(12) UK Patent Application (19) GB (11) 2 357 931 (13) A

(43) Date of A Publication 04.07.2001

(21) Application No 0025723.8

(22) Date of Filing 20.10.2000

(30) Priority Data
(31) 9926096 (32) 04.11.1999 (33) GB

(51) INT CL[7]
H04N 5/64

(52) UK CL (Edition S)
H4J JA J30F J31T

(56) Documents Cited
EP 0910226 A2 EP 0605224 A1 EP 0370619 A2
EP 0356871 A2 WO 97/09842 A2

(58) Field of Search
UK CL (Edition S) H4J JA JAB
INT CL[7] H04N 5/64 , H04R 5/02 7/06
Online: WPI, JAPIO, EPODOC

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(54) Abstract Title
Audio-visual apparatus with distributed mode flat panel loudspeakers

(57) Audio visual apparatus (10) having a casing (12) having front (14), rear (15), opposed side (16,18) and top (20) faces. A display screen (22) is associated with, and generally in the plane of, the front face (14). A loudspeaker (24) is mounted in the plane of the top face (20) to form a centre channel speaker. Loudspeakers (26) are mounted in the plane of the respective opposed side faces (16,18) to form respective left and right channel speakers. A loudspeaker (32) is mounted in the rear face (15) to form a woofer or sub-woofer.

Each loudspeaker (24,26,32) comprises an acoustic radiator in the form of a panel (28, 30, 34) capable of supporting resonant bending waves and a transducer (not shown) mounted on the panel (28, 30) to excite resonant bending waves in the panel (28, 30) to produce an acoustic output.

Fig1

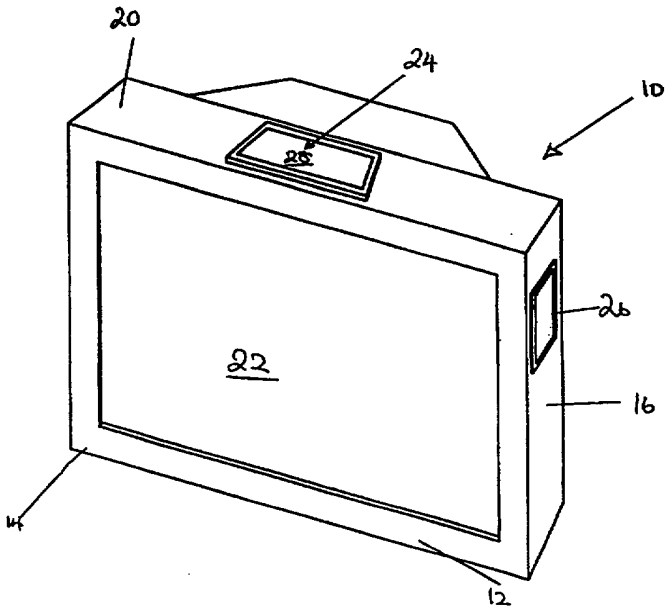

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Fig1

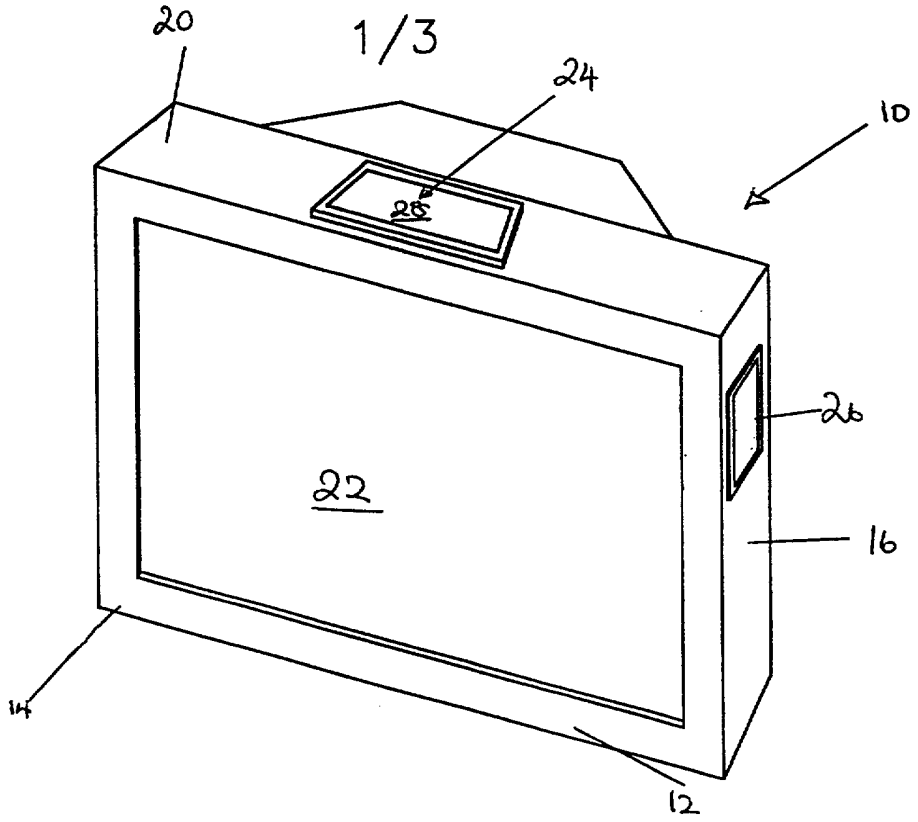


Fig2

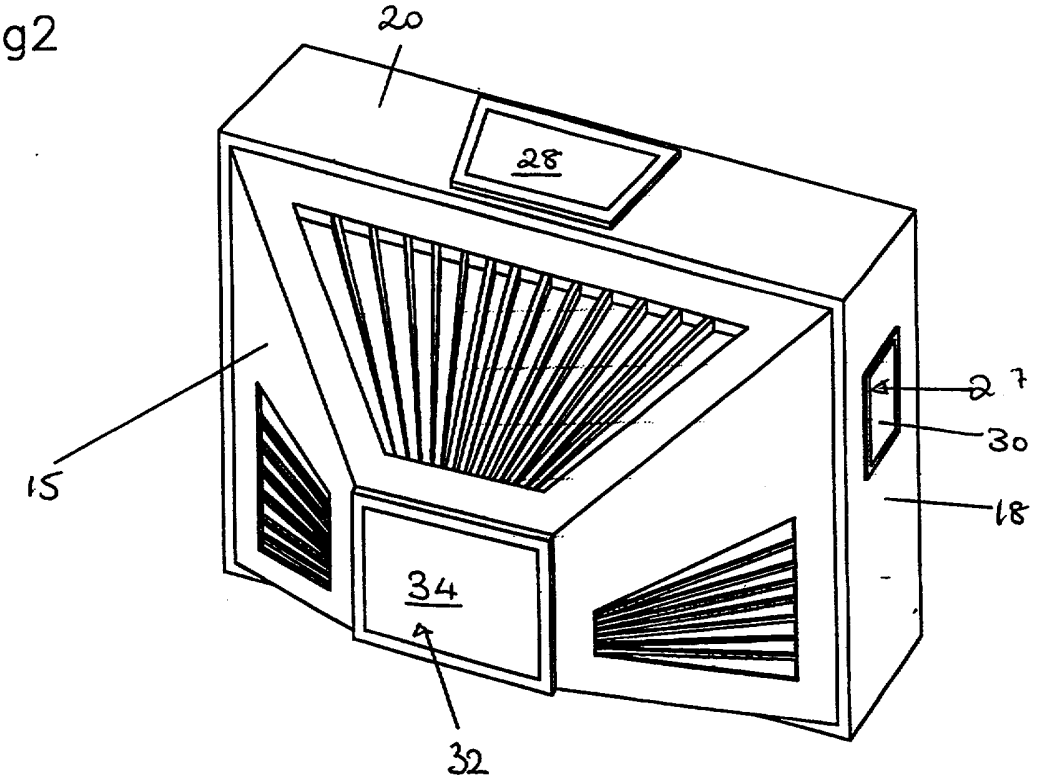


Fig 3 PRIOR ART

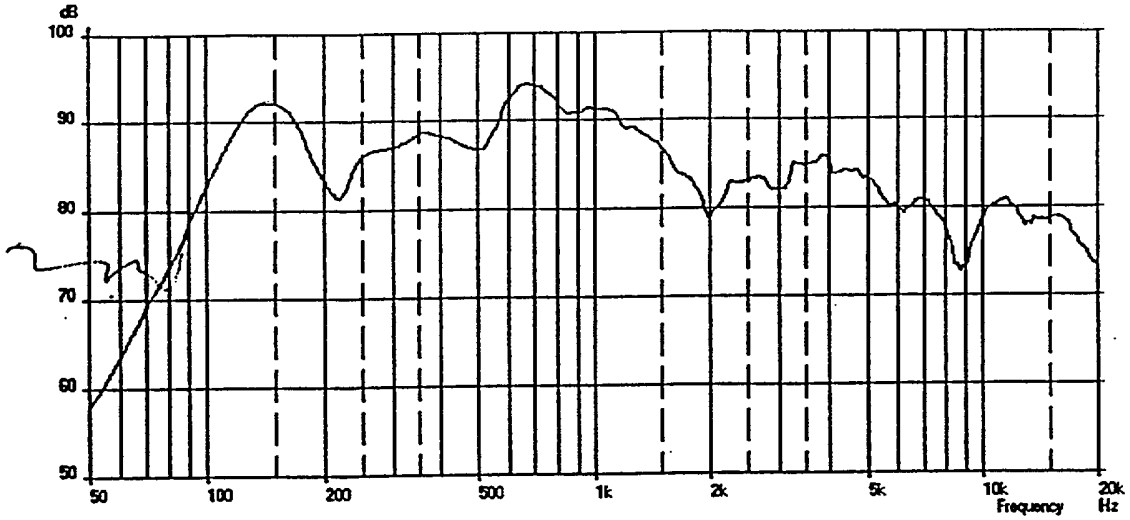


Fig 4

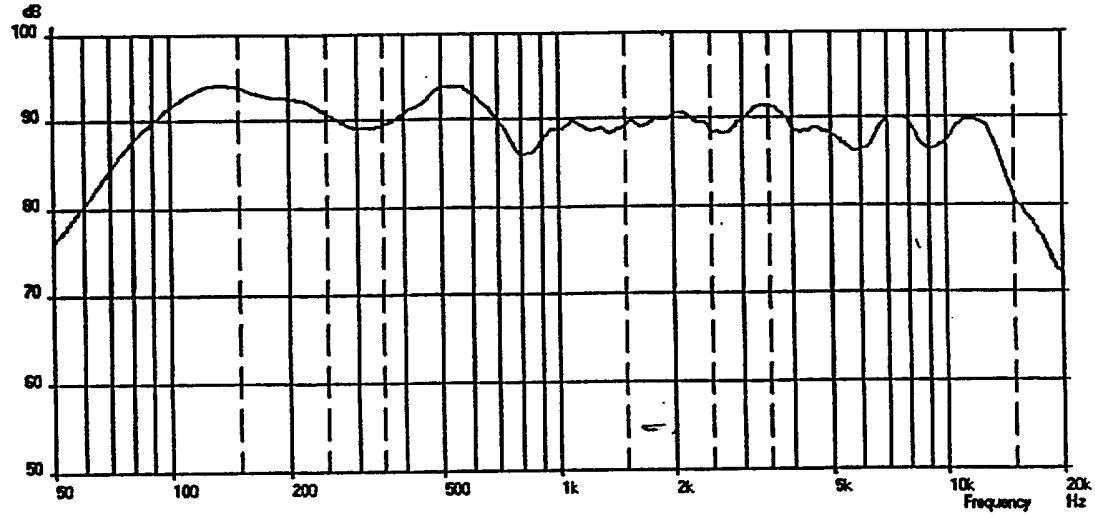
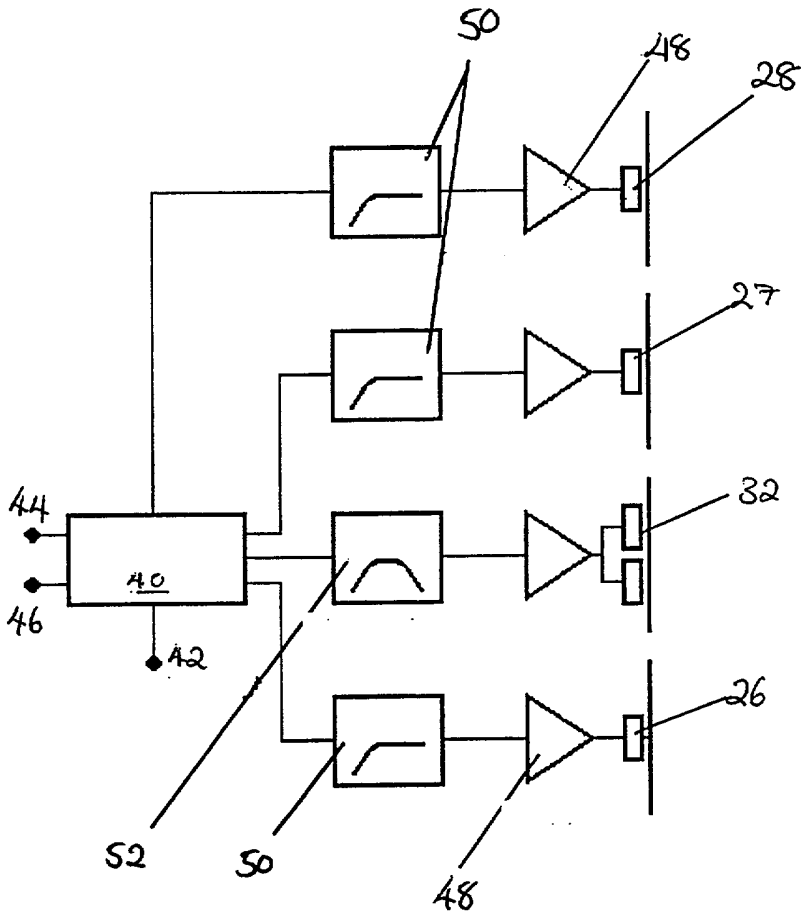


Fig5



TITLE: AUDIO-VISUAL APPARATUS

DESCRIPTION

TECHNICAL FIELD

The invention relates to audio-visual apparatus, e.g. of the nature of a television or the like device, including visual displays such as computer monitors.

BACKGROUND ART

It is a problem to provide a compact television including high quality audio output without resorting to separate stand-alone loudspeakers to carry left, right and centre channel information and to carry low frequency signals such as are normally handled by so-called woofers or subwoofers. It is an object of the invention to mitigate this problem by providing a compact audio-visual apparatus.

DISCLOSURE OF INVENTION

According to the invention there is provided audio visual apparatus comprising a casing having front, rear, opposed side and top faces, a display screen associated with, and generally in the plane of, the front face, a

bending wave loudspeaker associated with, and generally in the plane of, the top face to form a centre channel speaker, and respective bending wave loudspeakers associated with, and generally in the plane of the respective opposed side faces to form respective left and right channel speakers, the association of the casing with the loudspeakers being such that the casing forms a baffle for the loudspeakers each of the bending wave loudspeakers comprising an acoustic radiator capable of supporting bending waves and a transducer mounted on the acoustic radiator to excite bending waves in the acoustic radiator to produce an acoustic output.

The loudspeaker may be a bending wave speaker comprising an acoustic radiator capable of supporting bending waves and a transducer mounted on the acoustic radiator to excite bending waves in the acoustic radiator to produce an acoustic output. It is preferred to use as the loudspeaker a resonant bending wave mode loudspeaker having an acoustic radiator and a transducer fixed to the acoustic radiator for exciting resonant bending wave modes. Such a loudspeaker is described in WO98/09842 and other patent applications and publications and may be referred to as a distributed mode loudspeaker.

The properties of the acoustic radiator may be chosen to distribute the resonant bending wave modes substantially evenly in frequency. In other words, the properties or parameters, e.g. size, thickness, shape, material etc., of the acoustic radiator may be chosen to

smooth peaks in the frequency response caused by "bunching" or clustering of the modes. The resultant distribution of resonant bending wave modes may thus be such that there are substantially minimal clusterings and disparities of spacing.

In particular, the properties of the acoustic radiator may be chosen to distribute the lower frequency resonant bending wave modes substantially evenly in frequency. The distribution of resonant bending wave modes is less dense at lower frequency than at higher frequency and thus the distribution of the lower frequency resonant bending wave modes is particularly important. The lower frequency resonant bending wave modes are preferably the ten to twenty lowest frequency resonant bending wave modes of the acoustic radiator. For an acoustic radiator for use in a personal data assistant, the lower frequency resonant bending wave modes may all be below 2 kHz - IS THIS TRUE?

The resonant bending wave modes associated with each conceptual axis of the acoustic radiator may be arranged to be interleaved in frequency. Each conceptual axis has an associated lowest fundamental frequency (conceptual frequency) and higher modes at spaced frequencies. By interleaving the modes associated with each axis, the substantially even distribution may be achieved. There may be two conceptual axes and the axes may be symmetry axes. For example, for a rectangular acoustic radiator, the axes may be a short and a long axis parallel to a

short and a long side of the acoustic radiator respectively. For an elliptical acoustic radiator, the axes may correspond to the major and minor axis of the ellipse. The axes may be orthogonal.

The transducer location may be chosen to couple substantially evenly to the resonant bending wave modes. In particular, the transducer location may be chosen to couple substantially evenly to lower frequency resonant bending wave modes. In other words, the transducer may be mounted at a location spaced away from nodes (or dead spots) of as many lower frequency resonant modes as possible. Thus the transducer may be at a location where the number of vibrationally active resonance anti-nodes is relatively high and conversely the number of resonance nodes is relatively low. Any such location may be used, but the most convenient locations are the near-central locations between 38% to 62% along each of the length and width axes of the panel, but off-central. Specific locations found suitable are at 3/7,4/9 or 5/13 of the distance along the axes; a different ratio for the length axis and the width axis is preferred.

The transducer may be grounded or partially grounded. The transducer may be piezoelectric. A piezoelectric transducer mounted on the casing of the personal data assistant might produce a satisfactory buzzing sound but distributed mode technology as described above may improve the clarity of reproduced speech.

The acoustic radiator may have selected values of certain physical parameters which enable the acoustic radiator to sustain and propagate input vibrational energy in a predetermined frequency range by a plurality of resonant bending wave modes in a least one operative area extending transversely of thickness such that the frequencies of the resonant bending wave modes along at least two conceptual axes of the operative area are interleaved and spread so that there are substantially minimal clusterings and disparities of spacings of said frequencies, the acoustic radiator when resonating have at least one site at which the number of vibrationally active resonance anti-nodes is relatively high and a transducer mounted wholly and exclusively on the acoustic radiator at one of said sites on the acoustic radiator, the transducer being capable of vibrating the acoustic radiator in the predetermined frequency range to couple to and excite the resonant bending wave modes in the acoustic radiator and cause the acoustic radiator to resonate and produce an acoustic output.

The acoustic radiator may be in the form of a panel. The panel may be flat and may be lightweight. The material of the acoustic radiator may be anisotropic or isotropic. The panel shape and size does not have to be ideal or rectangular. Elongated or curved panels may be used. Larger panels will have lower cut-off frequency, but could be more modally sparse.

The invention takes advantage of the diffuse wide

angle sound dispersion of resonant bending wave panel loudspeakers, e.g. of the kind described in WO97/09842, which provide effective sound radiation to the viewer/listener, even when substantially the edge of the resonant panel is presented to the listener. This is in marked contract to the sound beaming characteristics of conventional pistonic loudspeakers, which would lead to a severely compromised sonic performance if made as described above.

Specifically, the radiation from a broadband bending wave panel is wide angle, up to 180 degrees. For an open panel there is a degree of null at right angles to the panel but when a panel is fitted in a baffle the null is suppressed since the partially inverted phase rear radiation component is removed. The result is almost perfect hemispherical radiation over the frequency range which allows the loudspeaker panels to be mounted on the sides of the casing at right angles or close to it, depending on the casing design or style, and still give good presentation to the audience.

Sympathetic reflections from local boundaries may enhance the width of the stereo image and the sense of spaciousness in the reproduction.

The rear face of the loudspeaker may have associated therewith a loudspeaker to form a woofer or subwoofer channel. The loudspeaker may be a resonant bending wave loudspeaker, or may be pistonic. Alternatively, the loudspeaker associated with the rear face of the audio

visual apparatus may be simply supported at its edges and forced to operate as a timpanic diaphragm at low frequencies.

The lower frequency channel(s) may be a summed mono signal working below 300Kz or less where directionality and directivity is less critical. A single larger resonant bending wave loudspeaker working in this case in hybrid mode, with distributed mode operation above about 150z and forced symmetric mode at lower frequencies may be fitted to the rear of the casing or console, if exciters are placed on a central vertical axis and the panel is simply supported at its lateral edges and the exciter spacing is calculated for suitable and modal density drive in the frequency range of interest.

BRIEF DESCRIPTION OF DRAWINGS

The invention is diagrammatically illustrated, by way of example, in the accompanying drawings, in which:

Figure 1 is a front perspective view of a television of the invention;

Figure 2 is rear perspective view of the television of Figure 1;

Figure 3 is a frequency response graph of a typical prior art television;

Figure 4 is a frequency response graph of an equivalent system of the present invention, and

Figure 5 is a block circuit diagram of the device of Figures 1 and 2.

BEST MODES FOR CARRYING OUT THE INVENTION

Figures 1 and 2 show a television (10) having a casing (12) having front (14), rear (15), opposed side (16,18) and top (20) faces. A display screen (22) is associated with, and generally in the plane of, the front face (14).

A loudspeaker (24) is mounted in the plane of the top face (20) to form a centre channel speaker. Loudspeakers (26,27) are mounted in the plane of the respective opposed side faces (16,18) to form respective left (27) and right (26) channel speakers. A loudspeaker (32) is mounted in the rear face (15) to form a woofer or sub-woofer

Each loudspeaker (24,26,27,32) comprises an acoustic radiator in the form of a panel (28, 30, 34) capable of supporting resonant bending waves and a transducer (not shown) mounted on the panel (28, 30) to excite resonant bending waves in the panel (28, 30) to produce an acoustic output.

Three mid-range/treble panels (typical frequency range 300Hz to 15kHz) of the following specification are used for left and right channel:

Panel Dimensions:	190mm X 103mm X 3.5mm
Material:	3.5mm Rohacell LG51 on Amber EF72-glassveil scrim
Exciter/panel:	2 x Peerless Ø25mm (S98-82) wired in series 10Ω nom.
Mass:	3g brass disc (3.2mm Ø11.9mm) attached with hitack double sided tape (Tesa BDF 49695 – red backing)
Damping pad:	Blue (1.5mm X Ø10mm),
Exciter positions(x,y):	42/75mm, and 61/117mm from bottom left corner, rear of panel. Left and right panels are handed (mirror images of each other, panel described is LH).
Mass position:	35/106mm, from bottom left, on rear of panel.
Damper position:	placed under exciter at 42/75mm on rear of panel.

Mounting:	3mm Miers double sided foam, mounted all way round other than 110mm gap in sides at centre. Secured with red hi-tack tape.

The centre channel (typical frequency range 300Hz to 15kHz) is built along the same lines, but with the following differences:

Panel Dimensions:	≈190mm x ≈107mmx 3.5mm
Mounting:	5mm Miers double sided foam, mounted all way round.

The woofer (typical frequency range 80Hz to 300Hz) has the following specification:

Panel Dimensions:	260mm x 220mm x 2mm
Material:	4mm Rohacell compressed to 2mm (no skins)
Exciter/panel:	2xNEC Ø25mm (NX43-04), 4Ω nom/channel)
Exciter positions(x,y):	130/50mm, 130/170mm from bottom left corner of rear of panel Exciters are grounded to frame with plastic bracket.
Mounting:	5mm Miers foam, mounted along sides only. Secured with red hi-tack tape.

The loudspeaker panels are notably discreet, and not much can be seen from the front of the television. In particular there is no need for visible grilles on the front. Use is made of the unique directivity properties of DML, in that the listener hears direct sound from the edges of the panels hemispherical radiation pattern, and non-destructive interference from reflections from the boundaries of the room.

The TV cabinet does not have to be sealed - no box is required for any of the drivers. Ventilation grilles (required to keep the electronics cool) are not affected. It is advantageous however to increase the length of the smallest path between back and front of woofer panel.

The low frequency unit is slim, and thanks to its radiation properties, can be hidden away on the back of the cabinet. Left and right panels do not have to be handed, but can be if especially even directivity characteristics are required

Figure 3 shows the measured frequency response (9 point spatial 'power' average at approximately 1m in the front of the screen) of prior art conventional television speakers using MIssa measurement system.

Figure 4 shows a 9 point spatial average at approximately 1m (on-axis of the screen) of the complete system (without the centre channel) of Figures 1 and 2. As is shown, the frequency response for the system of Figures 1 and 2 is smoother and thus more desirable than that of the frequency response measured for a standard system shown in Figure 3.

Figure 5 is a block circuit diagram of the device of Figures 1 and 2. The circuit comprises a surround processor (40) which receives input from a surround output (42), a line in left (44) and a line in right (46). The surround processor sends signals to drive the four speakers (24,26,27,32) via amplifiers (48) and electronic equalisers (50, 52).

There are two types of electronic equaliser, the first type of electronic equaliser (50) restricts the bandwidth to the mid-range/treble speakers (24,26,27) and prevent low frequencies driving the speakers (24,26,27) below their normal operating range. The first type of

electronic equaliser (50) comprises a first order hi-pass passive filter (a single capacitor, 50μF 50v)) and a small series inductor (0.07mH) to slightly reduce the extreme high frequency level. The second type of electronic equaliser (52) feeds the low frequency panel through a simple 2nd order low-pass or band-pass filter (inductor=7mH, capacitor=300μF)

INDUSTRIAL APPLICABILITY

The invention thus provides an attractive and simple alternative to conventional box speakers for audio visual apparatus.

CLAIMS

1. Audio visual apparatus comprising a casing having front, rear, opposed side and top faces, a display screen associated with, and generally in the plane of, the front face, a bending wave loudspeaker associated with, and generally in the plane of, the top face to form a centre channel speaker, and respective bending wave loudspeakers associated with, and generally in the plane of the respective opposed side faces to form respective left and right channel speakers, the association of the casing with the loudspeakers being such that the casing forms a baffle for the loudspeakers, each of the bending wave loudspeakers comprising an acoustic radiator capable of supporting bending waves and a transducer mounted on the acoustic radiator to excite bending waves in the acoustic radiator to produce an acoustic output.

2. Audio visual apparatus according to claim 1, wherein each bending wave loudspeaker is a resonant bending wave mode loudspeaker having an acoustic radiator and a transducer fixed to the acoustic radiator for exciting the resonant bending wave modes.

3. Audio visual apparatus according to claim 2, wherein the properties of the acoustic radiator are chosen to distribute the resonant bending wave modes substantially evenly in frequency.

4. Audio visual apparatus according to claim 2 or claim 3, wherein the resonant bending wave modes associated with a first conceptual axis of the acoustic radiator are

arranged to be interleaved in frequency with the resonant bending wave modes associated with a second conceptual axis.

5. Audio visual apparatus according to any one of claims 2 to 4, wherein the transducer location couples substantially evenly to the resonant bending wave modes.

6. Audio visual apparatus according to any one of the preceding claims, wherein the acoustic radiator is in the form of a panel.

7. Audio visual apparatus according to claim 6, wherein the panel is flat.

8. Audio visual apparatus according to any one of the preceding claims, wherein the rear face of the audio visual apparatus has associated therewith a loudspeaker to form a woofer or subwoofer channel.

9. Audio visual apparatus according to claim 8, wherein the loudspeaker associated with the rear face of the audio visual apparatus is a resonant bending wave loudspeaker.

10. Audio visual apparatus according to claim 8, wherein the loudspeaker associated with the rear face of the audio visual apparatus is simply supported at its edges and forced to operate as a timpanic diaphragm at low frequencies.

11. Audio visual apparatus according to claim 8, wherein the loudspeaker associated with the rear face of audio visual apparatus is pistonic.

INVESTOR IN PEOPLE

Application No: GB 0025723.8 14 **Examiner:** Geoff Holmes
Claims searched: All **Date of search:** 27 April 2001

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): H4J (JA JAB)

Int Cl (Ed.7): H04N 5/64 H04R 5/02 7/06

Other: Online: WPI, JAPIO, EPODOC

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
Y	EP 0910226 A2	(THOMSON-BRANDT) fig 1	1-11
Y	EP 0605224 A1	(KABUSHIKI) figs 1 and 2	1-11
Y	EP 0370619 A2	(BOSE) figs 1 and 2	1-11
Y	EP 0356871 A2	(TELEFUNKEN) fig 1	1-11
Y	WO 97/09842 A2	(VERITY GROUP) particularly fig 27 and page 69 lines 19-26	1-11

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
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