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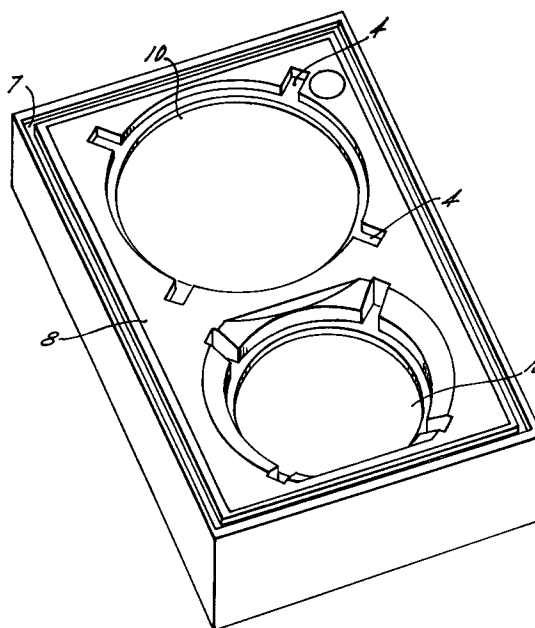
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**AT BE CH DE DK ES FR GB GR IE IT LI LU MC
NL PT SE**(71) Applicant: **HARDIGG INDUSTRIES, INC.**
393 North Main Street
South Deerfield
Massachusetts 01373 (US)(72) Inventor: **Von Kries, Karl**
29 Pleasant, 2
Northampton, Massachusetts 01060 (US)

Inventor: **Steel, Arthur G.**
114 Old Amherst Road
Sunderland, Massachusetts 01375 (US)
Inventor: **Aponte, René R.**
55 Empire Street, Unit 75
Chicopee, Massachusetts 01013 (US)
Inventor: **Turk, Joel K.**
170 Rt. 2
Shelburne Falls, Massachusetts 01370 (US)

(74) Representative: **Freylinger, Ernest T.**
Office de Brevets
Ernest T. Freylinger
321, route d'Arlon
Boîte Postale 48
L-8001 Strassen (LU)(54) **Rotomolded speaker enclosure.**

(57) A rotomolded speaker enclosure system which functions both as an acoustically accurate speaker box and an integral part of a waterproof and virtually shock proof transport combination wherein at least two speaker boxes are locked together along a water-tight seal. The speaker motors in the combination are facing one another to avoid damage. Moreover, the rotomolded speaker enclosure provides recessed speaker mountings so that speakers are protected from flat impact while in operation.

*FIG. 1***EP 0 669 783 A1**

Background of the Invention:

Field of the Invention

This invention relates to the field of acoustic speakers and more particularly to speaker enclosures or cabinets.

Prior Art

Speaker enclosures have traditionally been made from several individual pieces to form an enclosure of varying dimensions and shapes. Plywood, particle board and chip board are among the standard materials used. Other materials, less frequently used include metal and plastic. Where metal is used it is usually aluminium which has been milled into a square or rectangular shape with one face open (i.e., five sides are made up of the milled out aluminum and the sixth side is the access for the milling machine and the hole where a speaker and grill would be positioned). Plastic is generally glued or otherwise fastened together to create a similar five sided cuboid enclosure with the sixth side being open for mounting of speakers and grills. Whatever the material, a substantial amount of labor in assembly time is required to build the five sides of a cabinet. After the cabinet is constructed, speakers are mounted in holes on a face plate and the face plate fastened to the enclosure. The speaker sits against the face plate and is clipped thereon. Clips are generally fastened to the face plate using screws or the like. Clips generally have a raised portion to trap the speaker rim against the face plate, thus holding it in place.

Prior to the invention described herein, the standard in the industry has been to create large box dimensions for resonant sound. Industry standard is approximately 18-24 inches in depth. More recent technology has included the use of ports to enhance sound quality.

Those of skill in the industry have believed that the particular construction of audio speakers, as set forth above, produced better sound quality. Heavy enclosures allegedly reduced vibration and deep chambers provided for superior resonance.

Concomitant to the structural parameters of the traditional speakers are drawbacks stemming directly from those features which were thought to benefit the sound quality. Traditional bass enclosures and tunings hold as their design goal, accurate reproduction of what is known in the art as an "equal energy per octave response" through the bass (20HZ-500HZ) frequencies; this is also known as a "flat" response. As far as linear energy propagation or output SPL (sound pressure levels) are concerned, the traditional speakers approach accuracy, however, this bass energy is not usable musi-

cally, for the following reasons; it typically has no useable apparent pitch below 160HZ (the box tuning adds its own resonant note which is louder than the fundamental note creating a drone masking the fundamental pitch of the input source). In effect, by using the traditional enclosure, a non-musical chordal speaker response with a constant drone has been created. This chordant effect is magnified by low level woofer oscillations and distortions created by air turbulence effects within the box itself. These distortions also cause the impedance of the woofer to vary dramatically, which correspondingly causes a demand for more amplifier drive power at the oscillation points. This also causes significant drawbacks mechanically and electrically; and, by extension, severe acoustic nonlinearities are experienced as well. Tuning byproducts inherent in traditional speaker design are in large part responsible for the current emphasis on very heavy, stiff woofer cone construction materials (graphite, carbon fiber, Kevlar cone treatments) in an attempt to negate the mentioned problems; clearly a treatment of the symptom, not the problem.

Another disadvantage of traditional speaker manufacture is related to economic considerations. Because speaker shell components are cut to many different off-sizes a substantial amount of plywood must be used with a significant amount of waste. The wasted plywood generally cannot be used and so is an unrecoverable expense. The method also requires a large amount of labor. Moreover, wood is moisture sensitive and can be seriously compromised by a moist environment. This not only adversely affects the durability of speaker but is detrimental to sound quality. Prior art techniques such as painting and plastic lamination have been used to combat the moisture problem but are only relatively effective and add to production costs.

Summary of the Invention:

The above-discussed and other drawbacks and deficiencies of the prior art are overcome or alleviated by the Rotomolded speaker enclosure of the present invention. Basic rotomolded enclosures of the type contemplated herein are described in commonly assigned U.S. Patent No. 4,284,202 which is incorporated herein by reference.

One piece rotomolded speaker enclosures are made in a single molding operation requiring very little labor. Plastic material is merely placed in a mold of predetermined dimensions and the rotomolding process is begun. Rotomolding utilizes all material placed in the mold so that no waste is created. Moreover, as is known to the art, plastic is virtually impervious to water and resistant to many chemicals.

Another important feature associated with Rotomolding speaker boxes is that the rotomolding process inherently creates thicker corners and edges which advantageously provides for greater impact strength in these critical regions.

It has also been discovered that sound quality may be enhanced while at the same time reducing the size of virtually every parameter of traditional speaker construction. Much smaller part dimensions, and lengths, more shallow cabinet depth, very small compression chambers, etc. combine with the rotomolded shell to produce better sound. The combination of different parameters and materials creates a small, efficient air pump or lung analog having advantages over conventional speakers such as: more accurate fundamental pitch reproduction, smooth response, deeper octaves of usable response and excellent reproduction of very hard-to-capture input sources (e.g., upright base).

Another feature of the present invention is that the speaker grills are mounted in recesses over the speaker horns so that the enclosure will be the primary source of speaker motor protection and the grill only secondary thereto.

The above-discussed and other features and advantages of the present invention will be appreciated and understood by those skilled in the art from the following detailed description and drawings.

Brief Description of the Drawings:

Referring now to the drawings wherein like elements are numbered alike in the several FIGURES:

FIGURE 1 is a perspective view of the invention showing one recessed speaker well and another speaker well with integral horn;

FIGURE 2 is a cross-sectional view of the un-separated invention showing two speaker wells opposed to each other immediately after rotomolding;

FIGURE 3 is a cross-sectional view of a speaker enclosure with provision for integral horn;

FIGURE 4 is a cross-sectional special speaker, for use with the rotomolded enclosure of the invention which has a waveguide-dust cap arrangement;

FIGURE 5 is a plan view of FIGURE 4;

FIGURE 6A is a depiction of a prior art speaker mounting plate;

FIGURE 6B is a cross section of FIGURE 6A;

FIGURE 6C is a depiction of a prior art horn in a speaker mounting plate;

FIGURE 6D is a cross section of FIGURE 6C;

FIGURE 7A is a perspective view of a molded horn integral with the mounting plate;

FIGURE 7B is a cross sectional view of FIGURE 7A;

FIGURE 7C is a perspective view of speaker in a recessed speaker well of the invention;

FIGURE 7D is a cross sectional view of FIGURE 7C; and

FIGURE 8 is a perspective view of speakers in the rotomolded cabinet with four ports shown, FIGURE 8a is a cross sectional blown-up view of a tapered port.

FIGURE 8b is a cross sectional blown-up view of a cylindrical non-tapered port.

FIGURE 8c is a plan view of a tapered port of the invention.

FIGURE 9 is a perspective view of a wave guide of the invention.

FIGURE 9a is an end view of a wave guide of the invention.

FIGURE 10 is a perspective view of a speaker enclosure showing one of the preferred positions of a wave guide.

FIGURE 11 is a perspective view of a speaker enclosure having a complete sound deflection panel mounted therein.

Detailed Description of the Preferred Embodiment:

New and improved speakers can be produced easily and economically yet with superior qualities, by the Rotomolding process of the present invention. A 3-D, solid modeling CAD package is used to create a computer model of the mold, which is then "exploded" into individual mold pieces. Each mold piece is CNC machined out of thick aluminium plates, which are joined together to form the final mold. Advantages of this method include a small amount of machine shop labor, greater mold accuracy as compared to the traditional methods, and the ability to make a family of similar molds by only changing one part of the 3D solid model. Additionally, complex curves can be easily created which would be difficult or impossible by traditional methods. Another advantage of the modular mold is that it allows different products to be made simply by switching machined mold inserts. For example, two speaker designs (one using a 15" bass driver and a 2" horn, the other using a 15" driver and a 12" coaxial mid-tweeter) can be molded with the same basic mold simply by switching the mold insert for the 2" horn with the mold insert for the 12" coaxial mid-tweeter, since most of the speaker shell is the same the general enclosure, the 15" bass driver, the ports, etc. This modular approach allows one to make one flexible mold and an assortment of inserts instead of a dedicated mold for each product. This approach is made possible only by the high precision of machined mold components.

The Rotomolding approach allows a manufacturer to make a pair of speaker enclosures which fit together, speaker-facing-speaker, forming a water tight seal. This can best be seen in FIGURES 2 and 3.

FIGURE 2 shows a cross-sectional view of a rotomolded product comprising two speaker enclosures 1 and 2 fitting together along watertight separation line 3. FIGURE 3 shows a lip 5 which engages a sealing recess 7 when the speaker enclosures 1 and 2 are secured together.

When separated, each speaker enclosure reveals unique speaker mounting arrangements and important structural parameters which function together to provide a much better speaker system than prior art devices.

By utilizing the rotomolding process, a speaker well 10 can be integrally molded into the speaker enclosure 1. Moreover, mounting satellite recesses 4 are also molded in the rotomolding process. This allows speakers to be mounted below the surface of the speaker enclosure (see FIGURE 1). Because the recesses 4 even the mounting hardware is below the front plane of the enclosure. The most easily detectible benefit of this arrangement is that the speaker itself is much better protected from damage. Speakers traditionally were mounted atop a face plate (see FIGURE 6A) of the enclosure where a flat impact could create severe damage to the speaker, whereas the speakers in the invention, being mounted out of harm's way, are not subject to stresses from a flat frontal impact. Moreover, the speakers are protected from more pointed impact by a grill which is mounted within the speaker well above the speaker.

As important as the above benefits are to the art of speaker enclosures and transportability, the importance of the construction parameters and concomitant gains in sound quality of the speakers of the present invention are even greater.

The design and construction of the speakers of this invention were occasioned by an interest in providing even piston response at all bass bandwidth frequencies, as opposed to the traditional "flat", "equal energy per octave" response of traditional speakers. This requires very small enclosures and compression chambers: for example, an approximately .8 cubic foot enclosure is utilized for a 12 inch bass speaker. Another example is a 1.5 cubic foot enclosure used for a 15 inch speaker. As one of skill in the art will recognize, enclosure areas of these dimensions for speakers of the diameters mentioned are radically different from the three to four cubic foot enclosures necessary in traditional speaker design. Moreover the speaker enclosures of the invention are typically nine inches or less from the front of the speaker motor to the back of the enclosure. This is substantially

less than the 18-24 inch depths in industry standard boxes. The invention also utilizes two inch ports 16 as opposed to four inch ports in the prior art. The particular dimensions selected for each diameter speaker are based upon the following design parameters.

All of the dimensions utilized in the present invention are selected to provide for lower cabinet air turbulence and a smooth low frequency rolloff below 200 Hertz. Limiting the amount of space behind the speaker to a range of from 2.5 cubic feet to 3.0 cubic feet for 15" diameter cone drivers, and proportionally smaller volumes for smaller cone drivers reduces the amount of trapped air behind the speaker cone. The less trapped air the less air the speaker must evacuate with each pulse and therefore detrimental oscillation and distortion effects are minimized. Moreover the low frequency rolloff below 200 Hertz is at approximately 6 decibels per octave as opposed to a typical > 18 db per octave steep rolloff at 40-50 Hz, slightly below speaker free air resonance. Smaller overall dimensions of these speakers makes them easier to transport in standard automobiles. Smaller size also reaps the benefit of lesser flex and cabinet resonance than traditional speakers. Avoiding flex and cabinet resonance is important to speaker efficiency. Cabinet vibration "damps" the speaker output, negatively affecting audio quality.

With a view to further reducing unnecessary and detrimental vibration, the speaker enclosures of the invention do not use the traditional flexible baffleboard which has no central support. This has been omitted in favor of attaching the speaker magnet directly to the rear wall 18 of the enclosure. Moreover, each speaker mounting bolt is secured to supports and braces which are themselves attached to the rear wall 18 of the enclosure. This arrangement significantly reduces the damping action of vibrating speaker enclosure, and thus provides more acoustically accurate sound.

To further eliminate turbulence effects, sound deflection panels 26 or wave guides 27 are utilized to direct turbulence effects away from the speaker motor 30. This has the added advantage of using the turbulence related air movement to power feed the single or double 2 inch ports 16.

Ports 16 can be located around the speaker motor 30 as illustrated in FIGURE 8. It will be understood however, by one of skill in the art that FIGURE 8 is used by way of illustration and not by way of limitation. Ports of the invention may be placed in any conventional location. All of the ports may be used or none of them as the manufacturer desires.

Ports 16 are integrally formed in the face structure 8 of speaker enclosure 1 or 2 and can be a hollow conical or hollow frustoconical shape. Wall

15 of port 16 is in the range of from about 1 to about 4 inches in length, while the hollow defined by the wall is approximately 1 to 3 inches and is most preferably 2 inches in diameter.

In accordance with a selection made by the manufacturer the port 16 can be, as mentioned, frustoconical or cylindrical; where a frustoconical shape is chosen the angle of taper is in the range of from 0° to 5° with the most preferable range being from 0° to 3°. This is illustrated in FIGURES 8a and 8b. FIGURE 8c is also provided to illustrate a top plan view of a frustoconical port of the invention.

For use with the speaker enclosure of the present invention is a speaker motor 30 fitted with a novel x-shaped dust cap 33. The cap is positioned over the apex dome 35 of the speaker motor 30 and is mounted upon the diaphragm 39. The particular shape of the cap 33 is effective in eliminating any turbulence effects which are not suppressed in the speaker enclosure 1. It has been found that even though the enclosure of the invention prevents turbulence to a large extent, the dust cap 33 is beneficial to the arrangement. Increased benefits beyond those achieved by using the enclosure itself include greater SPL, better sound stage, greater sonic imaging and clearer acoustic centering of perceived sound origin point, and better tracking to mid-bass or high frequency transducers with corresponding greater articulation.

To further aid in the reproduction of accurate sound, a wave guide 26 can be installed within the compression chamber 12 of enclosure 1 or 2. Those of skill in the art will appreciate that a wave guide may be positioned in various locations within the compression chamber of a speaker enclosure, however, it has been found that a particular shape of wave guide is preferred for use with the rotomolded enclosure of the invention.

One embodiment of the wave guide 26 is shown in FIGURE 9 in perspective view, with FIGURE 9a being a top view of the guide. FIGURE 10 depicts the wave guide 26 in a preferred location within a speaker enclosure in perspective view.

Functionally, the wave guide 26 partially blocks the acoustic pathway from one of the speaker motors 30 to port 16 while still allowing full access by another speaker motor 30 to port 16. As will be appreciated, the degree of restriction of the acoustic pathway affects the quality of sound and the wave guide may be positioned in innumerable different locations to create different acoustic effects. The most preferred placement of the wave guide 26 is as shown in FIGURE 10, wherein the angle corner 28 of the wave guide 26 is immediately adjacent one of the speaker motors 30. The wave guide is constructed of rigid foam or wood and can be easily manufactured.

Alternatively, a sound deflection panel 27 can be disposed between two speaker motors in a given speaker enclosure. This can partially or completely isolate the individual speaker motors and create, to varying degrees, relative to how complete the sound deflection panel is, two distinct compression chambers 12. The material can be wood, hard plastic or foam and is anchorable to the speaker enclosure by conventional means. FIGURE 11 shows an embodiment using a complete sound deflection panel.

The invention produces advantage over current bass reproducers including:

- 1) Accurate fundamental pitch reproduction
- 2) Smooth (not "flat") response
- 3) Deeper octaves of usable response
- 4) More response to severe equalization needs in modern music
- 5) Faster transient response
- 6) Shorter "hang time" at each note
- 7) Greater dynamic range
- 8) Greater SPL without distortion
- 9) More accurate spatial sound imaging
- 10) More uniform impedance curve
- 11) Greater compatibility as component of passive crossover network
- 12) less back-EMF
- 13) Faster midband response at crossover points
- 14) One-half to two-thirds small in size and weight
- 15) Greater speaker transducer reliability
- 16) Shallow front to back dimension
- 17) Less flex and cabinet resonance due to very short sidewalls
- 18) Excellent reproduction of very hard-to-capture input sources (eg. upright bass)

While preferred embodiments have been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustrations and not limitation.

Claims

1. A speaker system comprising a rotomolded speaker enclosure having at least one integrally molded speaker well of sufficient preselected dimension to accept a speaker motor for mounting completely within the speaker well such that a frontal plane of the enclosure is not interrupted by the speaker motor.
2. A speaker system is claimed in claim 1 wherein at least two such speaker enclosures

fit together to form a water tight seal.

3. A speaker system as claimed in claim 1 wherein said speaker well includes an integrally molded horn. 5
4. A speaker system as claimed in claim 1 wherein said speaker well further includes integrally molded satellite recesses for accepting mounting hardware designed to hold a speaker motor in the speaker well. 10
5. A speaker system as claimed in claim 1 wherein said speaker well further comprises a receptacle for accepting a grill disposed over said speaker motor. 15
6. A speaker system as claimed in claim 1 wherein the enclosure is constructed using side walls of less than eleven inches from front to back of the enclosure. 20
7. A speaker system as claimed in claim 1 wherein each enclosure includes a compression chamber wherein said chamber is effectively dimensioned such that air turbulence is minimized. 25
8. A speaker system as claimed in claim 1 wherein said enclosure includes an integrally molded horn with an integrally molded speaker motor receptacle, said horn being formed such that said horn effectively is an extension of a cone of the speaker motor, the horn having walls which diverge pursuant to substantially similar geometric parameters as the speaker cone. 30 35
9. A speaker system as claimed in claim 1 wherein the enclosure includes at least one port having a diameter of less than four inches and a tube length of from one to four inches. 40
10. A speaker system as claimed in claim 1 wherein the enclosure includes at least one sound deflector panel to redirect air turbulence away from the speaker motor. 45
11. A speaker system as claimed in claim 1 wherein the speaker motor includes an x-shaped dust cap positioned in spaced relationship to an apex dome of said speaker motor. 50
12. A speaker system as claimed in claim 1 wherein a wave guide is positioned within a compression chamber of the enclosure. 55
13. A speaker system as claimed in claim 9 wherein the port is of cylindrical shape.
14. A speaker system as claimed in claim 9 wherein the port is of frustoconical shape.
15. A speaker system as claimed in claim 14 wherein the angle of the frustoconical shape is from 0 to 5°.
16. A speaker system as claimed in claim 1 wherein a speaker motor magnet is mounted directly on a rear wall of the enclosure.

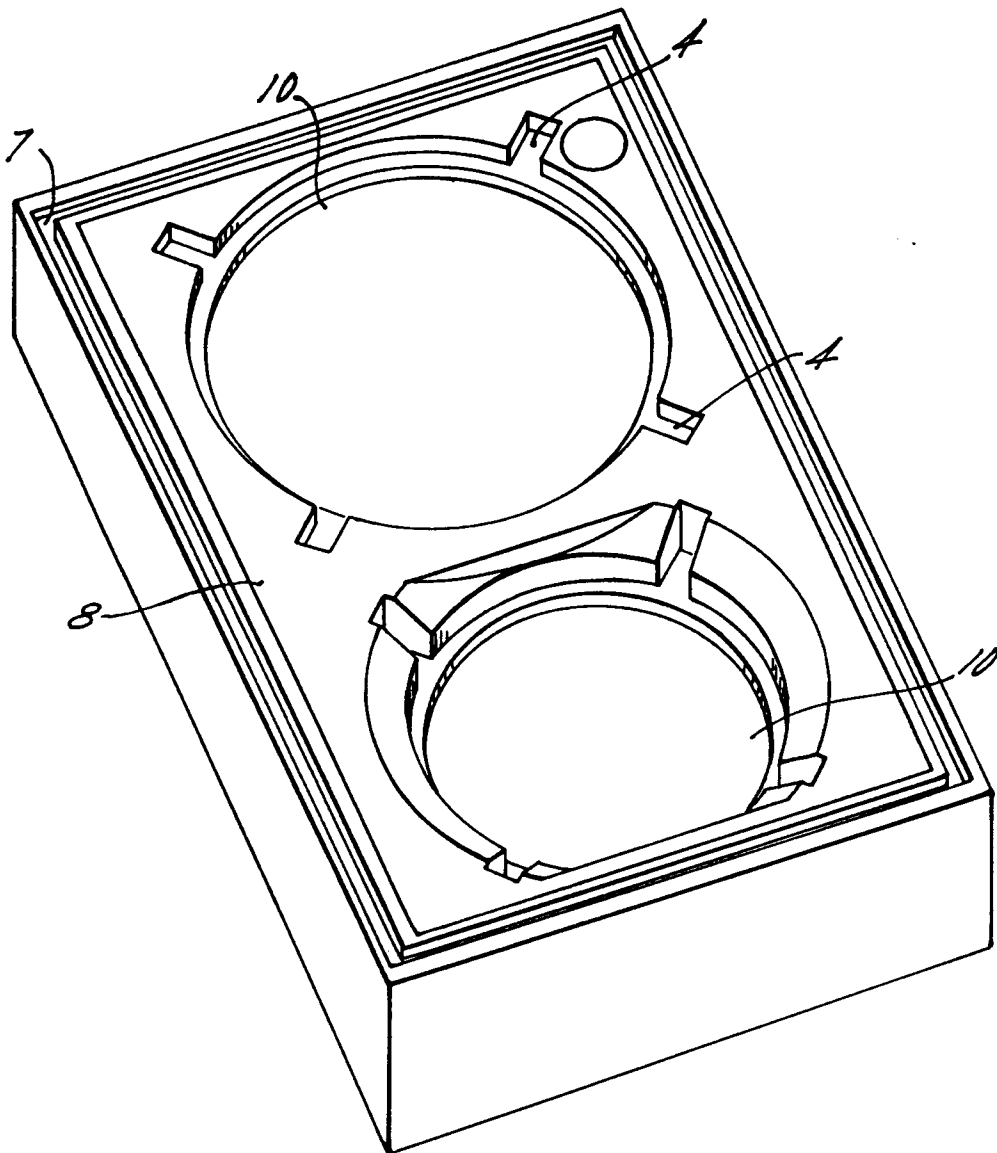


FIG. 1

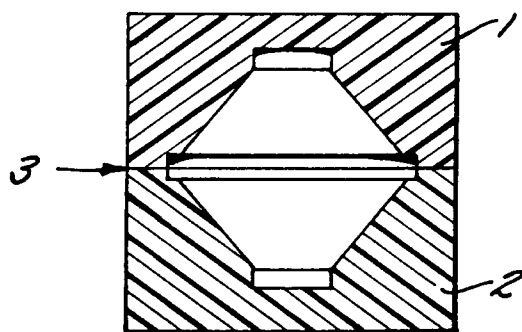


FIG. 2

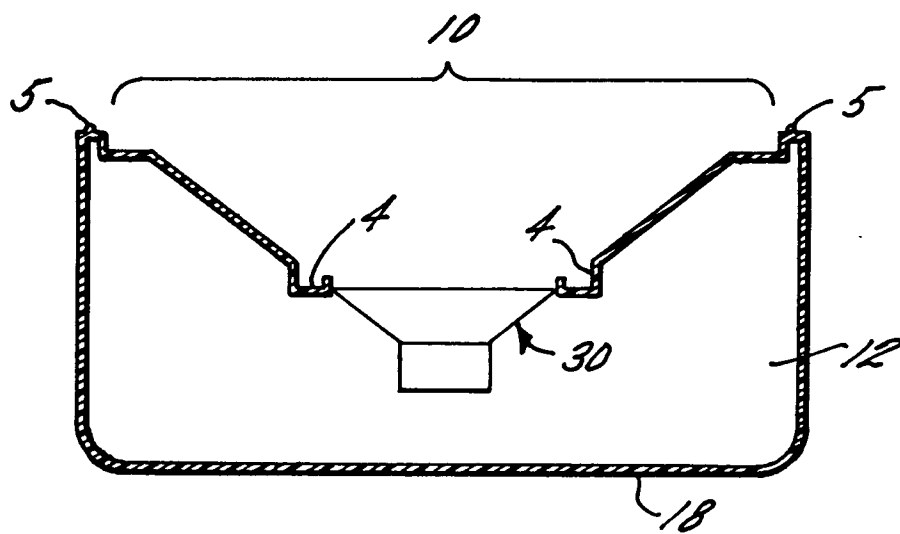


FIG. 3

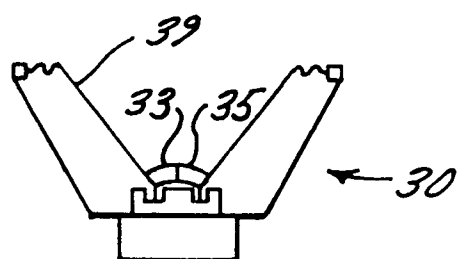


FIG. 4

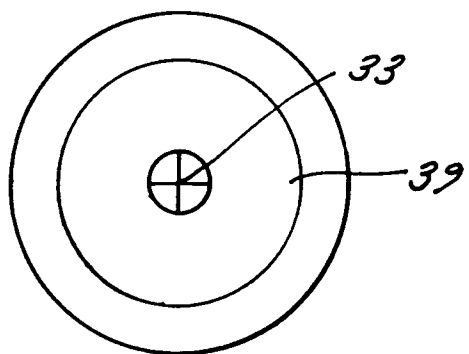


FIG. 5

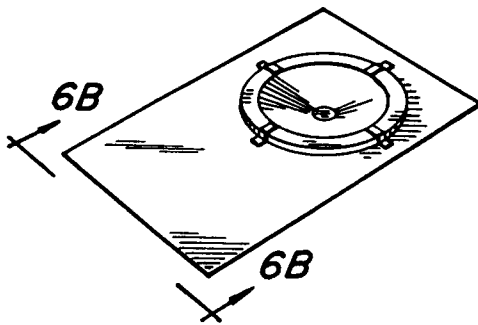


FIG. 6A
(PRIOR ART)

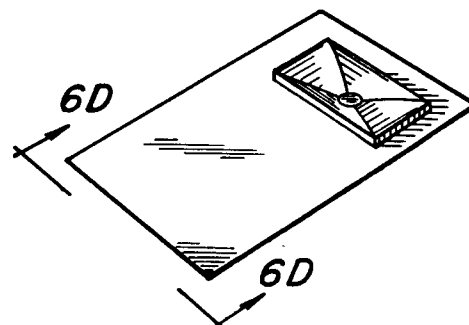


FIG. 6C
(PRIOR ART)



FIG. 6B
(PRIOR ART)



FIG. 6D
(PRIOR ART)

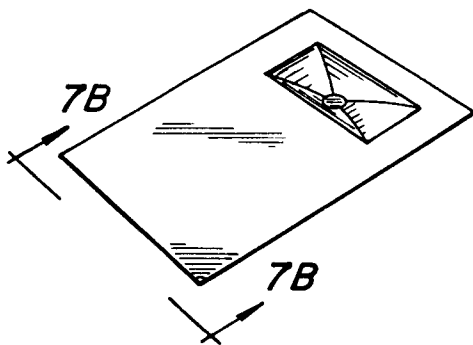


FIG. 7A

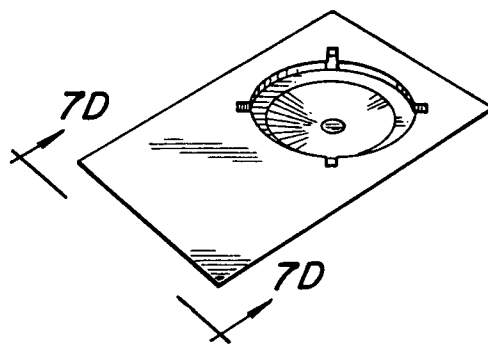


FIG. 7C



FIG. 7B



FIG. 7D

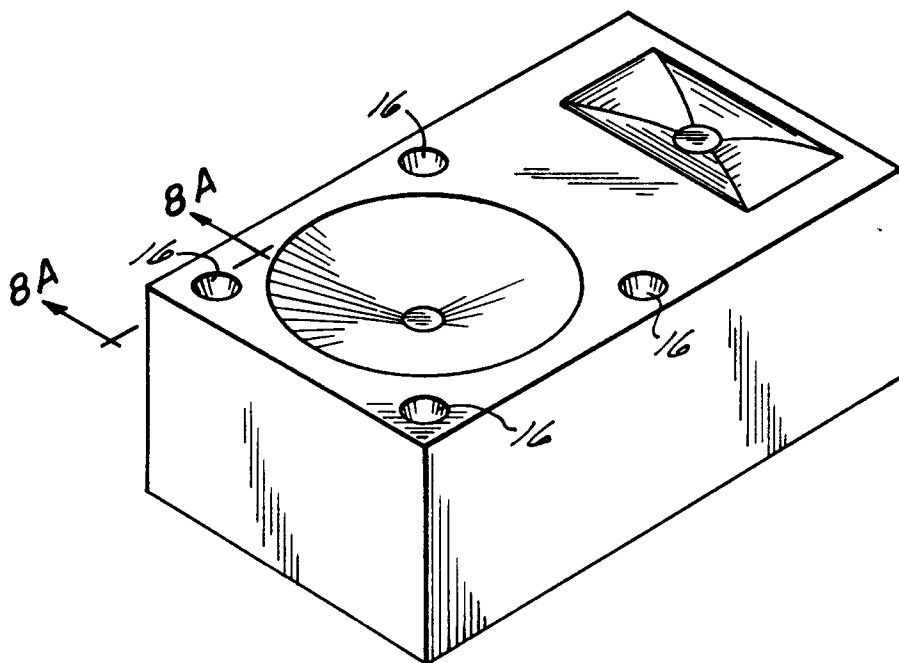


FIG. 8

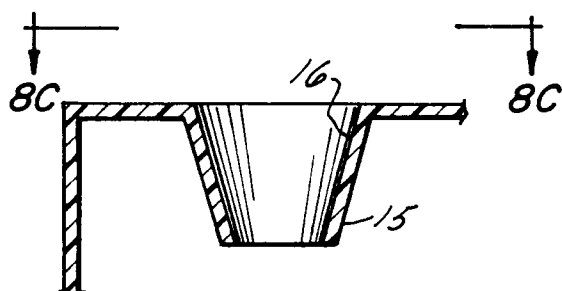


FIG. 8A

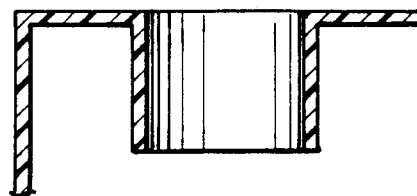


FIG. 8B

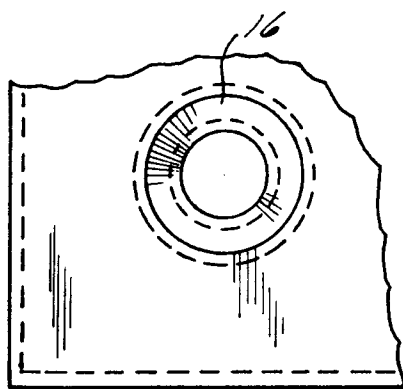


FIG. 8C

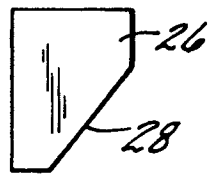


FIG. 9A

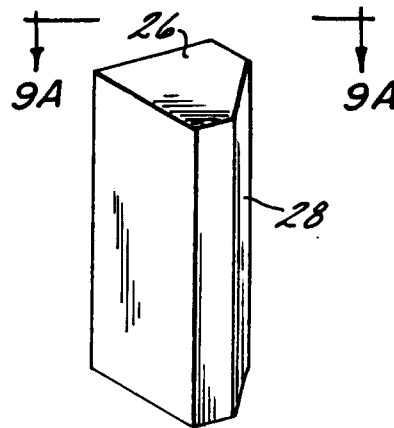


FIG. 9

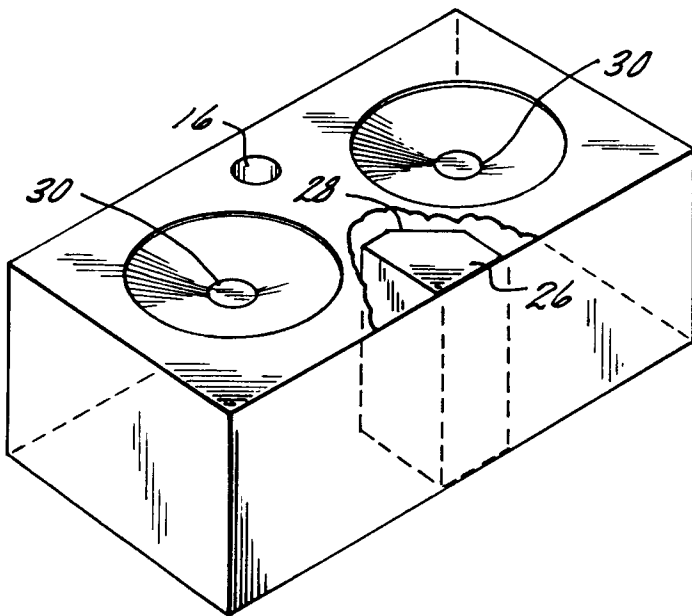


FIG. 10

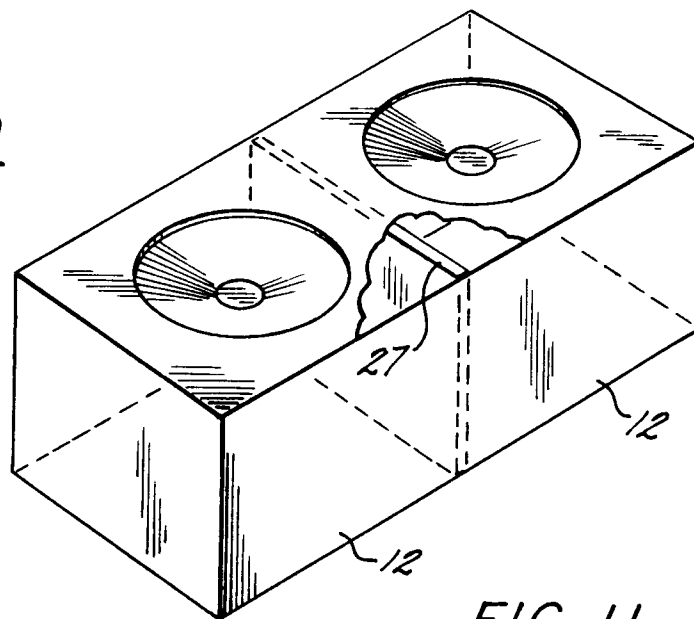


FIG. 11



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 10 2842

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)
Y	FR-A-2 576 544 (ETS PAUL BOUYER & CIE) * page 5, line 38 - page 6, line 10; figure 3 * ---	1	H04R1/02 H04R31/00 H04R1/30 H04R1/28 H04R9/02
Y	US-A-5 115 884 (FALCO) * column 1, line 48 - line 52 * * column 4, line 27 - line 29; figures * ---	1 5	
A	US-A-4 168 762 (GRIFFIN, JR.) * column 3, line 30 - line 49; figures * ---	1	
A	US-A-4 313 032 (THOMAS ET AL.) * abstract; figure 4 * ---	3,8	
A	US-A-5 147 986 (COCKRUM ET AL.) * abstract; figures * ---	10,12	
A	PATENT ABSTRACTS OF JAPAN vol. 017 no. 680 (E-1476) ,14 December 1993 & JP-A-05 227591 (MATSUSHITA ELECTRIC IND CO LTD) * abstract * ---	11	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H04R
A	WO-A-82 03961 (GALE, GEORGE A.) * abstract; figures * ---	13,14	
A	EP-A-0 459 682 (AKROYD, JOE SPEIGHT) * abstract; figure 1 * -----	16	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 13 June 1995	Examiner 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			