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⑤④ **IMPROVEMENTS IN OR RELATING TO MICROPHONES.**

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Description

Background of the Invention

The present invention relates to microphones and more particularly to a noise cancelling microphone.

Noise cancelling microphones are in the main required for communications use in environments where there is a high ambient noise level. Such microphones are designed to discriminate against interference in the form of distant noise sources and to discriminate in favour of close speech sounds. They are constructed so as to be sensitive to the pressure gradient of the sound field in their vicinity, thereby discriminating between close sources which produce a large pressure gradient and distant sources which produce a small pressure gradient. In addition, the microphones are normally mounted on a headset boom so as to allow close positioning to the user's mouth and hence maximise the speech sound signal level available.

One known form of noise cancelling microphone employs a piezoelectric transducer in which an electrical output is obtained using acoustic pressure to mechanically deform a diaphragm made from a piezoelectric material. Such microphones are disclosed in our UK Patent Specification No. 1 515 287 which describes both first order pressure gradient and second order pressure gradient noise cancelling microphones employing piezoelectric transducers. The noise cancelling function requires that the construction of the inside of the microphones and the location of their diaphragms be highly symmetric so that cancellation of equal opposite sound pressure due to distant interference sources can occur.

Summary of the Invention

An objective of the present invention is to provide a noise cancelling device in the form of a pressure gradient microphone employing a piezoelectric material as a transducer, the microphone providing noise cancelling performances superior to that of currently available microphones.

According to the present invention there is provided a microphone having a piezoelectric transducer element contained within a housing, the transducer element being in the form of a diaphragm of piezoelectric material having at least two arms extending therefrom, each arm providing a respective electrically conductive path to a respective part of the diaphragm, the housing comprising two mutually engageable housing parts between which the diaphragm is sandwiched during assembly to divide the housing into two separate chambers, each housing part having one or more sound vents for admitting sound to a respective one of the chambers, the housing parts being designed so that when they are assembled together the resulting housing defines within its structure at least two guide channels each of which is provided for receiving a respecti-

ve one of the arms extending from the diaphragm.

In one embodiment two sound vents are provided in each housing part, the two sound vents being disposed opposite to one another such that the complete housing when assembled may provide part of a second order pressure gradient microphone.

In a preferred embodiment of the present invention each of the mutually engageable housing parts have identical features. Conveniently each housing part is manufactured from a plastics material using an injection moulding process.

In a specific embodiment of the present invention each housing part has an aperture, preferably cylindrical in shape, extending through its centre, each of two longitudinal side walls of the housing part being formed with a respective elongate groove portion, two other longitudinal side walls of the housing part each carrying a respective arm complementary with the groove portions thereby enabling two housing parts to be assembled together by sliding the arms of one housing part into the groove portions of the other housing part.

In a preferred embodiment of the present invention each arm of at least one of the housing parts has a respective channel formed on its inside facing surface whereby, after assembly of the two housing parts into the assembled housing, the assembled housing defines within two side walls the two guide channels for receiving the arms of the diaphragm. Two electrical contacts may also be provided, each contact having a portion adapted to be received in the guide channel and having a curved end portion for abutting against, within the guide channel, an electrically conductive surface of one of the arms extending from the diaphragm, the electrically conductive surface forming an electrical path to a metallised electrode on a surface of the diaphragm. Each electrical contact also has a terminal end adapted for extending out of the guide channel for connection into a socket associated with a pre-amplifier circuit.

In a referred embodiment at least two membranes are provided for each sound vent, one of the membranes serving to protect the sound vent from the environment and the other membrane serving to damp the sound before entering the sound vent.

Brief Description of the Drawings

The present invention will be described further, by way of example, with reference to the accompanying drawings in which:

- Figure 1 illustrates diagrammatically a noise-cancelling microphone not in accordance with the present invention,
- Figure 2 is a perspective view of a complete noise-cancelling microphone in accordance with one embodiment of the present invention,
- Figure 3 is an exploded view of the microphone of Figure 2,

Figure 4 is an exploded view of the microphone capsule in Figure 3, and

Figure 5 is a representation of an electrical contact which can be used in place of the contact shown in Figure 4.

Referring to Figure 1 of the drawings the microphone comprises a cylindrical housing 1 in which is contained a piezoelectric transducer. The piezoelectric transducer comprises a diaphragm 10 of piezoelectric material extending across the interior of the housing 1 to define therein two chambers 3 and 5, the diaphragm 10 being provided with metal electrodes (not shown) on each of its major surfaces across which an electrical output is developed when the diaphragm 10 is mechanically deformed.

Four sound vents 2, 4, 6 and 8 are provided through the cylindrical wall of the housing 1 to allow sound pressure to act on the major surfaces of the diaphragm 10. The sound vents 2 and 8 together with the diaphragm 10 form one first order pressure gradient unit and the sound vents 4 and 6 together with the diaphragm 10 form a second first order pressure gradient unit. By having the sound vents which are opposite to each other admitting pressures to the same surface of the diaphragm 10, the resultant force acting on the diaphragm 10 is the difference of the forces obtained from the two first order pressure gradient combinations; the effective force on the diaphragm 10 is then proportional to the second order of the pressure gradient which is the characteristic of a second order pressure gradient microphone.

In order to provide a microphone having a noise cancelling performance of high quality the necessary requirements are to arrange for each chamber to be as near identical as possible in its shape and volume, for the diaphragm to be accurately mounted within the housing and for good electrical connection to be maintained between the metal electrodes on the major surfaces of the diaphragm and external pre-amplifier circuitry. The need for these requirements has given rise to embodiments of the present invention which are described below.

Description of a Preferred Embodiment

Referring to Figures 2 and 3 of the drawings a complete microphone according to one embodiment of the present invention comprises a microphone capsule 12 in which is housed a piezoelectric transducer, a protective stainless steel mesh 14 which also serves to shield the transducer from outside electrical noise and a protective capsule cover 16. The piezoelectric transducer is in the form of a diaphragm of polyvinylidene fluoride (PVdF) having surfaces coated in gold or aluminium to define metallised surfaces. The material used for the microphone capsule 12 is advantageously CYCOLAC LA (Trade mark of Borg-Warner Corporation) which is a low temperature impact resistant material designed for injection moulding and having a desirable coefficient of li-

near expansion within the range $110 \text{ to } 120 \times 10^{-6} \text{ K}^{-1}$.

Terminal ends 21, 23 of electrical contacts project from a side plate 22 of the capsule 12 to define a plug assembly for engagement within a socket 24 of a pre-amplifier 26, circuit 26 being of known type.

Referring to Figure 4 of the drawings the microphone capsule comprises two identically formed, mutually engageable plastic housing parts 30, 32. As each of the parts 30, 32 is identical their description hereinafter will be primarily with reference to the part 30, occasional reference being made to features of the part 32 when necessary.

The part 30 has a generally oblong shaped body which is manufactured by an injection moulding process, the internal and external dimensions of each part conforming to fine tolerances. The part 30 has a cylindrically shaped aperture 34 extending through its centre, the aperture 34 and the internal walls of the part 30 together defining, after assembly of the capsule, a chamber on one side of the diaphragm of the piezoelectric material. Each of two longitudinal external side walls of the part 30 are formed with a respective elongate rectangular groove portion 36, 38; the other two longitudinal side walls 37, 39 each carrying a respective arm 40, 42. The arms 40, 42 each have a respective channel formed on their inside facing surfaces, the channels being identical to a pair of channels 44, 46 shown on the part 32. Each side wall 37, 39 is provided with a respective sound vent, sound vent 48 being shown for side wall 37, extending through the respective side wall to the central aperture 34 thereby forming a conduit through which sound waves may be admitted to the central aperture 34.

Each of the arms 40, 42 on the part 30 is dimensioned to be complementary with the rectangular groove portions on the part 32 thereby enabling the parts 30, 32 to be snugly fitted together by sliding the arms 40, 42 into the groove portions and to define within the side walls of the complete capsule housing two guide channels.

The transducer element is formed from a piezoelectric plastics material such as polyvinylidene fluoride (PVdF) and comprises two circular layers 52 and 54 of PVdF which together form a laminate, each layer 52 and 54 having an integral arm 56 and 58 respectively made also of PVdF. The laminate when sandwiched between the housing parts 30, 32 so as to cover the aperture 34, serves as a diaphragm separating the two chambers defined within the capsule housing. Each of the arms 56 and 58 is received in a respective one of the guide channels defined in the side walls of the assembled capsule housing.

The diaphragm is provided with metallised electrodes on opposing sides and each arm is also metallised to provide an electrically conductive path from each of the metallised electrodes.

Two electrical contacts 60 are also provided for insertion along the respective guide channels defined in the side walls of the capsule housing.

The electrical contacts 60 are inserted into the ends of the guide channels remote from the diaphragm and are provided with curved end portions for abutting against and for providing maximum pressure engagement with the metallised surfaces of the arms 56 and 58. In this way compensation is provided for any thermal mismatch between the different materials of the arms 56, 58 and the contacts 60. Two types of contact 60 are illustrated in Figures 4 and 5.

Referring to Figure 4 the contact 60 is formed as a single shaped metal part having its terminal end 23 rolled into a pin contact. The pin contact is connected to an oblong portion 27 the width of which conforms to the width of the groove portions 36, 38 in the housing part 30 and the other end of the contact 60 has its remote end portion 25 curved in a direction away from the plane defined by the oblong portion 27.

Referring to Figure 5 the contact 60 is manufactured as a two part contact, one part being the terminal end 23 which is in the form of a solid wire. The other part comprises the oblong portion 27 having an abutment 29 and the curved portion 25. One end of the solid wire is spot welded to the abutment 29 extending from the oblong portion 27.

The curved end portion 25 in Figure 5, is considerably longer to that of the curved end portion of the contact shown in Figure 4, the longer curved end portion 25 being found in practice to compensate better for any thermal mismatch that may arise.

The two housing parts 30, 32 are covered at their ends by side plates 22, 24, the side plates 22, 24 and the housing parts 30, 32 being held together by four long pins 70. The pins 70 extend through holes 72 and 76 formed through the corner regions of the side plates 22, 24 and through elongate holes 74, 75 formed through the corner shoulders of the housing parts 30, 32. Additionally or alternatively the housing parts 30, 32 may be glued together. The terminal ends 23 of the electrical contacts 60 project through holes 80 in the side plate 22 and through holes 82 formed in a silicon sealing gasket 84. The gasket 84 mates with a plastic housing end 25 of the pre-amplifier 26 to prevent moisture reaching the terminal ends 21, 23.

Four small vents 90 are provided in the side plate 24 each of which is positioned between adjacent pairs of the holes 76, and aligned with the guide channels in the side walls of the capsule housing via respective vents 91 in the housing part 32. The small vents 90 and 91 serve to equalise the ambient barometric pressure within the two chambers defined within the capsule housing. A small resilient ring-shaped grommet 92 is also provided for location between the side plate 24 and the back surface of the capsule cover 16 to serve as a pressure pad for the housing parts 30, 32.

Each of the sound vents is covered by a sound damping membrane 94 made from a polyester cloth and each membrane 94 is covered by a further membrane 96 mounted in an oblong frame.

The membranes 96 serve to protect the sound vents and the membranes 94 from the outside environment but must also be sufficiently compliant to allow sound to be transmitted into the sound vents. The membranes 96 may suitably be formed from a silicon web moulding. The metal mesh 14 (see figure 3) serves to both shield the transducer from outside electrical noise and to protect the membranes 94, 96 from dirt and thereby aids cleaning.

Claims

1. A microphone having a piezoelectric transducer element contained within a housing, the transducer element being in the form of a diaphragm of piezoelectric material characterised in that the diaphragm has at least two arms extending therefrom, each arm (56, 58) providing a respective electrically conductive path to a respective part of the diaphragm, the housing comprising two mutually engageable housing parts (30, 32) between which the diaphragm is sandwiched during assembly to divide the housing into two separate chambers, each housing part (30, 32) having one or more sound vents (48) for admitting sound to a respective one of the chambers, the housing parts (30, 32) being designed so that when they are assembled together the resulting housing defines within its structure at least two guide channels each of which is provided for receiving a respective one of the arms (56, 58) extending from the diaphragm.
2. A microphone as claimed in claim 1 characterised in that two sound vents (48) are provided in each housing part, (30, 32) the two sound vents (48) being disposed opposite to one another such that the complete housing when assembled may provide part of a second order pressure gradient microphone.
3. A microphone as claimed in claim 1 or claim 2 characterised in that each of the mutually engageable housing parts (30, 32) are formed with identical features.
4. A microphone as claimed in any one of claims 1 to 3 characterised in that each part (30, 32) is manufactured from a plastics material using an injection moulding process.
5. A microphone as claimed in claim 4 characterised in that the material has a coefficient of linear expansion, substantially within the range $110 \text{ to } 120 \times 10^{-6} \text{ K}^{-1}$.
6. A microphone as claimed in any one of claims 1 to 5 characterised in that each housing part (30, 32) has an aperture (34) extending through its centre, each of two longitudinal side walls of the housing part (30, 32) being formed with a respective elongate groove portion, (36, 38) two other longitudinal side walls (37, 39) of the housing part

(30, 32) each carrying a respective arm (40, 42) complementary with the groove portions (36, 38) thereby enabling two housing parts (30, 32) to be assembled together by sliding the arms (40, 42) of one housing part (30, 32) into the complementary groove portions (36, 38) of the other housing part (30, 32).

7. A microphone as claimed in claim 6 characterised in that the aperture extending through the centre of the housing part (30, 32) is substantially cylindrical in shape.

8. A microphone as claimed in claim 6 or claim 7 characterised in that each arm (40, 42) of the housing part (30, 32) has a respective channel (44, 46) formed on its inside facing surface whereby, after assembly of the two housing parts (30, 32) into the assembled housing, the assembled housing defines within two side walls the two guide channels for receiving the two arms (56, 58) extending from the diaphragm.

9. A microphone as claimed in claim 8 characterised in that two electrical contacts (60) are provided, each contact (60) having a portion adapted to be received in the guide channel and having a curved end portion (25) for abutting against, within the guide channel, an electrically conductive surface of one of the arms (56, 58) extending from the diaphragm, the electrically conductive surface forming an electrical path to a metallised electrode on a surface of the diaphragm, each electrical contact also having a terminal end (23) adapted for extending out of the guide channel for connection into a socket associated with a pre-amplifier circuit (26).

10. A microphone as claimed in any one of claims 1 to 9 characterised in that at least two membranes (94, 96) are provided for each sound vent, (48) one of the membranes (96) serving to protect the sound vent from the environment and the other membrane (94) serving to damp the sound before entering the sound vent (48).

Patentansprüche

1. Mikrofon mit einem innerhalb eines Gehäuses angeordneten piezoelektrischen Wandlerelement, das als Membran aus einem piezoelektrischen Werkstoff ausgebildet ist, dadurch *gekennzeichnet*, dass die Membran mindestens zwei sich von dieser weg erstreckende Arme hat, jeder Arm (56, 58) jeweils eine elektrisch leitende Bahn zu einem zugeordneten Teil der Membran bildet, das Gehäuse zwei miteinander in Eingriff bringbare Gehäuseteile (30, 32) umfasst, zwischen denen die Membran bei der Montage eingelegt wird, um das Gehäuse in zwei getrennte Kammern zu unterteilen, jeder Gehäuseteil (30, 32) eine oder mehrere Schallöffnungen (48) aufweist, um Schall in eine jeweilige Kammer einzulassen, und die Gehäuseteile so ausgeführt sind, dass nach

ihrem Zusammenbau das resultierende Gehäuse innerhalb seines Aufbaus mindestens zwei Führungskanäle bildet, von denen jeder vorgesehen ist, um einen jeweiligen der sich von der Membran weg erstreckenden Arme (56, 58) aufzunehmen.

2. Mikrofon nach Anspruch 1, dadurch *gekennzeichnet*, dass zwei Schallöffnungen (48) in jedem Gehäuseteil (30, 32) vorgesehen sind, die derart einander gegenüberliegend angebracht sind, dass das vollständige Gehäuse nach dem Zusammenbau Teil eines Mikrofons für Schalldruck zweiter Ordnung bilden kann.

3. Mikrofon nach Anspruch 1 oder 2, dadurch *gekennzeichnet*, dass jeder der gegenseitig in Eingriff stehenden Gehäuseteile (30, 32) mit identischen Merkmalen ausgebildet ist.

4. Mikrofon nach einem der Ansprüche 1 bis 3, dadurch *gekennzeichnet*, dass jeder Teil (30, 320) aus Kunststoff unter Verwendung eines Spritzgussverfahrens hergestellt ist.

5. Mikrofon nach Anspruch 4, dadurch *gekennzeichnet*, dass der Kunststoff einen linearen Ausdehnungskoeffizienten im wesentlichen innerhalb eines Bereiches von 110 bis $120 \times 10^{-6} \text{ K}^{-1}$ hat.

6. Mikrofon nach einem der Ansprüche 1 bis 5, dadurch *gekennzeichnet*, dass jeder Gehäuseteil (30, 32) eine sich durch seinen Mittelpunkt erstreckende Öffnung (34) hat, dass jeder der beiden Seitenlängswände des Gehäuseteils (30, 32) jeweils mit einem Längsnutabschnitt (36, 38) ausgebildet ist, dass zwei weitere Längsseitenwände (37, 39) des Gehäuseteils (30, 32) jeweils einen Arm (40, 42) aufweisen, der komplementär zu den Längsnutabschnitten (36, 38) ist, um dadurch den Zusammenbau der beiden Gehäuseteile (30, 32) zu ermöglichen, indem die Arme (40, 42) des einen Gehäuseteils (30, 32) in die komplementären Längsnutabschnitte (36, 38) des anderen Gehäuseteils (30, 32) eingeschoben werden.

7. Mikrofon nach Anspruch 6, dass die sich durch den Mittelpunkt des Gehäuseteils (30, 32) erstreckende Öffnung eine im wesentlichen zylindrische Form hat.

8. Mikrofon nach Anspruch 6 oder 7, dadurch *gekennzeichnet*, dass jeder Arm (40, 42) des Gehäuseteils (30, 32) einen an seiner nach innen gerichteten Oberfläche jeweils einen Kanal (44, 46) hat, so dass nach dem Zusammenbau der beiden Gehäuseteile (30, 32) in das montierte Gehäuse dieses innerhalb der beiden Seitenwände die beiden Führungskanäle zur Aufnahme der beiden Arme (56, 58) bildet, die sich von der Membran weg erstrecken.

9. Mikrofon nach Anspruch 8, dadurch *gekennzeichnet*, dass zwei elektrische Kontakte (60) vorgesehen sind, wovon jeder einen Abschnitt aufweist, der im Führungskanal aufgenommen wer-

den kann und der einen gekrümmten Endabschnitt (25) hat, der sich innerhalb des Führungskanals gegen eine elektrisch leitende Fläche eines der sich von der Membran weg erstreckenden Arme (56, 58) legt, dass die elektrisch leitende Fläche eine elektrische Bahn zu einer metallisierten Elektrode auf einer Oberfläche der Membran bildet, und jeder elektrische Kontakt ferner ein Abschlusssende (23) hat, das sich aus dem Führungskanal erstreckt und mit einer Buchse verbindbar ist, die einer Vorverstärkerschaltung (26) zugeordnet ist.

10. Mikrofon nach einem der Ansprüche 1 bis 9, dadurch *gekennzeichnet*, dass für jede Schallöffnung (48) mindestens zwei Membrane (94, 96) vorhanden sind, wovon eine (96) dazu dient, die Schallöffnung gegenüber der Umgebung zu schützen und die andere Membran (94) dazu dient, den Schall vor Eintritt in die Schallöffnung (48) zu dämpfen.

Revendications

1. Microphone comportant un élément formant transducteur piézoélectrique contenu dans un boîtier, l'élément formant transducteur ayant la forme d'une membrane en matériau piézoélectrique, caractérisé en ce que la membrane présente au moins deux bras qui s'en étendent, chaque bras (56, 58) réalisant un chemin électriquement conducteur respectif conduisant à une partie respective de la membrane, le boîtier comportant deux parties (30, 32) de boîtier, venant mutuellement en prise, entre lesquelles la membrane est prise en sandwich au cours de l'assemblage pour diviser le boîtier en deux chambres distinctes, chaque partie (30, 32) du boîtier présentant un ou plusieurs événements acoustiques (48) pour admettre le son dans l'une respective des chambres, les parties (30, 32) du boîtier étant conçues de façon que lorsqu'elles sont assemblées ensemble, le boîtier résultant définit à l'intérieur de sa structure au moins deux canaux de guidage dont chacun est conçu pour recevoir l'un, respectif, des bras (56, 58) qui s'étendent depuis la membrane.

2. Microphone selon la revendication 1, caractérisé en ce que deux événements acoustiques (48) sont prévus dans chaque partie (30, 32) de boîtier, les deux événements acoustiques (48) étant disposés en face l'un de l'autre de façon que, une fois assemblé, le boîtier complet puisse faire partie d'un microphone à gradient de pression du second ordre.

3. Microphone selon la revendication 1 ou 2, caractérisé en ce que chacune des parties (30, 32) du boîtier qui viennent en prise mutuellement sont prévues avec des caractéristiques identiques.

4. Microphone selon l'une quelconque des revendications 1 à 3, caractérisé en ce que chaque partie (30, 32) est fabriquée en un matériau pla-

stique par le procédé de moulage par injection.

5. Microphone selon la revendication 4, caractérisé en ce que le matériau a un coefficient de dilatation linéaire qui se trouve sensiblement sur la plage allant de 110 à $120 \times 10^{-6} \text{ K}^{-1}$.

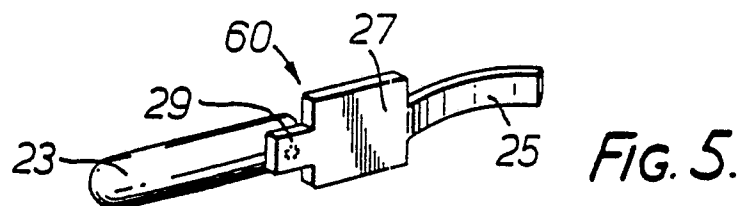
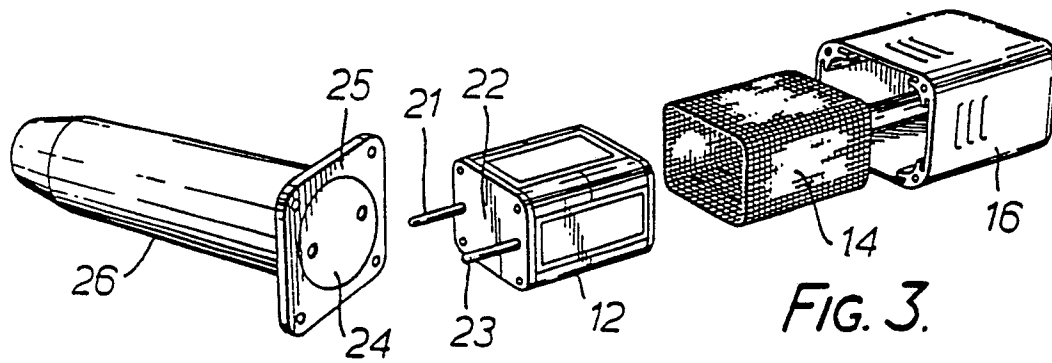
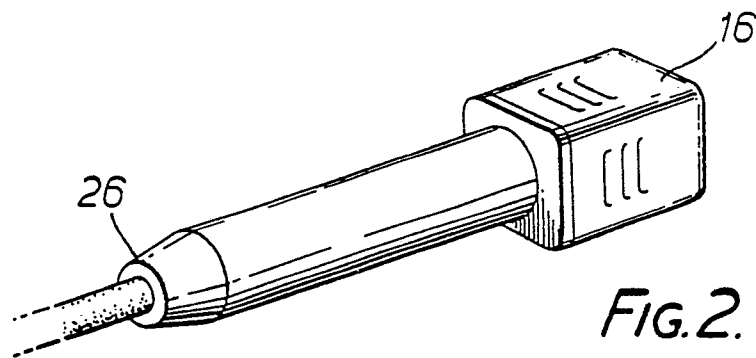
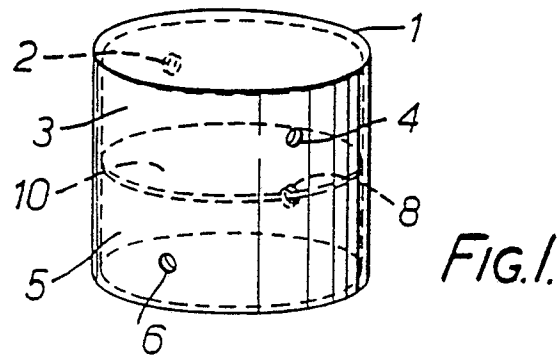
6. Microphone selon l'une quelconque des revendications 1 à 5, caractérisé en ce que chaque partie (30, 32) du boîtier présente une ouverture (34) qui s'étend à travers son centre, chacune des deux parois latérales longitudinales de la partie (30, 32) du boîtier présentant une portion (36, 38) formant rainure allongée respective, deux autres parois latérales longitudinales (37, 39) de la partie (30, 32) du boîtier portant chacune un bras respectif (40, 42) complémentaire de la portion formant rainure (36, 38), permettant ainsi d'assembler ensemble les deux parties de boîtier (30, 32) en faisant coulisser les bras (40, 42) de l'une des parties de boîtier (30, 32) dans les portions formant rainure complémentaire (36, 38) de l'autre partie de boîtier (30, 32).

7. Microphone selon la revendication 6, caractérisé en ce que l'ouverture qui s'étend à travers le centre de la partie de boîtier (30, 32) est de forme sensiblement cylindrique.

8. Microphone selon la revendication 6 ou 7, caractérisé en ce que chaque bras (40, 42) de la partie (30, 32) de boîtier présente un canal respectif (44, 46) formé sur sa surface qui fait face vers l'intérieur, ce par quoi, après assemblage des deux parties de boîtier (30, 32) pour donner le boîtier assemblé, le boîtier assemblé définit, à l'intérieur des deux parois latérales, les deux canaux de guidage pour recevoir les deux bras (56, 58) qui s'étendent depuis la membrane.

9. Microphone selon la revendication 8, caractérisé en ce qu'il est prévu deux contacts électriques (60), chaque contact (60) présentant une portion conçue pour être reçue dans le canal de guidage et présentant une portion d'extrémité courbe (25) pour venir, à l'intérieur du canal de guidage, buter contre une surface électriquement conductrice de l'un des bras (56, 58) qui s'étendent depuis la membrane, la surface électriquement conductrice formant un chemin électrique jusqu'à une électrode métallisée prévue sur une surface de la membrane, chaque contact électrique présentant aussi une extrémité formant borne (23) conçue pour s'étendre hors du canal de guidage et se connecter dans une fiche femelle associée à un circuit préamplificateur (26).

10. Microphone selon l'une quelconque des revendications 1 à 9, caractérisé en ce qu'au moins deux membranes (94, 96) sont prévues pour chaque événement acoustique (48), l'une des membranes (96) servant à protéger l'événement acoustique à l'égard de l'environnement et l'autre membrane (94) servant à amortir le son avant son entrée dans l'événement acoustique (48).



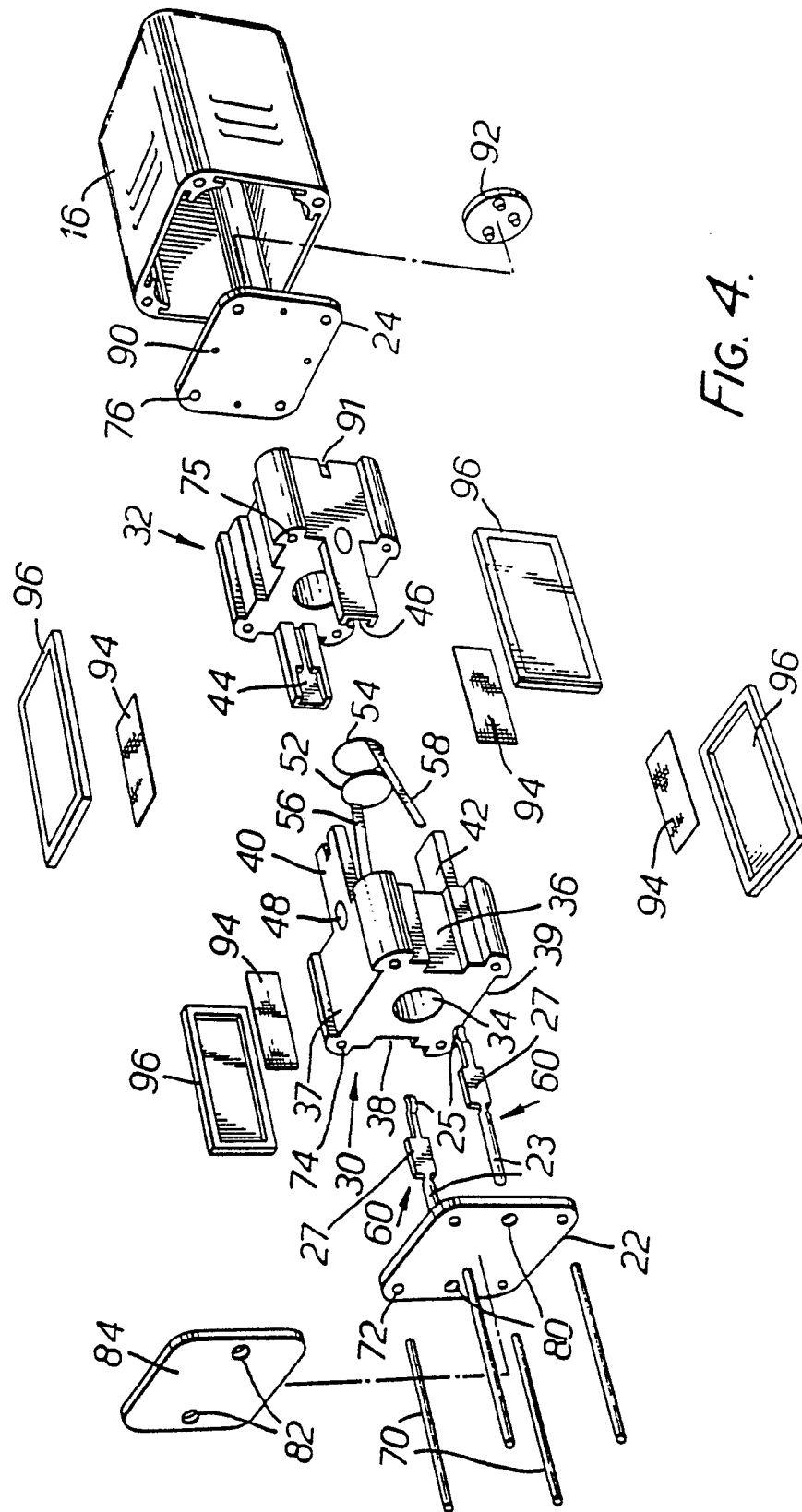


FIG. 4.