(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 641 142 A1**

(12) **EUROPEAN PATENT APPLICATION**

(21) Application number : **94304380.2**

(22) Date of filing : **16.06.94**

(51) Int. Cl.^{6} : **H04R 1/28,** H04R 1/26, H04R 3/14

(30) Priority : **27.08.93 GB 9317850**

(43) Date of publication of application : **01.03.95 Bulletin 95/09**

(84) Designated Contracting States : **DE DK ES FR GB IT**

(71) Applicant : **BRITISH BROADCASTING CORPORATION**
Broadcasting House
London W1A 1AA (GB)

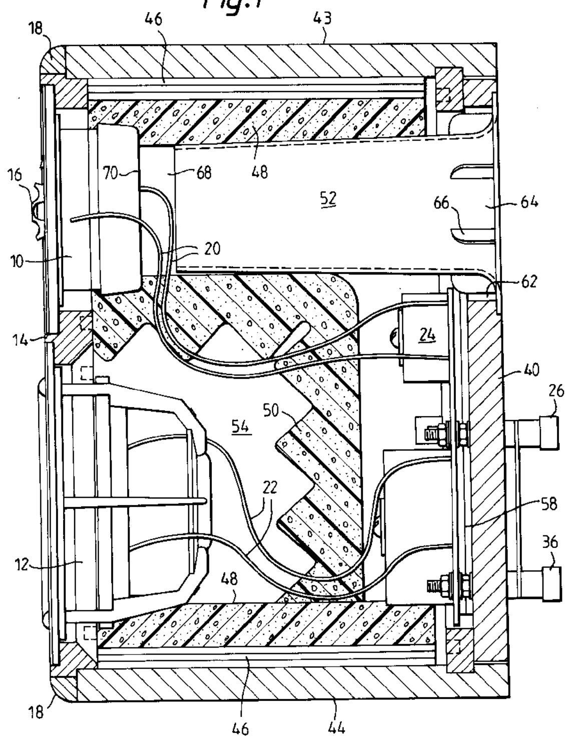
(72) Inventor : **Whitehead, Graham**
268A, Kinghill Avenue
Hayes, Middlesex, UB4 8BY (GB)

(74) Representative : **Lloyd, Patrick Alexander Desmond**
Reddie & Grose
16 Theobalds Road
London WC1X 8PL (GB)

(54) **Vented enclosure loudspeakers.**

(57) A loudspeaker assembly comprises a cabinet having top, bottom and side walls, a rear wall and a front baffle. A tweeter (10) and woofer (12) are mounted on the front baffle and connected to a crossover and filter unit. A flared vent pipe (64) is mounted in a port (62) in the rear wall extending into the cabinet. The vent pipe is coaxial with the tweeter and spaced from the tweeter such that the air gap (68) between the pipe and tweeter behaves as if it were a part of the vent pipe, increasing the acoustic length of the pipe, improving the low-frequency response of the assembly and reducing port noise.

Fig.1



EP 0 641 142 A1

This invention relates to loudspeakers and in particular to vented enclosure loudspeakers having a vent pipe.

Vented enclosure loudspeakers are well known. It is fundamental to baffle loudspeakers to prevent sound energy radiating from the rear of the loudspeaker to interfere destructively with the sound energy radiating from the front of the loudspeaker, particularly at lower frequencies. The baffle also provides a passive radiating surface in addition to the loudspeaker. Many loudspeakers are mounted in completely closed enclosures which attempt to provide an infinite baffle and provide a finite air volume behind the loudspeaker. Vented enclosure loudspeakers known as Bass-reflex or Helmholtz resonators include a port in the enclosure. The size and spacing port is chosen, in combination with the size of the enclosure and the resonance of the loudspeaker to delay the rear wave-front from the loudspeaker so that it interferes constructively with the forward wave-front, broadening and reinforcing the low-frequency response.

It is also well known to use a vent pipe rather than a simple vent aperture to increase low-frequency response. The vent pipe, which extends into the enclosure, acts as an inductor, having a considerably greater inductance than a vent opening of the same diameter. This enables the volume of the enclosure, or cabinet to be reduced whilst maintaining the low-frequency response.

Reduction in cabinet size is of particular importance to the Hi-fi industry as loudspeaker cabinets with good low-frequency responses are large items. As most loudspeakers are used in the domestic environment, cabinet size is often an important consideration when purchasing loudspeakers.

There exists, therefore, a need to produce a loudspeaker which has a small cabinet but which does not sacrifice low-frequency response.

We have appreciated that under some circumstances a vent pipe behaves as if it is longer than its actual physical length. The invention resides in this realisation and its incorporation into a loudspeaker.

More specifically, the invention is defined in the independent claim to which reference should be made.

A loudspeaker embodying the invention has the advantage that a low-frequency response may be obtained for a given cabinet size that hitherto was only obtainable from a larger cabinet size.

Preferred and advantageous features of the invention are set out in the dependent claims.

A second aspect of the invention provides a mesh grille for a high frequency loudspeaker, or tweeter. We have appreciated that such a grille performs the physical function of protecting the tweeter, and the acoustical function of diffusing the high frequency sound to achieve an improved acoustic distribution.

A preferred embodiment of the invention will now be described, with reference to the accompanying drawings, in which:

Figure 1 is a sectional view of a loudspeaker embodying the invention;

Figure 2 is a sectional view of the baffle assembly and cabinet of figure 1;

Figure 3 is a sectional view of the rear panel of figure 1 with the vent pipe in position;

Figure 4 is a front view of the outer face of the rear panel;

Figure 5 is a front view of the front baffle;

Figure 6 is a front view of a first tweeter grille;

Figure 6a is a front view of a second preferred tweeter grille;

Figure 7 shows the connectors on the rear panel of figure 4; and

Figure 8a and 8b are, respectively high frequency and low frequency crossover unit circuit diagrams.

The loudspeaker assembly of figure 1 is a Helmholtz base-reflex resonator comprising a high frequency loudspeaker or tweeter 10 and a low frequency loudspeaker or woofer 12.

The tweeter and woofer may be standard commercially available units such as DYNAUDIO Types 260 and 15W75-08 manufactured by Dynaudio A/S of Denmark. The tweeter 10 and woofer 12 are mounted on a front baffle 14 shown more clearly in figure 5. The tweeter is protected by a grille 16 which, as can be seen from figure 6 has a solid annular outer section 15 and a foraminous dome-shaped central portion 17. A second, preferred tweeter grille is shown in figure 6a. The edges of the holes of the central portion are rounded. The grille 16 protects the tweeter from accidental damage and acts to diffuse the high frequency sounds from the tweeter. As the ratio of wavelength of radiated sound to tweeter diameter is low compared to low-frequency sounds produced by the woofer 12, the tweeter tends to produce a very directional radiation pattern. The grille 16 acts to produce a more diffuse sound pattern.

The edges 18 of the front baffle 14 are rounded to reduce diffraction effects which can be caused by sharp edges. Although the top and bottom edges are only visible in the figures, the side edges are similarly rounded.

The tweeter 10 and woofer 12 are each connected by a pair of wires 20,22 to a crossover and filter unit 24. The high frequency unit of the crossover and filter is illustrated in figure 9 and comprises positive and negative input terminals 26,28 and output terminals 30,32 to the tweeter 10. First, second and third capacitances C_1, C_2 and C_3 are arranged in series on the positive line. Typical capacitances are C_1: 2.2µf ; C_2 : 8.2µf and C_3 2.2µ f. An inductor L_1 is arranged between the positive and negative lines and has a typical inductance L_1 = 250µH. A first resistance R_1 =

10.Ω is arranged in parallel with capacitor C_3 and a second resistance R_2 = 10Ω is arranged at the output of R_1/C_3 across the positive and negative lines. The value of R_2 depends on the balance between the woofer and tweeter and is typically between 8Ω and 18Ω.

The low frequency unit comprises a second inductor L_2 arranged in parallel with a third resistor R_3 between input 34 and output 36 on the positive line. Inductor L_2 has a typical inductance of 2.7mH and resistor R_3 a resistance of 12Ω. A capacitor C_3 of 2.2μf is arranged across the outputs to the woofer 12. The crossover and filter units are conventional and do not form a part of the invention. The input terminals from two units are arranged on the outside of the rear panel 40 of the cabinet with shorting links 42 connecting positive to positive and negative to negative.

Inside the cabinet, the top 43, sides, not shown, and bottom 44 are lined with three layers of sound deadening pads 46. A layer of acoustic foam 48 is arranged inside the sound deadening pad layer and a second layer of sculptured foam 50 is arranged between the woofer 12 and tweeter 10 to define two cavities 52, 54 best seen from figure 2.

The rear panel 40 has two layers of sound deadening pads 58 on its inside surface and is mounted on a rear frame assembly 60 which is glued in place in the cabinet walls as seen most clearly from figure 2. The rear panel includes a port 62 which is a circular opening of diameter approximately 60mm. A flared vent pipe 64 is mounted in the port extends inwards as shown. The vent pipe is a generally cylindrical tube which flares at its outer end and has a series of fins 66 on its outer surface at its outer end. When in position the gaps between the fins are filled with a suitable inert filter such as ISOPON P38.

The vent pipe is itself known and available through Dynaudio A/S as part no: ARG 255019. The vent pipe which is tapered along its length and flared at the outer end has a typical length of 145 mm and diameter of 60 mm. The cabinet illustrated has external dimensions of approximately 300 X 200 X 180 mm, considerably smaller than that for which the vent pipe is intended.

The arrangement of the vent pipe is crucial to the performance of the loudspeaker assembly. The pipe acts as an 'inductor' to tune in resonance with the 'capacitance' of air within the cabinet, driven by the woofer diaphragm. The acoustical length of the pipe is normally taken to be the actual pipe length, plus a correction at each end proportional to the radius of the pipe.

Normally, to vent a cabinet of this size to a low frequency, it would be expected to use a long, or a narrow pipe, in order to achieve a high inductance to resonate with the low cabinet capacitance. This pipe would have a high resistance to airflow, and would be prone to audible turbulent effects at high powers. This embodiment uses a large diameter vent for the cabinet size, but generates less of these undesirable effects.

As can be seen from Figure 1, the vent pipe 64 is coaxial with the tweeter 10 and arranged relative to the tweeter such that the air between the tweeter and the end of the pipe is coupled to the pipe. This has the effect of causing the pipe to behave acoustically as if it were a pipe of greater length.

The increase in effective length in the pipe is due to aerodynamic effects between the pipe and the tweeter body. Repositioning the pipe away from or out of alignment with the tweeter does not result in the extra effective port length. The relative spacings of the vent pipe and the rear of the tweeter body are such that the airflow to and from the end of the pipe is linearised as it passes the tweeter. In the embodiment shown, the volume of air between the tweeter and the physical end of the pipe is approximately the same as the normal end correction volume which would be made. The end-correction to be added to the actual pipe length is extended to include not only a portion of the volume of air around the end of the vent as is common practice, but also a portion of the volume of air around the rear of the tweeter body. By this means, the end correction to be added to the inner end of the vent is in the order of twice that which would otherwise be added.

A natural effect of the linearising of airflow is a further reduction of turbulent noise around the inner end of the vent.

It will be appreciated that the dimensions and spacings are empirical. However, the given tweeter and vent pipe may be arranged such that the pipe has an effective length greater than its physical length and the low frequency response of the assembly is enhanced without the detrimental effects of increased turbulent noise.

A long pipe within a vented cabinet may also be expected to suffer from 'organ pipe resonances' or standing waves within the length of the pipe. The sculptured acoustic foam 50 is arranged within the cabinet such that frequencies which may excite these modes are damped before they reach the vent. The thickness and density of the foam are such that the low Helmholtz frequencies are unaffected.

Claims

1. A loudspeaker assembly comprising a tweeter and a woofer mounted in a vented cabinet, and a vent pipe extending from a port in the cabinet into the cabinet, the vent pipe being arranged with respect to the rear of the tweeter such that the effective acoustical length of the vent pipe is greater than its physical length.

2. A loudspeaker assembly according to claim 1,

wherein the vent pipe is aligned with the tweeter.

3. A loudspeaker assembly according to claim 2, wherein the vent pipe is coaxial with the tweeter.

4. A loudspeaker assembly according to claim 1, 2 or 3, wherein the distance between the innermost end of the vent pipe and the rear of the tweeter is a fraction of the diameter of the vent pipe.

5. A loudspeaker assembly according to any of claims 1 to 4, wherein the cross-sectional area of the innermost end of the vent pipe is approximately half the cross-sectional area of the rear of the tweeter.

6. A loudspeaker assembly according to any preceding claim, wherein the port is in the rear face of the cabinet opposite the tweeter.

7. A loudspeaker assembly according to any preceding claim, comprising a foraminous grille arranged over the front of the tweeter.

8. A loudspeaker assembly according to claim 6, wherein the grille comprises a solid outer annulus and a domed foraminous central portion.

9. A loudspeaker assembly according to any preceding claim, wherein acoustic foam is arranged in the cabinet to reduce standing waves within the vent pipe.

Fig.1

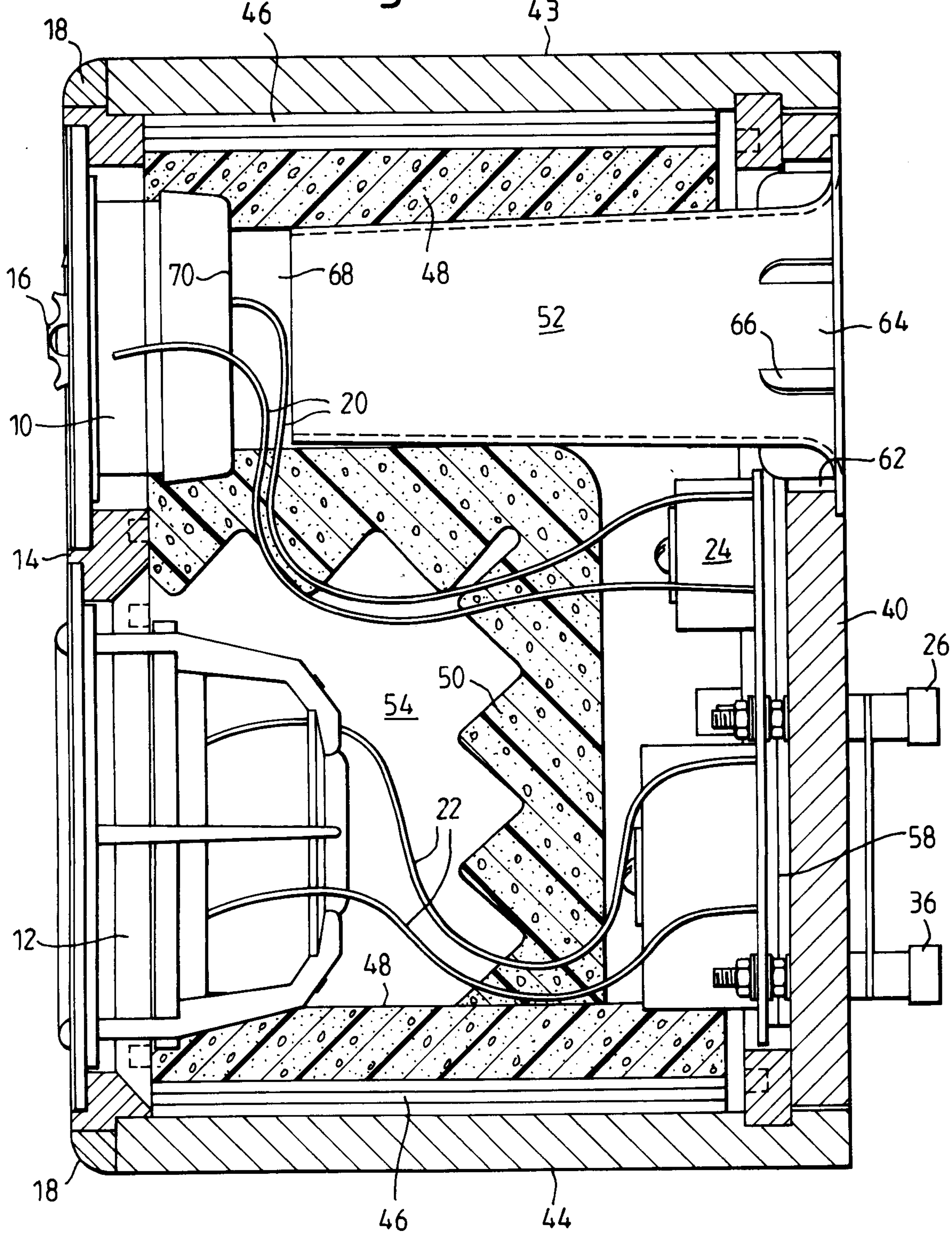

18
46
43
16
70
68
48
52
66
64
20
10
62
14
24
40
26
50
54
58
22
36
12
48
18
46
44

Fig. 2

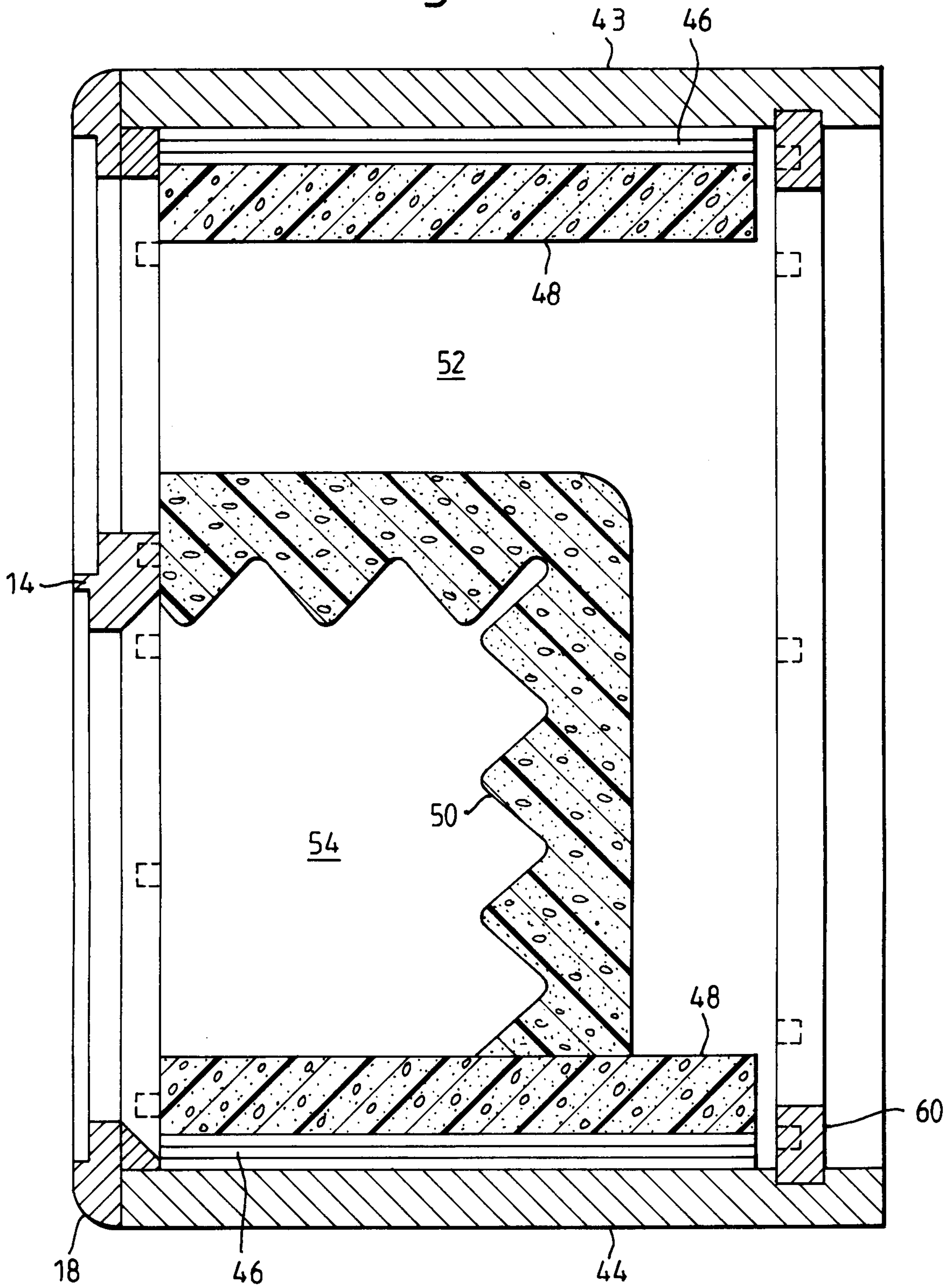


Fig. 3

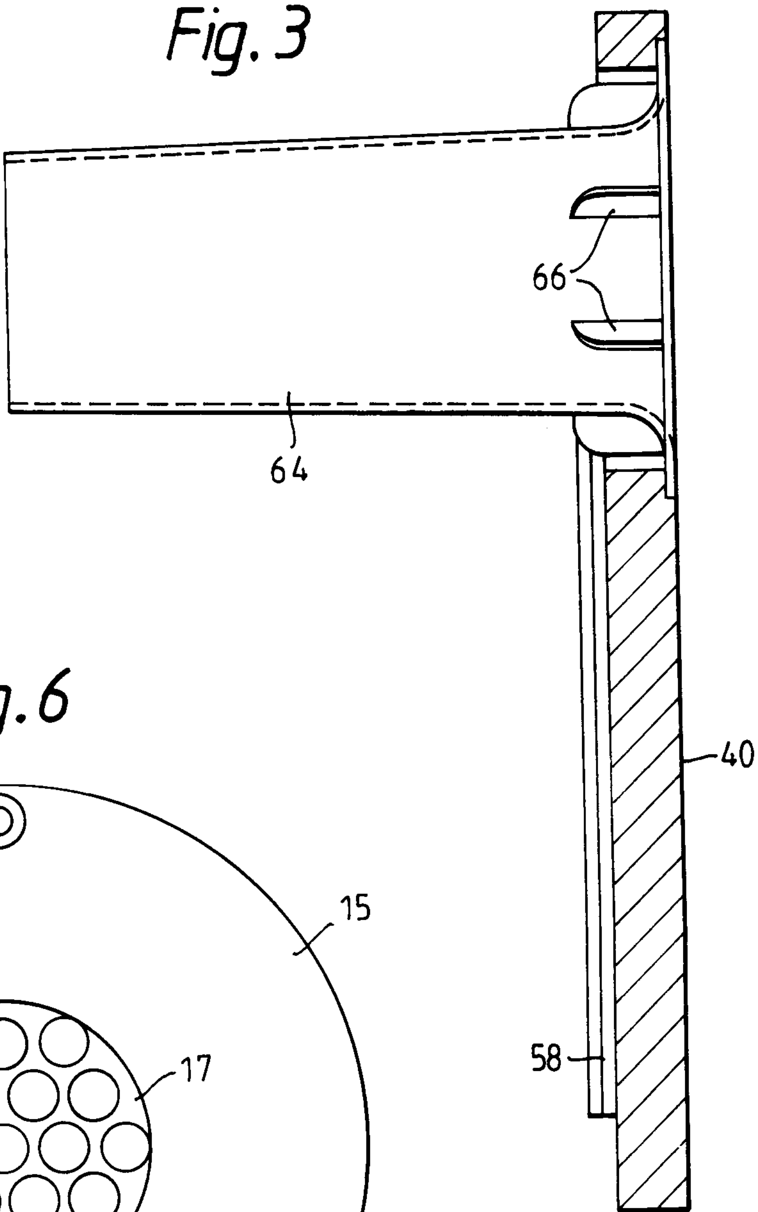


Fig. 6

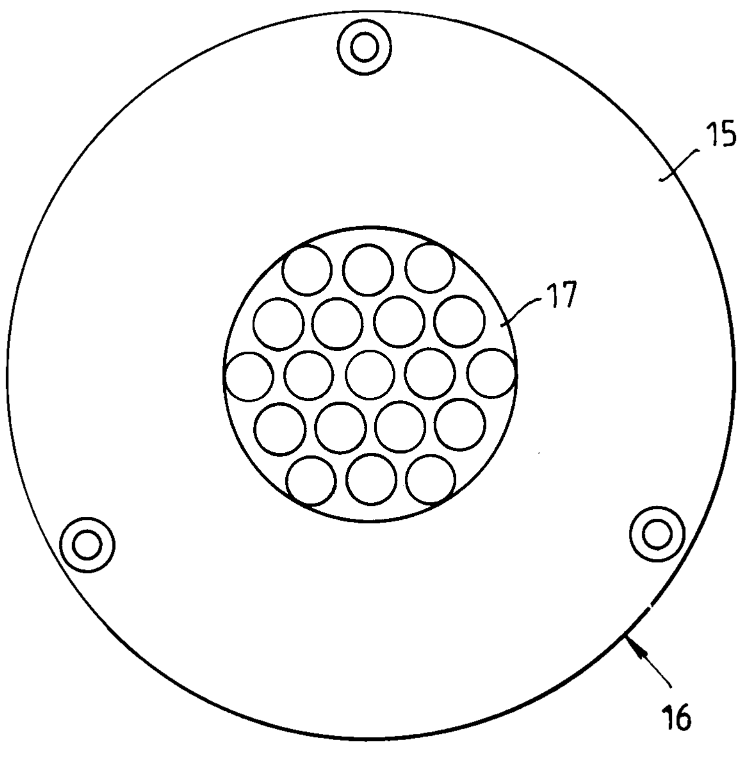


Fig. 4

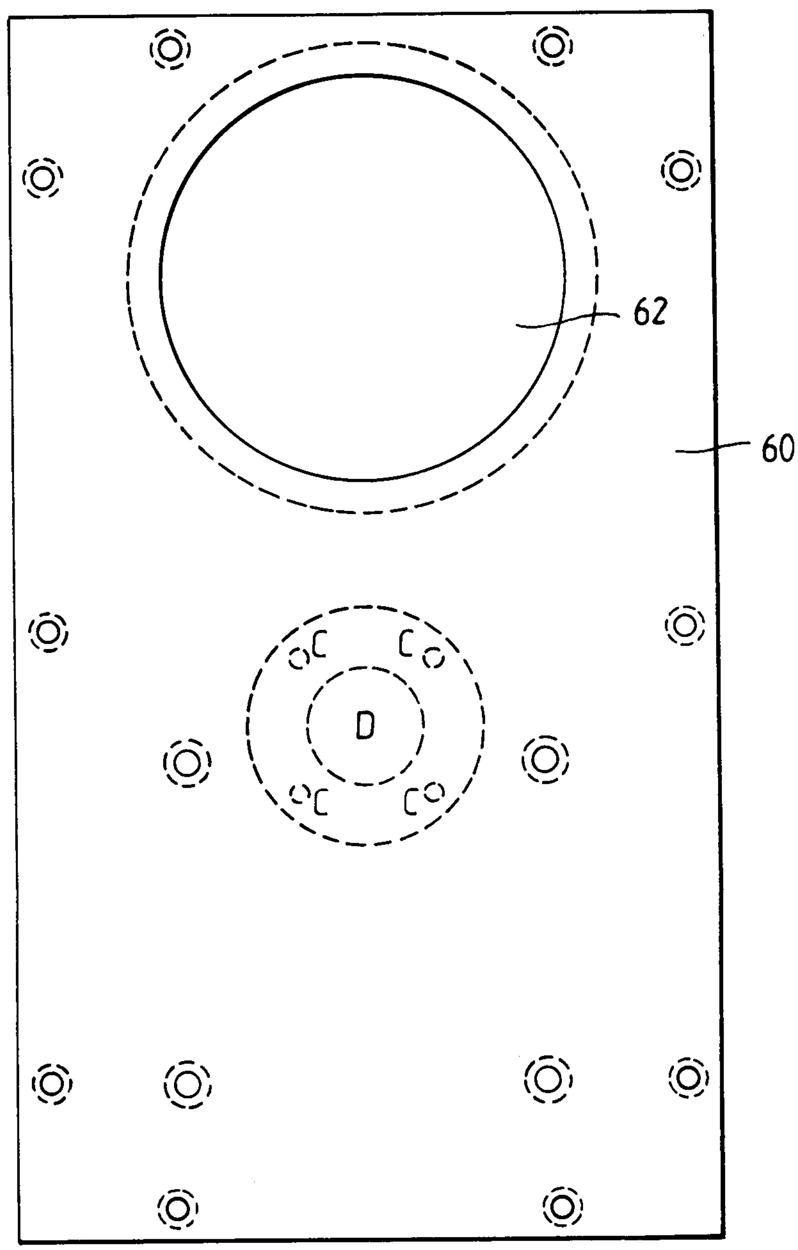


Fig. 5

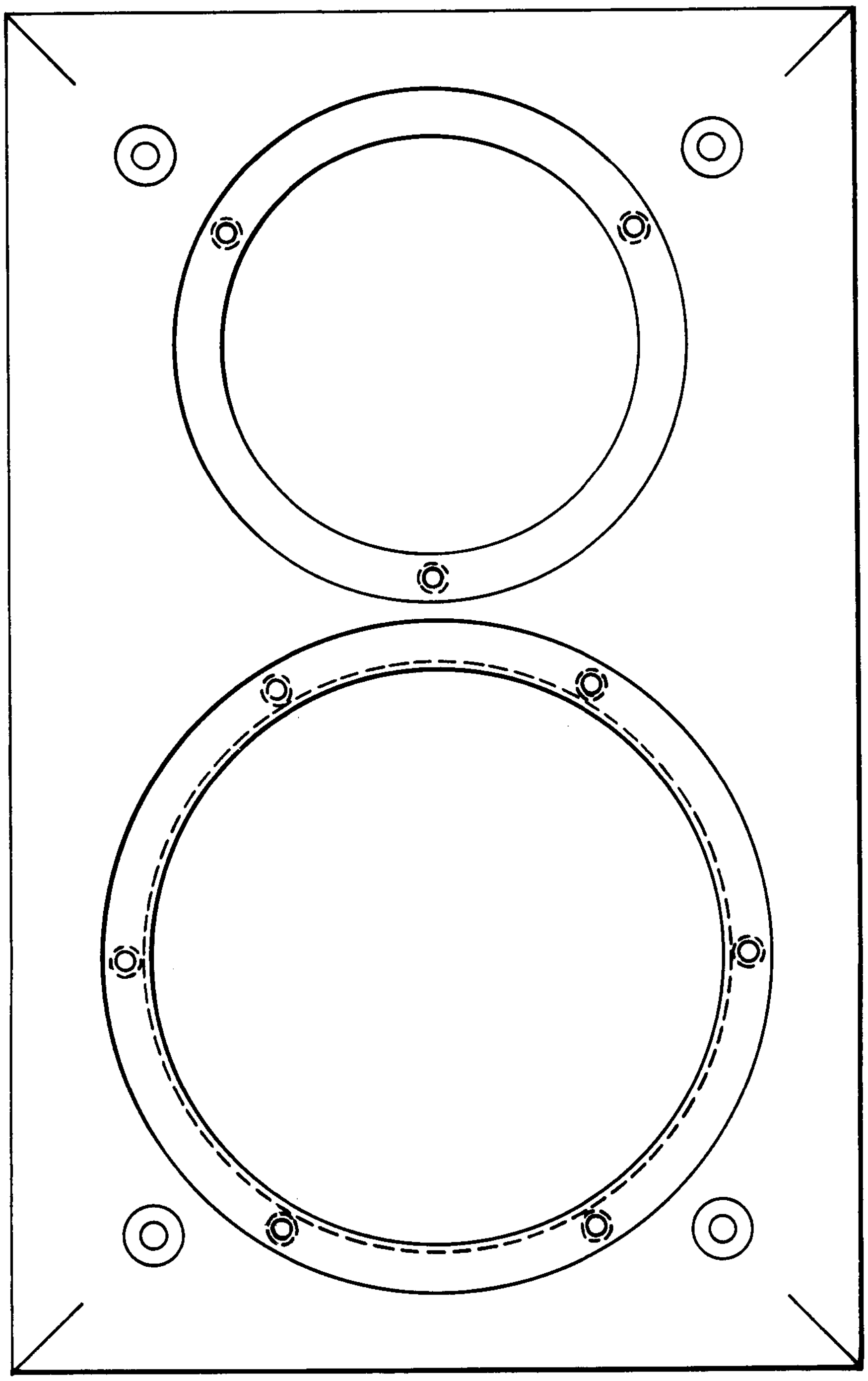


Fig.6A

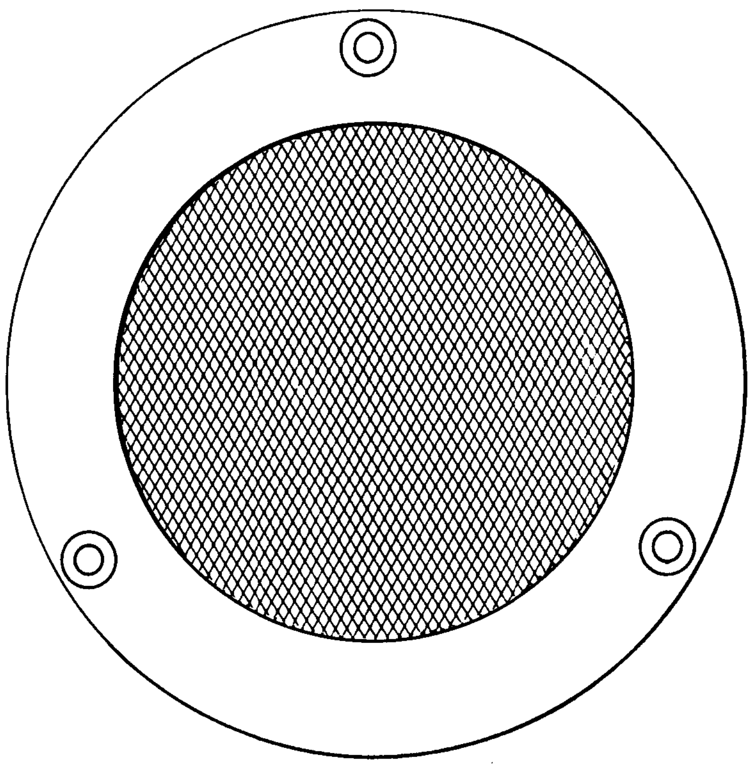


Fig 7

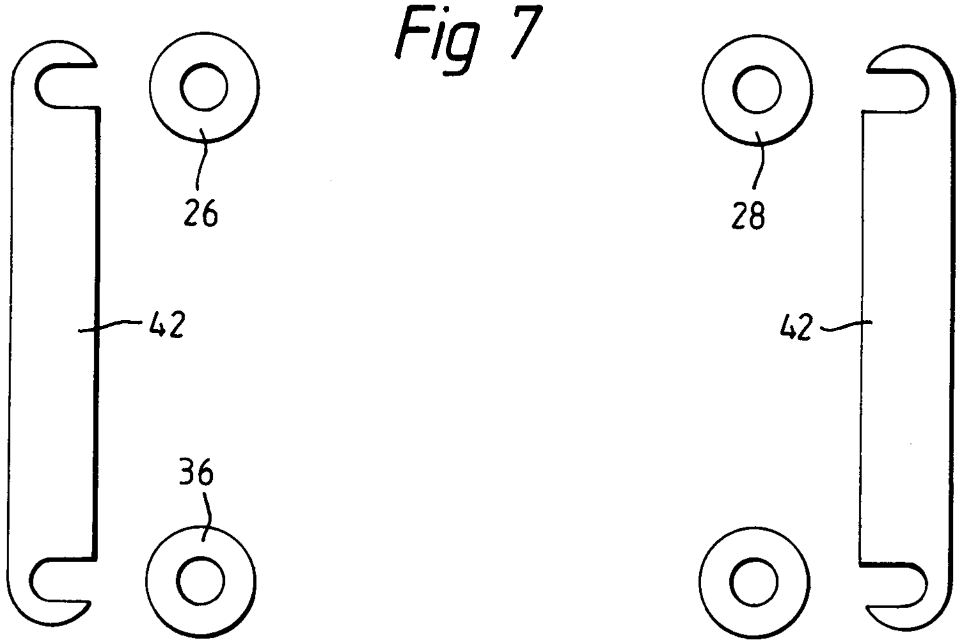


Fig. 8a

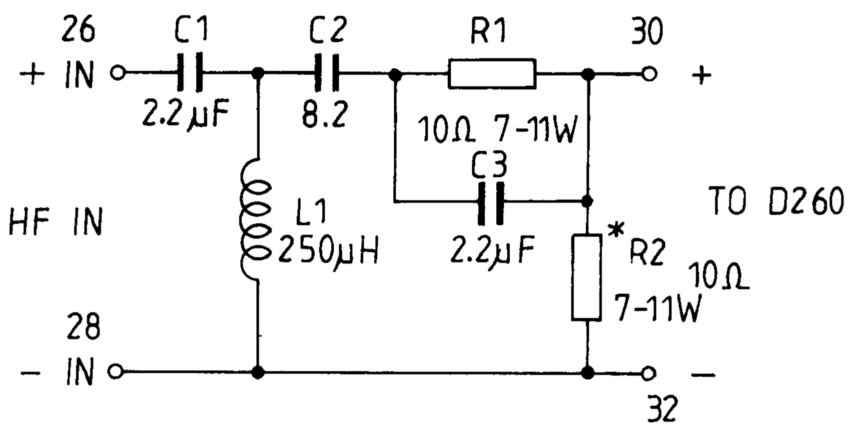
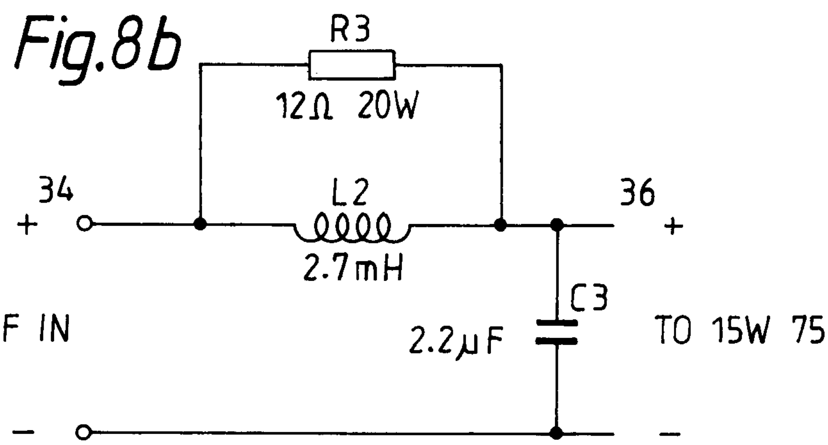


Fig.8b



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 30 4380

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	PATENT ABSTRACTS OF JAPAN vol. 016, no. 079 (E-1171) 26 February 1992 & JP-A-03 267 899 (NEC HOME ELECTRON LTD) * abstract *	1	H04R1/28 H04R1/26 H04R3/14
A	US-A-4 635 748 (PAULSON) * column 2, line 15 - line 51; figure 1 *	1-3	
A	US-A-3 952 159 (SCHOTT) * column 4, line 15 - column 5, line 22; figures *	1,4,6	
A	GB-A-2 049 351 (SHAUN) * page 1, line 76 - line 125; figure 1 *	1,9	
A	US-A-4 131 179 (POPE) * column 2, line 12 - line 35; figure 1 *	1,7,8	
P,A	EP-A-0 565 369 (CELESTION INTERNATIONAL) * page 2, column 2, line 11 - page 3, column 3, line 32; claim 1 *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6): H04R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 December 1994	Gastaldi, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)