United States Patent

[11] 3,596,733

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[33] **Argentina**
[31] **218.851**

[54] **FLAT DIAPHRAGM FOR SOUND TRANSDUCERS AND METHOD FOR MANUFACTURING IT**
22 Claims, 14 Drawing Figs.

[52] **U.S. Cl.** **181/32,** 156/229, 264/321, 181/31
[51] **Int. Cl.** **G10k 13/00,** H04r 7/00, B32b 31/00
[50] **Field of Search** 181/32, 31.1; 156/229, 196, 223; 264/321, 45, 51

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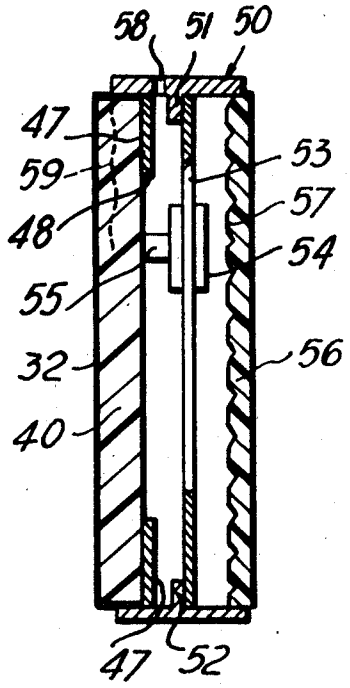
Attorney—Tashof & Osheroff

ABSTRACT: A flat diaphragm for sound transducers and a method for producing it, including providing in a cellular platelike member a pretensioned front face and a rear face defining an irregularly shaped figure portion including a central stiffened portion at a zone out of the geometric center of said figure portion, and a marginal vibration damper portion substantially circumscribing said figure portion, said central stiffened portion defining a center for capturing vibrations. The flat diaphragm is preferably made of a granular expanded-bonded cellular, strong, stiff, imperforated plastics platelike member.



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2 Sheets-Sheet 1

FIG. 1

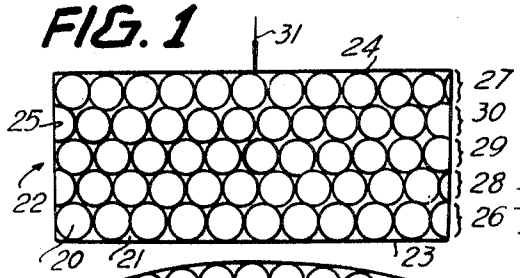

FIG. 2

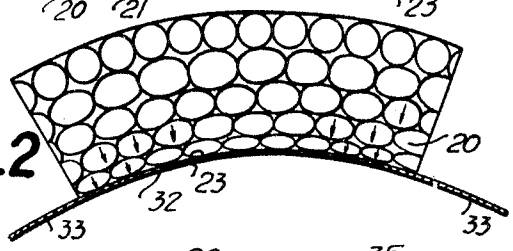

FIG. 3

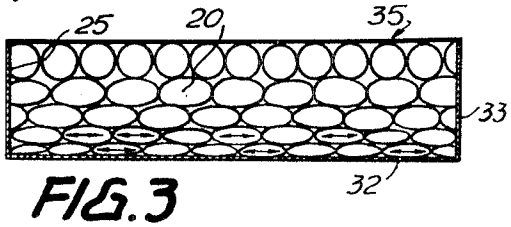

FIG. 5

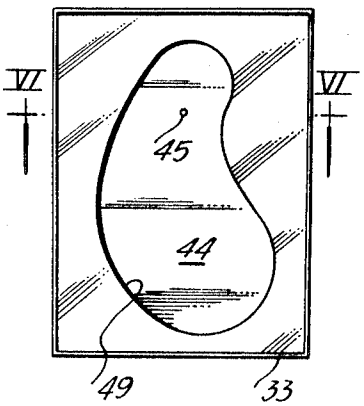

FIG. 4

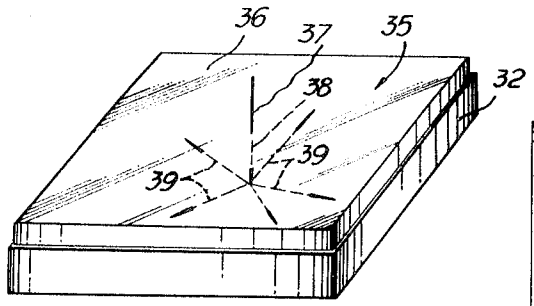

FIG. 7

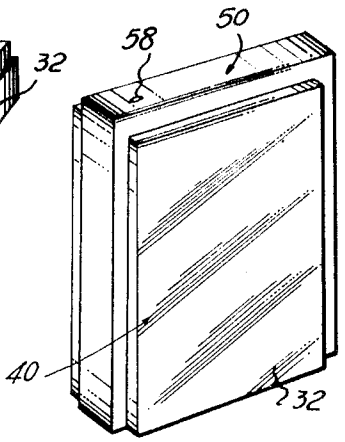

FIG. 6

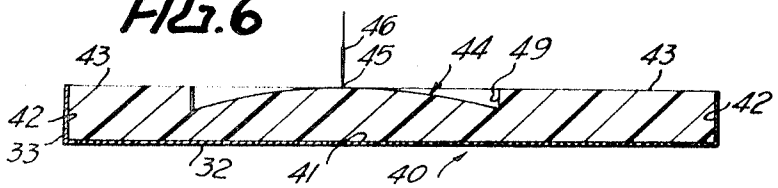

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FIG. 8

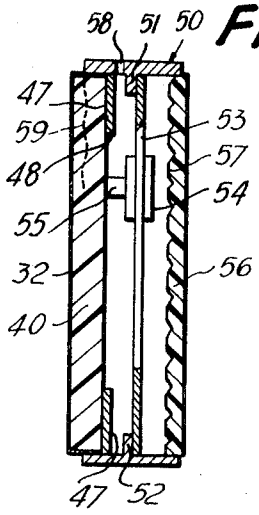


FIG. 9

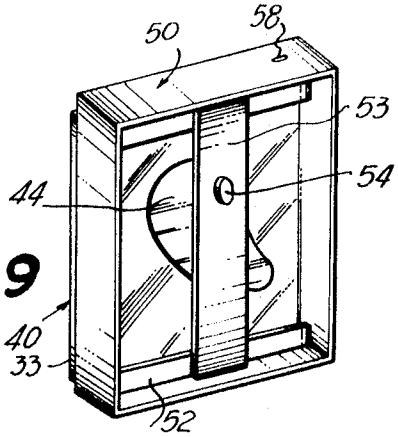


FIG. 10

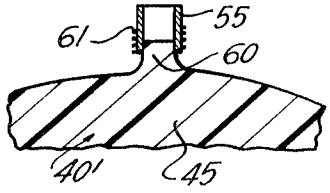


FIG. 11

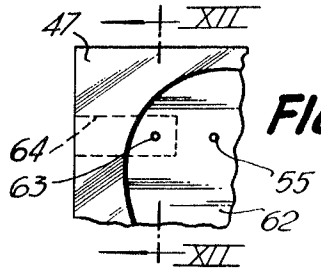


FIG. 12

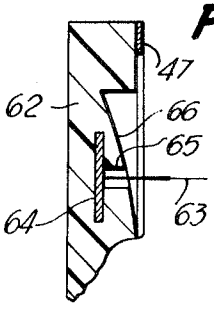
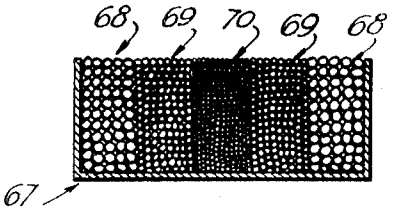


FIG. 13



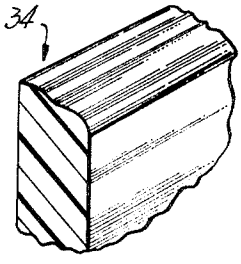


FIG. 14

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FLAT DIAPHRAGM FOR SOUND TRANSDUCERS AND METHOD FOR MANUFACTURING IT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention refers to a substantially flat diaphragm to be used in sound transducers and to a method for manufacturing said substantially flat diaphragm and more particularly, the present invention is mainly used in connection with so-called "flat loudspeakers" which provide an excellent reproduction of sound, although it may likewise be used in connection with the manufacture of microphones.

2. Description of the Prior Art

It is well known in the vibration-transducing art for loudspeakers and microphones, that either the coil of the magnet assembly has to vibrate the diaphragm (in the case of a loudspeaker) or the diaphragm has to capture the vibrations, to transmit them to the coil of the magnet assembly (in the case of a microphone). In both events, the diaphragm is resiliently supported by its edge or marginal portion and has to vibrate in a plane substantially perpendicular to the axis of the coil. In other words the coil (hereinafter called "voice coil") of the magnet assembly drives or is driven by the diaphragm in a pistonlike manner. Thus a mass of air is required in front and behind the diaphragm and which is moved thereby.

During the following description, reference will be mainly made to the diaphragm of the present invention in connection with loudspeakers, although it will be obvious to those skilled in the art, that the concept of the invention is likewise applicable to microphones.

According to recent developments certain attempts have been made to replace the conical diaphragm configuration, where the conical diaphragms are formed from paper pulp and the like, by flat diaphragms made of expanded cellular plastics materials such as polystyrene, where the voice coil is mounted in a perforation of the diaphragm or in a recess made in said diaphragm, and the diaphragm as such operates on the same principle as to the to-and-fro vibrations, as in the well-known above-mentioned conical diaphragms. Some attempts have also been made to provide diaphragms of planar form but with a central funnel-shaped portion defining an opening where the voice coil is to be housed. While all these flat loudspeaker embodiments operate on the same principle as the above-mentioned conical loudspeakers, the housings for these flat loudspeakers are smaller in depth.

In all these loudspeakers either the low frequencies or the high frequencies lack in fidelity upon being electroacoustically reproduced, so that in practice, additional woofers or tweeters are required for high fidelity arrangements. The aim is of course, to provide a single loudspeaker capable of providing a high efficiency, both within the upper and lower frequency ranges.

SUMMARY OF THE INVENTION

In this connection the present invention represents an important advance in the art, by providing a flat diaphragm which does not require a substantial mass of air in front and behind the diaphragm, because the latter does not vibrate according to the old, above-explained, principle. The diaphragm is preferably made of a granular, expanded-bonded cellular, strong, stiff plastics platelike member, such as polystyrene or polyurethane, where at least the layer including the front face is pretensioned both in a direction substantially perpendicular to the front face plane and in a direction within said front face plane, so that said layer could be compared with a tensioned hide of a drum, while the additional or remaining layers between said front face and the rear face of said platelike member are, considered from said front face toward said rear face, under decreasing stresses, so that any percussion or vibration applied to the rear face will substantially move through those layers towards the front face and will mainly there be diverted or decomposed substantially perpendicularly to its original direction due to the high tension of the front layer.

Thus, the pertinent portion of the platelike member will vibrate from the axis of the center of percussion towards its edge portion and may thereby transform the vibration into sound. According to this principle, it is believed that this diaphragm is the first diaphragm which vibrates in its own plane from a center of percussion and substantially perpendicularly to the direction of said percussion.

When the diaphragm is used for a loudspeaker, the percussion is of course produced by the voice coil which is operatively connected to the rear face of the platelike member.

A further feature according to the present invention is that the point of connection or center of percussion of said voice coil with regard to the rear face of said platelike member is such that it is out of the geometric center of the active rear portion of the platelike member which is intended to be vibrated. Thus, a number of straight channels are at least theoretically formed between the center of percussion and the edge of the portion of the platelike member which is intended to be vibrated, which channels have different lengths, so that in principle only the channels which coincide with the length of the transmitted frequency will vibrate, thereby providing high fidelity without distortion.

Still a further feature of the present invention is to manufacture the portion of the platelike member which is to be operatively connected to the voice coil in such a way that it becomes a stiffer portion than the rest of the platelike member, so as to achieve a better sound reproduction for high frequencies.

Tests have shown that the better the edge of the marginal portion of the platelike member is rigidly retained withing a frame member or clamping means, the more accurate is the sound reproduction and it is also important, that the platelike member is an integral member without the usual central perforation, as used in the prior art diaphragms, because such a perforation tends towards a state of resonance.

Accordingly, the present invention refers to a substantially flat diaphragm to be used in sound transducers made of a cellular, strong, stiff platelike member, having a flat front face, a rear face and side faces connecting said front and rear faces, a layer including said front face, said layer being pretensioned in a direction substantially perpendicular to the front face plane and in a direction within said front face plane and the remaining layers of said platelike member between said front face and said rear face are gradually under minor stresses from said front face towards said rear face.

The present invention is likewise concerned with a loudspeaker including a flat diaphragm of the type hereinbefore defined, wherein at least a portion of said side faces is rigidly framed in a frame projecting beyond the rear face of said diaphragm and supporting a magnetic assembly including a voice coil in vibration-transmitting relationship with a central stiffer portion of said diaphragm, which is outside the geometric center of said diaphragm.

FInally, this invention refers also to a method for manufacturing a substantially flat diaphragm to be used in sound transducers, comprising the steps of forming a granular expanded-bonded cellular, strong, stiff plastic platelike member, having a flat front face, a rear face and side faces connecting said front and rear faces, said platelike member defining a marginal portion substantially circumscribing a figure portion of the rear face, said figure portion including a central stiffer portion at a zone out of the geometric center of said figure portion, thereby defining in said figure portion substantially straight channels of different length between said central portion and said marginal portion, adhering to said flat front face a thin sheetlike member having a free marginal portion projecting beyond said front face, bending said platelike member with said adhered sheetlike member to define a concavely shaped front face, urging said bent platelike member with the adhered sheet member into substantially planar condition, adhering the marginal portion of said sheetlike member to at

least said side faces, framing said side faces having said marginal portion of said sheetlike member adhered thereto into a shape-retaining frame to maintain said platelike member in substantially planar condition, and providing damper means on the rear face of said marginal portion capable of substantially damping vibrations in said marginal portion.

BRIEF DESCRIPTION OF THE DRAWINGS

Further features and details of the present invention will become more apparent during the course of the following description, wherein reference is made to the accompanying drawings, which facilitate the explanation of the present invention and wherein a number of embodiments of loudspeakers are also shown by way of example. More particularly,

FIG. 1, is a sketch showing the granular arrangement of an expanded-bonded cellular, strong, stiff plastics platelike member.

FIGS. 2 and 3 are similar views as FIG. 1, showing said same platelike member during different steps of the process to manufacture the diaphragm in accordance with the present invention.

FIG. 4 is a sketch in perspective view of a parallelepipedic platelike member which enables explaining the theory of decomposition of vibrations.

FIG. 5 is a plan view of the rear face of a platelike member defining a diaphragm in accordance with the present invention.

FIG. 6 is a cross section along line VI–VI of FIG. 5.

FIG. 7 is a perspective view mainly showing the front side of a flat loudspeaker, using the diaphragm in accordance with the present invention.

FIG. 8 is a longitudinal section through the loudspeaker of FIG. 7.

FIG. 9 is a perspective view from the rear side of the loudspeaker shown in FIG. 7, with the rear lid being removed.

FIG. 10 is a schematic detail, in longitudinal section of a preferred way of connecting the voice coil to the diaphragm.

FIG. 11 is a detail in plan view, of a portion of a loudspeaker in accordance with the present invention, having a special arrangement to become the equivalent of a tweeter.

FIG. 12 is a cross section along line XII–XII of FIG. 11.

FIG. 13 is a sectional view of a mold, filled with a particular arrangement of starting material to manufacture a diaphragm according to another alternative.

FIG. 14 is a perspective view of a portion of the side face of the plastics platelike member according to a further alternative.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The diaphragm which could be defined as the "core portion" of the present invention, is preferably manufactured as a granular, expanded bonded cellular, strong, stiff, plastics platelike member, conveniently made of polystyrene or polyurethane. The platelike member **22** (see FIG. 1) consists of expanded granules **20** which, although in this figure are shown as all being of substantially the same size, are in practice, not so uniform. These granules **20** are glued together forming in between them alveolar cells **21** which contain moisture as an intrinsic feature arising during the production of the platelike member **22**. The granules **20** are rather resilient. The platelike member **22** has usually a substantially parallelepipedic shape and comprises a front face **23**, a rear face **24** and side faces **25**. For the purpose of this invention is may be considered that between the front face **23** and the rear face **24** a number of layers are formed which for convenience of explanation will be defined by the rows of granules shown in FIG. 1. Thus, the front face **23** which defines a front face plane is defined by a front face layer **26**, the rear face **24** forms part of a rear face layer **27** and there are in between both a number of intermediate layers **28, 29** and **30**. Obviously in practice each layer may be formed of more than one row of granules and the granules will not be so perfectly aligned in rows as shown in FIG. 1. Due to the fact that the granules **20** are rather resilient and in between the granules there are the alveolar cells **21**, the platelike member **22** provides in itself an internal damping, if a percussion or a vibratory movement is, for instance, applied to the rear face **24**, as indicated by arrow **31**.

To achieve a good sound reproduction it is however desirable to eliminate as far as possible, this damping feature which tends to produce distortions, and reduces the output.

To this end it is advisable to remove the moisture from the cells **21** as far as possible, which can be achieved by subjecting the manufactured platelike member **22** to heat and thereafter sealing the faces **23, 24** and **25**, such as by spraying thereon a thin coating of a suitable resin, sufficiently fluid so as to permit the coating operation and capable of being cured into a sealing film. Since these resins are readily available on the world market, it is not considered necessary to forward more details thereabout.

According to the present invention is is however not necessary to perform the sealing step as a separate step, but may be carried out simultaneously with another step which will now be explained.

Even if the moisture is substantially withdrawn from the platelike member **22**, the physical constitution of the granules themselves is still too resilient to provide an optimum capacity for transforming vibrations without distortion, and to avoid loss of vibration transmission energy.

It is well known that in percussion instruments, such as for instance, drums, the percussion impact is transformed into sound if the hide of the drum is under suitable tension. The vibrations move from the center of percussion towards the edge of the drum and if the center of percussion does not coincide with the geometric center of the tensioned hide, particular sound effects may be achieved presumably due to the fact that not all, so to say, "radial vector" sections or channels will vibrate, but only those which are within the particular frequency range.

Reference will later on be made to this particular aspect, as related to the present invention.

Bearing in mind the foregoing it is necessary to provide the platelike member **22** and particularly the granules **20**, with oriented tensions, so as to reduce the resiliency of the granules, at the same time as the size of alveolar cells is reduced. Furthermore, since the voice coil of the magnetic assembly (not shown, but which may be considered as schematically represented by arrow **31**) should be able to transfer the vibrations, in case of a loudspeaker, to the platelike member **22** and to capture the vibrations, in case of a microphone, in a rather padded way, the granules of the layer which are in operative contact with the voice coil should be under no tension, or a minimum tension. Tests have shown that the best transmission of vibrations is achieved if for instance, the percussion center, schematically indicated by arrow **31**, is on the rear face **24** and the opposite face, namely the front face **23**, is the one having granules under the maximum advisable tension and the intermediate layers **28** to **30** are gradually under minor tension or stresses.

To achieve this effect it is necessary to subject the granules **20** to two stresses in an increasing proportion from the rear face **24** towards the front face **23**. These stresses should be oriented both substantially perpendicularly to the front face **23** and parallelly to said front face **23**.

Once the platelike member **22** of FIG. 1 has been produced, said platelike member is curved as shown in FIG. 2, so that the front face **23** becomes concavely shaped. Due to this bending of the platelike member **22**, the granules of the front layer **26** are subject to a maximum stress which will elongate them and the successive layers **28, 29, 30** and **27** will be subject to gradual decreasing stresses and the entire height of the platelike member **22** will be reduced. Due to the elongation of the granules **20**, the alveolar cells will be reduced in size; particularly the alveolar cells existing in the front face layer **26**. Once the bending has been completed, heat may be applied to the platelike member in order to eliminate at least part of the

moisture within the cells **21** and thereafter the aforementioned sealing film may be applied to the faces **23**, **24** and **25** and said film may be of an adhesive type, at least for the front face **23** which will then be covered with a sheetlike member **32** having marginal portions **33** projecting beyond said front face **23**.

The sheetlike member **32** may be for instance made of paper or fabric. The face opposite the one to be adhered to the front face **23** may have a suitable decoration or design. Instead of using an adhesive spray for the front face, a mere sealing spray can be used and the sheetlike member **32** can be adhered to the front face by other suitable anchoring means such as by means of minuscule spikes forming part of the same fabric.

As an alternative with regard to the step just described, tests have shown that the bending of the platelike member **22** can be automatically achieved, if the sheetlike member is made of a shrinkable material, for instance a fabric. In that event, after the drying step and the spraying step, bearing in mind that the sealing spray, at least for the front face, is of an adhesive nature, the shrinkable fabric is applied to the front face **23** and soaks in part of the spray, whereby the fabric shrinks and bends the platelike member **22**.

Due to the fact that the sheetlike member **32** is adhered to the front face **23**, the granules of the front face layer **26** are substantially barred from relative internal movement so that the alveolar cell spaces are now more or less maintained in their new size, which is smaller.

As the next step, it is now necessary to communicate to the granules **20** a second stress, parallel to the planes defined by the layers. To this end, the bent platelike member of FIG. **2** is now urged, with the adhered sheetlike member **32**, into substantially planar condition as shown in FIG. **3**. Since the granules are now tensioned in planes parallel to their layer, they will again become somewhat more flattened, so that thereby the total height of the platelike member **22** is further reduced. Simultaneously, the sheetlike member becomes also tensioned in its own plane and in order to anchor the sheetlike member in its tensioned state, the marginal portions **33** are now adhered at least to the side faces **25**. If the length of the marginal portions **33** is somewhat larger, they may be turned over to cover the edge portions of the rear face **24**, without changing the final result.

Thus, a flat diaphragm with pretensioned layers is achieved, where the tensions gradually decrease from the front face towards the rear face.

If the area of the front face **23** of the diaphragm is relatively small, and the tensions are relatively high, in order to increase the anchoring surface necessary for anchoring the marginal portions **33** of the sheetlike member **32** on the side faces, these instead of being flat as shown in FIGS. **1** to **3**, may be irregular, for instance defining serrations **34**, as shown in FIG. **14**.

Turning now to FIG. **4**, the latter shows the tensioned platelike member **35** sheathed with the sheet like member **32** and the free rear face is now identified by new reference numeral **36**, since said rear face is now either under no tension or under slight tension.

Assuming that the diaphragm or tensioned platelike member **35** is used for a loudspeaker and that the voice coil (not shown) transmits a vibration schematically indicated by line **37**, onto the rear face **36**, said vibration will move into the mass of the platelike member **35** towards the front face, as indicated by dotted arrow **38** and will there decompose, due to the high tension, into vibrations **39**, which are substantially parallel to the front face layer **26**, whereby the diaphragm will vibrate within its plane. In practice, the vibration **37**, **38** will not entirely move forward up to the front face, but will in part already be decomposed in the intermediate layers **28** to **30**, so that the entire diaphragm will mainly vibrate in a plane parallel to the general plane of the diaphragm. Additional tests have shown that the fidelity of these vibrations is best, if the side faces of the diaphragm are rigidly retained within a frame or a clamp, to which reference will be made later on.

Returning now to FIG. **3**, wherein an intermediate stage of the manufacture of the diaphragm is shown, and bearing in mind the theoretical explanation given in connection with FIG. **4**, the tensioned platelike member **35** should be so manufactured that it includes a central stiffer portion which is the portion to which the voice coil is to be connected. The central stiffer portion is located in a zone outside of the geometric center of said platelike member. This may be achieved in different manners, one of which is shown in FIGS. **5** and **6** and another one is shown in FIG. **13**.

Dealing first with the embodiment of FIGS. **5** and **6**, when molding the platelike member of FIG. **1**, the latter should not be a parallelepipedic body where the entire rear face **24** is parallel to the flat front face **23**, but the platelike member **40** should have a flat front face **41**, side faces **42** and a rear face defining a marginal portion **43** substantially circumscribing a figure portion **44** of a particular shape, similar to the human ear. This figure portion **44** is cap-shaped so that the portion of the maximum height, due to the maximum height, defines a central stiffer portion **45**, which central stiffer portion is located within a zone of said figure portion **44** which is out of the geometric center thereof (see FIG. **5**). Conveniently, the flat marginal portion **43** defines a plane parallel to the flat front face **41** and the maximum height zone of the cap-shaped figure portion **44** is tangent to said plane.

The sheetlike member **32** including the marginal portions **33** is likewise shown in FIG. **6**. It is obvious that the diaphragm of FIG. **6** has been subjected to the steps as explained in connection with FIGS. **1** to **3**. The central stiffer portion **45** is connected to the voice coil schematically indicated by arrow **46**. The marginal portion **43** is provided with damper means capable of substantially damping vibrations in said marginal portion. These damper means may be achieved by any kind of layer linked to said marginal portion. For instance, a spray may be applied on said marginal portion **43** and which hardens the latter or any kind of rigid plate, such as for instance damper plate **47** (see FIG. **8**) may be mounted onto the rear face of said marginal portion. The damper plate **47** has a central cutout portion corresponding to the figure portion **44**, defining thus an edge **48** which the embodiment as shown in FIG. **6**, is coplanar with the edge **49** of the marginal portion **43**.

If the center of percussion, which is defined by arrow **46**, is located within the center of the central stiffer portion **45**, then as is apparent from FIG. **5**, the radii which extend from the center of **45** to the edge **49** are of different lengths. Each radius may be considered as a sound channel. Since each radius is of a different length, each sound channel is only able to transmit one particular sound different from the other sounds. The length of each radius is equal to a multiple of a predetermined wavelength. Therefore, one or eventually several channels of similar lengths are capable of reproducing one particular audible tone. Since the marginal portion **43** is dampened by the damper plate **47** only the figure portion **44** is in sound-transmitting relationship with the voice coil. This arrangement may be compared, for instance, with a guitar having cords of different lengths, each cord corresponding to one of the sound channels. Therefore, those channels which are out of phase with a transmitted wavelength, are substantially inoperative. Thus distortion is very considerably reduced, and the substantial absence of stationary waves increases the output of the system.

Conveniently, the diaphragm or platelike member **40**, including substantially all the features hereinbefore explained, is at least partially mounted in a frame **50** which firmly grips at least part of the side faces as clearly shown in FIGS. **7** and **8**. Frame **50** may be connected to the damper plate **47** and is furthermore provided with a pair of inwardly projecting ribs **51**, **52** for supporting a nonmagnetic crossbar **53** (see FIGS. **8** and **9**) in spaced relationship with said diaphragm or platelike member. Crossbar **53** in turn supports the magnet assembly **54** including the voice coil **55**, which is in vibration-transmitting relationship with the central stiffer portion **45**.

The rear portion of the frame **50** is preferably closed by a cover lid **56**, which may be made of the same material as the diaphragm, but which conveniently provides an inner face having a frustoconical damping projections **57**.

The frame **50** is provided with at least one perforation **58** arranged between the diaphragm **40** and the lid **56**, so that the air housed therein is in free communication with the ambient air to maintain an equilibrium in pressure.

It will be appreciated that when the diaphragm of the present invention is used as a loudspeaker, practically no sound box is required, nor is it necessary to have a substantial volume of air in front and behind the diaphragm, since the sound wave will be generated by moving within the diaphragm as indicated by vibrations **39** in FIG. **4** and also one of said vibrations is indicated in dotted lines and identified by reference numeral **59** in FIG. **8**.

The sheetlike member **32** will not only cooperate in producing a better sound transducer but protects at the same time, the plastics platelike member and in addition affords means for any kind of illustration or decoration, as previously stated.

The arrangement as shown in FIG. **8** can be embedded within the wall of a room, precisely because the lid **56** is provided, without jeopardizing the sound-reproducing qualities.

In the embodiment of FIG. **10**, the central stiffer portion **45** of a platelike member **40'** has a cylindrical projection **60**, onto which the voice coil member **55**, having the usual coil **61**, is fitted, whereby a good vibration-transmitting relationship is achieved. It will be appreciated that contrary to the prior art, the portion where the voice coil is related to the diaphragm is the thickest portion.

In FIG. **11** a portion of a diaphragm **62** is shown, having the damper plate **47** and the voice coil **55**, similarly as in the previous embodiment described. In addition, a second magnetic assembly is provided including the voice coil **63**, which is in contact with an insert **64**. In FIG. **12**, the proper position of the insert **64** with regard to the thickness of the diaphragm **62** is shown. The diaphragm has a blind bore **65** entering from its rear face **66** through which passes the voice coil **63** (only schematically indicated by an arrow in FIG. **12**) which is in vibrating contact with insert **64** without entering into contact with the diaphragm **62**. The insert **64** is usually a thin brass or aluminum plate and can act as a tweeter if so required.

The particular shape of the embodiment of the diaphragm **40** shown in FIG. **6** and which is provided in order to form the central stiffer portion **45**, can be replaced by producing a parallelepipedic platelike member to define the diaphragm body, formed of zones having different hardness or stiffness.

In this alternative embodiment polyurethane particles are preferably used as starting material. These particles are preexpanded in different batches to different granular sizes. Care should be taken that no complete preexpansion of the granules or particles takes place. The classified different-sized granules are then housed in a preestablished manner in a mold **67**, wherein the largest particles **68** are housed in the marginal or outer portion of the mold **67**. The next smaller size **69** is then poured into the mold to define an annular zone and then finally the smallest size particles or granules **70** are housed in the mold to complete the mold. This arrangement is then expanded to form a diaphragm. The stiffest zone will correspond to the zone of the smaller granules. It is obvious that the shape of the mold can be adjusted to ear shape to define the figure portion corresponding to the one identified by reference numeral **44** in FIG. **5**, having also a marginal outer zone.

It will be understood that improvements may be introduced into the embodiments described by way of example and modifications may be made in the method employed without departing from the scope of the invention, specifically defined in the following claims.

I claim:

1. A substantially flat diaphragm to be used in sound transducers, made of a cellular, strong, stiff platelike member, having a flat front face, a rear face and side faces connecting said front and rear faces, a layer including said front face, additional layers between said layer including said front face and said rear face, said front face defining a front face plane, said layer including said front face being pretensioned in a direction substantially perpendicular to said front face plane and in a direction within said front face plane and said additional layers of said platelike member between said front face and said rear face are gradually under minor stresses from said front face towards said rear face.

2. The diaphragm as claimed in claim **1**, further comprising a marginal vibration damper portion, a figure portion, a central stiffer portion, and wherein said platelike member defines said marginal vibration damper portion which substantially circumscribes said figure portion on said rear face, said figure portion including said central stiffer portion at a zone out of the geometric center of said figure portion, and said central stiffer portion defining a center for capturing vibrations.

3. The diaphragm as claimed in claim **2**, wherein said platelike member is made of granular expanded-bonded cellular, strong, stiff, plastics.

4. The diaphragm as claimed in claim **1**, wherein said front face is sheathed with a tensioned thin sheet member having marginal portions anchored on said side faces.

5. The diaphragm as claimed in claim **4**, wherein said side faces are irregular to increase the anchoring surface for said marginal portion of said sheetlike member.

6. The diaphragm as claimed in claim **4**, wherein said sheetlike member is adhesively adhered to said front face and said side faces.

7. The diaphragm as claimed in claim **4**, wherein said sheetlike member is paper.

8. The diaphragm as claimed in claim **4**, wherein said sheetlike member is a fabric.

9. The diaphragm as claimed in claim **2**, wherein said figure portion is ear shaped.

10. The diaphragm as claimed in claim **2**, wherein said central stiffer portion is of larger width than the remaining portions of said figure portion.

11. The diaphragm as claimed in claim **10**, further comprising a cylindrical projection and wherein said central stiffer portion is integral with said cylindrical projection, said cylindrical projection is adapted for supporting a voice coil.

12. The diaphragm as claimed in claim **2**, wherein said platelike member has a blind bore, a thin short metal insert inserted in said platelike member and accessible from said rear face through said blind bore present in said platelike member, and said metal insert passing through said marginal vibration damper portion and being partially housed in said figure portion.

13. The diaphragm as claimed in claim **3**, wherein said plastics platelike member has predetermined zones formed by preexpanded granules of different sizes.

14. A loudspeaker comprising a substantially flat diaphragm made of a granular expanded-bonded cellular, strong, stiff plastics platelike, imperforate member, having a flat front face, a rear face and side faces connecting said front and rear faces, said platelike member defining a marginal vibration damper portion, a figure portion on said rear face, said marginal vibration damper portion substantially circumscribing said figure portion, a layer including said front face and defining a front face plane, said layer being pretensioned in a direction substantially perpendicular to said front face plane and in a direction within said front face plane, additional layers between said layer including said front face and said rear face, said additional layers of said platelike member between said front face and said rear face are gradually under minor stresses from said front face towards said rear face, a central stiffer portion, said figure portion including said central stiffer portion at a zone out of the geometric center of said figure portion, a frame having a rear portion, at least a part of said side faces being rigidly framed in said frame, said frame projecting with its rear portion beyond said rear face of said diaphragm, a nonmagnetic crossbar mounted in said frame and spaced away from said rear face of said diaphragm, a mag-

netic assembly including a voice coil supported by said nonmagnetic crossbar and in vibration-transmitting relationship with said central stiffer portion, a tensioned thin sheet member having marginal portions, said front face of said diaphragm being sheathed with said sheet member, said marginal portions being anchored on said side faces of said diaphragm.

15. The loudspeaker as claimed in claim **14**, further comprising a cover lid including frustoconical damping projections, said rear portion of said frame being closed by said cover lid, said frustoconical damping projections being directed towards the rear face of said diaphragm, said frame having a bore connecting the inside between said diaphragm and said cover lid with the outside.

16. The loudspeaker as claimed in claim **14**, wherein a damper plate is mounted on said marginal vibration damper portion of said diaphragm.

17. A method for manufacturing a substantially flat diaphragm to be used in sound transducers, comprising the steps of:

a. forming a granular expanded-bonded cellular, strong, stiff plastics platelike member having a flat front face, a rear face and side faces connecting said front and rear faces, said platelike member defining a marginal portion substantially circumscribing a figure portion on the rear face, said figure portion including a central stiffer portion at a zone out of the geometric center of said figure portion, thereby defining in said figure portion substantially straight channels of different length between said central stiffer portion and said marginal portion,

b. adhering to said flat front face a thin sheetlike member having a free marginal portion projecting beyond said front face,

c. bending said platelike member with said adhered sheetlike member to define a concavely shaped front face,

d. urging said bent platelike member with the adhered sheet member into substantially planar condition,

e. adhering the marginal portion of said sheetlike member to at least said side faces,

f. framing said side faces having said marginal portion of said sheetlike member adhered thereto into a shape-retaining frame to maintain said platelike member in substantially planar condition, and

g. providing damper means on the rear face of said marginal portion capable of substantially damping vibrations in said marginal portion.

18. The method as claimed in claim **17**, comprising the additional step of subjecting said platelike member to heat in order to remove moisture from said platelike member and sealing by spray said faces of said platelike member from the outside prior to adhering said sheetlike member.

19. The method as claimed in claim **17**, wherein said platelike member is bent prior to adhering said sheetlike member thereto.

20. The method as claimed in claim **17**, wherein said sheetlike member is of the shrinkable type and is adhered by adhesive to said flat front face to produce the bending of said platelike member by shrinkage of said sheetlike member.

21. A method for manufacturing a substantially flat diaphragm to be used in sound transducers, comprising the steps of:

a. forming a granular expanded-bonded cellular, strong, stiff plastics platelike member having a flat front face, a rear face and side faces connecting said front and rear faces, said platelike member defining a marginal portion substantially circumscribing a figure portion on the rear face, said figure portion including a central stiffer portion at a zone out of the geometric center of said figure portion, thereby defining in said figure portion substantially straight channels of different length between said central stiffer portion and said marginal portion,

b. bending said platelike member to define a concavely shaped front face,

c. adhering to said flat front face a substantially unshrinkable thin sheetlike member having a free marginal portion projecting beyond said front face,

d. urging said bent platelike member with said adhered sheet member into substantially planar condition,

e. adhering the marginal portion of said sheetlike member to at least said side faces,

f. framing said side faces having said marginal portion of said sheetlike member adhered thereto into a shape-retaining frame to maintain said platelike member in substantially planar condition, and

g. providing damper means on the rear face of said marginal portion capable of substantially damping vibrations in said marginal portion.

22. A method for manufacturing a substantially flat diaphragm to be used in sound transducers, comprising the steps of:

a. forming a granular expanded-bonded cellular, strong, stiff plastics platelike member having a flat front face, a rear face and side faces connecting said front and rear faces, said platelike member defining a marginal portion substantially circumscribing a figure portion on the rear face, said figure portion including a central stiffer portion at a zone out of the geometric center of said figure portion, thereby defining in said figure portion substantially straight channels of different length between said central stiffer portion and said marginal portion,

b. adhering, by means of a liquid adhesive, to said flat front face, a thin shrinkable fabric having a free marginal portion projecting beyond said front face,

c. allowing liquid of said adhesive to be soaked in by said fabric,

d. allowing shrinking of said fabric and thereby bending said platelike member to define a concavely shaped front face,

e. urging said bent platelike member with the adhered fabric into substantially planar condition,

f. adhering the marginal portion of said fabric to at least said side faces,

g. framing said faces having said marginal portion of said fabric adhered thereto into a shape-retaining frame to maintain said platelike member in substantially planar condition, and

h. providing damper means on the rear face of said marginal portion capable of substantially damping vibrations in said marginal portion.