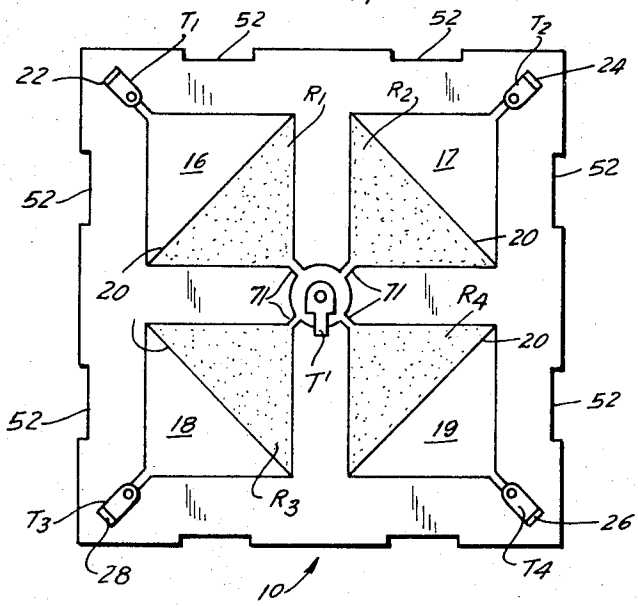


FIG. 7

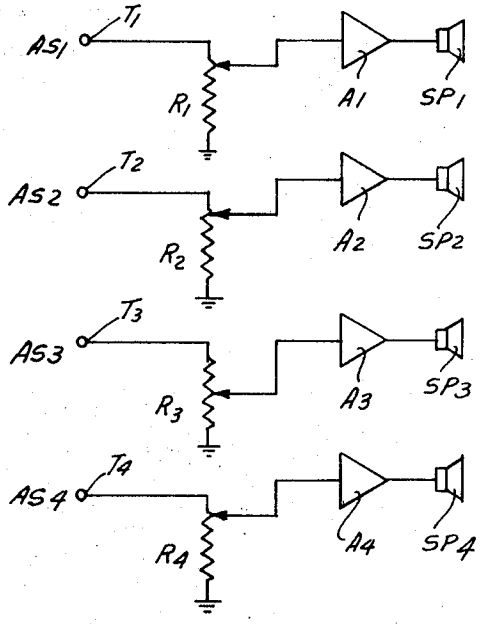
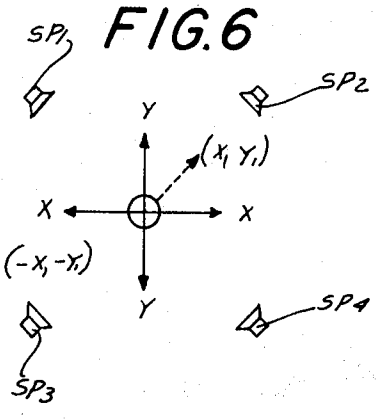


FIG. 6



INVENTOR
HIROAKI KOMATSU
BY James and Franklin
ATTORNEY

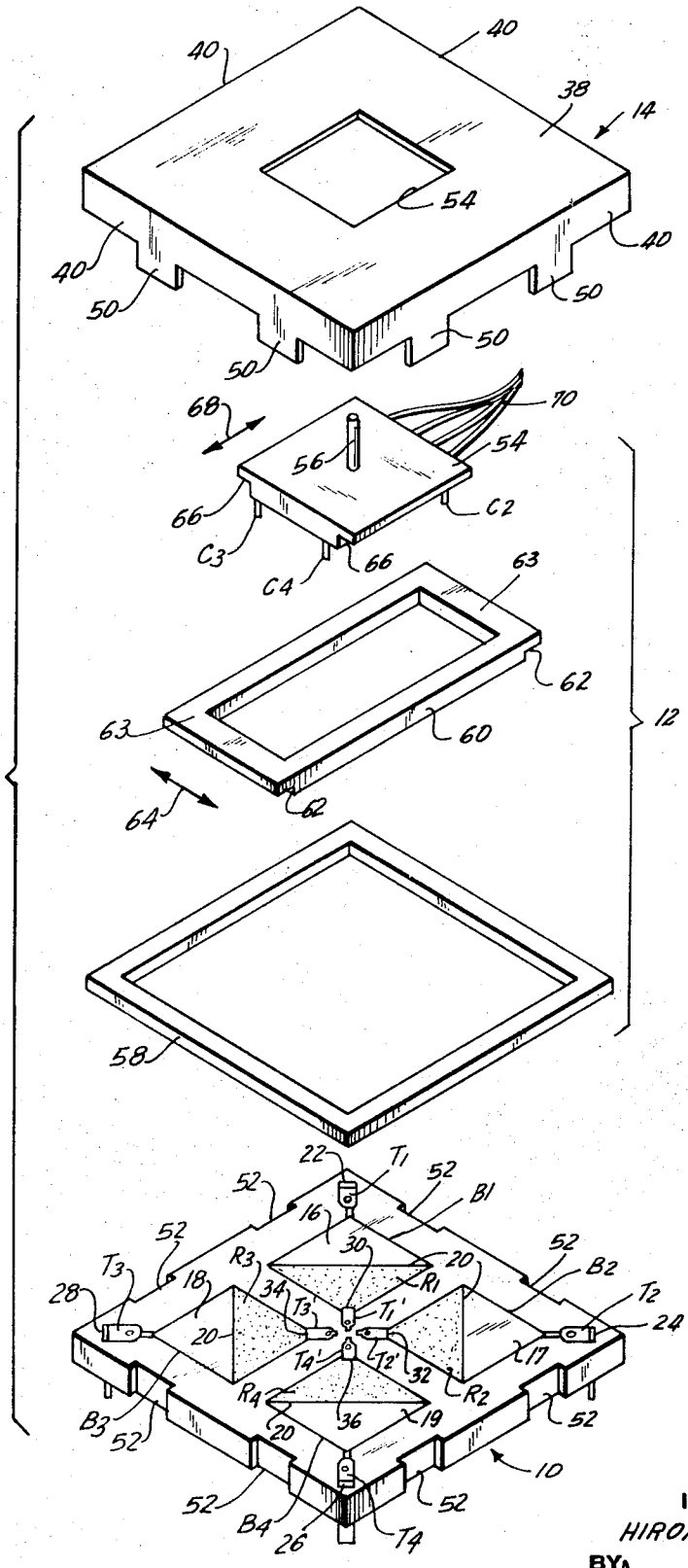


FIG. 2

INVENTOR
HIROAKI KOMATSU
BY James and Franklin
ATTORNEY

FIG. 3

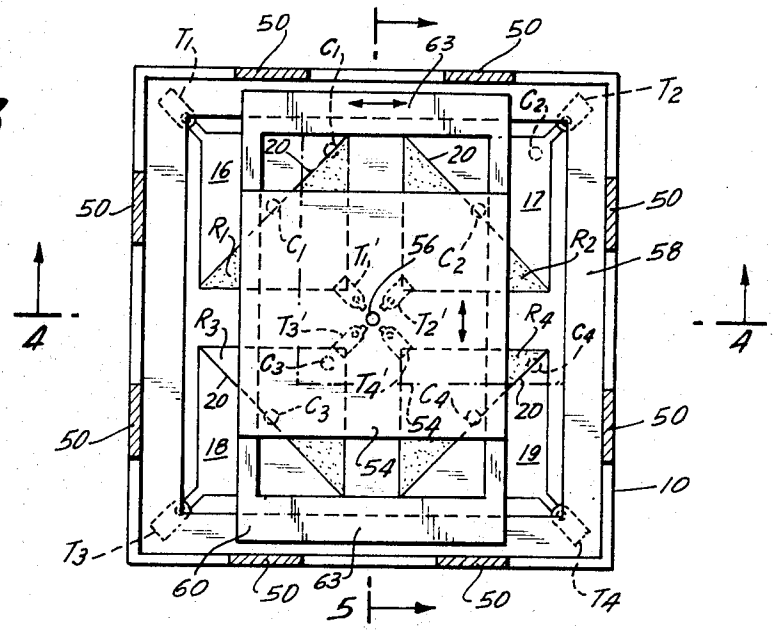


FIG. 4

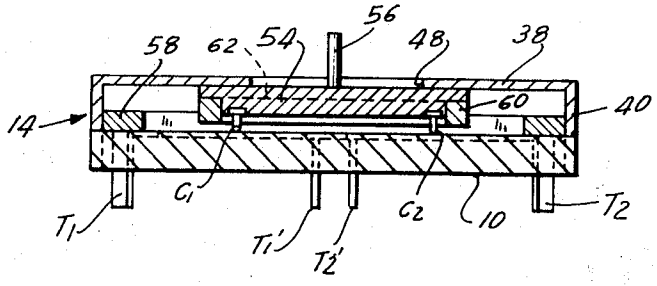
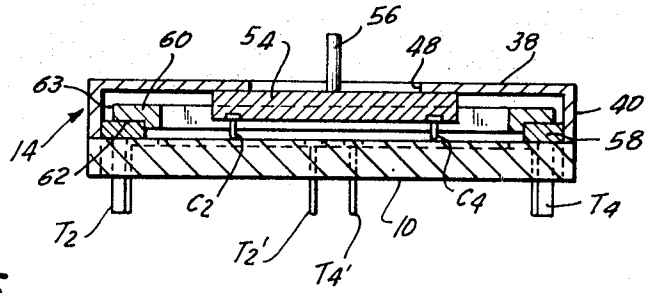
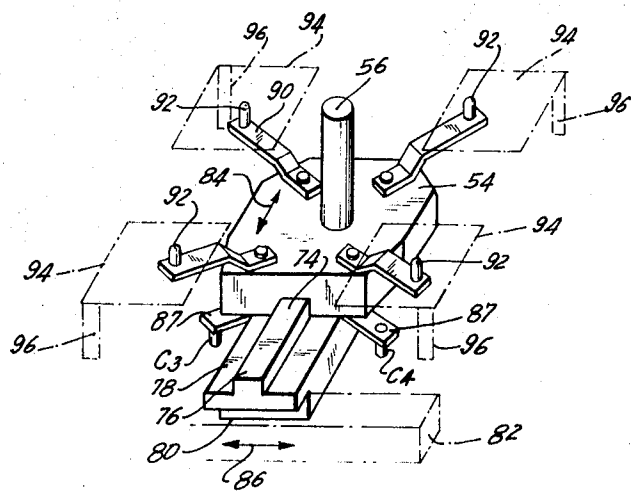


FIG. 5



INVENTOR
HIROAKI KOMATSU
BY James and Franklin
ATTORNEY

FIG. 9



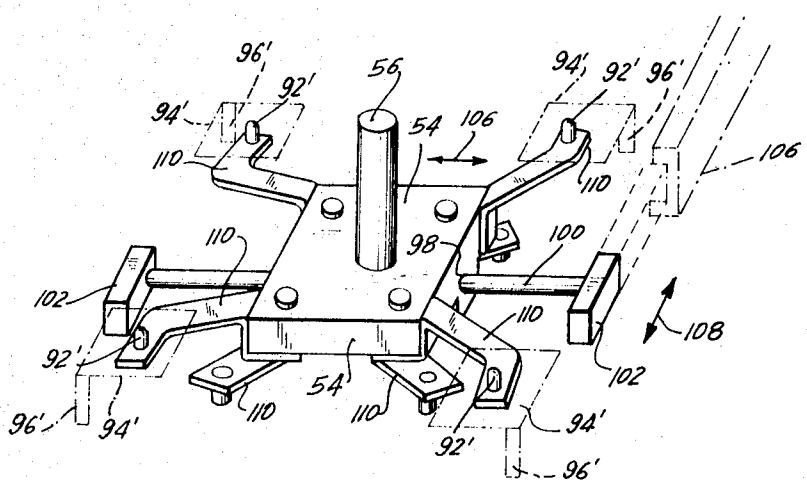


FIG. 10

INVENTOR
HIROAKI KOMATSU
BY James and Franklin
ATTORNEY

SINGLE CONTROL DEVICE FOR PLURAL VARIABLE RESISTORS

This invention relates to a variable resistor and particularly to a variable resistor suitable for use in volume balance adjustment of a multi-channel stereo sound system.

In a typical sound system volume adjustment is effected through a variable resistance or potentiometer mechanism. The audio signal is applied to one end of a resistive element, the other end of said element being connected to a reference voltage source. The speaker through its associated amplifier is operatively electrically connected to the wiper of the variable resistance device whereby adjustment of the wiper position along the resistive element is effective to vary the voltage of the operatively utilized point along the length of the resistive element, thereby to regulate the audio volume of the speaker.

With the advent of stereo sound systems it was found necessary and desirable to provide a volume balance adjustment mechanism to enable the listener to control the position of a balanced output from the two channels. In typical prior art systems of this type each speaker is provided with a variable resistor device, said device being appropriately operatively connected to a common rotatable control knob which is thereby adapted to simultaneously increase or decrease the volume of one speaker relative to the volume of the other. The listener merely adjusts the balance control knob in accordance with the desired position of the balanced sound source relative to the speakers. In the case where two additional speakers are provided an additional rotatable control knob is necessary to adjust the balance of the two additional speakers.

A recent development in stereo sound systems is the four-channel stereo record or tape. In accordance with this new development four separate channels are provided and at least four speakers (one for each channel) are positioned within the listening room, generally with two speakers in front of the listener and two speakers at his rear. Increased listening enjoyment results from being surrounded and engulfed by sound. Ideally the listener should have the illusion that he is actually sitting in the midst of the orchestra. The importance of a balanced output from the plurality of speakers is paramount in such a multi-channel sound system. Thus in order to obtain maximum listening pleasure the speaker outputs should be precisely balanced in accordance with the listener's desire. The same is true for a dual channel system utilizing four or more speakers.

The desired position of the apparent sound source may be coincident with the listener's position or the listener may desire to move the apparent sound source away from the listening position depending upon the particular selection he is listening to and his individual taste. In either case, the use of two twin variable resistor control knobs is not only cumbersome but, particularly in the case of a four-channel stereo system, becomes quite confusing to the listener. Proper speaker balance utilizing such prior art control mechanisms can be achieved only by exhausting trial and error and is particularly burdensome in a four-channel system where the control mechanism is generally located some distance from the listening position, which is preferably near the middle of the room. Moreover, regardless of the number of channels, where more than two speakers are utilized, the provision for a separate variable resistor mechanism for each speaker unduly increases the number of parts necessary and the manufacturing expense.

It is a primary object of the present invention to provide an improved variable resistor particularly adapted for use in volume balance adjustment of a multi-channel stereo sound system.

It is another object of the present invention to provide a variable resistor of the type described which utilizes a minimum of parts and is less expensive to manufacture than prior mechanisms of this type.

It is yet another object of the present invention to provide a variable resistor for use in volume balance adjustment of a multi-channel stereo sound system which utilizes a single control knob which is so constructed that the listener may readily adjust the volume balance to a position corresponding to the desired listening position relative to the several speakers with precise visual conformation thus eliminating the need for multiple trial and error adjustments.

It is still another object of the present invention to provide a variable resistor of the type described which is adapted to simultaneously adjust the resistances associated with a plurality of sound speakers in such a manner as to provide a balanced output for any desired listening position.

To these ends the present invention comprises a single device adapted to perform the functions of a plurality of variable resistors or potentiometers in a predetermined cooperative manner. The device comprises a plurality of resistive elements adapted to be operatively electrically connected, respectively, to a like number of sound speakers, the audio volume of said sound speakers being controlled by the resistance value of the operative portions of their respective resistive bodies. A common control mechanism is adapted to simultaneously vary the resistive values of said plurality of resistive bodies thereby to simultaneously increase or decrease the audio volume of selected speakers. The control mechanism comprises a floating carrier mounted for movement in any direction within a given plane. The floating carrier is provided with a plurality of depending electrical contacts adapted respectively to slide along the resistive bodies thereby to vary the resistance value of the operative portions thereof. The carrier is moved to any desired position by means of a single control member extending through the housing of the device, and means are provided for accurately visually correlating the position of the control member with the apparent sound source resulting from the audio volume of the various speakers.

To the accomplishment of the above, and to such other objects as may hereinafter appear, the present invention relates to a variable resistor mechanism particularly adapted for use in sound systems as defined in the appended claims and as described herein, taken together with the accompanying drawings, in which:

FIG. 1 is a perspective view of a control device constructed in accordance with the present invention;

FIG. 2 is an exploded perspective view of the device of FIG. 1 showing the substrate cover member and the slider mechanism;

FIG. 3 is a top plan view of the device of FIG. 1 with the cover member removed;

FIG. 4 is a cross-sectional view taken along the line 4—4 of FIG. 3 showing the complete device;

FIG. 5 is a cross-sectional view taken along the line 5—5 of FIG. 3 showing the complete device;

FIG. 6 is a schematic illustration of a typical positional relationship of the speakers, the listener and the apparent sound source;

FIG. 7 is a schematic circuit diagram showing a four-channel audio circuit utilizing the present invention;

FIG. 8 is a plan view of an alternate embodiment of the substrate; and

FIGS. 9 and 10 show alternate embodiments of the slider mechanism.

The present invention will be here specifically described in connection with a four-speaker sound system and is particularly useful in a four-channel system wherein each speaker is operatively connected to a separate channel. It should be noted, however, that the present invention is equally applicable to sound systems having a different number of channels. For example, the specific embodiments described herein may also be utilized with a conventional dual channel stereo system utilizing four speakers. Similarly, as will be apparent from the description hereinafter, the device may be readily modified for use with any number of speakers and/or channels.

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the views, and more particularly to FIG. 7 thereof, there is

shown in schematic form the electrical circuitry with which the present invention is associated. As there illustrated four resistors R1, R2, R3 and R4 are each connected, respectively, between an audio signal there designated AS1, AS2, AS3 and AS4 and a reference voltage source. For simplicity, all resistors are there shown grounded. Four sound speakers, SP1, SP2, SP3 and SP4 are operatively connected, respectively, to their associated audio signals AS1, AS2, AS3 and AS4 through movable contacts C1, C2, C3 and C4, respectively, and associated audio amplifiers A1, A2, A3 and A4, respectively. Contacts C1–C4 are adapted to movably electrically engage resistive elements R1–R4, respectively, along the lengths thereof, thereby to vary the resistance value of the operative portion of said resistances through which the respective audio signals travel. These resistors are effective to attenuate the audio signal which is fed to the audio amplifier. That is, the larger the resistance value of the operative portions of said resistors the greater the attenuation and thus the lower the audio volume emanating from the speaker. Accordingly, the volume of each speaker may be adjusted by adjusting the position of its associated contact C along its respective resistor R.

Referring now to FIGS. 1 and 2, the device of the present invention comprises a substrate generally designated 10, a slider mechanism generally designated 12 and a housing or cover member generally designated 14. Substrate or base 10 comprises a thin sheet of insulating material such, for example, as bakelite, and is provided with four electrically operative bodies B1, B2, B3 and B4 deposited thereon in appropriately spaced relationship. In the specific embodiment shown each electrically operative body is square in shape and the bodies are symmetrically spaced on the substrate 10 at the corners thereof. Each body comprises a resistive portion R1–R4, respectively, and a conductive portion 16, 17, 18 and 19, respectively, of triangular shape separated by a diagonal 20. As will become apparent hereinafter the shape and size of the electrically operative bodies and the portions thereof which comprise a resistive material are primarily a matter of design choice in accordance with the desired operating characteristics. Bodies B1, B2, B3, B4 are deposited on the upper surface of substrate 10 by any conventional printing process using an appropriate masking technique. Electrical terminals T1, T2, T3 and T4 are each secured at one of their ends to the remote corners of electrically operative bodies B1–B4, respectively, near the four corners of the substrate 10, the other ends of these terminals extending downwardly through slots 22, 24, 26 and 28 respectively provided in substrate 10 for that purpose. A second set of four electrical terminals T1′, T2′, T3′ and T4′ are secured at one of their ends to the diagonally opposite inwardly facing corners of electrically operative bodies B1–B4, respectively, and extend downwardly through slots 30, 32, 34 and 36 respectively provided in substrate 10 for that purpose. Accordingly, a resistive path is provided between each terminal T and T′, said resistive paths corresponding to schematically illustrated resistors R1–R4 in FIG. 7

As best shown in FIG. 2, housing or cover member 14 comprises a generally square shaped top wall 38 and four downwardly extending side walls 40. The top wall 38 of housing 14 is provided with a generally square shaped aperture or window 48, the purpose of which will be apparent hereinafter. A plurality of tabs 50 extend downwardly from the lower edges of side walls 40 and are adapted to be received in a corresponding number of registering notches 52 at the side edges of substrate 10, the tabs 50 being folded under substrate 10 to secure the structure. Slider mechanism 12 is adapted to be housed within the enclosure formed by housing 14 and substrate 10 and includes a floating carrier member 54 made of an insulating material, a control member 56, a fixed guide rail 58, and a slidable guide rail 60.

Floating carrier member 54 is adapted to have universal two-dimensional movement within the enclosure formed by housing 14 and substrate 10. To this end guide rail 58 is substantially square and approximately the same size as substrate 10 and is adapted to be affixed to the top surface of substrate 10 by any suitable means in the position shown in FIG. 3. Guide rail 60 is rectangular in shape having its long sides 61 substantially equal in length to the side dimension of guide rail 58 and is provided with undercuts 62 along its short sides 63 adapted to slidingly engage opposite sides of guide rail 58. Accordingly, guide rail 60 is slidable along guide rail 58 in the direction indicated by arrow 64. Likewise carrier 54 is provided with undercuts 66 at opposite sides thereof adapted to engage the long sides of guide rail 60. Consequently carrier 54 is slidable along guide rail 60 in the direction indicated by the arrow 68. As a result of this construction carrier 54 is mounted relative to substrate 10 in floating relationship.

Carrier 54 is provided at its lower surface with four spaced depending electrical contacts C1, C2, C3 and C4 which are adapted to slidingly engage electrically operative bodies B1–B4 respectively. Contacts C1–C4 are operatively electrically connected by any suitable means to lead wires 70, which are adapted to extend outwardly of housing 14 through any suitable aperture therein (see FIG. 3). In practice, each of the lead wires 70 is electrically connected to a speaker SP and the terminals T′ are electrically connected to a reference voltage source. In the case where all resistors are to be connected to the same voltage, such as ground (FIG. 7), the four terminals $T'1$–T_4, may be replaced by a single terminal T′ electrically connected to all four resistors R1–R4 by suitable conductive areas 71 as shown in FIG. 8.

Control member 56 is secured at one end to the upper surface of carrier 54 centrally thereof by any suitable means and extends upwardly therefrom. As best shown in FIGS. 1, 4 and 5, when the device is assembled contacts C1–C4 are pressed into slidable engagement with electrically conductive bodies B1–B4, respectively, and control member 56 extends outwardly of housing 14 through window 48. To insure good electrical contact between contacts C and bodies B the contacts are preferably resilient. As best shown in FIG. 3 the spacing of contacts C1–C4 on the lower surface of floating carrier 54 is such that when control member 56 is centrally located in window 48, each contact is substantially located at the center of its respective electrically conductive square body. Accordingly, terminals T and contacts C are electrically connected almost exclusively by the conductive portions 18 of bodies B and thus the value of the operative resistances between the audio signals AS and speakers SP is substantially zero. Under these conditions all four speakers produce an equal sound volume and the apparent sound source is located centrally of the four speakers.

For example, referring to FIG. 6, if the speakers SP1–SP4 are located at the four corners of a square room, a balanced output or apparent sound source will occur at the precise center of the room. In operation, if the listener desires to move the apparent sound source to a different position he need only move the control knob 56 to a corresponding position within window 48 in housing 14. As an illustration, referring again to FIG. 6, wherein relative positions are indicated by mutually perpendicular X and Y coordinates, if the listener desires to move the apparent sound source to the extreme upper right hand position indicated by the coordinates X, Y, he will move the control knob 56 to the corresponding position within window 48. The resulting position of carrier 54 relative to substrate 10 is illustrated in broken lines in FIG. 3. As there shown, contacts C1–C4 have all been moved substantially to the upper right hand corner of their respective operative electrical bodies B1–B4. As a result, contact C3 is now engaged with the resistive portion R3 of body B3 at a location farthest from the diagonal 20. Accordingly, the maximum length of resistive material is interposed between terminal T3 and contact C3 and the audio signal AS3 has maximum attenuation with an accompanying maximum decrease in volume at speaker SP3. However, contacts C1, C2 and C4 remain electrically engaged with terminals T1, T2 and T4, respectively, through substantially zero resistance, contacts C1 and C4 having moved along the diagonals 20 of their respective bodies B1

and B4 and contact C2 having moved farther along the conductive portion 18 of its body B2. This condition is illustrated schematically in FIG. 7. Consequently, the volume at speakers SP1, SP2 and SP4 remain unchanged thereby producing an apparent sound source at the point X1, Y1. That is, to a listener positioned at the center of the room (coordinates 0,0) the sound appears to be emanating from the point X1, Y1. Conversely, a listener positioned at a location in the room diametrically opposite from the apparent sound source (coordinates −X1, −Y1) will get a perfectly balanced output from the four speakers.

In either case the listener may readily visually coordinate the speaker output with the position of the control knob 56 within the window 48. This is particularly advantageous in a multi-channel sound system wherein the listener may desire to experiment with different relative speaker volumes to produce unusual effects. The simultaneous adjustment and visual coordination feature of the present invention significantly facilitates such experimentation.

The embodiment of FIG. 2 is illustrative of merely one of the possible configurations which may be used. For example, window 48 has been disclosed as square but it will be apparent that the window may be of any desired configuration, preferably corresponding to the configuration of the sound field defined by the speakers. Thus if the speakers are placed at the corners of a rectangular room the window 48 would preferably have a corresponding rectangular shape. Likewise, the shape of bodies B1–B4 would be modified in accordance with the shape of the sound field and that of window 48. Moreover, the configuration of the resistive portions R1–R4 of bodies B1–B4 may be varied in any manner to result in the desired relative attenuation of the sound signals corresponding to a movement of the control knob 56. Finally, the slide mechanism 12 may take a variety of convenient forms which are adapted to provide the required floating movement of carrier member 54. Two such different forms are illustrated in FIGS. 9 and 10, respectively, wherein like reference numerals indicate like parts.

In the embodiment of FIG. 9 the carrier member 54 is provided at its lower surface with a central elongated groove 74 slidably receiving a correspondingly shaped elongated guide rail 76 projecting form the top surface of an elongated slidable support member 78. Member 78 is in turn provided with undercuts 80 at opposite ends thereof which are adapted to slidably engage fixed guide rails 82 (shown in broken lines) which may be mounted on the substrate 10 by any suitable means. In accordance with this construction the carrier 54 is slidable in the direction of arrow 84 along support member 78 which in turn is slidable on guide rails 82 in the direction indicated by arrow 86, thereby to afford the floating motion of carrier 54 within the enclosure formed by substrate 10 and housing 14. The contacts C1–C4 depend from resilient arms 87 extending outwardly from the lower surface of carrier 54 and are electrically connected by any suitable means through carrier 54 to outwardly extending resilient arms 90 which carry electrical contacts 92 extending upwardly therefrom. Contacts 92 are in turn slidably electrically engaged with conductive areas 94 (indicated in broken lines) on housing 14, said conductive areas being electrically connected to terminals 96 external of the housing 14. The speakers SP1–SP4 are accordingly electrically connected to the appropriate fixed external terminals 96 by suitable flexible wires (not shown). It will be appreciated that the conductive areas 94 are of a size and shape adapted to maintain electrical connection with contacts 92 in all possible positions of the carrier 54. This structure eliminates the need for an aperture in the housing 14 for the speaker wiring.

In the embodiment of FIG. 10 carrier 54 is provided with a cylindrical aperture 98 slidably receiving a cylindrical guide rod 100 which guide rod is provided at either end with slidable members 102 slidably received in U-shaped track members 104. Track members 104 may be secured by any suitable means either to substrate 10 or the side walls of housing 14. Consequently carrier 54 is slidable along rod 100 in the direction indicated by arrow 106 and rod 100 is in turn slidable along guide tracks 104 in the direction indicated by arrow 108 thereby to effect the required floating motion of carrier 54. Contacts C1–C4 are secured to one end of resilient members 110, said resilient members being bent to conform to the corners of carrier 54 to which they are secured and being provided with contacts 92′ at their outwardly extending ends. Contacts 92′ are likewise adapted to slidably electrically engage conductive areas 94′ on housing 14, which conductive areas are electrically connected to terminals 96′ external of housing 14. The speakers are again wired to their appropriate terminals 96′. It will be apparent that this embodiment provides a device of minimum vertical depth.

In accordance with the foregoing there is provided a variable resistor for use in volume balance control is a sound system which provides maximum effectiveness and convenience. In accordance with the present invention the audio volume of a plurality of speakers may be readily simultaneously adjusted by the manipulation of a single control knob whereby any desired balanced sound source may be selectively obtained. Moreover, the device provides precise visual correlation between the selected position of the apparent sound source with a like position of the control knob relative to the housing. The device is particularly effective for use with a multi-channel stereo sound system wherein the listener may readily adjust the volume balance of the respective speakers to produce interesting and desirable effects.

While only a limited number of embodiments of the present invention are herein specifically described, it will be appreciated that many variations may be made therein, all within the scope of the present invention as defined in the following claims.

I claim:

1. A control device for use in volume adjustment of a multi-speaker sound system comprising a housing, a plurality of electrically operative elements each having a given resistive pattern operatively mounted on said housing, a carrier mounting a plurality of contacts, said plurality of contacts slidably engaging said plurality of electrically operative elements, respectively, means for moving said carrier within said housing in at least two dimensions thereby to simultaneously move said contacts slidably along their respective electrically operative elements, thereby to simultaneously vary the operative resistances of said electrically operative elements, and means on said housing to visually correlate the position of said carrier with the relative values of said operative resistances, whereby when said contacts are operatively electrically connected respectively to a plurality of sound speakers and said electrically operative elements are electrically connected to an autio signal, the position of the apparent sound source may be varied.

2. The control device of claim 1, wherein said housing comprises a substrate and a cover member operatively connected together to form an enclosure, said plurality of electrically operative bodies being mounted in spaced relationship on said substrate, said cover member being provided with an opening in the wall opposite said substrate and said carrier moving means comprising a control member secured to said carrier and extending through said opening in said cover member.

3. The control device of claim 2, wherein said substrate is made of insulating material.

4. The control device of claim 3, wherein said electrically operative bodies and the resistive patterns thereon are positioned and shaped symmetrically about a point on said substrate.

5. The control device of claim 3, wherein said visual correlation means comprises a control member secured to said carrier and an opening in said housing of predetermined peripheral shape, said control member extending through said opening in said housing, the position of said control member relative to the periphery of said opening providing visual indication of the position of said apparent sound source relative to said speakers.

6. The control device of claim 2, wherein said electrically operative bodies and the resistive patterns thereon are positioned and shaped symmetrically about a point on said substrate.

7. The control device of claim 6, wherein said visual correlation means comprises said opening in said cover member, the position of said control member relative to said opening providing visual indication of the position of the apparent sound source relative to said speakers.

8. The control device of claim 6, wherein there are four electrically operative elements arranged symmetrically on a rectangular substrate and wherein said opening in said cover member is rectangular in shape.

9. The control device of claim 8, wherein said electrically operative bodies each comprise a resistive area and a conductive area, said carrier being movable within defined limits in a plane substantially parallel to said substrate and wherein when said carrier is positioned at the center of said defined planar area, said contacts are each positioned at the interface between the resistive and conductive areas of the electrically operative bodies which they engage.

10. The control device of claim 9, wherein said electrically conductive bodies are all rectangular in shape.

11. The control device of claim 10, wherein the interface between said resistive and conductive areas of said electrically operative bodies comprises the diagonal thereof.

12. The control device of claim 9, further comprising a plurality of conductive areas on said housing, means operatively electrically connected to said plurality of contacts respectively and slidably electrically engaging said plurality of conductive areas respectively, said plurality of conductive areas each being electrically connected to an electrical terminal mounted externally of said housing.

13. The control device of claim 8, wherein said electrically conductive bodies are all rectangular in shape.

14. The control device of claim 2, wherein said visual correlation means comprises a control member secured to said carrier and an opening in said housing of predetermined peripheral shape, said control member extending through said opening in said housing, the position of said control member relative to the periphery of said opening providing visual indication of the position of said apparent sound source relative to said speakers.

15. The control device of claim 2, further comprising a plurality of electrical terminals on said substrate accessible from the outside of said housing, each of said electrically operative bodies being connected between at least two of said terminals.

16. The control device of claim 2, wherein said slidable contacts are mounted on resilient arms extending outwardly and downwardly from said carrier.

17. The variable resistor device of claim 2, further comprising a slider mounted on said substrate for slidable movement relative thereto in a given direction, and means on said carrier for slidably engaging said slider in a direction substantially perpendicular to said given direction.

18. The control device of claim 1, wherein said visual correlation means comprises a control member secured to said carrier and an opening in said housing of predetermined peripheral shape, said control member extending through said opening in said housing, the position of said control member relative to the periphery of said opening providing visual indication of the position of said apparent sound source relative to said speakers.

19. The control device of claim 1, wherein said electrically operative bodies each comprise a resistive area and a conductive area, said carrier being movable within defined limits in a plane substantially parallel to said substrate and wherein when said carrier is positioned at the center of said defined planar ares said contacts are each positioned at the interface between the resistive and conductive areas of the electrically operative bodies which then engage.

20. The control device of Claim 19, wherein said housing comprises a substrate and a cover member operatively connected together to form an enclosure, said plurality of electrically operative bodies being mounted in space relationship on said substrate, said cover member being provided with an opening in the wall opposite said substrate and said carrier moving means comprising a control member secured to said carrier and extending through said opening in said cover member.

21. The control device of claim 19, wherein said electrically operative bodies and the resistive patterns thereon are positioned and shaped symmetrically about a point on said substrate.

22. The control device of claim 19, wherein said visual correlation means comprises a control member secured to said carrier and an opening in said housing of predetermined peripheral shape, said control member extending through said opening in said housing the position of said control member relative to the periphery of said opening providing visual indication of the position of said apparent sound source relative to said speakers.

23. A variable resistor device for simultaneously varying the operative resistance value of a plurality of resistors in a predetermined manner comprising a base member, a cover member operatively connected to said base member to form an enclosure, a plurality of resistive elements on said base member, a carrier means mounted in said enclosure for two dimensional movement parallel to the plane of said base member, said carrier mounting a plurality of electrical contacts, each of said contacts slidably engaging a resistive element on said base member, said cover member being provided with a window having a predetermined shape, an elongated control member secured to said carrier and extending outwardly of said housing through said window in said cover member whereby movement of said control member within said window is effective to vary the relative resistances of said resistive elements in a predetermined manner.

24. The variable resistor device of claim 23, further comprising a slider mounted on said substrate for slidable movement relative thereto in a given direction, and means on said carrier for slidably engaging said slider in a direction substantially perpendicular to said given direction.

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