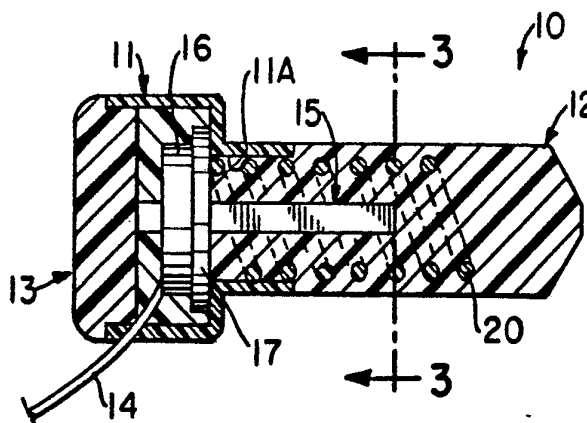




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification⁴ : H04R 1/28, 1/04, 1/46 H04R 17/02, 25/02</p>	A1	<p>(11) International Publication Number: WO 86/07517</p> <p>(43) International Publication Date: 18 December 1986 (18.12.86)</p>
<p>(21) International Application Number: PCT/US86/01148</p> <p>(22) International Filing Date: 22 May 1986 (22.05.86)</p> <p>(31) Priority Application Number: 741,249</p> <p>(32) Priority Date: 4 June 1985 (04.06.85)</p> <p>(33) Priority Country: US</p> <p>(71) Applicant: ACR ELECTRONICS, INC. [US/US]; 3901 N. 29th Avenue, Hollywood, FL 33022 (US).</p> <p>(72) Inventor: ROSENTHAL, James, M. ; 8951 S.W. 53rd St., Cooper City, FL 33328 (US).</p> <p>(74) Agents: RELSON, Morris et al.; Darby & Darby P.C., 405 Lexington Avenue, New York, NY 10174 (US).</p>		<p>(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK, FR (European patent), GB (European patent), IT (European patent), KR, LU (European patent), NL (European patent), NO, SE (European patent).</p> <p>Published <i>With international search report.</i> <i>With amended claims.</i></p>

(54) Title: EAR MICROPHONE



(57) Abstract

An ear microphone (10) of the bone conduction type includes a piezoelectric transducer (15) mounted on a printed circuit board (17) having an amplifier (16) thereon and the transducer is surrounded by a helically wound spring (20). The spring also isolates the transducer from severe mechanical shocks, thereby preventing damage. A semi-soft compound (12) which encases the transducer (15) and spring (20) dampens airborne noise that would otherwise be detected by the electroacoustic transducer. The semi-soft potting compound also waterproofs the ear microphone and provides a comfortable casing that conforms to a user's auditory canal. A cable (14) extends from the amplifier (16) to some point external to the ear microphone so that detected signals can be electronically processed.

FOR THE PURPOSES OF INFORMATION ONLY

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

AT Austria	GA Gabon	MR Mauritania
AU Australia	GB United Kingdom	MW Malawi
BB Barbados	HU Hungary	NL Netherlands
BE Belgium	IT Italy	NO Norway
BG Bulgaria	JP Japan	RO Romania
BR Brazil	KP Democratic People's Republic of Korea	SD Sudan
CF Central African Republic	KR Republic of Korea	SE Sweden
CG Congo	LI Liechtenstein	SN Senegal
CH Switzerland	LK Sri Lanka	SU Soviet Union
CM Cameroon	LU Luxembourg	TD Chad
DE Germany, Federal Republic of	MC Monaco	TG Togo
DK Denmark	MG Madagascar	US United States of America
FI Finland	ML Mali	
FR France		

1

1

5

10

EAR MICROPHONEBACKGROUND OF THE INVENTION1. Field of the Invention

This invention pertains to microphones and more particularly to ear microphones of the vibration pickup type that receive sound through bone conduction.

15

2. Description of the Prior Art

The high noise level existing in many environments such as on factory floors, and in the cockpits of small aircraft or in motorcycles, for example, prevents use of conventional microphones for electronic communication by, for example, intercom or radio, since conventional microphones pick up the noise making speech difficult to understand. Further, a person working in such environment often does not have the free use of his hands. In the factory, the person may be working with his hands, and while flying an airplane or operating a motor vehicle he will obviously need his hands to control the plane or motor vehicle. Therefore, microphones which need not be hand held and which are not sensitive to environmental noise are desirable in these and similar environments.

20

25

30

Ear microphones of the vibration pickup type are known which are fitted into the external auditory canal of the ear of the user to pickup his voice which is conducted through his bones to the external auditory canal wall.

35

Such an ear microphone has been described and disclosed in U.S. patent 4,150,262.

-2-

1 Such devices however, pick up a substantial
amount of environmental acoustical energy. Further,
contamination from moisture or other pollutants can damage
the microphone. Additionally, such devices can become
5 extremely uncomfortable in the user's ear after extended
use.

 It is thus an object of the present invention to
provide a microphone of the type designed to be inserted
into the ear canal of the user to provide an electrical
10 signal derived from the user's voice or other vibrations.

 It is still another object of the invention to
provide an ear microphone which effectively dampens en-
vironmental acoustic energy to cancel environmental noise.

 It is yet another object of the invention to
15 provide an ear microphone which is comfortable for extended
periods of use in the user's ear.

 It is a further object of this invention to pro-
vide an ear microphone that is impervious to moisture
and environmental contaminants.

20 SUMMARY OF THE INVENTION

 In accordance with an illustrative embodiment
demonstrating objects and features of the present invention,
there is provided an ear microphone for insertion into the
external auditory canal of the ear of a user to pick up the
25 user's voice, or other vibrations, via bone conduction
within the user's body. The ear microphone includes an
electroacoustic transducer that provides an electrical
signal in response to mechanical vibration. The transducer
is surrounded by a semi-soft compound which encases the
30 transducer and dampens airborne noise that would otherwise
be detected by the electroacoustic transducer. The semi-
soft compound additionally waterproofs the microphone and
provides a comfortable casing that conforms to the user's
external auditory canal. The foregoing brief description,
35 as well as further objects, features and advantages of the
present invention will be more completely understood from
the following detailed description of a presently preferred,

-3-

1 but nonetheless illustrative embodiment of the invention,
with reference being had to the drawings herein.

DESCRIPTION OF THE DRAWINGS

5 Figure 1 is a side elevational view of the ear
microphone in accordance with the present invention;

Figure 2 is a cross-sectional view taken through
line 2-2 of figure 1.

Figure 3 is a cross-sectional view taken through
line 3-3 of figure 1.

10 Figure 4 is an exploded view showing assembly of
elements of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to Figures 1, 2, 3 and 4, Figure 1
shows an external view of the microphone 10 according to
15 the present invention in which housing 11 and element 12
enclose an electroacoustic transducer element 15. Cable 14
extends into housing 11 for connection to amplifier circuitry
16 also disposed within housing 11. Amplifier 16,
which may be a semiconductor device or mounted on a printed
20 circuit board 17, is in turn connected to transducer 15.
The electrical signal from microphone 10 is carried by
cable 14 for further processing, such as amplification
and reproduction. Cover 13 is disposed on a rear end of
housing 11 to form a closure for housing 11. Housing 11
25 and cover 13 may be of a rigid material, such as a hard
plastic.

Figure 2 is a cross-sectional view taken through
line 2-2 of figure 1 and shows internal elements of the ear
microphone 10. These elements include the microphone
30 transducer element 15 which may be a piezoelectric bimorph,
bender-mode type element. As will be clear to those
skilled in the art, electroacoustic transducer elements
other than piezoelectric elements can be used. Also,
piezoelectric elements other than bender mode or bimorph
35 elements can be used. Generally, as is known in the art,
bimorph elements, which consist of two or more layers of
crystal elements having an electrode therebetween, are up

-4-

1 to 15 times more sensitive than "unimorph" elements. While
twister-mode piezoelectric elements can also be used,
bender mode piezoelectric elements, as described further,
will be more sensitive to the mechanical vibrations found
5 in the external auditory ear canal.

Amplifier 16 may be of any conventional type
which amplifies the minute electric signals generated by
the piezoelectric element. Amplifier 16 also provides a
matched load to the output of transducer element 15. The
10 amplified signal is coupled to cable 14.

Spring 20 is a helically coiled compression
spring which acts as a protective device to surround
piezoelectric transducer 15 and isolates it from severe
mechanical shocks to prevent damage to transducer 15.
15 Spring 20 can be inserted into opening 11A of housing 11
and held there by spring tension against an internal wall
of housing 11. Transducer 15 and spring 20 both extend out
from housing 11 through opening 11A.

Element 12 is of a semi-soft potting compound
20 having sufficient flexibility to conform to the user's ear
canal yet has sufficient rigidity to transmit vibrations
received from the ear canal to the transducer. Element 12
has a generally cylindrical shape adapted to fit into the
user's external auditory ear canal and contacting the walls
25 thereof. Element 12 extends into opening 11A and encloses
transducer 15 both in housing 11 and at its extension out
of housing 11.

One potting compound that has been found useful
is Silastic E RTV (room temperature vulcanizing) Silicone
30 Rubber, manufactured by the Dow Corning Corporation. This
material is a two-part room temperature curing molding
rubber. It has a duro-meter hardness, Shore A, of 40 after
a 7-day curing period. Element 12 has a generally cylin-
drical shape of a size adapted to fit snugly, yet comfort-
ably within the user's external ear canal. Optimum opera-
35 tion of the microphone will result when element 12 is in
intimate contact within the user's ear canal.

-5-

1 As shown in Figure 3, the bender-mode, bimorph
piezoelectric transducer 15 has a rectangular cross-section.
Sides 15A and 15B are long sides of the rectangular cross-
5 section, whereas 15C and 15D are short sides of the rectan-
gular cross-section. The transducer is most sensitive to
vibrations orthogonal to faces 15A and 15B, which vibra-
tions are transmitted from the bone structure of the ear
canal through element 12. Vibrations occurring in direc-
10 tions other than orthogonal to surfaces 15A and 15B and
received by element 12 will generally include vector
components which are orthogonal to sides 15A and 15B and
therefore are sufficiently detectable by transducer 15.
Also, a translation of the direction of energy will occur
15 within element 12 so that vibrations which initially do not
have vector components orthogonal to longitudinal faces 15A
and 15B, will be translated so that they do have such
orthogonal components.

 Additionally, it will be noted that the piezoelec-
tric transducer 15 will be at least partially sensitive to
20 forces that are orthogonal to surfaces 15C and 15D although
at a much reduced sensitivity.

 In operation, the user's voice will be conducted
from his throat through the bones of his head and to the
walls of his external auditory ear canal. Element 12, in
25 addition to providing conduction of vibrations from the
wearer's ear canal to the piezoelectric transducer 15 also
serves to dampen airborne vibrations. Internal losses
within the semi-soft compound of element 12 will cause such
dampening. Additionally, while the semi-soft compound of
30 element 12 provides a reasonable mechanical impedance
match to the human ear it does not provide nearly as good
an acoustic impedance match to air and consequently, air-
borne acoustic energy does not couple well to the semi-soft
compound nor therefore to piezoelectric element 15 con-
35 tained therein. Furthermore, housing 11 and cover 13
will further block airborne acoustic energy from transducer
15. Thus, effective noise cancellation of ambient environ-
mental noise is provided.

-6-

1 Further, the use of a soft rubber potting com-
pound as described above permits complete waterproofing of
the device, and insulates the piezoelectric element 15 and
5 amplifier 16 from moisture which may be present in the
wearer's ear or from other contaminants present in the
environment in which the ear microphone is used.

10

15

20

25

30

35

-7-

What is claimed is:

1. An ear microphone comprising:
an electroacoustic transducer; and
semi-soft compound enclosing at least a portion
of said transducer, said semi-soft compound having a shape
adapted for insertion into a user's ear.
2. The ear microphone according to claim 2 further
comprising a housing, wherein said transducer is partially
disposed within said housing and partially extends out from
said housing.
3. The ear microphone according to claim 2 wherein
said semi-soft compound has a cylindrical shape adapted for
insertion into a user's external auditory ear canal.
4. The ear microphone according to claim 3 further
comprising a helically wound compression spring surrounding
said transducer and disposed within said semi-soft compound.
5. The ear microphone according to claim 4 wherein
said electroacoustic transducer comprises a piezoelectric
transducer.
6. The ear microphone according to claim 5 wherein
said piezoelectric transducer comprises a bimorph piezoelectric
transducer.
7. The ear microphone according to claim 6 wherein
said bimorph piezoelectric transducer comprises a bender-mode
piezoelectric transducer.
8. The ear microphone according to claim 7 wherein
said transducer is of a rectangular parallelepiped shape having
a longitudinal axis aligned with a longitudinal axis of said
cylindrical shape of said potting compound and further includes

-8-

long faces and short faces, said transducer being sensitive to at least forces on said long faces.

9. The ear microphone according to claim 8 wherein said semi-soft compound comprises RTV silicone rubber potting compound.

10. The apparatus according to claim 9 further comprising an amplifier disposed within said housing.

AMENDED CLAIMS

[received by the International Bureau on 13 October 1986 (13.10.86);
original claims 1-10 replaced by amended claims 1-8 (2 pages)]

1. An ear microphone comprising:
 - an electroacoustic transducer;
 - a rigid housing, said transducer being partially disposed within said housing and partially extending out from said housing;
 - a helically wound compression spring partially disposed within and supported by said housing, and partially extending outward of said housing and surrounding said transducer;
 - semi-soft compound enclosing at least a portion of said transducer and said spring, said semi-soft compound having a shape adapted for insertion into a user's ear,
 - said compound being adapted to provide a better mechanical impedance match to the human ear than to air to thereby reduce response of said transducer to airborne vibrations.
2. The ear microphone according to claim 1 wherein said semi-soft compound has a cylindrical shape adapted for insertion into a user's external auditory ear canal.
3. The ear microphone according to claim 2 wherein said electroacoustic transducer comprises a piezoelectric transducer.
4. The ear microphone according to claim 3 wherein said piezoelectric transducer comprises a bimorph piezoelectric transducer.
5. The ear microphone according to claim 4 wherein said bimorph piezoelectric transducer comprises a bender-mode piezoelectric transducer.

6. The ear microphone according to claim 5 wherein said transducer is of a rectangular parallelepiped shaped having a longitudinal axis aligned with a longitudinal axis of said cylindrical shape of said compound and further includes long faces and short faces, said transducer being sensitive to forces on at least said long faces.

7. The ear microphone according to claim 1 wherein said semi-soft compound comprises RTV silicone rubber potting compound.

8. The apparatus according to claim 1 further comprising an amplifier disposed within said housing.

1/1

FIG. 1

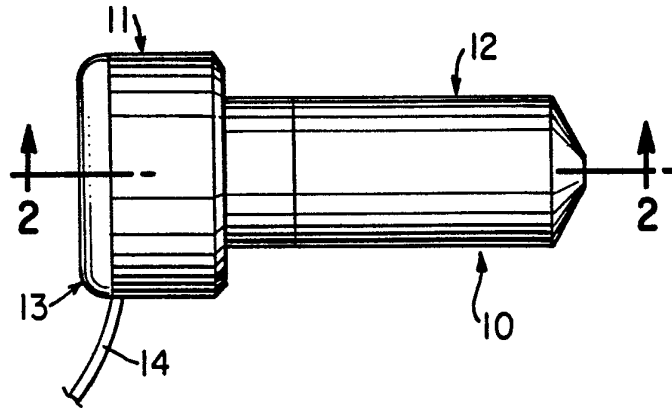


FIG. 2

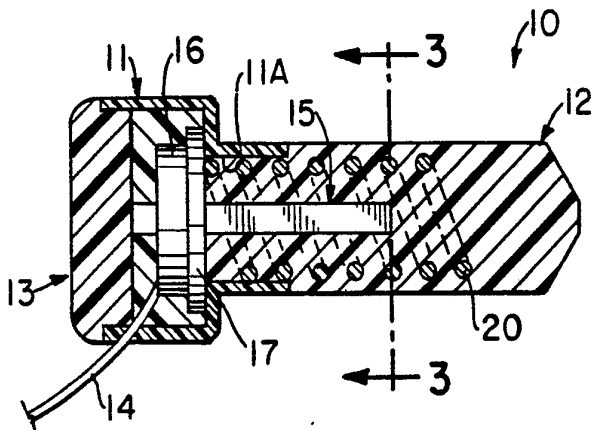


FIG. 3

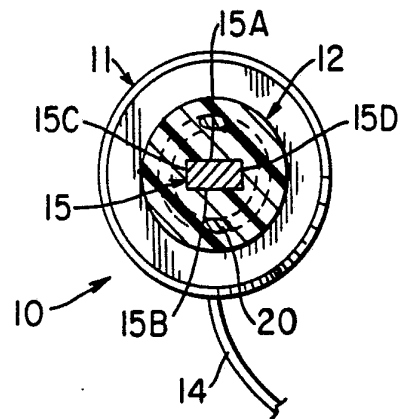
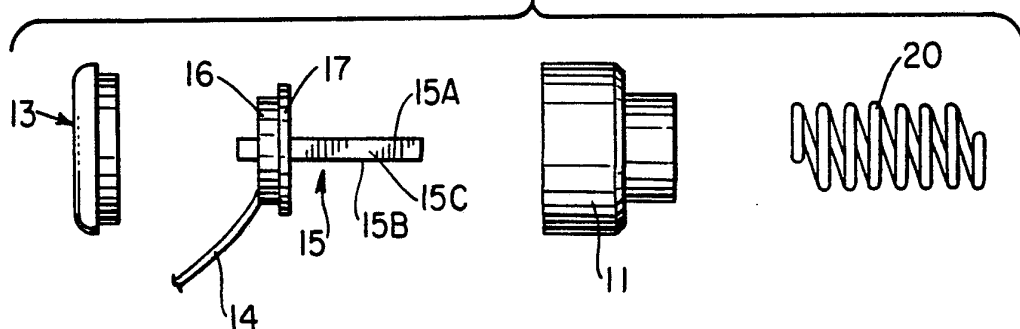
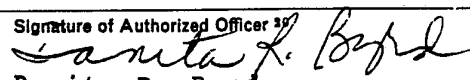


FIG. 4



INTERNATIONAL SEARCH REPORT PCT/US86/01148

International Application No

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³		
According to International Patent Classification (IPC) or to both National Classification and IPC Int. Cl. ² - HO4R 1/28, 1/04, 1/46, 17/02, 25/02 U.S. Cl. - 381/114; 179/107BC, 107E, 110A, 121C, 180		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁴		
Classification System	Classification Symbols	
U.S.	179/107BC, 107E, 110A, 121C, 179, 180 381/114	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category ⁶	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
<u>X</u>	JP, B, 59-33388, 01 March 1984.	<u>1</u>
<u>Y</u>	See pages 5-6	<u>3</u>
<u>A</u>		5-8
Y	US, A, 4,150,262 (Ono) 17 April 1979. See column 1, lines 33-46 and column 9, lines 20-38.	1, 2
A	US, A, 4,323,999 (Yoshizawa et al.) 06 April 1982.	1-3
A	US, A, 4,334,315 (Ono et al.) 08 June 1982.	1-3
A,P	US, A, 4,588,867 (Konomi) 13 May 1986.	1, 2, 5-7, 10
<p>¹⁵ * Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search ¹	Date of Mailing of this International Search Report ²	
03 July 1986	13 AUG 1986	
International Searching Authority ¹	Signature of Authorized Officer ³	
ISA/US	 Danita R. Byrd	