PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : H04R 1/02

A1

(11) International Publication Number: **WO 00/54552**

(43) International Publication Date: 14 September 2000 (14.09.00)

(21) International Application Number: PCT/GB00/00801

(22) International Filing Date: 9 March 2000 (09.03.00)

(30) Priority Data:

9905374.6	10 March 1999 (10.03.99)	GB
9922511.2	24 September 1999 (24.09.99)	GB

(71) Applicant *(for all designated States except US)*: NEW TRANSDUCERS LIMITED [GB/GB]; 37 Ixworth Place, London SW3 3QH (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: AZIMA, Henry [CA/GB]; 3 Southacre Close, Chaucer Road, Cambridge CB2 2TT (GB). JARVIS, Edward [GB/GB]; 5 The Fairway, Wood End, Bluntisham, Cambridgeshire PE17 3LF (GB). OWEN, Neil, Simon [GB/GB]; Treewick Cottage, Silver Street, Buckden, Cambridgeshire PE18 9TS (GB). DUNK, Kieron [GB/GB]; 2 The Aisled Barn, Hilton, Cambridgeshire PE18 9NA (GB).

(74) Agent: MAGUIRE BOSS; 5 Crown Street, St. Ives, Cambridgeshire PE17 4EB (GB).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, 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, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, 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

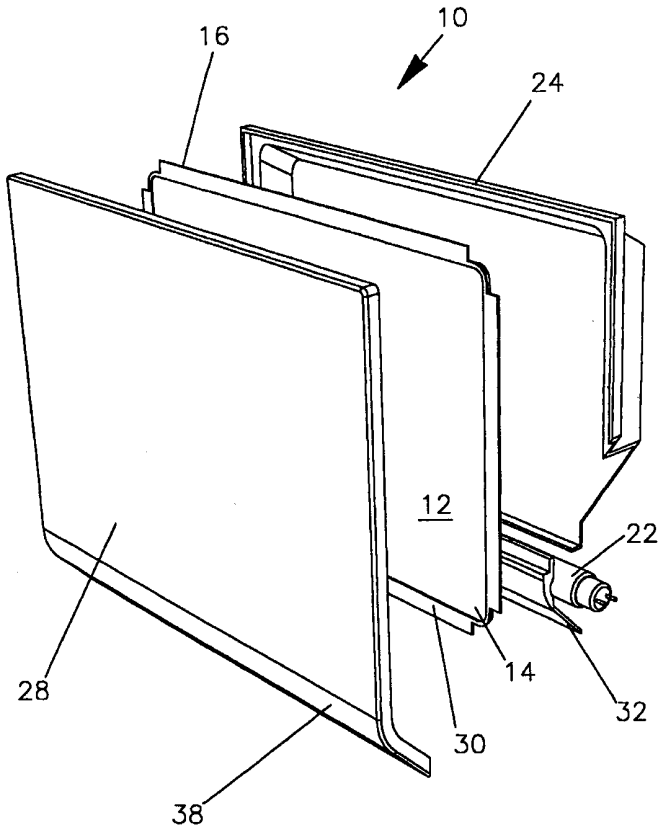
With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: RESONANT-MODE PANEL LOUDSPEAKER WITH LIGHT EMITTER

(57) Abstract

A combination panel-form loudspeaker/light comprising a panel (12) having a front face (14) and rear face (16), a vibration exciter (18, 20) mounted to the member to excite bending-wave vibration in the member, and a light emitter (22) mounted at or adjacent to the panel and arranged to illuminate an area adjacent to the panel.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

TITLE:

RESONANT-MODE PANEL LOUDSPEAKER WITH LIGHT EMITTER

DESCRIPTION

TECHNICAL FIELD

The invention relates to loudspeakers and more particularly to bending wave panel-form loudspeakers e.g. of the general kind described in International patent application WO97/09842.

BACKGROUND ART

The technology described in International Patent application WO97/09842 has come to be known as distributed mode or DM technology and among other things, WO97/09842 describes a ceiling tile/loudspeaker combination. A feature of bending wave panel-form loudspeakers is that they may be made flat and of shallow depth and may thus be

wall or ceiling mounted in a domestic, or other, environment to occupy a minimum of space. It has also been suggested that the flat front face of the loudspeaker may be disguised as a picture or mural.

It is an object of the invention to extend the utility of such wall or other surface mounting of panel-form loudspeakers for other purposes, by combining such loudspeakers with other devices in synergistic combinations.

DISCLOSURE OF INVENTION

According to the invention, there is provided a panel-form loudspeaker comprising a bending wave panel having a front face and rear face, a vibration exciter mounted to the panel to excite bending-wave vibration in the panel, and a light emitter mounted at or adjacent to the rear face of the panel and arranged to illuminate an area adjacent to the panel. A light reflector may be provided to direct light from the light emitter. The panel may be transparent or translucent.

The loudspeaker may comprise an enclosure defining a cavity enclosing at least a portion of the rear face of the panel. The light-emitter may be disposed in the cavity and may be arranged to emit light through at least one window therein. The enclosure may be transparent or translucent to light. The enclosure may be moulded from a clear plastic such as polycarbonate. The enclosure may be formed with one or more lenses to direct the emitted

light as desired. The lens(es) may be moulded integrally with the enclosure.

The enclosure is preferably acoustically opaque to prevent or reduce acoustic radiation from the rear face of the panel. The cavity may be dimensioned such as to modify the modal behaviour of the member, e.g. as taught in WO99/52322.

The light emitter may comprise a fluorescent device, or other device which does not emit significant heat. Such a device may be a low voltage device. Power to the light emitter may be supplied via electrically conductive lead(s) supplying power to the vibration exciter.

The loudspeaker may further comprise a front cover. The front cover will be acoustically transparent to allow acoustic radiation from the panel to pass through. The front cover is preferably opaque to light. The front cover may be arranged to extend beyond the panel perimeter and the enclosure. The loudspeaker may be adapted to be wall mounted or to be ceiling mounted, e.g. as a ceiling tile. Thus, when so mounted, the front cover may at least partly conceal the loudspeaker enclosure from view.

BRIEF DESCRIPTION OF DRAWINGS

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

Figure 1 shows an exploded perspective view of a panel-form loudspeaker embodying the present invention and

intended for wall mounting;

Figure 2a is a plan view of a panel-form loudspeaker embodying the present invention and generally as shown in Figure 1;

Figure 2b is a cross-section along line AA of Figure 2a;

Figure 2c is a side view of the loudspeaker of Figure 2a;

Figure 3 is a cross-sectional side view of an embodiment of light fitting or tile for a suspended ceiling;

Figure 4 is a cross-sectional side view of another embodiment of light fitting or tile for a suspended ceiling;

Figure 5 is a cross-sectional side view of yet another arrangement of suspended ceiling light fitting or tile;

Figure 6 is a cross-sectional side view of a further embodiment of suspended ceiling light fitting or tile, and

Figure 7 is a scrap cross-sectional side view relevant to the embodiments of Figures 3 to 6

BEST MODES FOR CARRYING OUT THE INVENTION

Figures 1 and 2 of the drawings show a panel-form loudspeaker/light fitting combination (10) comprising a resonant panel (12) having a front face (14) and rear face (16) and two vibration exciters (18,20) mounted on

the panel (12) to excite bending-wave vibration in the panel (12) to cause it to resonate and produce an acoustic output generally as described in WO 97/09842.

The loudspeaker (10) further comprises a shallow rear box-like enclosure (24) which defines a cavity (26) enclosing the rear face (16) of the panel (12). The enclosure (24) is acoustically opaque to prevent or reduce acoustic radiation from the rear face (16) of the panel (12). The panel (12) is mounted to the rear enclosure by means of a resilient suspension (30) extending around the perimeter of the panel (12).

A light-emitter (22) in the form of a fluorescent tube is mounted in a support (32) in the enclosure (24) and at the lower edge thereof, as seen in Figure 1. The enclosure (24) is transparent to light and moulded from a plastics material. The support (32) for the light-emitter (22) comprises a reflector (48) which directs the emitted light as desired. In this embodiment, the loudspeaker (10) is intended for wall-mounting and thus the light is directed outwardly through the top and sides of the transparent rear enclosure (24) so that the loudspeaker also forms a wall light.

A decorative front cover (28) is mounted to the enclosure (24) to cover the front face (14) of the panel (12) and the support (32). The front cover (28) is acoustically transparent and opaque to light. Accordingly, acoustic radiation from the panel (12), but not light from the fluorescent tube, is allowed to pass through the

cover (28). A lower portion (38) of the front cover is curved to match the profile of the support (32).

The front cover (28) extends beyond the edges (42) of the rear enclosure (24) so that when the loudspeaker is wall mounted, the front cover (28) conceals the enclosure from view.

Figure 2a is a rear view of the loudspeaker with the outline of internal components, e.g. the perimeter (40) of the panel (12) and the edges (44) of the fluorescent tube shown with dotted line.. The exciters (18, 20) are mounted off-centre of the panel (12) as taught in WO 97/09842. Thus the panel has the capability to sustain and propagate input vibrational energy by a plurality of resonant bending wave modes in at least one operative area extending transversely of thickness, wherein the frequencies of resonant bending wave modes are interleaved in a predetermined frequency range so that the resonant bending wave modes are substantially evenly distributed in frequency and wherein the vibration exciters are mounted on said operative area of the panel at preferential locations or sites for coupling to the resonant bending wave modes, to vibrate the panel and excite said resonant bending wave modes in the panel, the resonant bending wave modes in turn producing an acoustic output.

Figure 2b shows that the exciters (18,20) are mounted on the rear face (16) of the panel (12) and that additional support for the exciters (18,20) may be

provided by resiliently suspending them on the rear enclosure (24) e.g. as taught in WO98.31188. Accordingly, the rear enclosure comprises two inward projections or bosses (46) which are aligned with the exciters (18,20), so that the resilient suspension, not shown, can be disposed between the projections (46) and the exciters.

Figure 3 shows an embodiment of light fitting or tile/loudspeaker combination (10) for a suspended ceiling (not shown) comprising a translucent resonant panel (12) having a vibration exciter (18) thereon, e.g. as taught in WO97/09842 mounted in a box-like enclosure (24) to form a cavity (26) in which a fluorescent light fitting (22) is positioned. The mounting of the panel (12) in the enclosure (24) is indicated by arrows (34) and is described further with reference to Figure 7 below.

Figure 4 shows an embodiment of light fitting/loudspeaker combination (10) generally similar to that of Figure 3 and showing a vibration exciter (18) mounted on a translucent panel (12) at a position adjacent to the edge of the panel, as taught in WO99/37121, whereby the exciter can be hidden from view if desired.

Figure 5 shows an arrangement of suspended ceiling/loudspeaker combination (10) light fitting generally similar to that of Figures 3 and 4 and showing the resonant panel (12) mounted above the fluorescent light (22) in the enclosure and with a ceiling tile (36) in the form of an open grille below the light fitting

(22)

Figure 6 is a cross-sectional side view of an embodiment of suspended ceiling light fitting/loudspeaker combination (10) similar to those described above in Figures 3 to 5 and comprising a box-like enclosure (24) housing a curved light reflector (48) in the form of a resonant panel (12) excited by vibration exciter (18) and with fluorescent light fitting (22) mounted below the reflector (48) and a ceiling tile (36) in the form of an open grille below the light fittings to close the enclosure (24).

Figure 7 is a scrap cross-sectional side view showing how the resonant panel (12) and/or tile (36) in the embodiments of Figures 3 to 6 can be supported in the enclosure (24) at its edges by means of brackets (50) mounted on the edges of the panel (12) or tile (36), the brackets being formed with apertures (not shown) which are located and mounted on upstanding pegs (52) in the enclosure (24).

INDUSTRIAL APPLICABILITY

The invention thus provides a slim panel-form loudspeaker of increased utility, and which can be used to provide wall or ceiling lighting.

CLAIMS

1. A combination panel-form loudspeaker/light comprising a panel having a front face and rear face, a vibration exciter mounted to the member to excite bending-wave vibration in the member, and a light emitter mounted at or adjacent to the panel and arranged to illuminate an area adjacent to the panel.

2. A combination according to claim 1, comprising a light reflector positioned to direct light from the light emitter.

3. A combination according to claim 1 or claim 2, comprising an enclosure defining a cavity enclosing at least a portion of the rear face of the member.

4. A combination according to claim 3, comprising at least one window in the enclosure and the light-emitter is disposed in the cavity and is arranged to emit light through the at least one window.

5. A combination according to claim 3, wherein the enclosure is transparent or translucent to light.

6. A combination according to claim 5 wherein the enclosure is moulded from a clear plastics.

7. A combination according to any one of claims 3 to 6 wherein the enclosure is formed with at least one lens to direct emitted light.

8. A combination according to claim 7, wherein the lens is moulded integrally with the enclosure.

9. A combination according to any one of claims 3 to 8, wherein the enclosure is acoustically opaque to prevent

or reduce acoustic radiation from the rear face of the panel.

10. A combination according to any preceding claim, wherein the panel is translucent.

11. A combination according to any one of claims 1 to 9, comprising an acoustically transparent front cover which is opaque to light.

12. A combination according to claim 11, wherein the front cover is arranged to extend beyond the panel perimeter.

13. A combination according to any preceding claim, adapted to be wall mounted or to be ceiling mounted.

14. A combination according to claim 13, adapted as a fitment for a suspended ceiling.

Figure 1

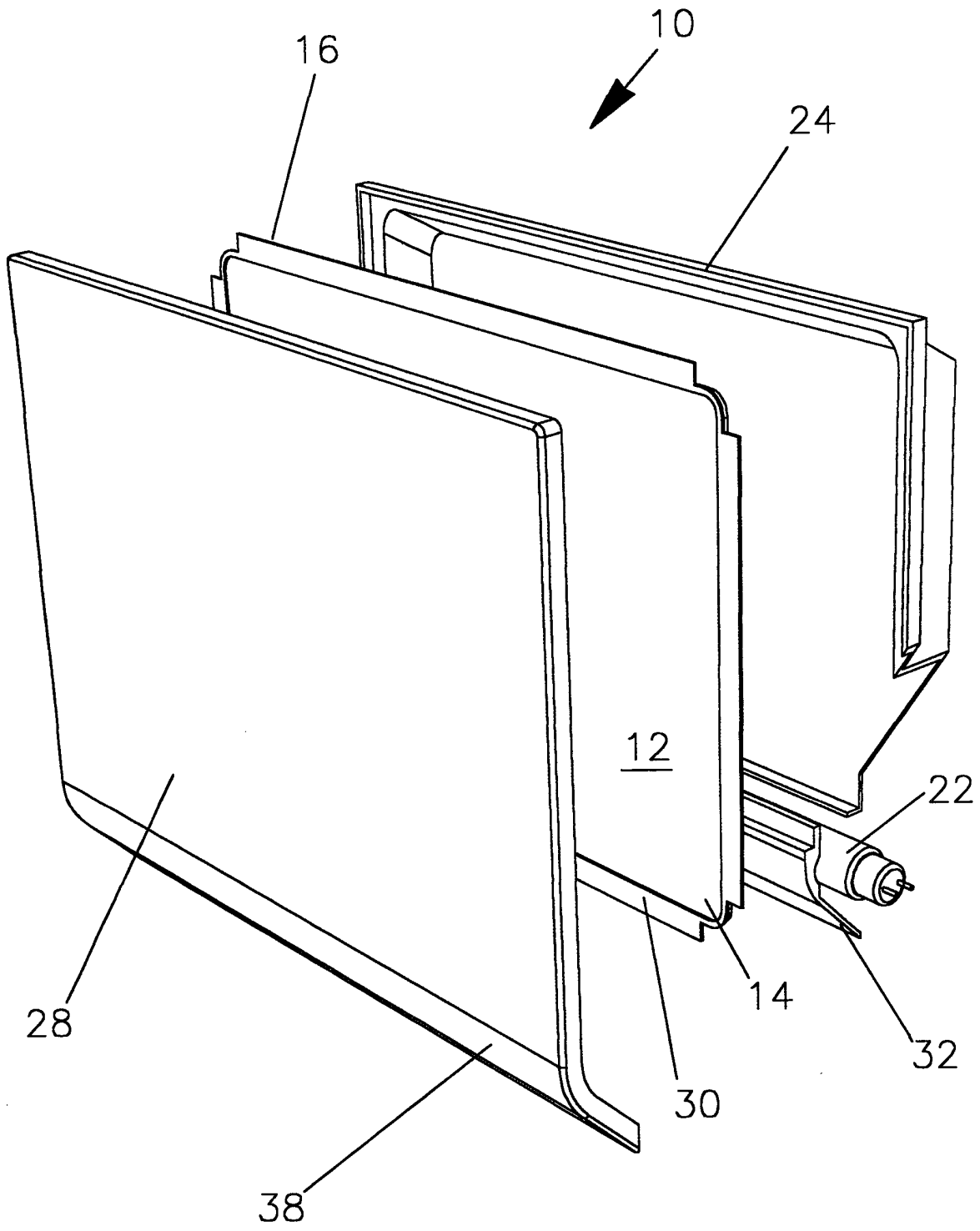


Figure 2c

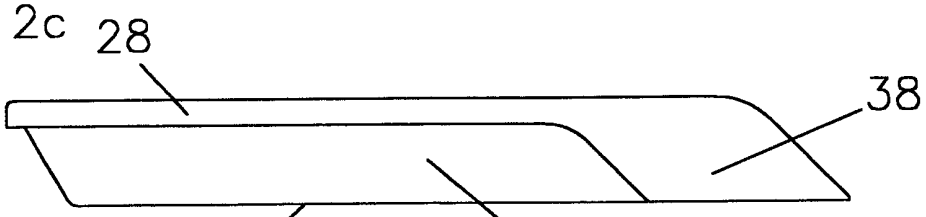


Figure 2a

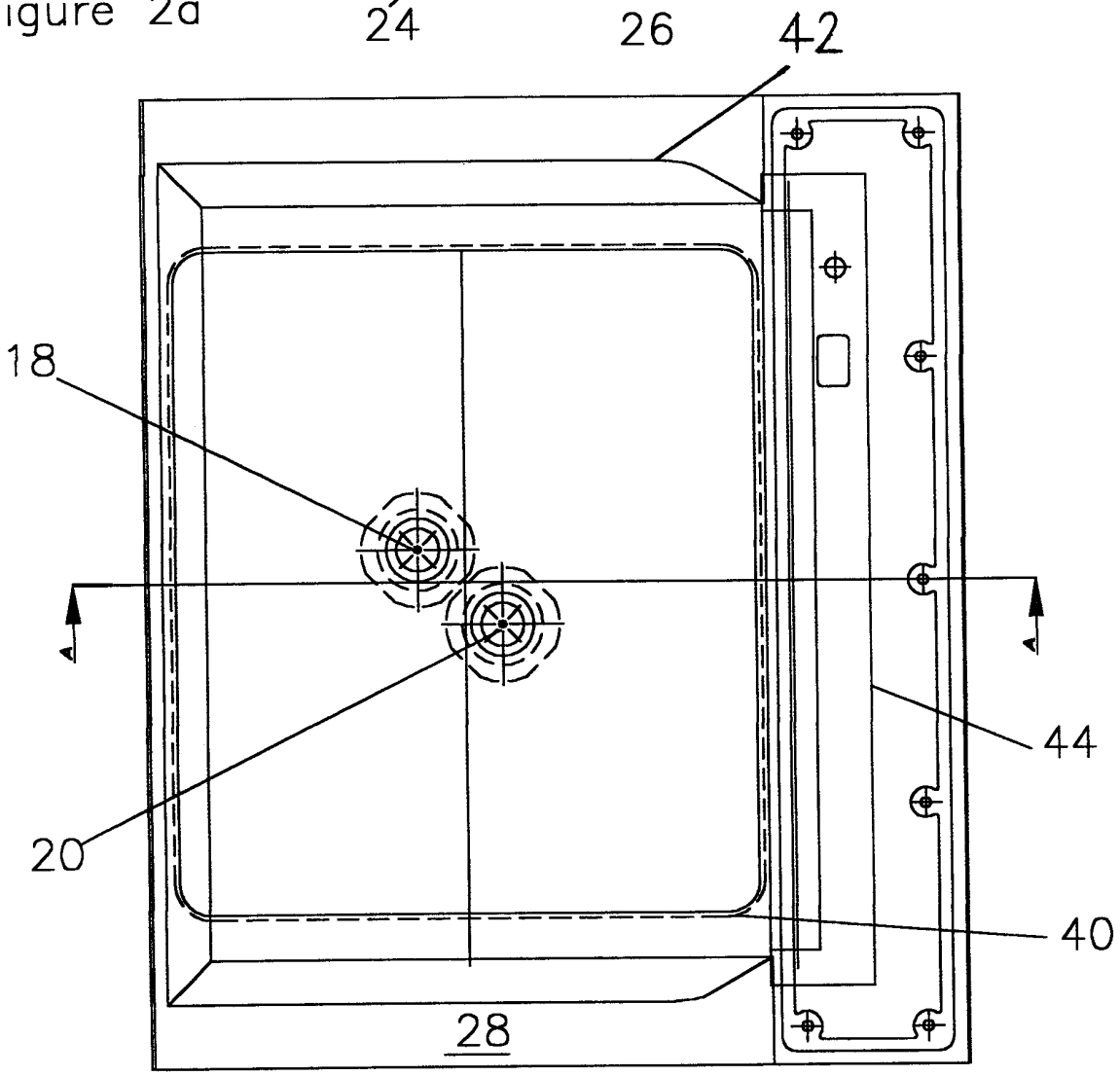


Figure 2b

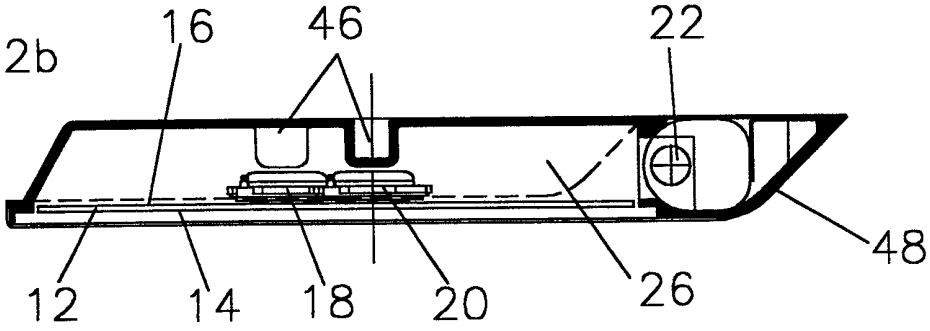


Figure 3

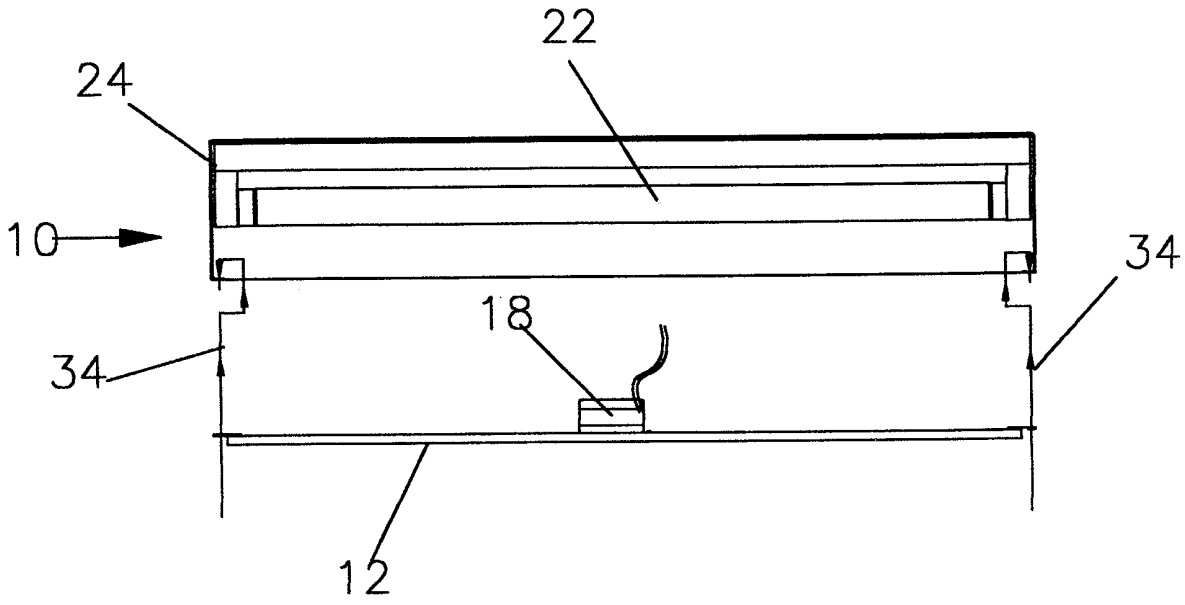


Figure 7

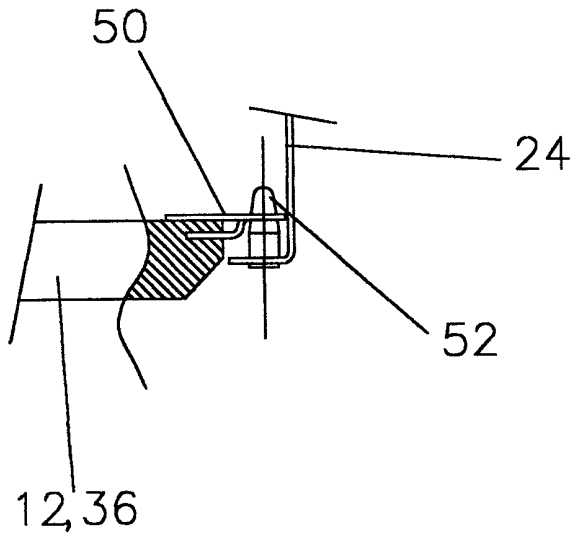


Figure 4

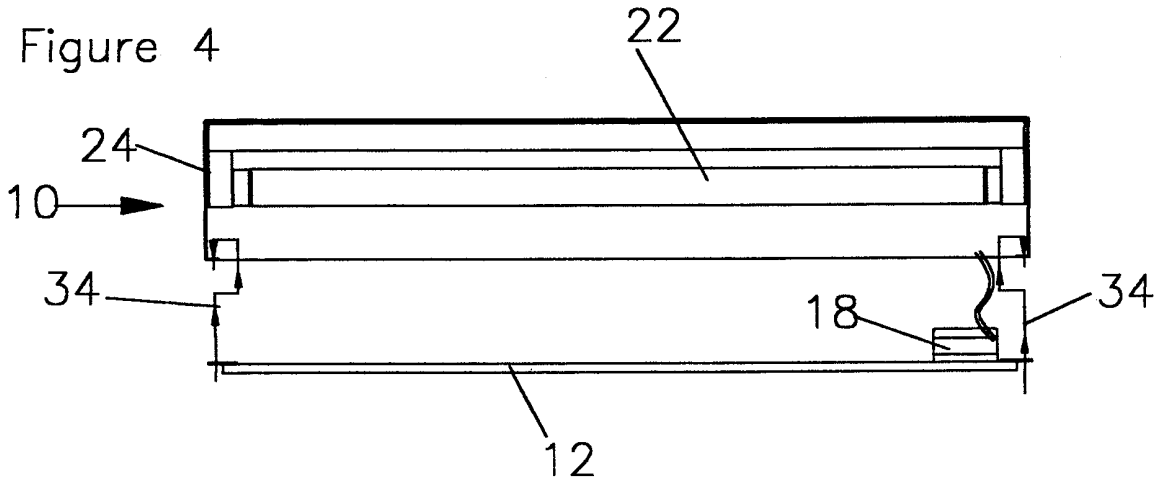


Figure 5

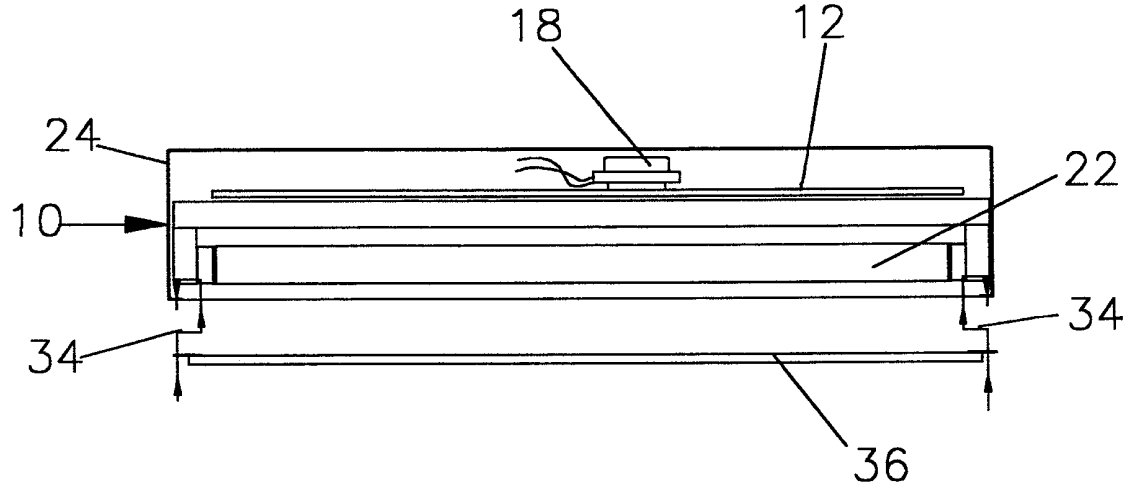
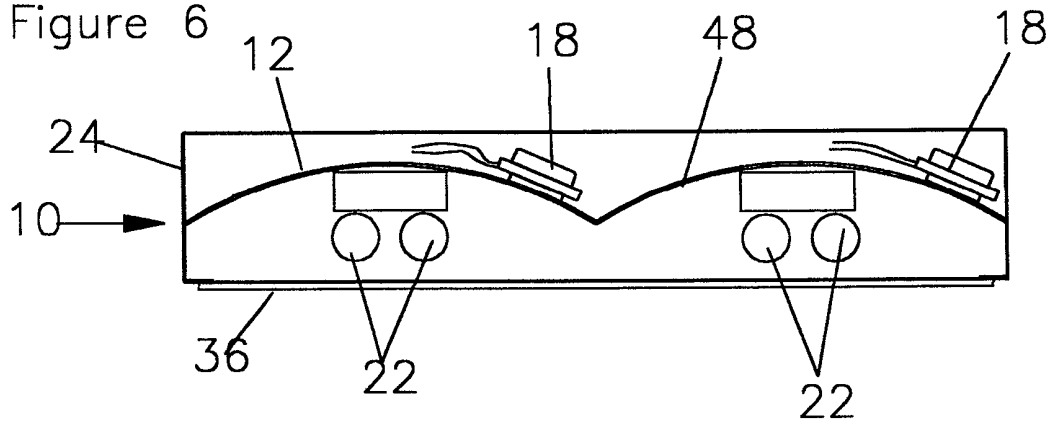


Figure 6



INTERNATIONAL SEARCH REPORT

Inter .onal Application No
PCT/GB 00/00801

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04R1/02

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 H04R

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 97 09840 A (AZIMA HENRY ;HARRIS NEIL (GB); COLLOMS MARTIN (GB); VERITY GROUP P) 13 March 1997 (1997-03-13) page 6, line 5 -page 8, line 12 page 11, line 27 -page 14, line 1; figures 2A,2B,4,5	1-3,9, 11,12
Y		4-7,10, 13,14
Y	US 4 559 584 A (KUWAHATA TOSHIKATSU ET AL) 17 December 1985 (1985-12-17) the whole document	4-7,10
Y	FR 2 649 575 A (THOMSON CONSUMER ELECTRONICS) 11 January 1991 (1991-01-11) page 2, line 23 -page 6, line 18; figures 1-6	4-7,10

-/--

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

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 June 2000	11/07/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Nieuwenhuis, P

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Inter. ɔnal Application No
PCT/GB 00/00801

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 97 09843 A (AZIMA HENRY ;HARRIS NEIL (GB); COLLOMS MARTIN (GB); VERITY GROUP P) 13 March 1997 (1997-03-13) page 6, line 8 -page 8, line 15 page 11, line 16 -page 13, line 13; figures 2A,2B,3A,3B ---	13,14
A	US 4 820 952 A (LEE KYE S) 11 April 1989 (1989-04-11) the whole document ---	1
P,X	WO 99 65274 A (NEW TRANSDUCERS LTD ;BANK GRAHAM (GB)) 16 December 1999 (1999-12-16) the whole document -----	1,3

INTERNATIONAL SEARCH REPORT

information on patent family members

Inter onal Application No
PCT/GB 00/00801

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9709840 A	13-03-1997	AT 177579 T	15-03-1999
		AT 177574 T	15-03-1999
		AT 177580 T	15-03-1999
		AT 177575 T	15-03-1999
		AT 186617 T	15-11-1999
		AT 177581 T	15-03-1999
		AT 177582 T	15-03-1999
		AT 177583 T	15-03-1999
		AT 177578 T	15-03-1999
		AT 177576 T	15-03-1999
		AT 179297 T	15-05-1999
		AT 177577 T	15-03-1999
		AT 179563 T	15-05-1999
		AT 176826 T	15-03-1999
		AT 179045 T	15-04-1999
		AT 179296 T	15-05-1999
		AT 177281 T	15-03-1999
		AT 179564 T	15-05-1999
		AT 177282 T	15-03-1999
		AT 179043 T	15-04-1999
		AT 179044 T	15-04-1999
		AU 702865 B	11-03-1999
		AU 6880196 A	27-03-1997
		AU 702920 B	11-03-1999
		AU 6880296 A	27-03-1997
		AU 702867 B	11-03-1999
		AU 6880396 A	27-03-1997
		AU 703015 B	11-03-1999
		AU 6880496 A	27-03-1997
		AU 702863 B	11-03-1999
		AU 6880596 A	27-03-1997
		AU 702873 B	11-03-1999
		AU 6880696 A	27-03-1997
		AU 702999 B	11-03-1999
		AU 6880796 A	27-03-1997
		AU 703061 B	11-03-1999
		AU 6880896 A	27-03-1997
		AU 703000 B	11-03-1999
		AU 6880996 A	27-03-1997
		AU 703071 B	11-03-1999
		AU 6881096 A	27-03-1997
		AU 703058 B	11-03-1999
		AU 6881296 A	27-03-1997
		AU 705592 B	27-05-1999
		AU 6881396 A	27-03-1997
		AU 703296 B	25-03-1999
		AU 6881496 A	27-03-1997
		AU 699890 B	17-12-1998
		AU 6881596 A	27-03-1997
		AU 703198 B	18-03-1999
US 4559584 A	17-12-1985	NONE	
FR 2649575 A	11-01-1991	NONE	
WO 9709843 A	13-03-1997	AT 177579 T	15-03-1999
		AT 177574 T	15-03-1999
		AT 177580 T	15-03-1999

INTERNATIONAL SEARCH REPORT

information on patent family members

Inter onal Application No
PCT/GB 00/00801

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9709843 A		AT 177575 T	15-03-1999
		AT 186617 T	15-11-1999
		AT 177581 T	15-03-1999
		AT 177582 T	15-03-1999
		AT 177583 T	15-03-1999
		AT 177578 T	15-03-1999
		AT 177576 T	15-03-1999
		AT 179297 T	15-05-1999
		AT 177577 T	15-03-1999
		AT 179563 T	15-05-1999
		AT 176826 T	15-03-1999
		AT 179045 T	15-04-1999
		AT 179296 T	15-05-1999
		AT 177281 T	15-03-1999
		AT 179564 T	15-05-1999
		AT 177282 T	15-03-1999
		AT 179043 T	15-04-1999
		AT 179044 T	15-04-1999
		AU 702865 B	11-03-1999
		AU 6880196 A	27-03-1997
		AU 702920 B	11-03-1999
		AU 6880296 A	27-03-1997
		AU 702867 B	11-03-1999
		AU 6880396 A	27-03-1997
		AU 703015 B	11-03-1999
		AU 6880496 A	27-03-1997
		AU 702863 B	11-03-1999
		AU 6880596 A	27-03-1997
		AU 702873 B	11-03-1999
		AU 6880696 A	27-03-1997
		AU 702999 B	11-03-1999
		AU 6880796 A	27-03-1997
		AU 703061 B	11-03-1999
		AU 6880896 A	27-03-1997
		AU 703000 B	11-03-1999
		AU 6880996 A	27-03-1997
		AU 703071 B	11-03-1999
		AU 6881096 A	27-03-1997
		AU 703058 B	11-03-1999
		AU 6881296 A	27-03-1997
		AU 705592 B	27-05-1999
		AU 6881396 A	27-03-1997
		AU 703296 B	25-03-1999
		AU 6881496 A	27-03-1997
		AU 699890 B	17-12-1998
		AU 6881596 A	27-03-1997
		AU 703198 B	18-03-1999
US 4820952 A	11-04-1989	DE 3731132 A	24-03-1988
WO 9965274 A	16-12-1999	AU 4156999 A	30-12-1999