United States Patent

Kasazima

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[45] **Oct. 31, 1972**

[54] **SINGLE CONTROL DEVICE FOR PLURAL VARIABLE RESISTORS**

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Feb. 3, 1971 Japan 46/3773

[52] **U.S. Cl.** **338/128,** 338/90
[51] **Int. Cl.** **H01c 9/02**
[58] **Field of Search**.................338/128, 130, 131, 90

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Primary Examiner—Lewis H. Myers
Assistant Examiner—D. A. Tone
Attorney—Maxwell James et al.

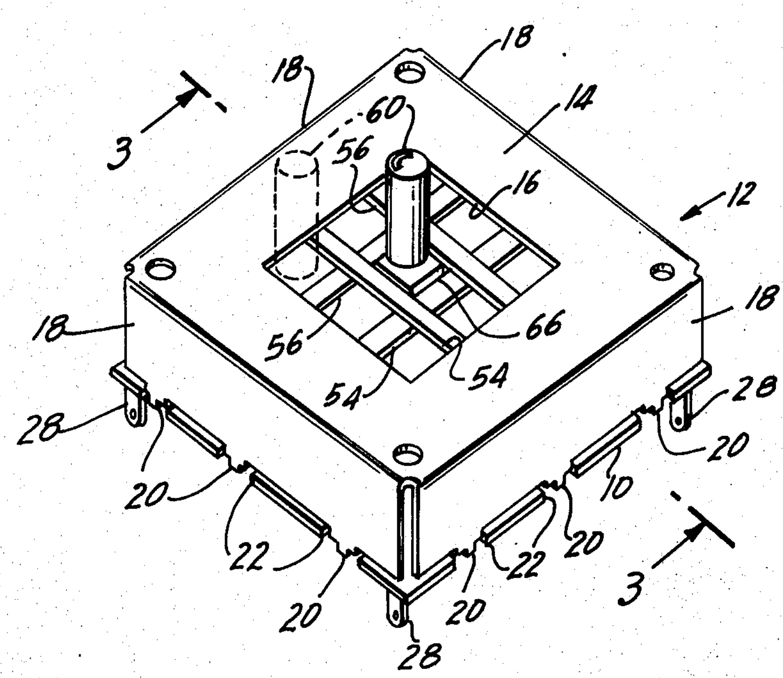
[57] **ABSTRACT**

An improved control device for use in volume adjustment of a multi-speaker sound system is provided with means for simultaneously adjusting the volume of some or all of the speakers in the system. A plurality of variable resistors are mounted on an insulating substrate, the effective resistance of each resistor being adjustable by sliding contact means.

In a first embodiment of the invention an independent sliding contact means is provided for each variable resistor, those sliding contacts being simultaneously adjustable by means of a control knob operatively connected to a crossover linkage arrangement. The control knob extends through a window in the housing whereby the position of the apparent sound source is adjusted by reference to the position of the control knob within the housing substrate.

In a second embodiment of the invention the individual resistors each comprise a unique resistive pattern and a single carrier is provided with a plurality of sliding contacts engaging that resistive pattern in a predetermined manner in response to the manual operation of the control knob.

10 Claims, 16 Drawing Figures



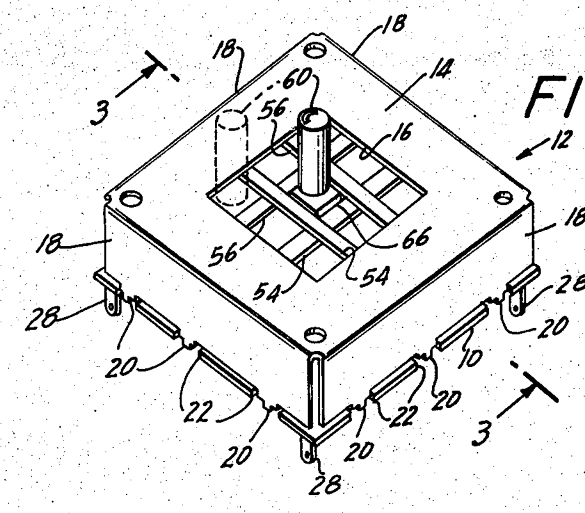


FIG. 1

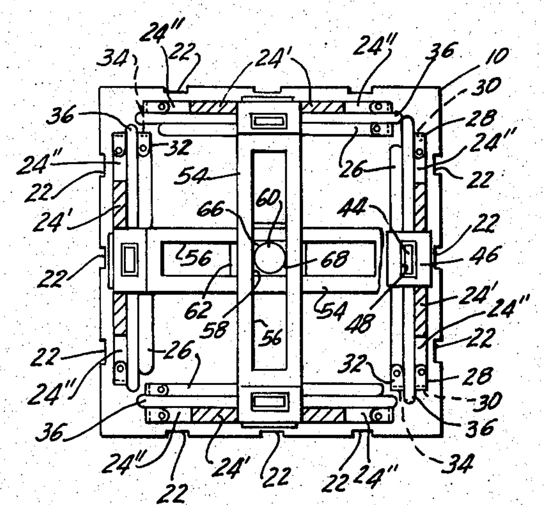


FIG. 2

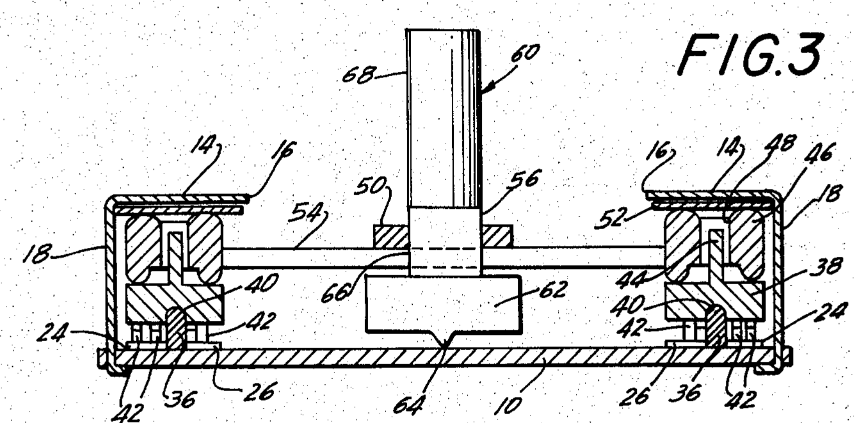


FIG. 3

FIG. 4

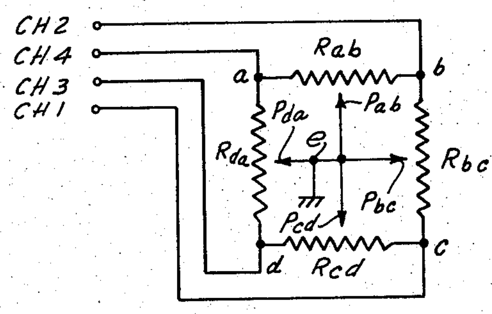
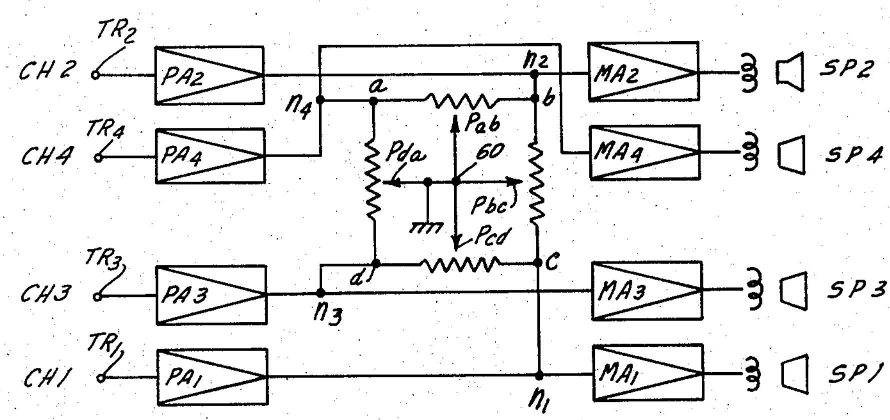


FIG. 5



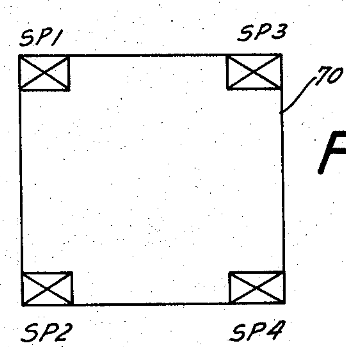


FIG. 6

FIG.7A

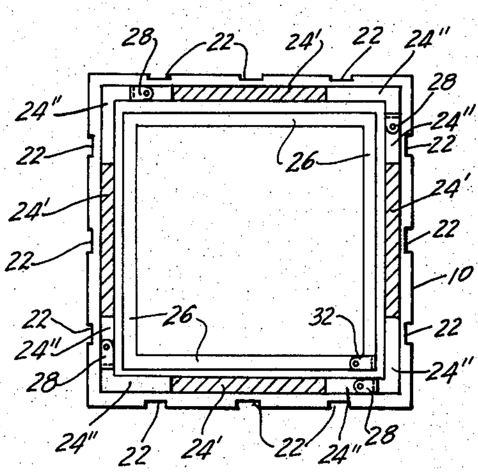
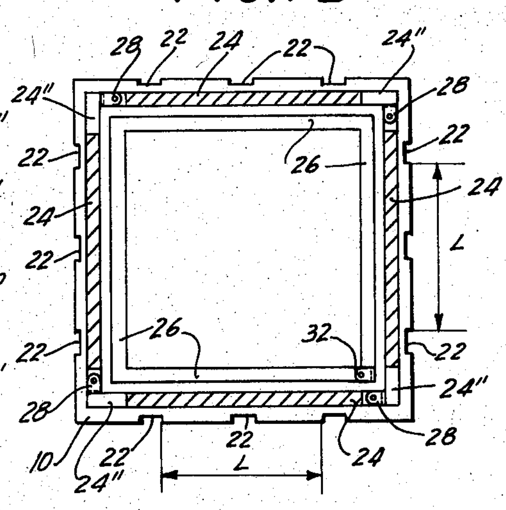


FIG.7B



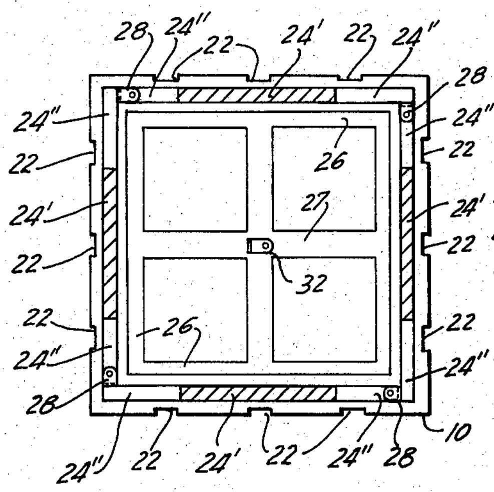


FIG.7C

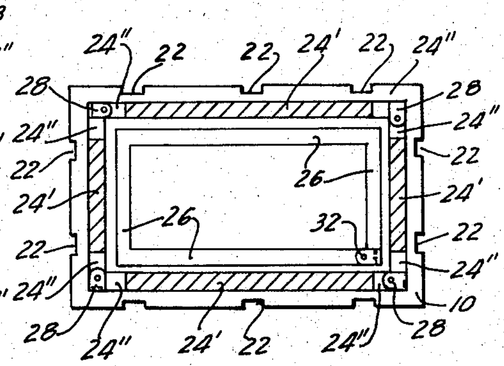


FIG.7D

FIG. 8A

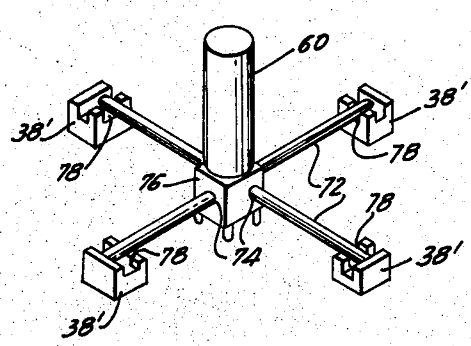
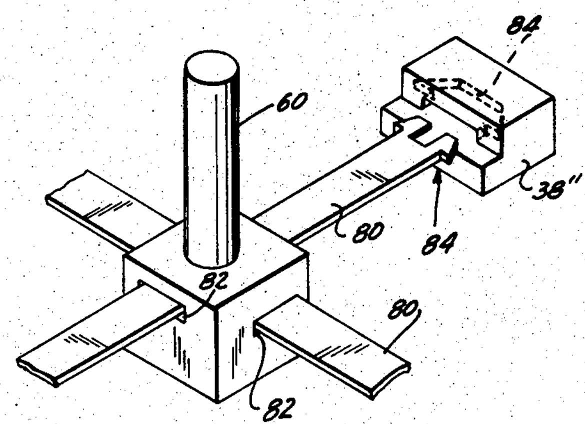


FIG. 8B



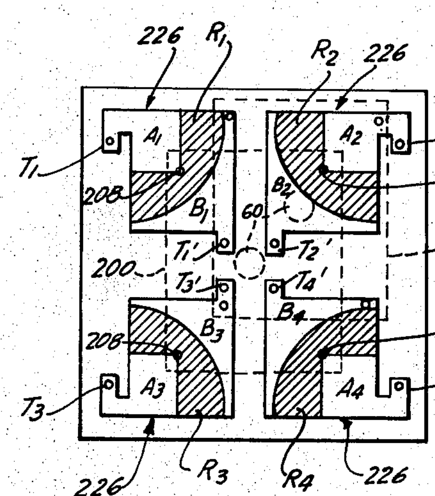


FIG. 11

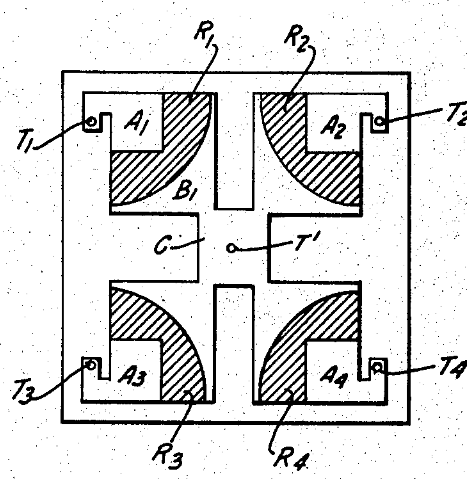


FIG. 12

FIG. 9

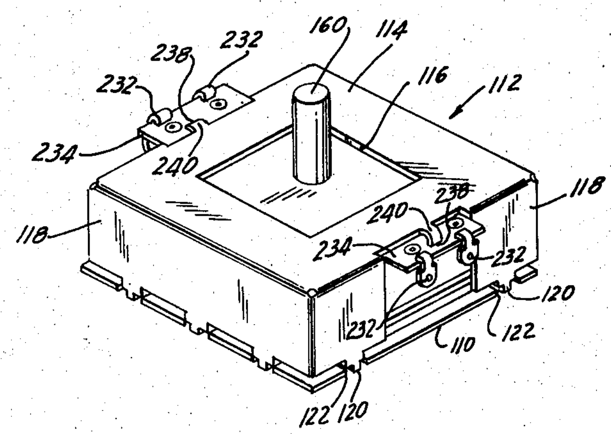

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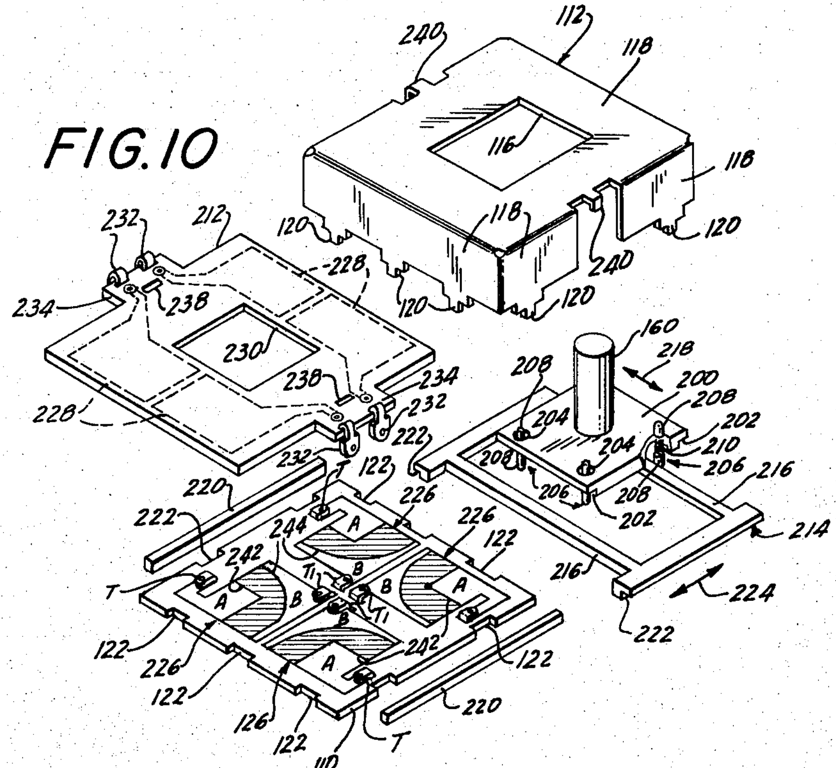
FIG. 10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SINGLE CONTROL DEVICE FOR PLURAL VARIABLE RESISTORS

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 be 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.

In copending application Ser. No. 133,941, filed by Hiroaki Komatsu on Apr. 14, 1971, now U.S. Pat. No. 3,662,313 entitled "Single Control Device for Plural Variable Resistors," and assigned to the assignee of the present invention, there is disclosed a control device for use in volume adjustment of a multi-speaker sound system, of the type here described, adapted to eliminate the above-mentioned problems by providing simultaneous adjustment of the resistances associated with a plurality of sound speakers by means of a single control knob so as to provide a balanced output for any desired listening position. Briefly, that device comprises a plurality of triangular shaped resistive elements disposed on a base member and operatively connected to a like number of sound speakers. The operative resistances and thus the audio volume of each of the associated speakers is adapted to be adjusted simultaneously by means of a plurality of electrical contacts carried on a floating carrier member movable in any direction within a given plane. The carrier is moved to any desired position by means of a single control member extending through a window in the housing of the device, that window being adapted to provide accurate visual indication of the resulting apparent sound source.

While that device represents a major improvement in the art, several limitations and drawbacks of that structure will be apparent. Those drawbacks and limitations result primarily from the triangular configuration of the resistive elements utilized. Thus while in accordance with that configuration the sound source, based upon the vector addition of the audio volumes of the speakers involved could be accurately moved by a corresponding movement of the control knob within the window with an accurate indication thereof, variations in the sound effect produced by the combination of relative and absolute audio volume of the speakers is somewhat limited. For example, in accordance with that structure the volume of only one speaker at a time could be reduced to zero. That would occur only when the control knob was moved completely to one corner of the indicating window and resulted in a maintenance of the maximum volume of three speakers while the fourth was reduced to zero. If the control knob was moved from the origin along either the X or Y axis to one side of the window, the two speakers at that side of the room would be maintained at maximum volume while the volume of the remaining two speakers at the other side of the room would be reduced by approximately one-half. Accordingly, the operator, by use of the control knob, could not test the balance of only two speakers without at least some interference or distraction from the output of the other two speakers. Moreover, with the control knob at one of the extreme edges of the window, movement of that knob along the edge would have no effect on the balance between the volume of the speakers positioned at that corresponding side of the room (which speakers were held at the maximum volume) but would instead be effective to provide an adjustment of the balance between the volumes of the speakers at the other side of the room.

Another drawback of the triangular resistance pattern of the aforementioned Komatsu application results from the fact that adjustment of the balance between diametrically opposing speakers could not be effected without affecting the volume of one or the other of the two remaining speakers. Both of these factors severely limit the versatility of the device, particularly when it is desired to test for a defective speaker. Finally, in the device disclosed in the aforementioned copending application, it was necessary to provide lead lines extending from the carrier member or in a second embodiment electrical terminals on the cover member in addition to the electrical terminals connected to the resistor patterns on the base. This structure not only increases cost of manufacture but may also significantly reduce reliability and result in increased maintenance cost.

It is a primary object of the present invention to provide an improved variable resistor of the type described adapted for use in volume balance adjustment of a multi-channel stereo sound system adapted to eliminate substantially all of the above-mentioned drawbacks.

It is another object of the present invention to design a variable resistor of the type described which is simpler and more compact in construction and substantially more versatile than prior art structures of this type.

It is yet another object of the present invention to provide a single control device for plural variable resistor adjustment which utilizes a minimum of inexpensive parts and is inexpensive to manufacture and assemble.

It is still another object of the present invention to provide a variable resistor of the type described wherein the apparent sound source of a multi-channel stereo sound system may be accurately varied by visual reference through the simultaneous adjustment of plural variable resistors and wherein the operator may test the volume adjustment of one or more speakers independently of the others.

To these ends the present invention comprises a control device for use in volume adjustment of a multi-speaker sound system and adapted to provide a versatile means for simultaneously adjusting the volume of some or all of the speakers in the system. Broadly, a device constructed in accordance with the present invention comprises a plurality of variable resistors mounted on an insulating substrate, a cover member secured to the substrate and defining an enclosure, a carrier mounted for sliding movement within that enclosure for movement parallel to the substrate in any direction and having a plurality of electrical contacts wipingly engaging said plurality of resistors respectively. The carrier is provided with a control member or knob extending through a window in the cover member. That window is adapted to simulate the listening room and the resistors are so arranged on the substrate that when they are properly electrically connected in circuit arrangement with a plurality of sound speakers having a corresponding arrangement, the location of the apparent sound source may be conveniently adjusted by reference to the location of the control knob within the cover member window.

In a first embodiment of the invention, the resistors are in the form of four narrow strips of resistive material disposed along the sides of a generally square substrate. Adjacent to each resistor and extending parallel thereto is a conductive strip. The carrier means comprises four carrier members each mounted for sliding movement along an elongated guide rail mounted on the substrate and extending parallel to the aforementioned conductive and resistive strips. The carrier members are provided with electrical contact members each having contacts biased into wiping engagement with the resistive and conductive elements thereby to provide an operative variable resistor circuit.

The carriers on opposite sides of the substrate are movable in unison via slotted crossover booms. An elongated control knob extends vertically through the slots in both booms at the crossover region, whereby movement of the knob is effective to simultaneously adjust the effective resistances of all four resistors. In accordance with this embodiment, the resistive strips may be varied in length and/or resistance value, thereby to vary the adjustment characteristic in accordance with individual desires and/or for use with rectangular rooms of varying dimensions. Two additional embodiments of the crossover control boom configuration are described.

In a second embodiment of the present invention, the substrate is provided with resistive patterns in a manner similar to that described in the aforementioned copending application. However, as here disclosed, the resistive patterns comprise a sandwich structure in which a resistive area is bounded on opposite sides by conductive areas. These patterns are so designed that one, two, or even three of the four resistors may be adjusted while the resistances of remaining resistors are maintained at zero. This feature provides greater versatility and facilitates independent speaker balancing and testing for defective speakers and/or channels.

This embodiment also includes an improved contact structure wherein each of the four contact members are mounted for horizontal movement with a plate-like carrier member but are vertically slidable relative thereto and comprise a pair of contacts spring biased in opposite directions into wiping engagement with the resistive patterns on the substrate and opposing conductive areas disposed on a second substrate mounted above and parallel to the first substrate. This structural arrangement provides improved electrical contact and a smooth and reliable operation with increased operating life.

To the accomplishment of the above and to such other objects as may hereinafter appear, the present invention relates to a control device for plural variable resistors as defined in the appended claims and as described herein, with reference to the accompanying drawings in which:

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

FIG. 2 is a top plan view of the device of FIG. 1 with the cover removed;

FIG. 3 is a cross sectional view taken along the line 3—3 of FIG. 1;

FIG. 4 is a circuit diagram of the variable resistors of FIG. 1;

FIG. 5 is a circuit diagram similar to FIG. 4 showing the variable resistors operatively connected in a four-channel sound system;

FIG. 6 is a schematic illustration of a room containing four stereo speakers;

FIGS. 7A–7D are plan views showing four illustrative embodiments of a substrate for use in the control device of FIG. 1, the substrate of FIG. 7D being designed for use in connection with an elongated rectangular room;

FIGS. 8A and 8B are perspective views of two additional embodiments of a crossover control boom structure for use in the control device of FIG. 1;

FIG. 9 is a perspective view of an assembled control device constructed in accordance with a second embodiment of this invention;

FIG. 10 is an exploded perspective view of the control device of FIG. 9; and

FIGS. 11 and 12 are plan views of two embodiments of an insulating substrate for use in the control device of FIG. 9.

The present invention will be here specifically described for use in a four-channel stereo system having four speakers, one for each channel. It will be apparent, however, that the device may be modified for use with other multi-channel sound systems having any number of channels and/or speakers.

Referring now to the drawings wherein like reference numerals designate like or corresponding parts throughout the several views and particularly to FIG. 1, there is shown an assembled control device in accordance with one embodiment of the present invention. That device comprises a substrate or base plate generally designated **10** and a cover member generally designated **12**. Cover member **12** comprises a top wall **14** having a generally square window or aperture **16** and four bent over side walls **18** having a plurality of tabs **20**. The cover member **12** is secured to base plate **10** by tabs **20** received in registering notches **22** in the base plate and bent thereover.

Base plate **10** preferably comprises a thin square substrate of electrically insulating material and as best shown in FIG. 2, is provided with four pairs of electrically operative elongated strips **24** and **26** extending along its four sides, respectively. The outer strips **24** comprise resistive material **24'** along a major portion of the length thereof, the segments **24''** at either end comprising conductive (i.e. metallic) material A pair of electrical terminals **28** are affixed to conductive areas **24''** at either end of strips **24** and extend through slots **30** in substrate **10** for the purpose of external electrical connection.

Inner strips **26** are formed of conductive material along their entire length and are each provided with one electrical terminal **32** at one end extending through a slot **34** in substrate **10** for external electrical connection.

Elongated guide rails generally designated **36** are operatively secured to the substrate **10** and extend between strips **24** and **26**. As best shown in FIG. 3, guide rails **36** are provided with a rounded upper surface, each adapted to provide a guiding slide support for a carrier member generally designated **38**. Each carrier member **38** is formed of a suitable electrically insulating material and is provided at its lower surface with a rounded groove **40** adapted to seat on guide rail **36** for sliding movement therealong. Depending from the lower surface of carrier **38** at either side of guide rail **36** are resilient electrical contacts **42** adapted, when carrier **38** is urged into sliding engagement with rail **36**, to wipingly engage strips **24** and **26** on substrate **10**. In the embodiment shown, three contacts **42** are provided on each carrier member, two engaging the strip **24** and one engaging the strip **26**. Those contacts are all electrically connected to one another in any suitable manner (not shown) (for example, by being formed integral on a single contact member having a connecting segment secured to the carrier **38** above the groove **40**), thereby to electrically connect the strips **24** and **26**.

Carriers **38** are formed with upwardly extending tongues **44**. Tongues **44** are received in vertical slots **48** formed in sliding blocks **46**, those blocks being disposed between carriers **38** and the upper wall **14** of cover member **12** and being adapted to urge carriers **38** into sliding engagement with their respective guide rails **36**. As a result, carriers **38** are moved along guide rails **36** by their engagement with blocks **46**. To facilitate smooth low friction sliding of block **46**, those blocks are formed with rounded upper surfaces **50**, those surfaces slidably engaging a thin sheet of low friction material **52** disposed between wall **14** of cover member **12** and blocks **46**. Sheet **50** is formed with a window **52** registering with window **16** in wall **14** to accommodate the control mechanism hereinafter described.

Opposing blocks **46** are affixed to opposite ends of a pair of control booms **54** in any suitable manner. As best shown in FIGS. **2** and **3**, booms **54** extend in mutually perpendicular crossover relationship and are provided with longitudinally extending slots **56**, those slots defining at their crossover point a generally square aperture **58**. An elongated vertically extending control knob **60** is received in aperture **58** through the slots **56** in both booms **54** and extends upwardly through windows **52** and **16** in sheet **50** and wall **14** of cover member **12**, respectively. Control knob **60** is supported at its lower end by a rectangular base member **62**, that base member being larger than aperture **58** in booms **54** and being provided with a downwardly extending teat **64** slidably engaging the substrate **10**. Control knob **60** is preferably provided at its lower end **66** with a square cross section being snugly received in square aperture **58** and at its upper end **68** with a generally circular cross section to facilitate manual gripping.

In accordance with the above construction, it will be appreciated that control knob **60** may be moved along either or both of longitudinal slots **56** in booms **54** to any location within window area **16**, and when so moved is adapted to adjust the positions of booms **54** along the opposite sides of substrate **10** bridged by those booms. Booms **54**, in turn, via the sliding blocks **46** at either end thereof are adapted to control the position of carriers **38** along guide rails **36** and thus the position of contacts **42** along strips **24** and **26**, thereby to vary the effective length of resistive material **24'** operatively connected in the external circuit, between one of the terminals **28** and terminal **32**. For example, in a typical embodiment, terminals **28** of resistive strip **24** would be connected in operative circuit arrangement with a multi-speaker sound system and conductive strip **26** would be grounded through terminals **32**, whereby a variable length of resistive material **24'** is operatively connected in the speaker system via terminal 28, contacts 42, conductive strip 26 and terminal 34.

FIGS. 7A–7D show alternative arrangements of the strips 24 and 26 on substrate 10, in which the four inner and outer strips are operatively connected to each other in a closed loop. In the embodiment of FIG. 7A, one of the two terminals 28 at either end of the strips 24 are eliminated and the conductive area 24'' at that end is extended and operatively connected to the terminal 28 of the adjacent strip 24. The conductive strips 26 are connected at their intersecting corners in a closed loop, a single terminal 32 being provided at one corner. This structure results in a simplification of the wiring system.

The embodiment of FIG. 7B is identical to that of FIG. 7A with the exception that the strips 24 comprise resistive material 24' along a length greater than the adjustment span L of the carriers 38, whereby the contacts 42 remain engaged with resistive material 24' along the entire adjustment span of carrier 38, thereby to vary the effective resistance from a maximum value at one end of the span to a minimum value (other than zero) at the other end of the adjustment span. In accordance with this arrangement, sound is always emitted from all four speakers and unnatural sound field generation is minimized.

The embodiment of FIG. 7C is again substantially identical to that of FIG. 7A with the exception that the conductive strips 26 are operatively connected to a centrally located terminal by means of intersecting conductive strips 27.

The embodiment of FIG. 7D also utilizes the structure of FIG. 7A but is rectangular in configuration, the length of one pair of resistive strips 24' being greater than that of the other. The two pairs of strips may be made of different resistive materials whereby the effective resistance of the longer strips is equal to that of the shorter strips thereby to maintain effective four speaker balance. This configuration is utilized with a correspondingly rectangular window area in the cover member to facilitate adjustment of the sound source within a rectangular room (or where the speakers are situated in a rectangular configuration other than a square).

The electrical circuit embodied in a control device of the type thus far described using one of the substrate configurations of FIGS. 7A–7D is best illustrated by the circuit diagram of FIG. 4, wherein the four terminals 28 are represented by nodes *a–d*, the four resistive strips are represented by resistors R_{ab}, R_{bc}, R_{cd} and R_{da}, and the terminal 32 is represented by node *e*. The node 60 represents the control knob 60 in FIG. 1 and the slider contacts 42 engaging the resistive strips are represented by pointers P_{ab}, P_{bc}, P_{cd} and P_{da}. As there shown, node *e* is grounded and the corner nodes *a, b, c* and *d* are operatively connected in circuit arrangement with the four channels CH1–CH4 of a sound system.

One such circuit arrangement is illustrated in FIG. 5. As there shown, each channel comprises a terminal TR at which the audio signal is introduced. That signal is amplified by a preamplifier PA and then passes through a master amplifier MA to its respective speaker SP.

Volume adjustment for individual channels is effected through attentuation of the audio signal at nodes n_1–n_4. Those nodes are each connected to one of the four corner nodes *a–d* (terminals 28) of the variable resistor. Thus in the illustrated embodiment node n_1 is connected to node *c*, node n_2 is connected to node *b*, node n_3 is connected to node *d* and node n_4 is connected to node *a*. It will be apparent that the amount of attenuation of the audio signal effected at nodes n_1–n_4 is inversely proportional to the effective resistance between that node and ground. Those resistances are in turn dependent upon the position of control knob 60. For example, in the central position of knob 60 illustrated, all four speakers will have equal sound volume. If control knob 60 is moved toward node *b* to its extreme upper right hand position in FIG. 5, the signal levels at nodes *a, b* and *c* will be maximally attenuated (in the embodiment of FIG. 7A these nodes would be grounded resulting in no audio signal at all at the output of the respective preamplifiers), and the audio signal at node *d* will be minimally attenuated. As a result, the volume of speaker SP3 is increased to its maximum level while the volume at speakers SP1, SP2 and SP4 is decreased to their minimum levels. If as shown in FIG. 7B, the adjustment span of the sliding contacts extends the full length of the resistive strips, the signal (voltage) level at each of nodes *a–d* varies between a maximum of one-half RI to a minimum of zero where R is the resistance of the full length of each resistor strip and I is the current.

As illustrated in FIG. 6, the speakers should be arranged in a configuration corresponding to the window 16 within which the control knob 60 is movable. Thus it is seen that speaker SP3 is located at the upper right hand corner of a square listening area 70 so that movement of the control knob 60 to the upper right hand corner (nodes *b* and n_2) of the window 16 of the control mechanism is effective to move the apparent sound source to the corresponding corner of the listening area 70.

It will be appreciated that various crossover linkages other than that shown in FIGS. 2 and 3 may be utilized to control the position of the sliding contacts 42 along the resistive strips 24'. To such alternative linkages are illustrated in FIGS. 8A and 8B.

In the embodiment of FIG. 8A, a pair of control rods 72 having a generally circular cross section are received respectively through a pair of mutually perpendicular but vertically spaced circular apertures 74 in a square block 76 affixed to the lower end of control knob 60. The carrier members here designated 38' comprise rectangular blocks having slots 78 adapted to receive the opposing ends of rods 72, whereby movement of the knob in any direction results in the mutually perpendicular sliding movement of the carriers associated with those rods.

FIG. 8B shows a construction similar to that of FIG. 8A. However, in this embodiment the crossover members are in the form of flattened elongated members 80 received in narrow crossover slots 82 and formed with resilient fork-like fastening members 84 at opposite ends. The carriers 38'' are in turn formed with correspondingly shaped receptacles 86 adapted to receive fastening members 84 in locking engagement.

The embodiments thus far described utilize elongated resistive strips, the effective resistances of which are controlled by four separated carrier members movable by means of a pair of crossover linkage members. That structure has certain advantages over the single slide carrier device disclosed in the aforementioned Komatsu application. Thus all of the operative electrical terminals may be conveniently located on the substrate or base, thereby to facilitate assembly and installation. Moreover, the device may be easily modified for use with a rectangular room of other than a square configuration merely by lengthening the resistive strips on one pair of sides of the base while maintaining the total resistance value of the strip the same (i.e., as by using a material of slightly different resistance per inch). Indeed, if desired the "per inch" resistance of individual resistive strips may be varied to provide different adjustment sensitivities. However, the versatility of this construction is somewhat limited with regard to desired variations in balancing patterns. Thus the volume at each speaker depends on the effective resistance of two strips so that two speakers cannot be balanced independently of the other two. This limitation presents a significant problem when it is desired to test the operativeness of one or more speakers and/or channels or to vary the balance in accordance with the particular selection being played.

The embodiment illustrated in FIGS. 9–12 is designed to provide such versatility while maintaining a simple and reliable construction which is easy to assemble and install. As illustrated in FIGS. 9 and 10, that device is similar in construction and operation to the device disclosed in the aforementioned copending Komatsu application and comprises a substrate **110** and a cover member **112** designed to fit over substrate **110** and be secured thereto by depending tabs **120** received within slots **122** in a manner identical to that already described with respect to FIG. 1. The cover member is provided with a window **116** in its top wall **118** through which the control knob **160** extends. Affixed to the lower end of control knob **160** is a single carrier member **200** in the form of a generally square plate of insulating material having stepped portions **202** on its underside along two parallel edges. Carrier **200** is provided with four small apertures **204**, one near each corner, those apertures slidably receiving contact elements **206**. Each contact element comprises a pair of oppositely facing metallic contacts spring biased away from each other by a small compression coil spring **210** disposed therebetween.

Carrier member **200** is mounted for universal sliding movement between substrate **110** and a second plate of insulating material **212** by means of a universal slide linkage comprising a rectangular guide frame **214** having guide rails **216** slidably supporting carrier **200** along stepped portions **202** for movement in a first direction indicated by arrow **218**, that frame being itself slidably mounted on a pair of guide rails **220** by means of stepped portions **222** for movement in a second direction indicated by arrow **224** perpendicular to said first direction. Guide rails **220** are secured to substrate **110** in any suitable manner.

The substrate **110** is provided on its top surface with four generally square electrically operative elements **226** each comprising a resistive pattern to be described hereinafter. The upper insulating plate **212** is provided on its lower surface with four electrically operative elements comprising conductive areas **228** facing and in general registration with elements **226** on substrate **110**. In addition, plate **212** is provided with a window **230** adapted to register with window **116** on cover member **112** through which control knob **160** is received.

As illustrated in FIG. **10**, each conductive area **228** on the lower surface of plate **212**, is electrically connected to a terminal **232**, said terminals being secured in pairs on two oppositely extending tongues **234** formed integral on plate **212**. Those tongues are received through openings **236** in opposite side walls **118** of cover member **112** and are provided with slots **238** receiving tabs **240** depending from the top wall **114** of cover member **112**, thereby to laterally stabilize plate **212** within the assembly.

In assembling the device guide frame **214** is mounted on guide rails **220**, carrier member **200** is mounted on frame **214**, plate **212** is placed atop carrier **200** and supported in that position by the four upwardly facing contacts **208**, control knob **160** extending through window **230**, and finally cover member **112** is disposed atop plate **212**, tabs **240** being received in slots **238**, and is secured to substrate **110** by tabs **120** received through slots **122** and bent under substrate **110**. When the device is thus assembled coil spring **210** on each contact member **206** is compressed between substrate **110** and plate **212**, whereby contacts **206** establish firm electrical connection between the registering electrical elements **226** and **228** on substrate **110** and plate **212**, respectively, and are moved along those elements by carrier member **200**. Because contacts **206** are vertically movable within apertures **204** in carrier member **200**, those contacts "float" between substrate **110** and plate **212** exerting equal pressure on both.

As best illustrated in FIG. **10**, electrically operative elements **226** on substrate **110** each comprise a resistive area R sandwiched between two conductive areas A and B. The resistive area R is in the form of a strip extending between the two adjacent outer sides of the square element **226**, and having a generally L-shaped outer boundary **242** with the outer conductive area A and an arcuate inner boundary **244** with the inner conductive area B. Consequently, the inner conductive area B encompasses both adjacent inner sides of the square elements **226**.

Terminals T are operatively electrically connected to the outer conductive areas A at the outer corners of the elements **226**. The inner conductive areas B are operatively electrically connected to terminals T' at the inner corners of elements **226**. Terminals T and T' extend through appropriate slots in the substrate **110** for external electrical connection to a sound system. That electrical connection is made in a manner identical to that shown and described in the aforementioned copending Komatsu application and accordingly will not be described in detail here. Suffice it to say that the volume of each of four speakers is controlled by the effective resistance connected between the grounded terminals T' on substrate **110** and the terminals **232** on plate **212**.

As best illustrated in FIG. **11**, when the control knob is located centrally of substrate **110** (centered within the window **116**), the contacts **208** are located centrally of elements **226** at the boundary **242** between the resistive areas R and the outer conductive areas A. Consequently, the entire resistive area R is connected between terminals T' and terminals **232** (via contact members **206** and conductive elements **228**) whereby substantially maximum volume is emitted from all four speakers. When the knob **160** is moved to its extreme position at one of the corners of window **116**, for example to the upper right hand corner as illustrated in FIG. **11**, the upper right hand contact **208** remains engaged with the outer conductive area A_2 and the other three contacts are moved fully across resistive areas R_1, R_3 and R_4 into engagement with the inner conductive areas B_1, B_3 and B_4, respectively. As a result the volume of one speaker, associated with the upper right hand element **226**, remains at its maximum level, while the volume of the remaining three speakers is reduced to zero. As noted with respect to the embodiment of FIG. **1**, this configuration is desirable for testing the performance of a particular speaker and/or channel without interference from the remaining speakers and/or channel.

A second desirable feature of the resistive pattern here illustrated is the ability to test the balance between any two adjacent speakers without interfering audio from the other two speakers. For example, when the knob **160** is in the upper right hand position illustrated in FIG. **11**, the balance between the two upper resistors R_1 and R_2 or the two right hand resistors R_2 and R_4 may be independently adjusted merely by sliding the knob in the horizontal or vertical direction, respectively. It will be apparent that under these conditions the effective resistance of the remaining two resistors is maintained at zero value because their respective contacts slide along the inner conductive areas B thereby shorting out the audio signal for those speakers.

It will be appreciated, that unlike the embodiment of FIG. **1** the resistive patterns here illustrated provide maximum resistance (i.e., maximum volume) to all four channels when the control knob is centrally located within the window, the resistance (volume) of one or more of those channels decreasing upon movement of the control knob away from the center of the window.

Finally, it has been found that the resistive pattern herein described provides exceptionally good accuracy in adjusting the apparent sound source by visual reference to the location control knob within the window opening in the cover member combined with increased versatility in providing pleasing sound effects.

Since, in operation, the inner terminals T' are all grounded, those terminals may be conveniently replaced by a central conductive area C operatively connecting all four inner conductive areas B to a single central terminal T', as illustrated schematically in FIG. **12**.

It will be appreciated from the foregoing that the present invention represents a significant improvement in control devices for multi-speaker sound systems. The embodiments here described are all constructed of an absolute minimum of simple inexpensive components arranged in a compact easy to assembly structure.

In addition to the improved structural features of the control devices herein described, the particular arrangements of plural resistors on an insulated substrate in accordance with this invention provides increased versatility and superior operating characteristics as compared to prior art structures.

The crossover construction shown in FIG. **1** is particularly useful in connection with elongated rectangular listening areas or where variations in the sensitivity of balance adjustment in mutually perpendicular directions is desired. Moreover, that configuration results in a simplified wiring system in which all external connections are made to terminals on the substrate.

The embodiment of FIG. **9** provides an extremely compact structure having improved "floating" electrical contact means and enhanced versatility which enables independent volume adjustment of one or more speakers.

While only a limited number of embodiments of the present invention have been herein specifically disclosed, it will be appreciated that many variations may be made therein without departing from the scope of the invention, as defined in the following claims.

I claim:

1. In 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 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, means on said housing to visually correlate the position of said carrier with the relative values of said operative resistances, the improvement wherein said resistive patterns include at least two conductive areas separated from each other by a resistive area on said electrically operative elements such that one or more of said contacts may engage one of said conductive areas on their respective electrically operative elements while the remaining contacts simultaneously engage the other of said conductive areas on their respective electrically operative elements, whereby when said contacts are operatively connected respectively to a plurality of sound speakers and said electrically operative elements are electrically connected to an audio signal, the position of the apparent sound source may be conveniently varied by reference to the position of said carrier.

2. The control device of claim **1**, wherein said resistive patterns are shaped to allow balancing of the effective resistances of one pair of electrically operative elements while the effective resistances of the other electrically operative elements are maintained at a value of zero.

3. The control device of claim **1**, wherein said housing comprises a rectangular substrate, there being four electrically operative elements arranged symmetrically on said substrate, and wherein said other conductive area of each of said elements extends along the full length of two adjacent sides of said element rectangle, whereby movement of said contacts along said two adjacent sides of one of said elements is ineffective to vary the resistance of that element.

4. The control device of claim **3**, wherein the boundary between said resistive area and said one conductive area is L-shaped.

5. The control device of claim 4, wherein the boundary between said resistive area and said other conductive area is arcuate.

6. A control device for use in volume adjustment of a multi-speaker sound system, comprising a first plate of electrically insulating material, a plurality of first electrically operative elements disposed on said first plate, first terminal means on said first plate operatively electrically connected to said elements, a second plate of insulating material spaced from and substantially parallel to said first plate, a plurality of second electrically operative elements arranged on said second plate substantially in registration with said first electrically operative elements on said first plate, second terminal means operatively electrically connected to said second elements, a carrier mounted between said plates for sliding movement parallel thereto in any direction, a plurality of contact elements mounted for movement with said carrier parallel to said plates, and movable relative to said carrier in a direction perpendicular to said plates, each of said contact elements comprising first and second electrical contacts extending in opposite directions toward said first and second plates, respectively, and resilient bias means operatively connected between said first and second contacts and effective to bias said contacts away from each other and into wiping engagement with opposing first and second electrically operative elements, respectively, said electrically operative elements on at least one of said first or second plates comprising a resistive pattern, whereby when said first and second terminal means are connected in operative circuit arrangement with said plurality of speakers, the position of the apparent sound source may be varied.

7. The control device of claim 6, wherein said resilient bias means comprises a compression coil spring.

8. The control device of claim 6, wherein said resistive patterns are shaped to allow balancing of the effective resistances of one pair of electrically operative elements while the effective resistances of the other electrically operative elements are maintained at a value of zero.

9. The control device of claim 7, wherein said resistive patterns include at least two conductive areas separated from each other by a resistive area on said electrically operative element such that one or more of said contacts may engage one of said conductive areas while the remaining contacts simultaneously engage the other of said conductive areas on their respective electrically operative elements.

10. A control device for use in volume adjustment of a multi-speaker sound system comprising a substrate and a cover member operatively connected to said substrate to define a housing enclosure, said substrate having a plurality of resistive strips disposed along the periphery of said substrate and a plurality of conductive strips disposed adjacent and parallel to said resistive strips thereby to define parallel pairs, first terminal means on said substrate operatively connected to said resistive strips, second terminal means on said substrate operatively connected to said conductive strips, a plurality of sliding contact means slidably mounted within said enclosure for movement along said parallel pairs of strips, respectively, said cover member having a window opening, a control knob extending out from said housing enclosure through said window, and means operatively connected between said control knob and said plurality of sliding contact means and effective upon movement of said control knob within said window area in a direction parallel to said substrate to simultaneously adjust the effective length of said resistive strips operatively connected between said first and second terminal means, whereby when said first terminal means are connected, respectively, to a plurality of sound speakers and said second terminal means is grounded, the position of the apparent sound source may be conveniently varied by reference to the position of said carrier within said window.

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