(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 May 2001 (25.05.2001)

PCT

(10) International Publication Number
WO 01/37256 A1

(51) International Patent Classification[7]: G10K 11/175

(21) International Application Number: PCT/GB00/02360

(22) International Filing Date: 16 June 2000 (16.06.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
9927131.4 16 November 1999 (16.11.1999) GB

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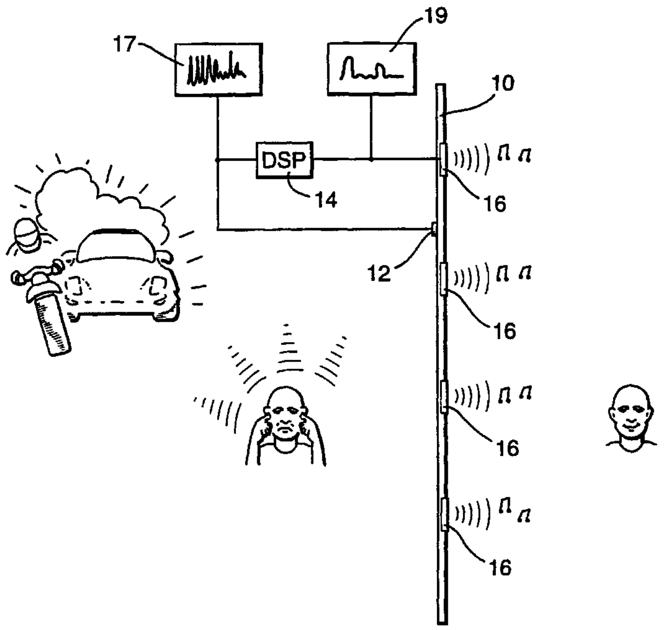
(81) Designated States *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: APPARATUS FOR ACOUSTICALLY IMPROVING AN ENVIRONMENT AND RELATED METHOD



(57) Abstract: The invention provides apparatus for acoustically improving an environment and a corresponding method. The invention features partitioning means in the form of a curtain (10) for producing a discontinuity in a sound conducting medium, such as air, and for absorbing sound. One or more microphones (12) serve for receiving acoustic energy and for converting it into electrical signals for supply to a digital signal porcessor (14). The processor employs an algorithm for performing a spectral transformation on the electrical signals, and outputs the transformed signals to output means (16) in the form of exciters (36).

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APPARATUS FOR ACOUSTICALLY IMPROVING AN ENVIRONMENT AND RELATED METHOD

The present invention relates to an apparatus for acoustically improving an environment, and to a related method.

Noise has been recognised as a major problem in industrial, office and domestic environments for many years now. Advances in materials technology have provided some solutions. However, the solutions have all addressed the problem in the same way, namely: the sound environment has been improved by decreasing noise levels in a controlled space. This, relatively inflexible approach, has been regarded as a major design guideline in the design of spaces as far as noise abatement is concerned.

The present invention seeks to provide a more flexible apparatus for, and method of, acoustically improving an environment.

The present invention in a broad sense provides an electronic sound screening system, comprising: means for receiving acoustic energy and converting it into an electrical signal, means for performing a spectral transformation on said electrical signal, and output means for converting the transformed signal into sound.

According to one aspect of the present invention, there is provided apparatus for acoustically improving an environment, comprising: partitioning means for producing a discontinuity in a sound conducting medium; means for receiving acoustic energy and converting it into an electric signal, means for performing a spectral transform on said signal and output means for converting said transformed signal into sound.

Sounds are interpreted as pleasant or unpleasant, that is wanted or unwanted, by the human brain. For ease of reference unwanted sounds are hereinafter referred to as "noise".

The means for performing a spectral transform may include a micro-processor or digital signal processor (DSP). A desktop or laptop computer can also be used. In either case an algorithm is employed to define the response of the apparatus to sensed noise. Noise to sound transformation is advantageously based on an algorithm contained in the processor or computer chip.

The algorithm advantageously works on the basis of building a real time transformation of ambient noise to create a more pleasing sound environment. The algorithm analyses the structural elements of the ambient noise and produces a transformation that either masks the original noise or builds harmonic elements on it in order to produce a pleasant sound environment.

A preferred algorithm operates by creating harmonics in the sound, by way of a series of band-pass filters, whose centre frequencies are multiples of a base frequency (i.e. lowest frequency). The algorithm is capable of detecting the frequency of certain 'disturbing' or unwanted sound events or noise and adjusts its filtering function in order to create a smoother sound output.

In a particularly preferred embodiment, the algorithm is modelled on the human auditory perception system and relevant experimental data available in handbooks of experimental psychology of hearing. Several case studies have been carried out in different situations/locations with diverse sound/noise environments. Digital recordings were made and the sound signals were then played back in different locations. The sound signals were also analysed with spectrograms and their results were compared to spectrograms of pieces of music and recordings of natural sounds. The analysis of the data has resulted in design criteria that were incorporated into the algorithm. The algorithm tunes the sound signal by analyzing, in real time, incoming noise and produces a sound output which can be tuned by the user to match different environments, activities or aesthetic preferences. The algorithm was programmed in MAX, a programming language available for Apple Macintosh (Trade Mark) computers. An example of the algorithm is described below.

The apparatus preferably has a partitioning device in the form of a flexible curtain. However, it will be appreciated that such device may also be solid.

The curtain preferably has one or more rigid or semi-rigid portions, which carry the output means.

The curtain may be formed from a plurality of modules manufactured from a flexible material, such as polyurethane or silicon rubber. Preferably each module has a substantially constant thickness of between 1 and 2mm. Modules can be assembled together to form screens or space dividers of different heights and constant width. A basic module size is typically 1200mm by 400mm to 450mm (width by height).

Each module advantageously includes an electrically conductive pathway moulded integrally within or screen printed on the curtain.

Two different basic modules may be used to create a screen: the first curtain module may have conductive pathways and incorporate the audio output means, and the second may also have conductive pathways and may connect a power supply, via a transformer, to the other curtain module(s) via the conductive pathways.

In a preferred embodiment, the second module(s) may include a DSP unit which performs digital signal processing on the input signal to produce a transformed signal, which is then output to one or more output devices. Power may be provided by a rechargeable lithium battery or a mains voltage supply via a transformer. Optionally the DSP unit may be configured to accept an infra-red input to the curtain, for a user to tune or switch on/off the output pleasant sound environment.

The curtain may also comprise two or more materials of differing acoustic properties. The materials may be separated by a space or volume, which may be evacuated or filled with a fluid, such as air or other material. At least one of the surfaces may be relatively stiff so as to act as a sound reflector. Examples of a stiff material include: glass and steel and laminates such as carbon-fibre epoxy and Kevlar (Trade Mark) epoxy. Such a stiff material may also be combined with a sound absorption material such as foam, or woven fabrics such as velvet or woven Kevlar (Trade Mark).

A particularly effective curtain includes a semi-flexible modular curtain formed from a sandwich material of aluminium honeycomb core and having a latex or polyurethane or elastomer rubber skin.

The partitioning medium may be translucent for visual appeal. However, it will be appreciated that it may also be opaque or indeed transparent.

According to another aspect of the present invention there is provided a method of manufacturing a curtain comprising the steps of: embedding an electrically conductive pathway in, or on, a flexible material, the electrical pathway being adapted to connect to a means for receiving audio energy and a means for transforming said energy into a signal, so as to modify its spectral composition and to provide, in use, a pathway for said transformed signal to an audio output means.

The electronic sound screening system of the present invention provides a pleasant sound environment by transforming noise into non-disturbing sound. The partitioning device can be seen as a smart textile that has a passive and an active element incorporated. The passive element acts as a sound absorber bringing the noise level down by several decibels. The active element then transforms the remaining noise into pleasant sound. The latter is achieved by recording and then processing the original sound signal with the use of an electronic system. The transformed sound signal may then be played back through speakers connected to the partitioning device.

The invention has a myriad of applications. For example, it may be used in shops, offices, hospitals or schools as an active noise treatment system.

Instead of resolving complex equations in order to construct a system that cancels noise in well described and controlled cavities (like the interiors of a car, or the cavity of the human ear), a universal system is provided which functions in any sound environment, by modifying its output.

According to another aspect the invention provides an active noise cancellation system comprising: at least one microphone arranged to sense noise, a digital signal processing (DSP) unit to create anti-noise and a set of loudspeakers to broadcast the anti-noise.

The digital signal processing (DSP) Unit may be obtained from Texas Instruments. The physical size of it is conveniently 100 by 150 mm approximately. Such a unit may include circuitry for data input through a PC using a parallel port. In the case that a large volume of them would be required, a non-reprogrammable DSP chip may be used instead and the parallel port would be omitted.

The present invention is smart and is able to predict (by recording previous noises) future noise, in order to modify a transfer function and compensate for non-real time processing. The relation of the function of the apparatus for screening or converting noise with the noise cancellation system is apparent. Both comprise the same components, but each uses them in a different way. The screening apparatus, instead of trying to cancel incoming noise, manipulates noises as a basis to construct harmonics.

Preferably the invention reduces the noise level down by 6-12 decibels.

The invention is described further, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a general schematic diagram illustrating operation of the invention;

Figures 2 and 3 show spectrograms respectively of street noise prior to acoustic transformation by the invention and sound generated following acoustic transformation;

Figure 4 is a schematic diagram of a first embodiment of the invention;

Figure 5 shows a curtain module employed in the embodiment of Figure 4;

Figure 6 is a plan view of an exciter or vibrator mounted on the curtain module of Figure 5;

Figure 7 is a cross-sectional view along the line AA in Figure 6;

Figure 8 is a perspective view of a mould for producing the curtain module of Figure 5;

Figure 9 shows a plurality of the curtain modules of Figure 5 connected together to form a curtain;

Figure 10 is a perspective view showing how the edges of respective curtain modules are mechanically connected together;

Figure 11 is a block circuit diagram representing the electrical circuitry employed in the present invention;

Figures 12 to 14 are flow diagrams representing an algorithm employed in the electrical circuit of Figure 11;

Figure 15 is a schematic diagram of a second embodiment of the present invention;

Figure 16 shows a curtain module employed in the second embodiment of Figure 15;

Figure 17 shows a plurality of curtain modules which are connected together and which include the curtain module of Figure 16;

Figure 18 is a schematic diagram of a third embodiment of the present invention;

Figure 19 shows a curtain module employed in the third embodiment of Figure 18;

Figure 20 is a perspective view of a panel employed in the curtain module of Figure 19; and

Figure 21 shows a modification of the mechanical connection shown in Figure 10 for joining curtain modules together.

Referring initially to Figures 1 to 3, there is shown in Figure 1 an apparatus for acoustically improving an environment, which apparatus comprises a partitioning device in the form of a curtain 10. The apparatus also comprises a number of microphones 12, which may be positioned at a distance from the curtain 10 or which may be mounted on, or integrally formed in, a surface of the curtain 10. The microphones 12 are electrically connected to a digital signal processor (DSP) 14 and thence to a number of loudspeakers 16, which again may be positioned at a distance from the curtain or mounted on, or integrally formed in, a surface of the curtain 10. The curtain 10 produces a discontinuity in a sound conducting medium, such as air, and acts primarily as a sound absorbing device.

Preferably, the curtain 10 comprises a flexible material, for example a translucent velvet textile woven from a transparent nylon or monofilament polyester yarn, or a moulded synthetic rubber or polyurethane sheet. Other suitable materials include woven fabrics and laminates formed from KEVLAR (trade mark) or carbon-fibre epoxy. Such materials all have good sound absorbing properties. The material may also be woven or overprinted with visual designs, information or colours, to provide an aesthetically pleasing result.

The microphones 12 receive ambient noise from the surrounding environment and convert such noise into electrical signals for supply to the DSP 14. A spectrogram 17 representing such noise is illustrated in Figure 1, and an example of such a spectrogram is shown in Figure 2. The DSP 14 employs an algorithm for performing a spectral transform on such electrical signals and provides an output in the form of modified electrical signals for supply to the loudspeakers 16. A spectrogram 19 representing such modified electrical signals is illustrated in Figure 1 and an example of such a spectrogram is shown in Figure 3. The sound issuing from the loudspeakers 16 is preferably an acoustic signal representing either the original ambient noise from which unwanted sounds and noise have been filtered out or masked and/or to which harmonic elements have been added to produce a pleasing quality. However, it is also possible for the sound issuing from the loudspeakers to be anti-noise for cancelling out the original noise.

A first embodiment of the present invention will now be described with reference to Figures 4 to 14. As shown in Figure 4, in this first embodiment, the microphones 12 and the loudspeakers 16 are both mounted on the curtain 10 itself. Otherwise this embodiment is as described in relation to Figure 1, like parts being designated by the same reference numerals.

Figure 5 illustrates a curtain module 20, which may constitute the whole of the curtain 10 or which, as in the present instance, may simply form a portion of the curtain 10. The curtain module 20 is formed from a flexible rubber material and has moulded within it a plurality of electrical wires 22, each extending from an upper edge 24 of the module 20 to a lower edge 26 of the module 20. The wires 22 cross one another respectively at nodes 28 where the wires are electrically interconnected and at intersections 30 where the associated wires remain electrically isolated. At the upper and lower edges 24, 26 of the curtain module, certain of the wires 22 terminate respectively in connectors 32 by which they may be electrically connected to wires in adjacent curtain modules.

In addition to the wires 22, the curtain module 20 also carries a respective microphone 12 and a respective loudspeaker 16 in the form of a power amplifier 34 and an exciter or vibrator 36. The exciter 36, which is mounted on a stiffened portion of the material of the curtain module 20, is shown in Figures 6 and 7. As shown, the exciter comprises a cup-shaped housing 38 containing a core 40 and an excitation coil 42. The housing 38 is arranged to be mounted on the stiffened portion of the curtain module 20 by way of a rigid annular ring 44, which is connected to the rim of the cup-shaped housing 38 by means of a resiliently flexible angled washer 46. When the coil 42 is excited, the core 40 vibrates to cause the stiffened portion of the curtain module 20 to vibrate at an acoustic frequency. More particularly, the annular ring 44 may be superglued onto the stiffened portion of the curtain module 20 so that when the core 40 vibrates the stiffened portion is subjected to pressure waves in the audible range.

The following is a description of how the curtain module may be manufactured relatively cheaply by moulding a synthetic rubber material:

a) Rotational moulding: In this case, polyurethane (PU) rubber is poured into a rotating drum which spins and also applies heat to the PU rubber. This procedure produces sheets of substantially constant thickness, but has a limitation in the size of the PU sheet, which is restricted by the size of the drum (the biggest sheet found in a U.K. manufacturer was 2400 mm long by 900 mm wide).

b) Sheet moulding: A lump of PU rubber of nearly the weight required to fill a flat mould is set on the centre of the mould in a semi-solid state, before being vulcanised. A steel tool presses the PU rubber to close the mould letting the PU rubber escape from certain outlets. Heat is applied and the PU rubber sets. The advantage of this procedure is that both sides of the PU sheet can be textured and can also have extruded characteristics (as opposed to only one part of the sheet being textured in the rotational moulding process). The obvious disadvantage is the fact that the bigger the size of the sheet to be cast, the higher the cost of the tool.

Figure 8 shows a specific mould 48 for producing the curtain module 20 of Figure 5. The mould 48 comprises a lower mould part 50 containing a well 52 for receiving a liquid to be moulded. The well 52 is surrounded by a spacer 54 on which a network of flat braided copper wires for forming the wires 22 are supported and held by way of two longitudinally extending clamps 56, 58. The copper wires serve not only for providing the wires 22 in the finished curtain module 20 but also to reinforce the PU sheet and inhibit tensile elongation under load without restricting the flexibility of the moulded sheet. The mould 48 also comprises an upper mould part 58 for lowering on to and closing the first mould part 50 during moulding.

In the present instance, a transparent two-part polyurethane (PU) rubber compound is employed in the moulding process. The compound is mixed as a liquid, passed through a vacuum chamber to be degassed, and then poured into the lower part 50 of the mould 48 and spread by means of aluminium straps (not shown) spanning the full width of the mould in order to obtain an even thickness. The mould 48 is then closed for moulding.

A "spark" or sandblasted finish may be applied to an inner surface of the mould to render the sheet translucent instead of transparent and/or to produce desired visual qualities. The polyurethane employed in the compound may if desired be pigmented to generate different colours in selected areas of the curtain module 20 to produce aesthetic designs. The liquid compound employed in the moulding process may also be modified with fire retardant for enhancing safety. Ultra-violet absorbers may also be added.

In order to produce stiffened portions in the material of the curtain module 20 to provide structural areas for carrying the various electrical components, a number of different approaches are possible. For example, hardeners can be added to selected regions of the fluid compound prior to or during moulding, or such regions can be cured or heat treated or resin may be applied following moulding. Alternatively, stiffened panels may be applied to the mould prior to introduction of the polyurethane compound, or polyurethane compounds of different hardnesses can be moulded together by means of a double moulding process. Another possibility is for the curtain to be formed from two or more layers of polyester or Mylar (trade mark) screen printed with the conductive pathways and layered together to incorporate rigid panels between them.

Figure 9 shows a plurality of the curtain modules 20 connected together to form the curtain 10. Adjacent modules are mechanically connected together along their respective upper and lower edges 24, 26 by means of a connection as shown in Figure 10, in which the upper edge 24 of one module 20 is formed with a channel 60 for receiving a rib 62 along the lower edge 26 of the adjacent module 20. The rib 62 is slotted into the channel 60 during assembly and is subsequently held in place by means of a pair of flanges 64 flanking the opening of the channel 60.

Respective wires 22 of each curtain module 20 are electrically inter-connected by way of the connectors 32 to respective wires 22 of the adjacent curtain module 20. It will be seen from Figure 9 that not all of the wires 22 are so connected but that the arrangement of the connection nodes 28 and connectors 32 is such that, at the foot of the curtain 10, there are provided first and second pairs of connectors 60, 64. The first pair of connectors 60 serve for electrically coupling the microphones 12 to a microphone pre-amplifier 62 and thence to the DSP 14. The microphones 12 determine the quality of the input signal, which in turn determines the quality of the transformation and of the output sound, and the provision of a pre-amplifier ensures a good quality signal. The second pair of connectors 64 serve for electrically coupling the exciters 36 and power amplifiers 34 to the DSP 14. A power supply 66, for example a lithium battery, connected to a power source (not shown) supplies power to all of the different circuit elements.

Figure 11 shows the electrical circuitry for the curtain 10 more clearly. As shown in Figure 11, each microphone 12 is connected between a pair of lines 68, 70 so that the microphones 12 are all connected in parallel. The lines 68, 70 are connected to the microphone pre-amplifier 62 and the DSP 14 to supply the electrical signals from the microphones 12 to the DSP 14 as an input. A pair of lines 72, 74 lead from the DSP 14 to supply an output signal to the power amplifiers 34 and exciters 36. As before, each power amplifier 34 and associated exciter 36 is connected between the lines 72, 74 so that the exciters 36 are all arranged in parallel. A further pair of lines 76, 78 leading from the power supply 66 serve for supplying power to the power amplifiers 34.

The DSP 14 serves to transform the electrical signals supplied from the microphones 12 into modified electrical signals for driving the exciters 36. For this purpose, the DSP 14 employs an algorithm, which in the present instance is programmed in using Opcode MAX/MSP software which is available in Macintosh (TM) computers. The DSP 14 contains a series of digital filters arranged to be active one at a time. Each digital filter comprises a number of bandpass filters, one of which has a low centre frequency and the others of which have frequencies which are multiples of this base frequency. A graphical interface is provided in order to tune the parameters of each filtering function, and the algorithm is programmed to make decisions in order to change the filtering function according to the incoming noise signal.

The algorithm serves firstly to tune the output level in order to modify or not modify peaks of the input noise signal. When sound incidents are happening, the output signal is increased to mask them. In this case, it is preferable for the overall sound energy for the controlled environment to increase, because that decreases the effect of noise disturbance caused to the brain. The same effect is achieved by producing a steady tone, like a constant hum, so as to concentrate on something when somebody is speaking. The algorithm serves secondly to adjust the filtering according to the quality of the incoming noise signal. This feature involves pattern recognition embedded in the software and enables the software to distinguish speech from traffic noise and thereby to adjust the filtering.

The algorithm will now be described in greater detail with reference to Figures 12 to 14.

Referring first to Figure 12, the noise received by each microphone 12 is converted to a digital electrical signal in an A/D converter (not shown) and is supplied as an input 100. The input is passed to an active decision sub-routine 102 illustrated in Figure 13 for analysis, and parameters of the input are extracted for subsequent use. Details of the sub-routine 102 are displayed on a display in step 104. The signal provided by the sub-routine 102 is then passed though a first series of stages R for recreating the ambient sound environment and through a second series of stages L for creating a musical output.

The first series of stages R will be described first.

In step 106, a ratio for the level of original to transformed noise is determined and is set. The input signal 100 is then supplied in step 108 to two groups 1 and 2 of five filters: the steepness (q-factor) and the gain of each filter are automatically adjusted, as described below, according to the criteria in sub-routine 102. The centre frequencies F_0 to F_5 of the five filters of each filter group are arranged to have a harmonic relation to one another.

The signal output from the two groups 1 and 2 of filters in step 108 is passed in step 110 to further filters for adding reverberation and echo frequencies, and this signal is mixed back in with the output of the two groups 1 and 2 of filters in step 112.

The resultant signal has its amplitude controlled in step 114 according to a predetermined level set by the user in step 116. Finally, the signal is passed in step 118 through a high pass filter for output in step 132.

In the series of stages L, the signal from the input 100 is past through a control step 120 in which it is determined whether the original noise is to be heard in the output or not. If not, the input signal is filtered out in step 122. If it is, the signal is passed through a gate in step 124. The determination in step 120 is effected by the user by way of a manual control and, if the user indicates that the original noise is to be heard, then they will also set a level of control in step 126. The signal output from the gate in step 124 is then controlled to the desired level in step 128 according to the predetermined amount set in step 126. Finally, the resultant signal is passed through another high pass filter 32 for output in step 132.

The signals obtained in steps 118 and 130 are combined in step 132 and are passed through a D/A converter to supply to the amplifiers to drive the exciters 36.

The active decision sub-routine 102 will now be described with reference to Figure 13.

Firstly, the input signal from step 100 is supplied to a sub-routine input 140. This input is analysed in step 142 into five frequency bands for evaluating the amplitude required for each of the five filters in the two filter groups 1 and 2. Following this analysis, a control output is supplied in step 144 for setting the gain of each of the five filters in the two filter groups 1 and 2. The control output is also supplied in step 146 to a circuit for setting the steepness or q-factor in each of the filter groups 1 and 2.

If desired, a further control may be imposed on the control output through a harm control sub-routine 148, which is illustrated in Figure 14. This sub-routine monitors the input signal to trigger a change from one filter group to the other in certain circumstances as described below.

Referring to Figure 14, the control output from the step 142 is supplied to a harm control input 150 and passed through a series of steps 152 in order to detect peaks in the input noise signal. In response to such peaks, the harm control sub-routine triggers in step 154 a change-over command. The change between the two filter groups 1 and 2 is effected in step 156, and the output of the currently selected filter group is supplied in step 160 as the output of step 180. The timing of the trigger commands is monitored in step 162 and adjusted in step 164 if it is considered to be too rapid.

A second embodiment of the invention will now be described with reference to Figures 15 to 17. This second embodiment constitute a modification of the first embodiment and like parts are designated by the same reference numerals. Only the differences will be described.

In the second embodiment, the microphones 12 are mounted on a portion of the curtain 10, as well as the loudspeakers 16. The DSP 14 and the power supply 66, in the form of a rechargeable battery and/or an AC/DC transformer, are also mounted on the curtain 10.

Figure 16 shows a curtain module 200 for use in the second embodiment, carrying both a microphone 12 and the DSP 14. As shown in Figure 17, it is envisaged in the second embodiment that the curtain module 200 will be employed with a further series of curtain modules 202, each bearing only a respective power amplifier 34 and exciter 36 but no further microphone 12.

A third embodiment of the invention is illustrated in Figure 18. Again, like parts are designated by the same reference numerals and only the differences in relation to the first embodiment will be described.

In the third embodiment, the microphones 12 and the DSP 14 are spaced at a distance from the curtain 10, and the loudspeakers 16 are mounted on the curtain 10. In this instance, each loudspeaker comprises an exciter 36 mounted on a rigid panel 210, which is inserted into the mould during moulding of the curtain 10 or which is produced as a part of the curtain with a double moulding process.

One possible form of the rigid panel 210 is illustrated in Figure 20 and comprises first and second skins 212, 214 with a honeycomb core 216 mounted between them. The combination of the honeycomb core 216 with the two skins 202, 214 results in a substantially rigid structure providing the panel 201.

Finally, a modification of the connection means illustrated in Figure 10 for connecting curtain modules together is shown in Figure 21. According to this modification, the upper and lower edges 24, 26 of each curtain module 20 are formed to be identical and to have a wedge-shaped portion 230 that thickens towards the edge of the curtain module 20. Each wedge shaped portion 230 terminates in a planar surface 232 arranged perpendicular to the main plain of the curtain module 20, and a groove 234 is provided in a side surface 236 of the wedge-shaped portion 230 and extends towards the planar surface 232. An elongate connector strip 238 formed with a pair of converging flanged edges 240 can be slotted into the groove 234 of adjacent curtain modules 20 for joining the curtain modules together.

It will be appreciated that a number of further modifications are possible in the invention as described without departing from the scope of the invention.

In particular, the wiring, and electrical circuit components, may be screen printed on to the surface of the curtain 10, rather than moulded in situ as described. Conductive inks are commercially available providing a very flexible, low resistance, screen printable medium. In this instance, the ink may need to be heat treated for a short time, for example 5 to 15 seconds, at a raised temperature in the range, for example, of 80 to 120 degrees centigrade.

The described exciters 36 may also be replaced by alternative loudspeakers 16, for example, piezo-electric speakers or other small sized flat speaker arrangements. Another possibility is to employ flexible piezo speaker film for the whole surface of the curtain 10, to act as the loudspeaker. The film may be stretched or curved in order to increase output quality.

In the embodiments described above, stiffened portions have been provided in the curtain 10 for mounting the loudspeakers 16. If the curtain material is stiff enough, however, such portions may be omitted altogether for ease of manufacture. Alternatively, if stiffened portions are provided, they may be selected to have a range of stiffnesses as desired.

Furthermore, the panel shown in Figure 20 and proposed for providing a stiffened curtain portion may alternatively be used in its own right as curtain module or as a partitioning device, since such a construction would be particularly effective at reducing the noise level.

According to the described embodiments of the present invention, ambient noise detected by the microphones 12 is replaced with a particular quality of relaxing, soothing or musical sound. It is also possible to employ the invention as a noise cancellation arrangement in which the ambient noise is cancelled out by broadcasting anti-noise. In this instance, the algorithm will, of course, be modified accordingly.

Claims

1. An electronic sound screening system comprising:
   - means for receiving acoustic energy and converting it into an electrical signal,
   - means for performing a spectral transformation on the electrical signal, and
   - output means for converting the transformed signal into sound.

2. Apparatus for acoustically improving an environment comprising:
   - partitioning means for producing a discontinuity and a sound conducting medium,
   - means for receiving acoustic energy and converting it into an electrical signal
   - means for performing a spectral transformation on said electrical signal, and
   - an output means for converting the transformed signal into sound.

3. Apparatus according to claim 2 in which the partitioning means comprise a curtain.

4. Apparatus according to claim 3 in which the curtain is translucent and comprises a woven or moulded material.

5. Apparatus according to claim 3 or 4 in which the curtain comprises relatively flexible and relatively inflexible portions.

6. Apparatus according to claim 5 in which the output means are mounted on the relatively inflexible portions of the curtain.

7. Apparatus according to any of claims 2 to 6 in which the partitioning means includes electrically conductive pathways.

8. Apparatus according to claim 7 in which the electrically conductive pathways are integrally moulded within the partitioning means or are defined by electrically conductive ink printed on the surface thereof.

9. Apparatus according to any of 2 to 7 in which the receiving means are mounted on the partitioning means.

10. Apparatus according to any of claims 2 to 8 in which the partitioning means comprises at least two materials of differing acoustic properties.

11. Apparatus according to claim 9 in which the materials of differing acoustic properties are separated by a space.

12. Apparatus according to any of claims 2 or 7 to 11 in which the partitioning means comprise a substantially rigid panel.

13. Apparatus according to any preceding claim in which the means for performing a spectral transformation includes a microprocessor or digital signal processor operating under control of an algorithm.

14. Apparatus according to claim 13 in which the means for performing a spectral transformation comprise a series of filters for filtering the electrical signal, and means for analysing structural elements of the acoustic energy and for adjusting the filters accordingly.

15. Apparatus according to claim 13 or 14 further including means for predicting, from previous noise, future noise, in order to modify a transfer function of at least one filter employed in the means for performing a spectral transformation whereby to compensate for non-real time processing, so that incoming noises are manipulated to construct harmonics which are then output as audio sound.

16. Apparatus according to claim 16 in which the noise level is reduced by 6 to 12 decibels.

17. A method of manufacturing a curtain for use in the apparatus of claims 1 to 14 comprising the steps of:

- providing electrically conductive pathways in or on a flexible material, the electrical pathways being adapted to connect to means for receiving audio energy and converting it into an electrical signal and means for performing a spectral transformation on said electrical signal, so as to modify the spectral composition of the signal and to provide, in use, a pathway for the transformed signal to an audio output means.

18. An active noise cancellation system comprising:
- at least one microphone arranged to sense noise,
- a digital signal processing device arranged to create anti-noise, and
- means for broadcasting the anti-noise.

19. A system according to claim 19 including a partitioning device arranged to form a discontinuity in an acoustic medium.

Fig.1.

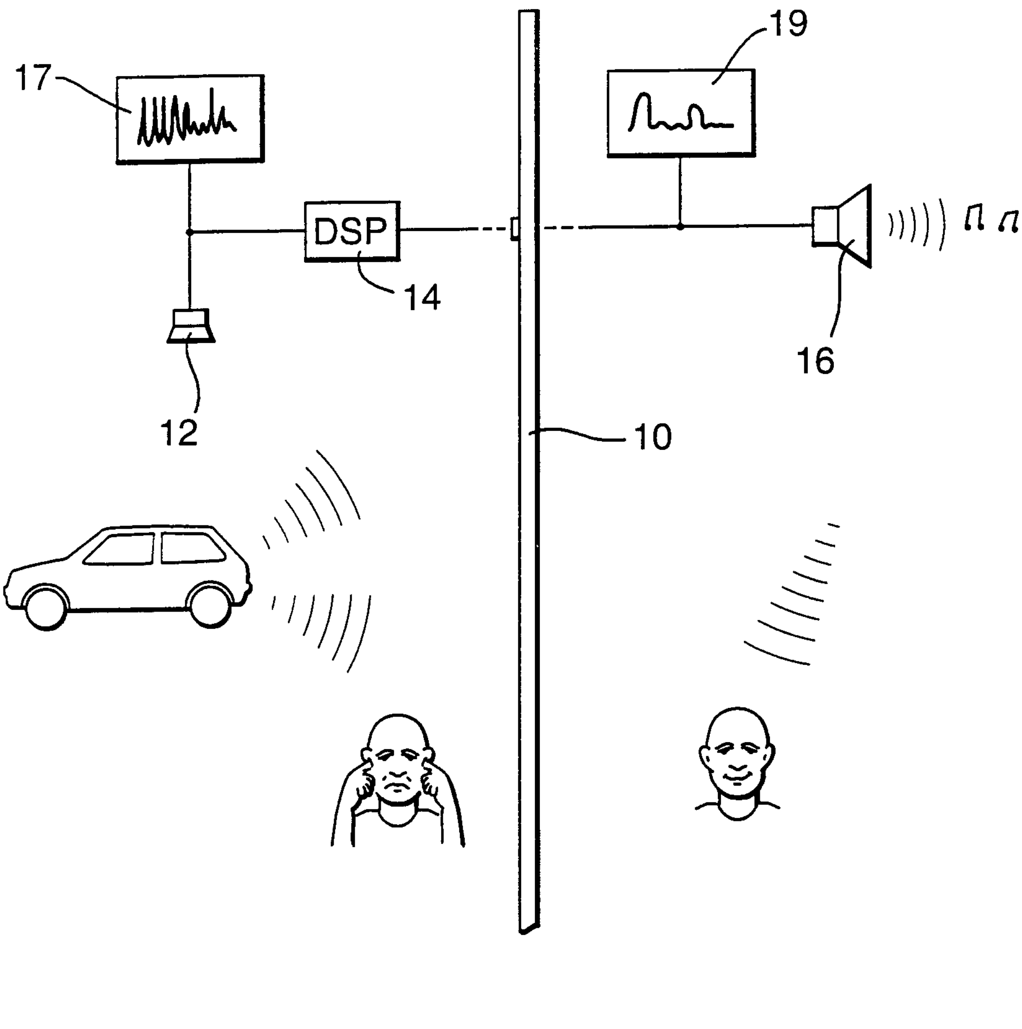


Fig.2.

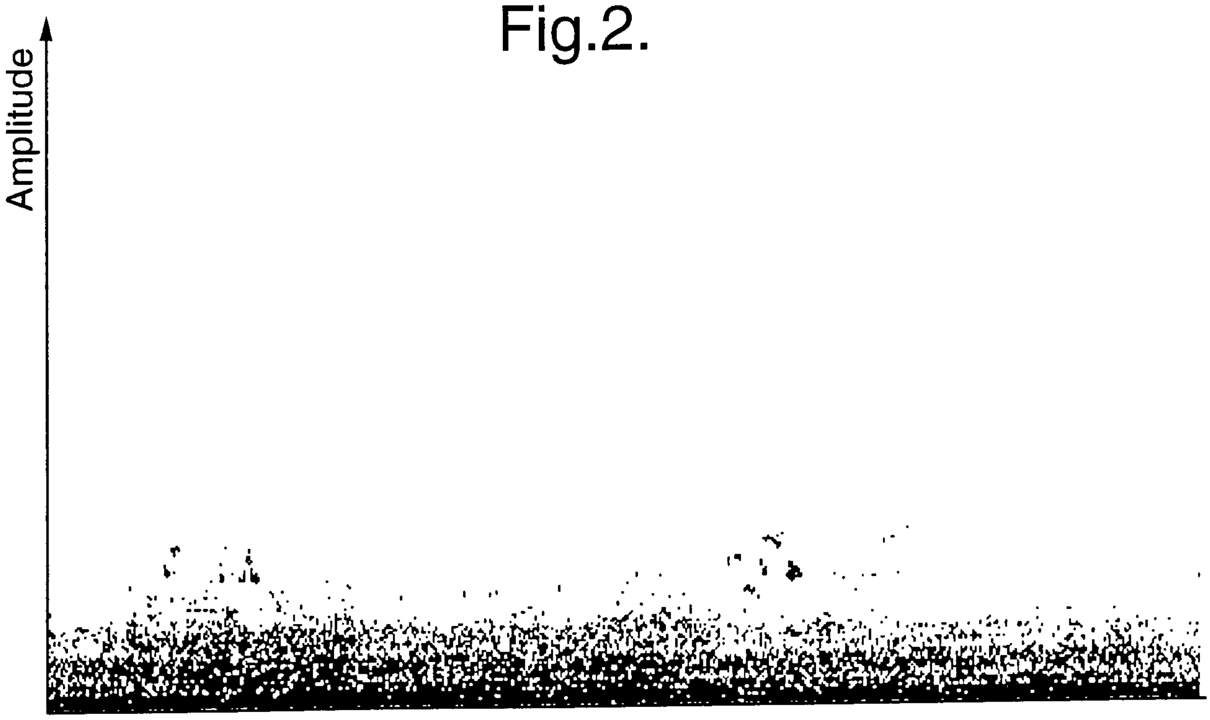


Fig.3.

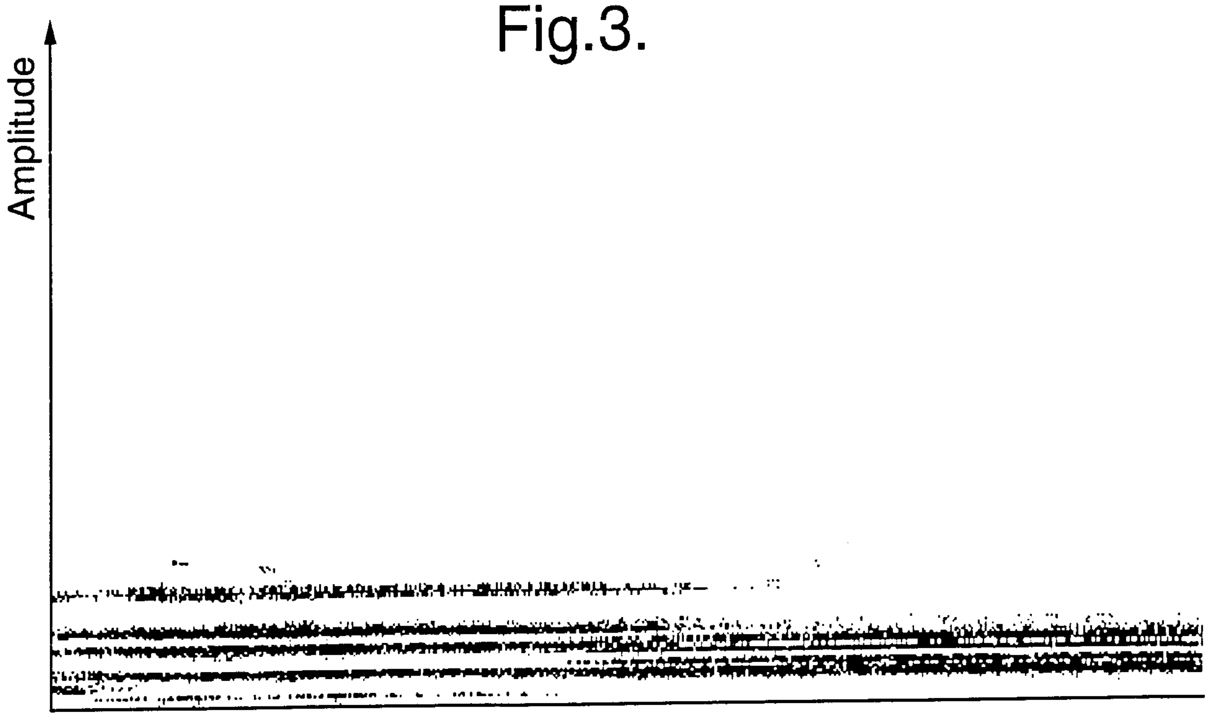


Fig.4.

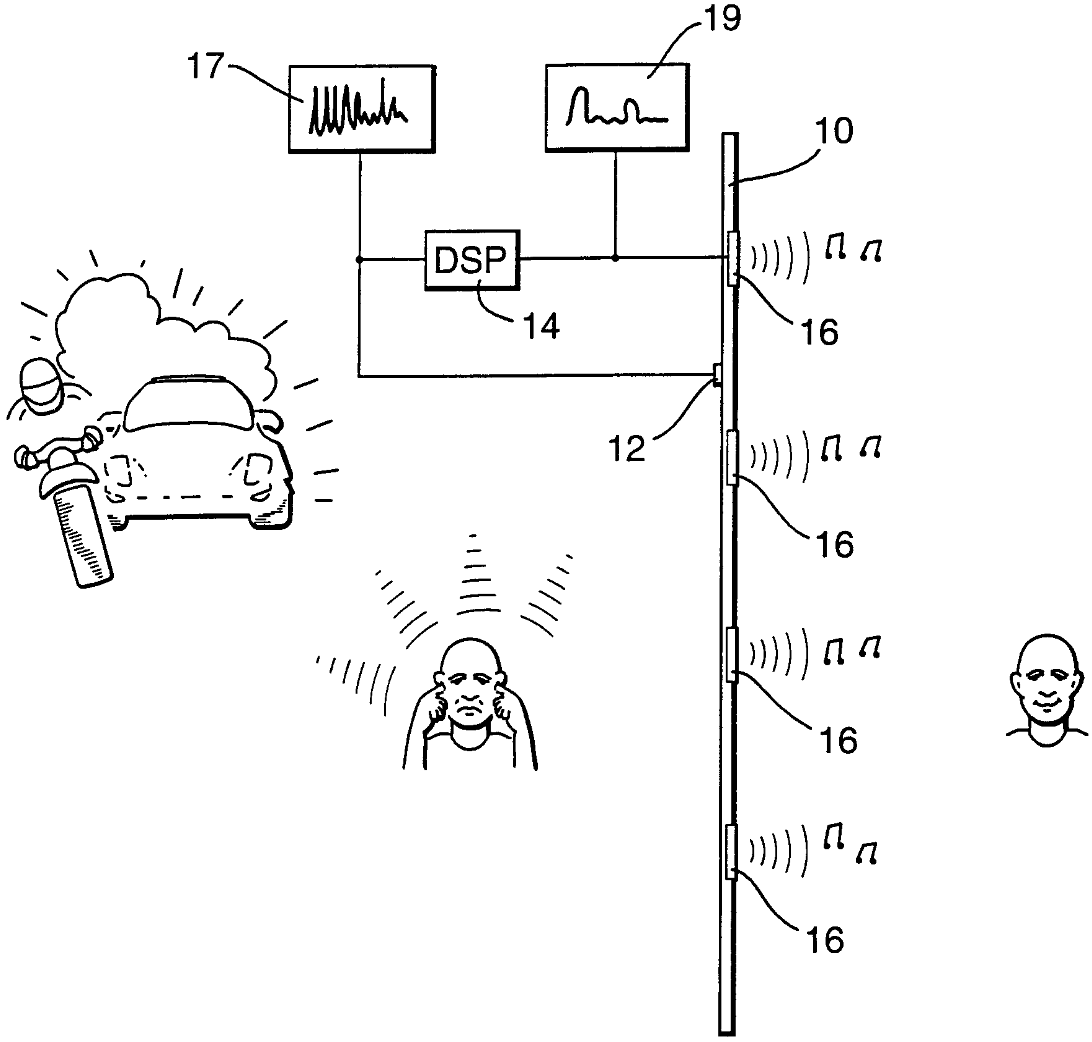


Fig.5.

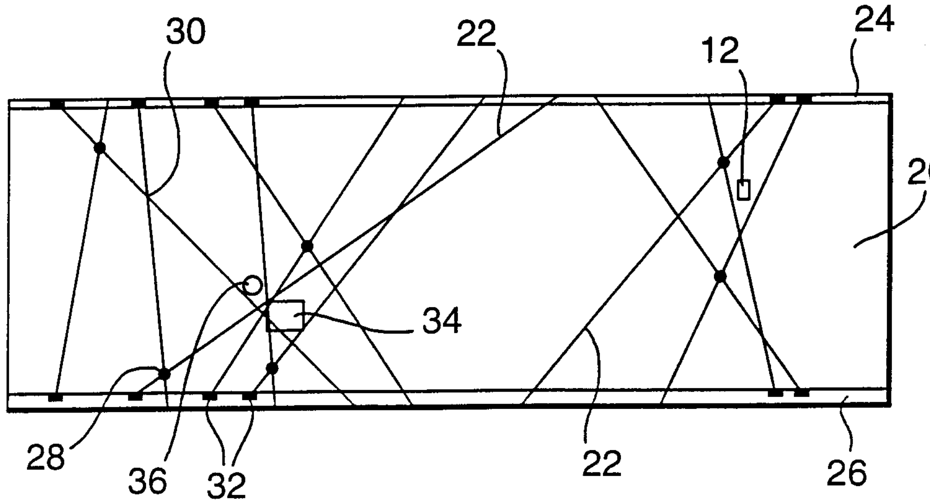


Fig.6.

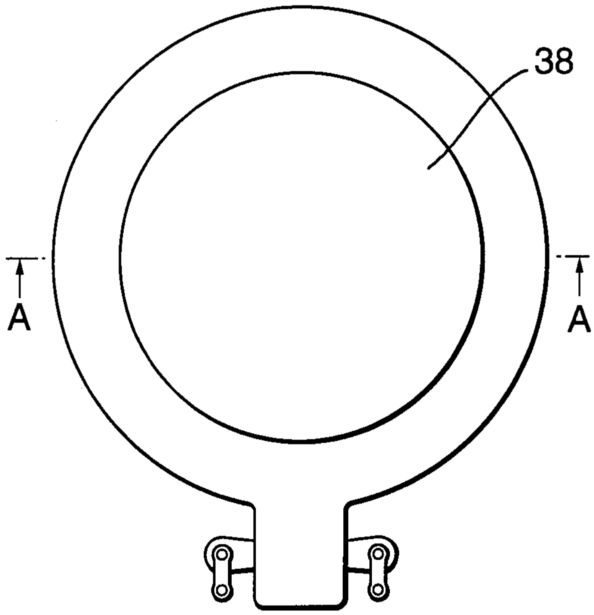


Fig.7.

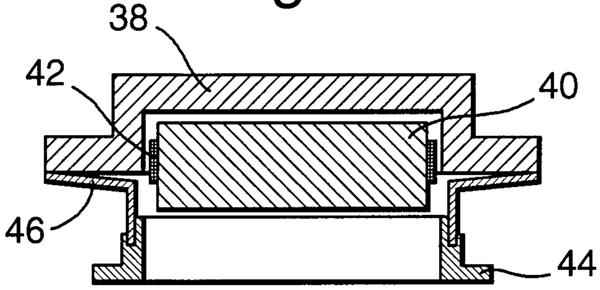


Fig.8.

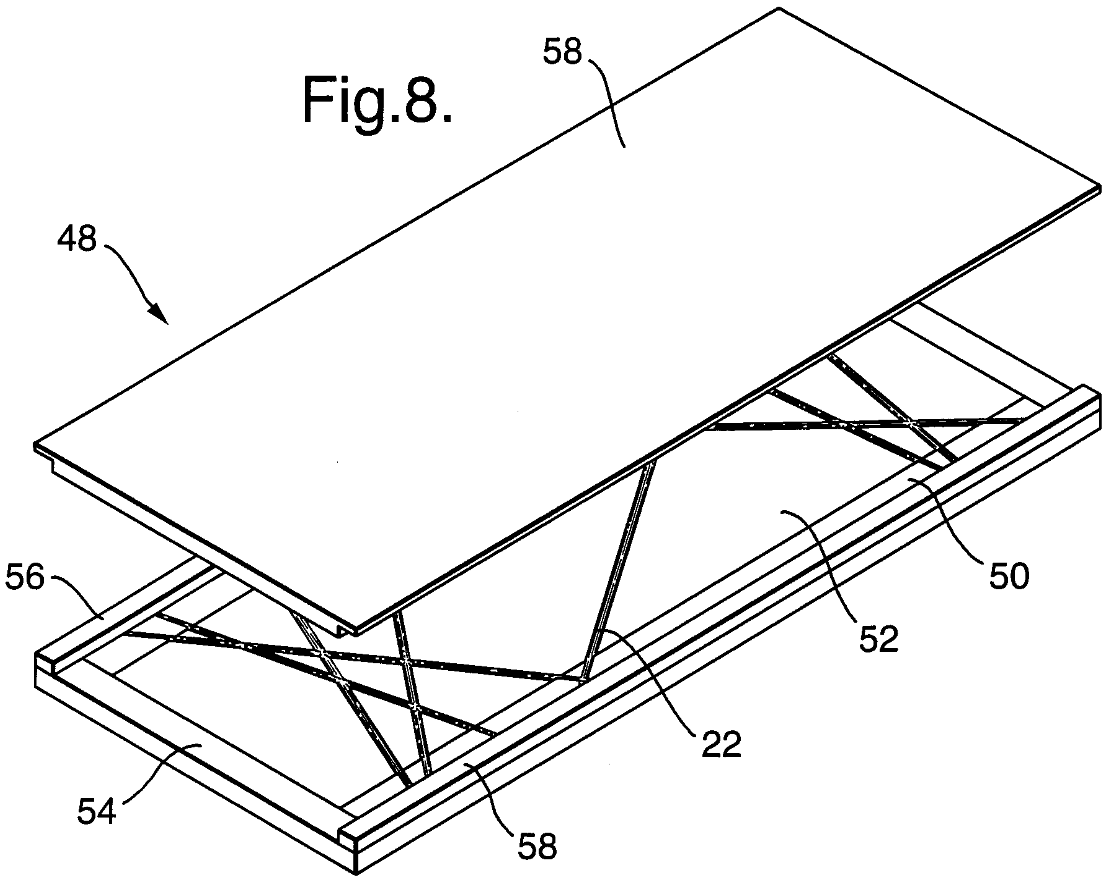


Fig.9.

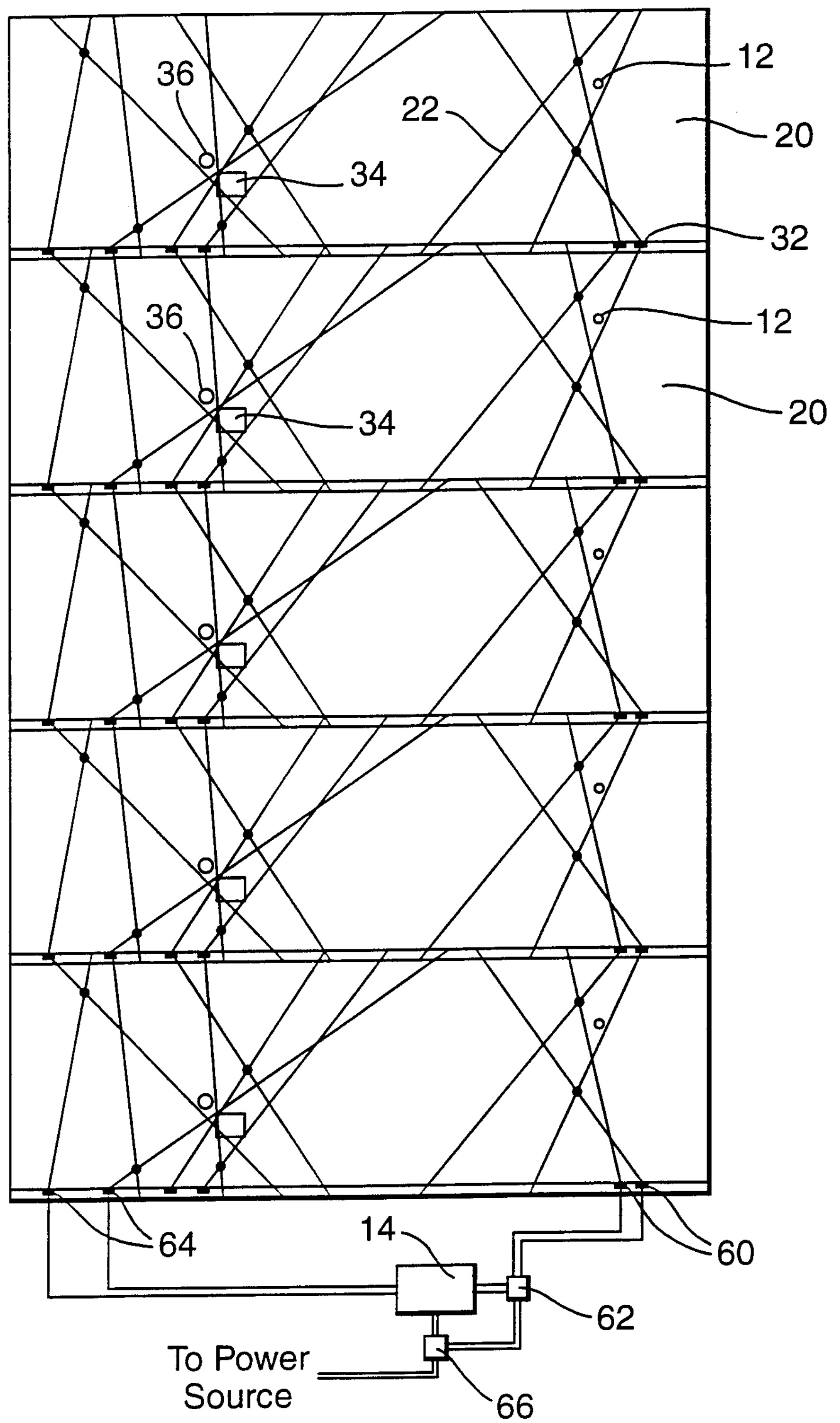


Fig.10.

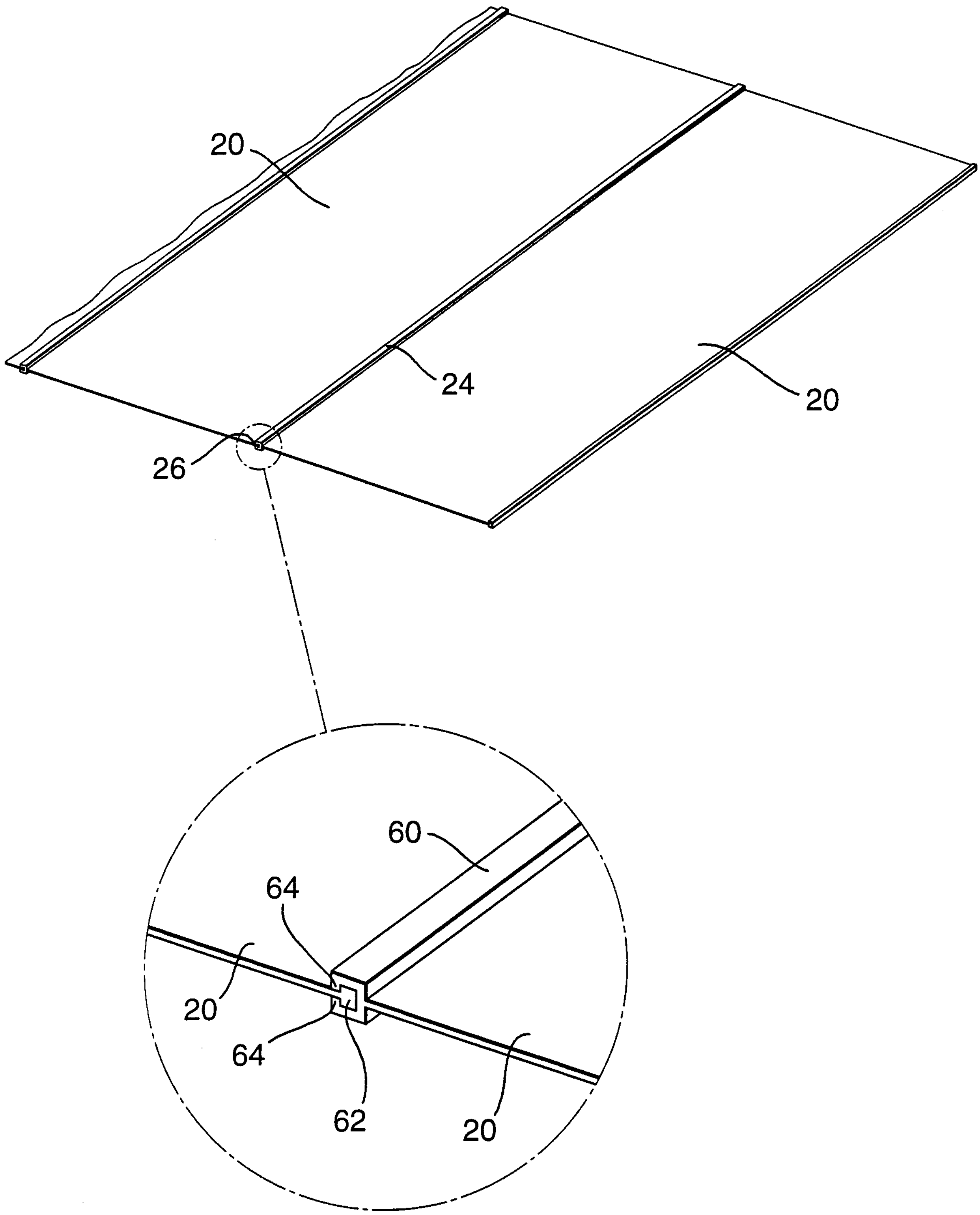


Fig.11.

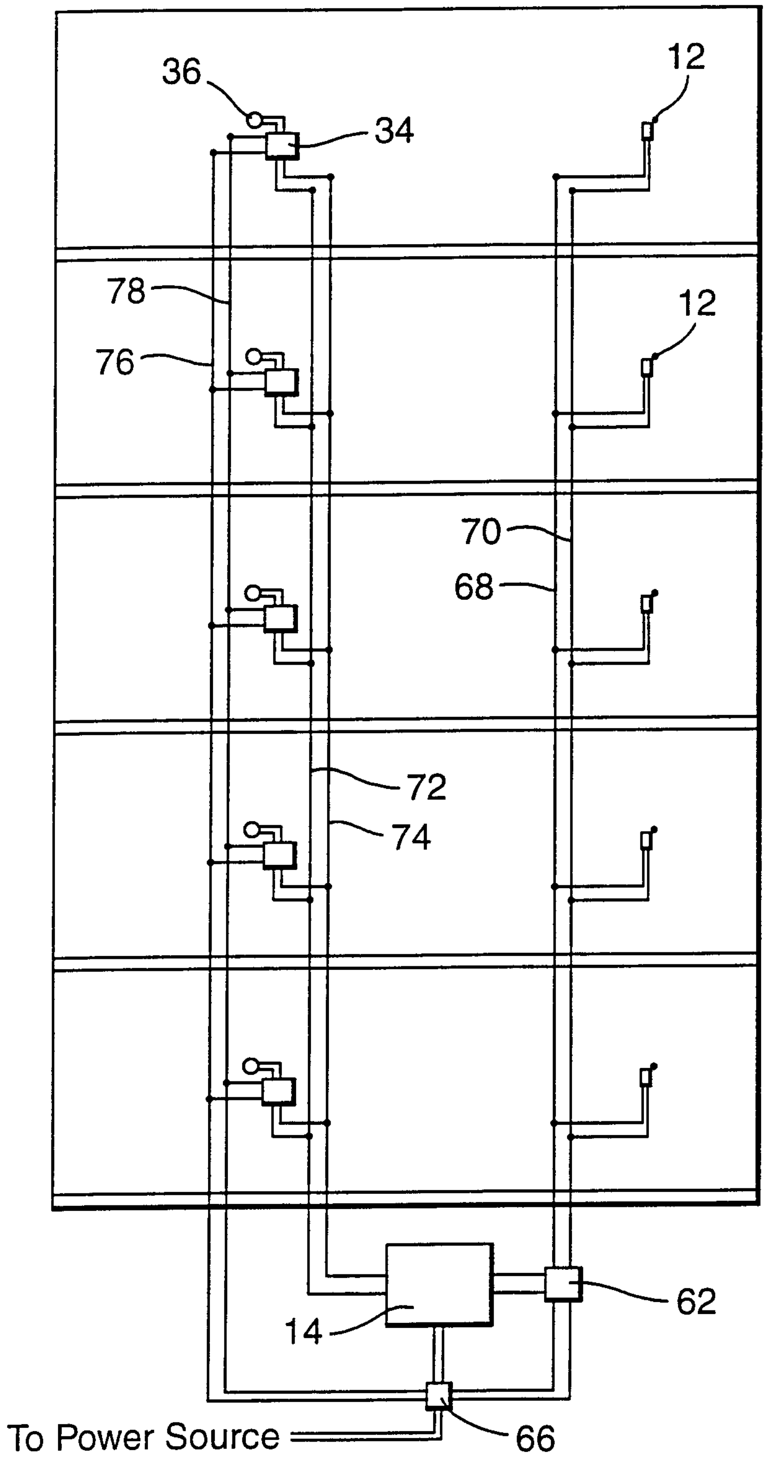


Fig.12.

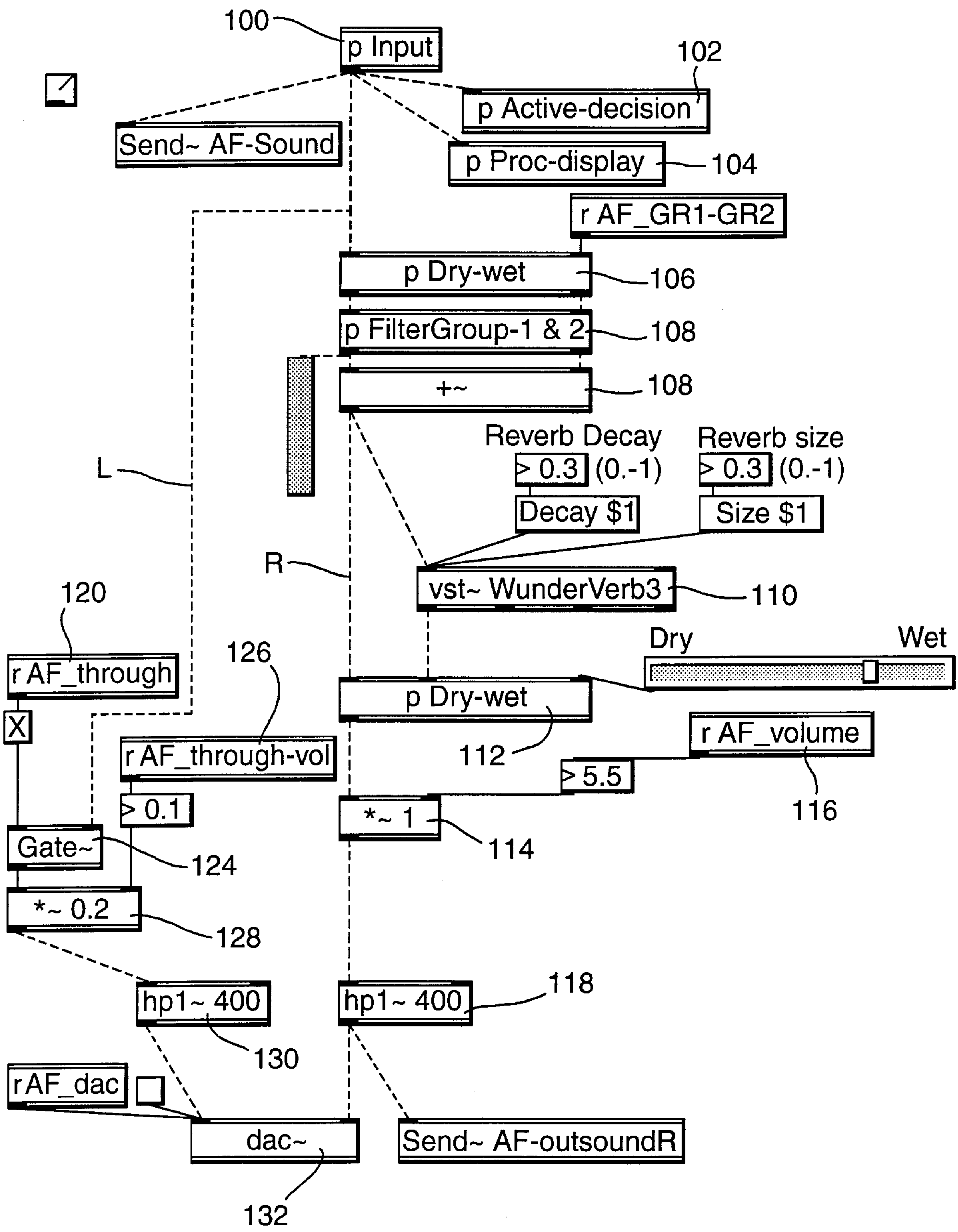

100
p Input
102
p Active-decision
Send~ AF-Sound
p Proc-display
104
r AF_GR1-GR2
p Dry-wet
106
p FilterGroup-1 & 2
108
+~
108
Reverb Decay
Reverb size
0.3
(0.-1)
0.3
(0.-1)
Decay $1
Size $1
L
R
vst~ WunderVerb3
110
120
r AF_through
126
Dry
Wet
X
r AF_through-vol
p Dry-wet
112
r AF_volume
5.5
0.1
116
*~ 1
114
Gate~
124
*~ 0.2
128
hp1~ 400
hp1~ 400
118
130
rAF_dac
dac~
Send~ AF-outsoundR
132

Fig.13.

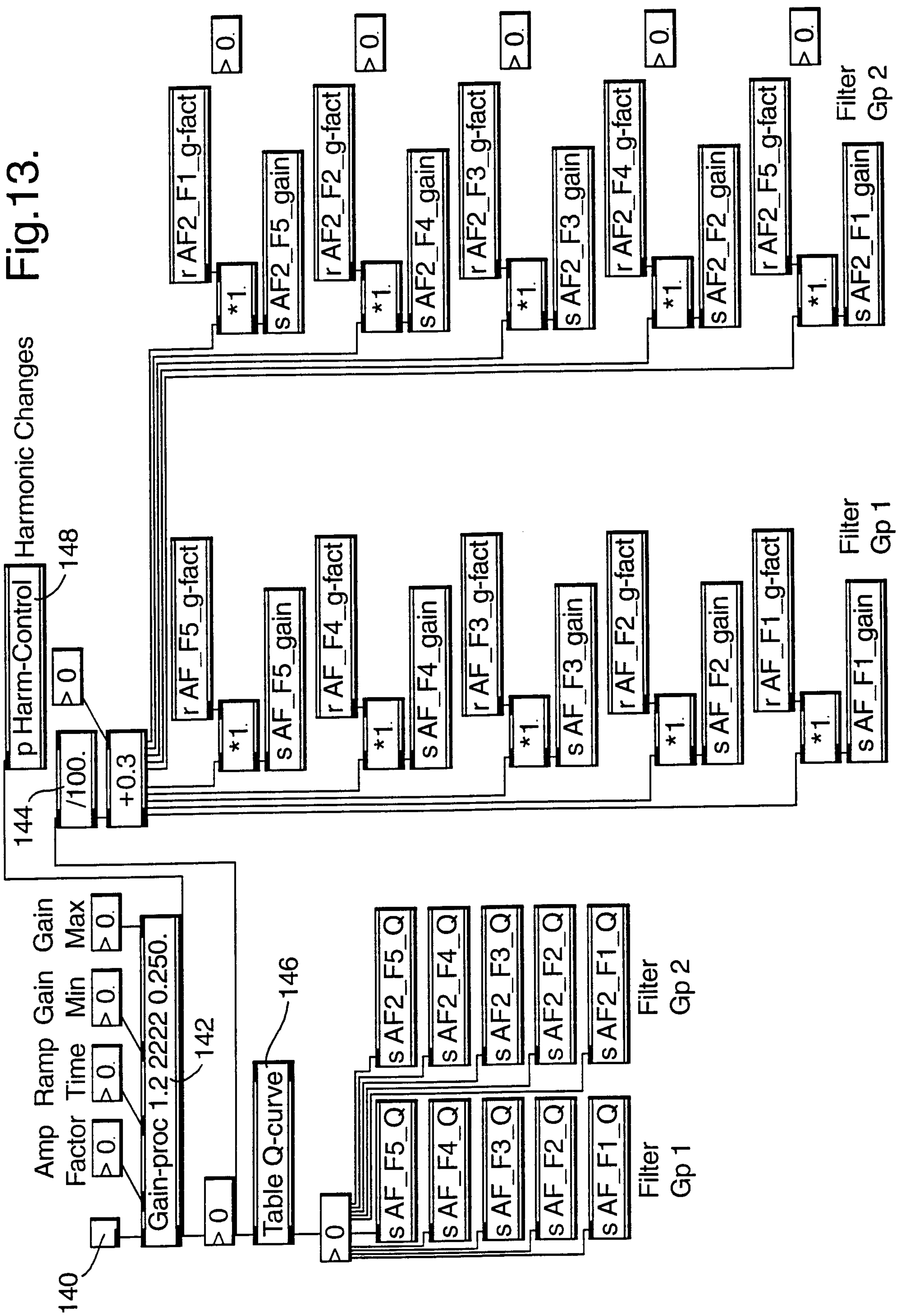

Harmonic Changes
p Harm-Control
148
144
/100.
>0
+0.3
r AF2_F1_g-fact
*1.
s AF2_F5_gain
r AF2_F2_g-fact
s AF2_F4_gain
r AF2_F3_g-fact
s AF2_F3_gain
r AF2_F4_g-fact
s AF2_F2_gain
r AF2_F5_g-fact
s AF2_F1_gain
>0.
Filter Gp 2
r AF_F5_g-fact
s AF_F5_gain
r AF_F4_g-fact
s AF_F4_gain
r AF_F3_g-fact
s AF_F3_gain
r AF_F2_g-fact
s AF_F2_gain
r AF_F1_g-fact
s AF_F1_gain
Filter Gp 1
Amp Factor
Ramp Time
Ramp Gain Min
Gain Max
>0.
Gain-proc 1.2 2222 0.250.
142
140
Table Q-curve
146
s AF2_F5_Q
s AF2_F4_Q
s AF2_F3_Q
s AF2_F2_Q
s AF2_F1_Q
Filter Gp 2
s AF_F5_Q
s AF_F4_Q
s AF_F3_Q
s AF_F2_Q
s AF_F1_Q
Filter Gp 1

Fig.14.

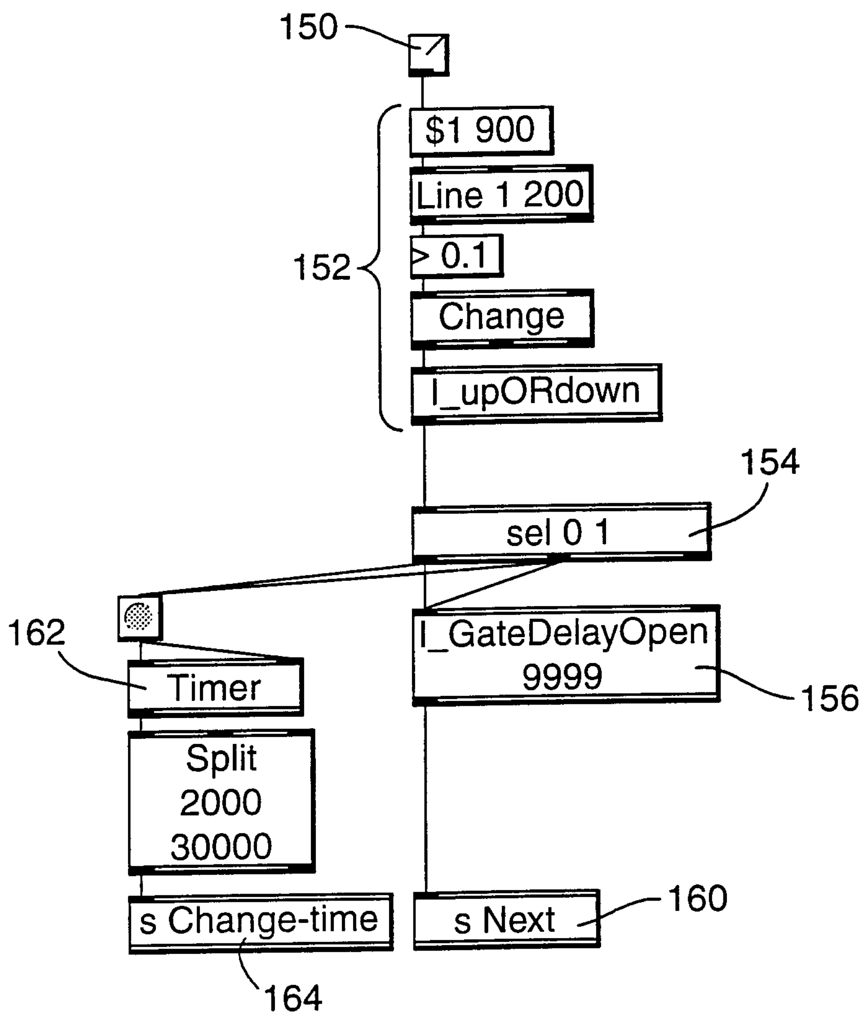

150
$1 900
Line 1 200
> 0.1
Change
l_upORdown
152
154
sel 0 1
162
Timer
l_GateDelayOpen 9999
156
Split 2000 30000
s Change-time
s Next
160
164

Fig.15.

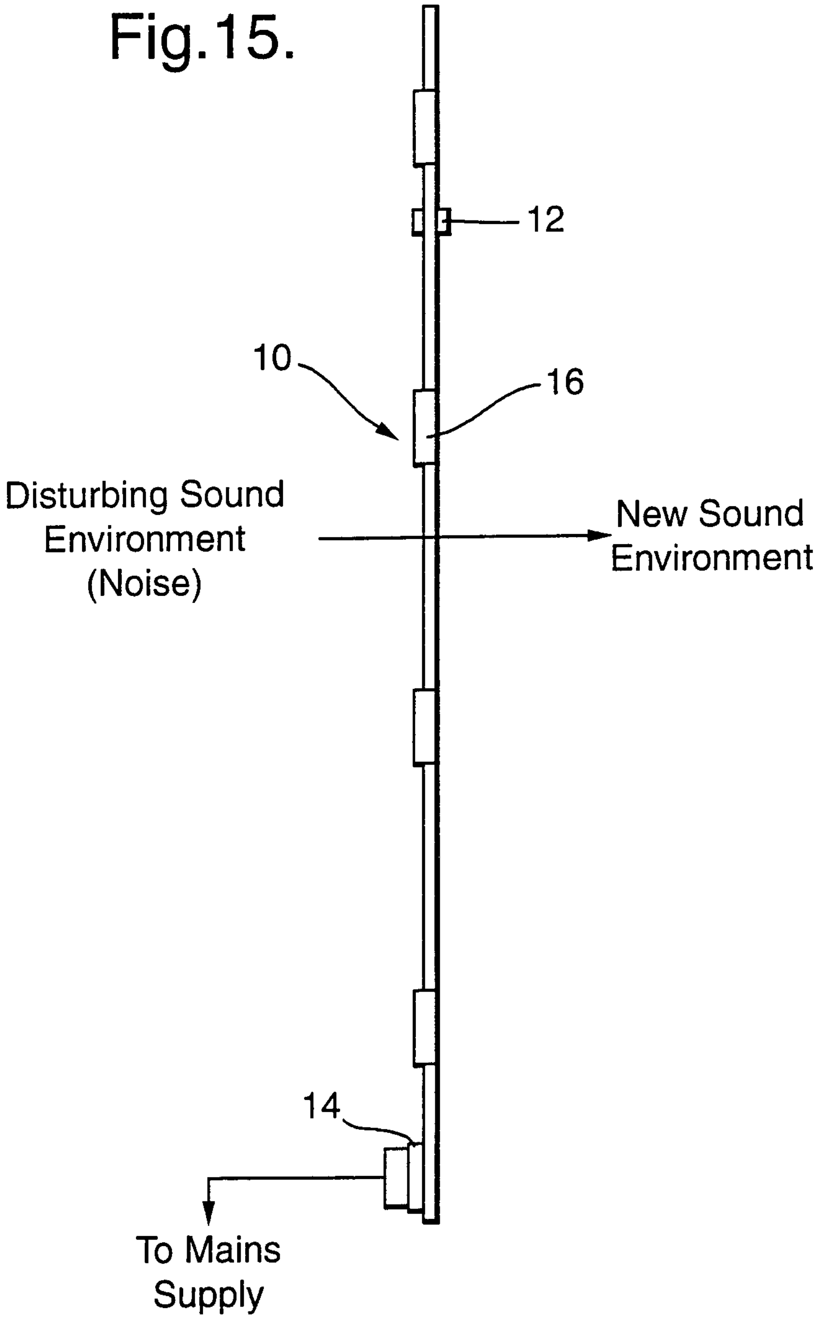

12
10
16
Disturbing Sound Environment (Noise)
New Sound Environment
14
To Mains Supply

Fig.16.

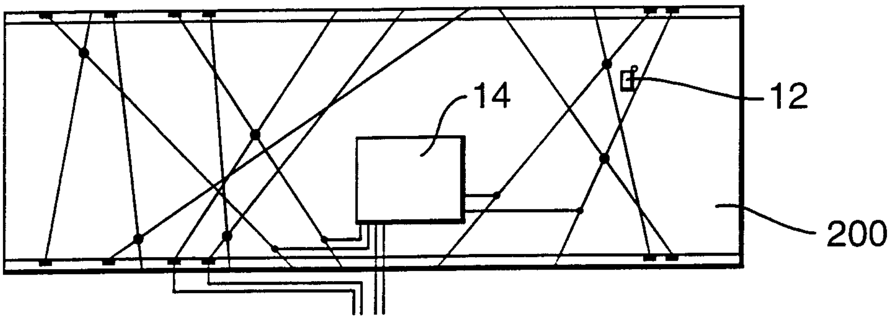

14
12
200

Fig.17.

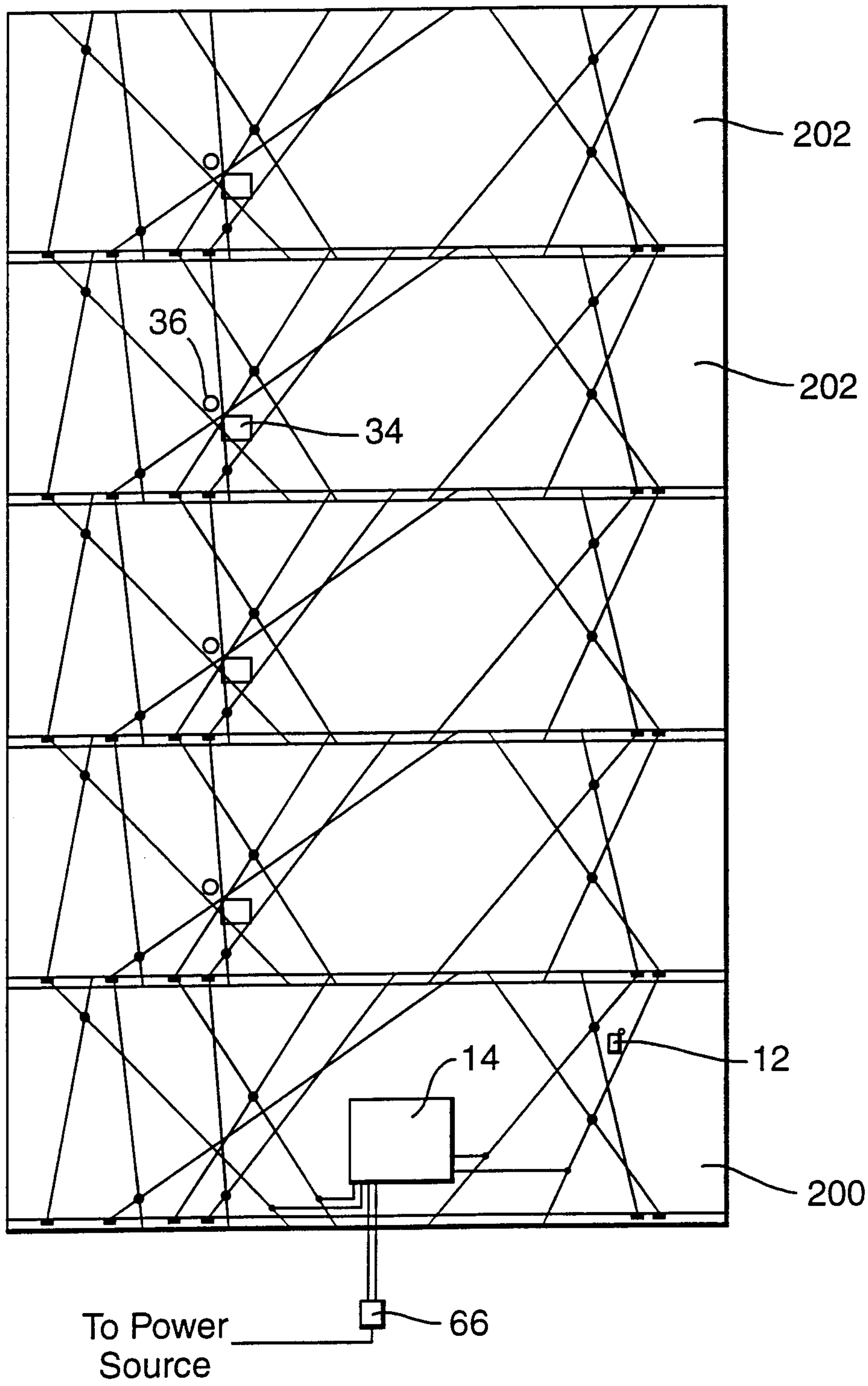


Fig.18.

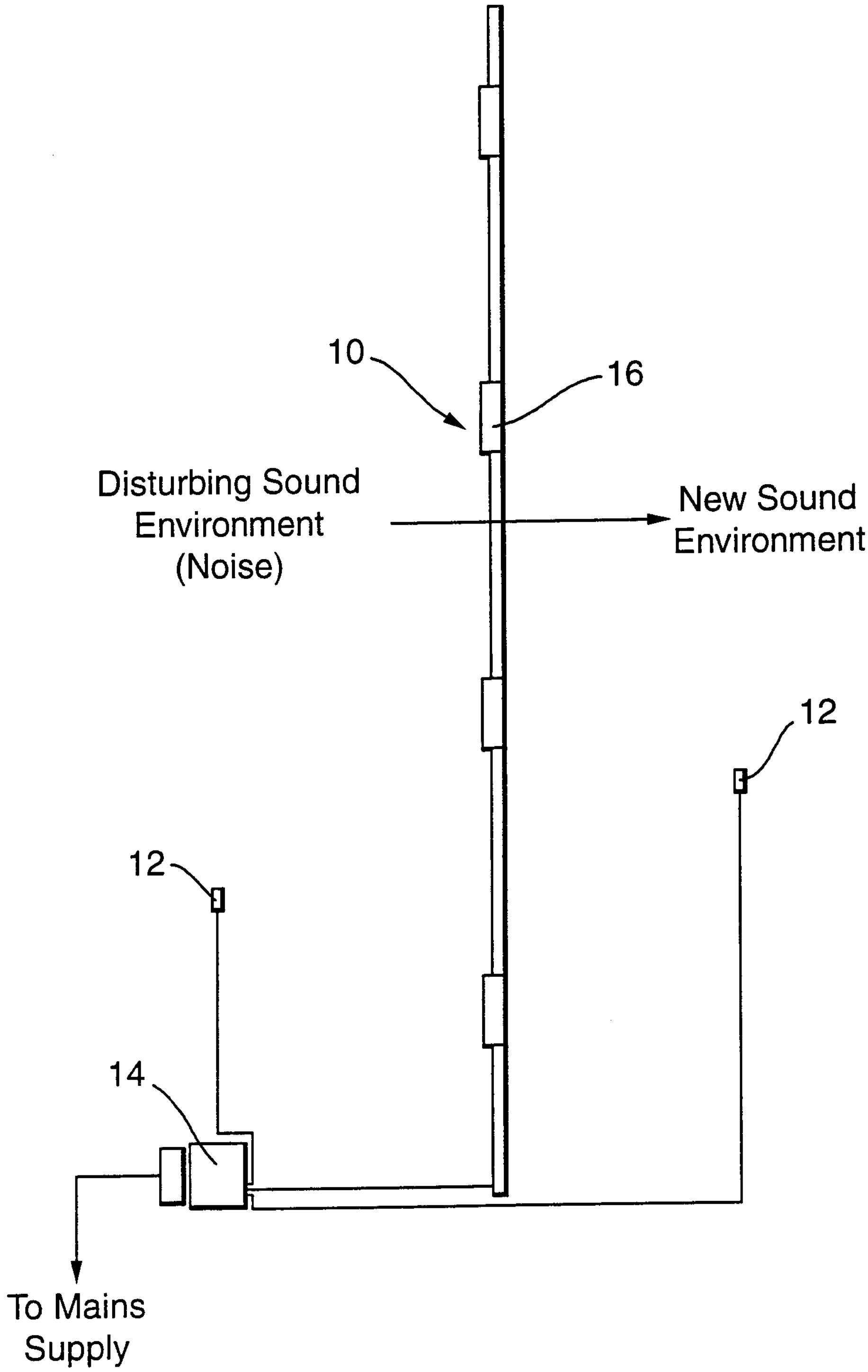

10
16
Disturbing Sound
Environment
(Noise)
New Sound
Environment
12
12
14
To Mains
Supply

Fig.19.

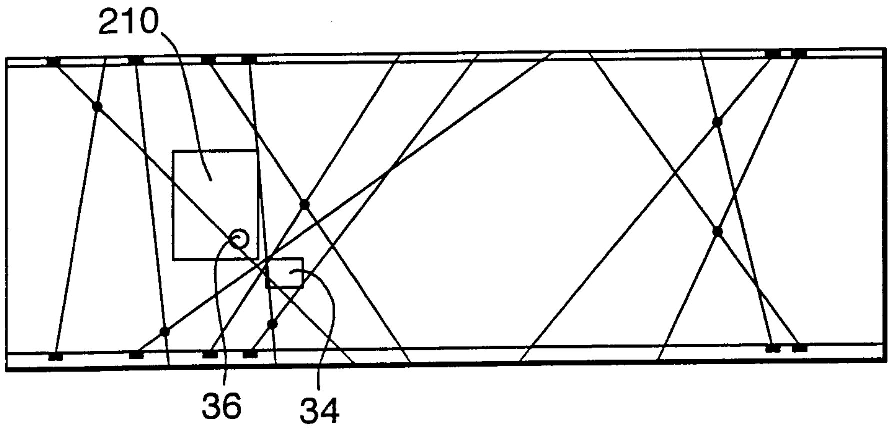


Fig.20.

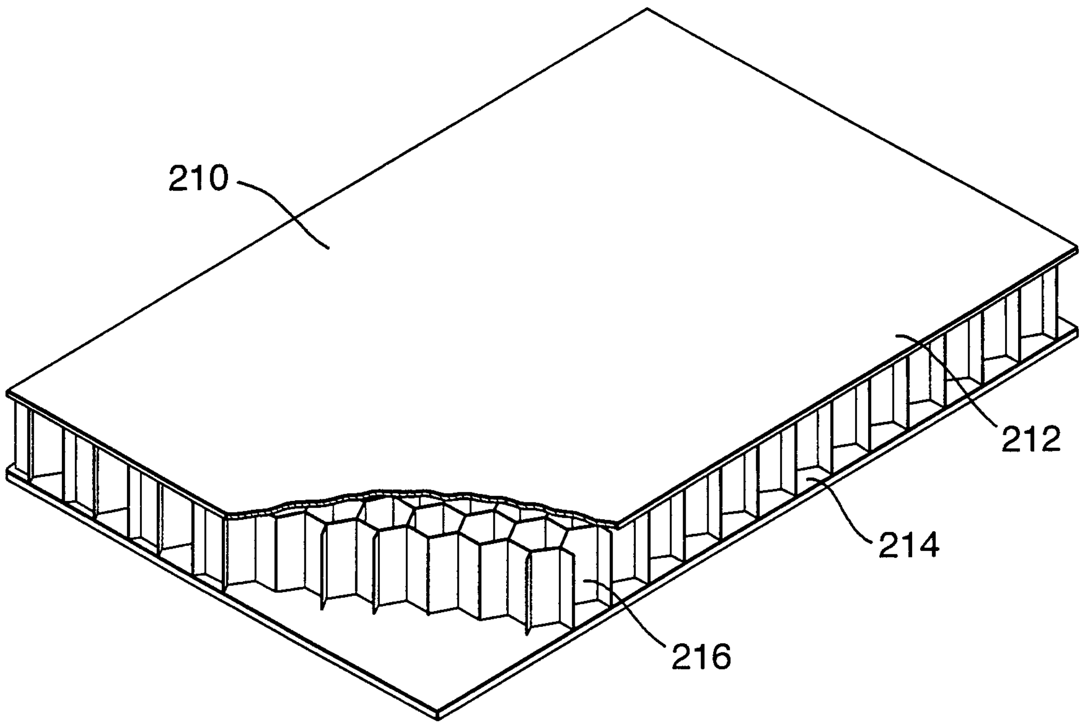
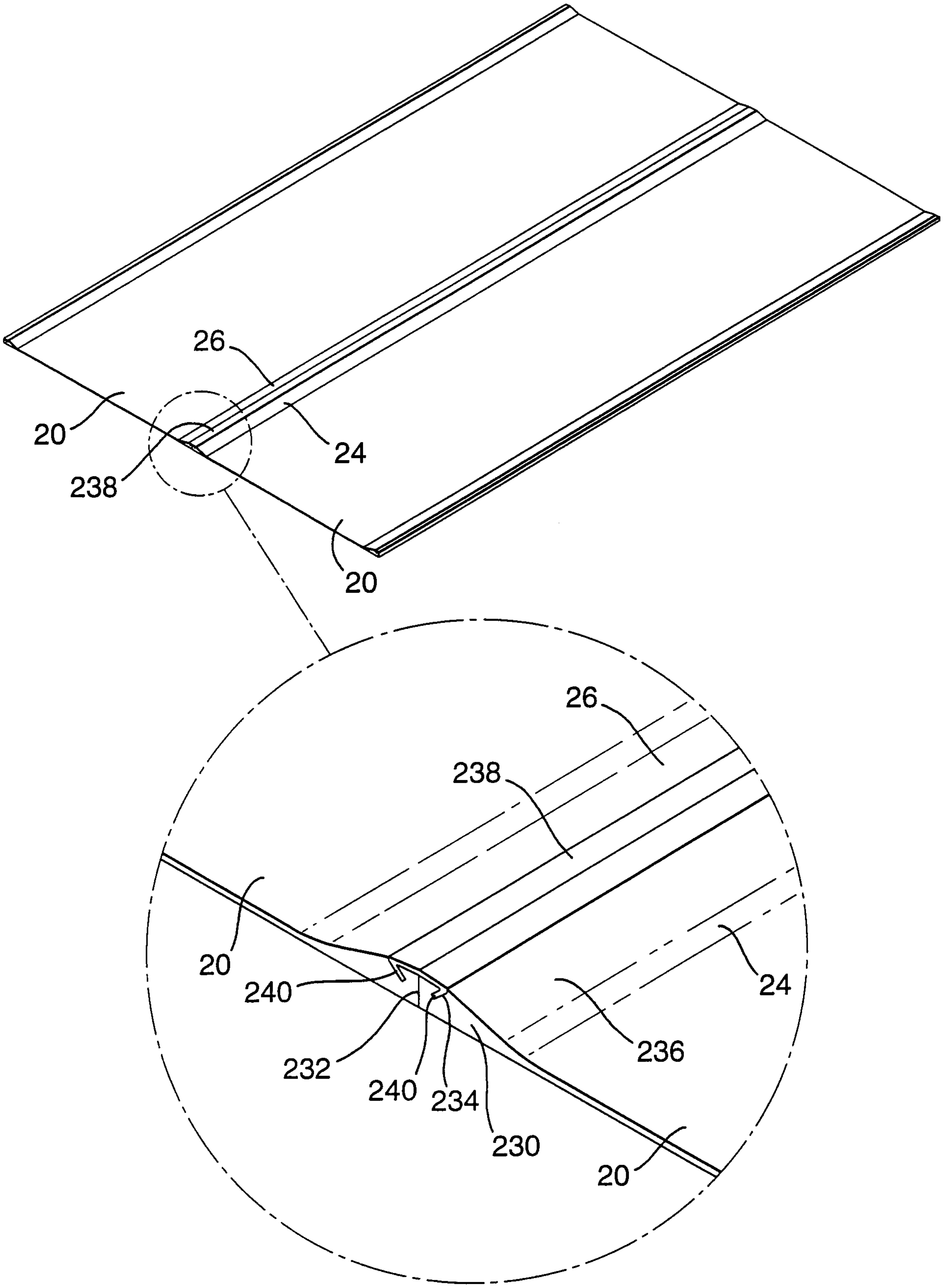


Fig.21.



INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/02360

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G10K11/175

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G10K A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 355 418 A (KELSEY RANDY J ET AL) 11 October 1994 (1994-10-11) abstract; claim 1	1,2,13, 14
X	US 5 105 377 A (ZIEGLER JR ELDON W) 14 April 1992 (1992-04-14)	18
Y	column 3, line 37 - line 65	18,19
Y	US 5 315 661 A (GOSSMAN WILLIAM ET AL) 24 May 1994 (1994-05-24)	18,19
A	column 5, line 30 -column 6, line 34	2
A	US 5 781 640 A (NICOLINO JR SAM J) 14 July 1998 (1998-07-14) column 2, line 10 - line 45	1,2

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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Date of the actual completion of the international search	Date of mailing of the international search report
19 September 2000	27/09/2000

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/02360

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 097 (E-1176), 10 March 1992 (1992-03-10) & JP 03 276998 A (MATSUSHITA ELECTRIC WORKS LTD), 9 December 1991 (1991-12-09) abstract	1,2

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 00/02360

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			AU	650259	B	16-06-1994
			AU	7240491	A	03-09-1991
			CA	2076007	A,C	10-08-1991
			DE	69132338	D	31-08-2000
			EP	0521868	A	13-01-1993
			JP	5503622	T	10-06-1993
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			CA	2142013	A,C	03-03-1994
			DE	69231190	D	27-07-2000
			EP	0657058	A	14-06-1995
			JP	8500193	T	09-01-1996
			WO	9405005	A	03-03-1994
US 5781640	A	14-07-1998	NONE			
JP 03276998	A	09-12-1991	NONE			