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Sebesta et al.

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[54] **HEAD CONTACT MICROPHONE SYSTEM**

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[22] Filed: **Oct. 20, 1970**

[21] Appl. No.: **82,520**

Related U.S. Application Data

[63] Continuation of Ser. No. 678,974, Oct. 30, 1967, abandoned.

[52] **U.S. Cl.** **179/156**

[51] **Int. Cl.** **H04m 1/05**

[58] **Field of Search** 179/156

[56] **References Cited**

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[57] **ABSTRACT**

An inertial microphone is suspended within a helmet, for contact with the head. It is surrounded and shielded from external air turbulence. The microphone is uniquely mounted to inhibit the physical transmission of ambient noise and vibration to it through its mounting. One's face and hands remain unencumbered. Voice vibrations pass through the skull and head tissue, on to the microphone. Satisfactory speech communication is obtained even while in 100 knot winds and/or in noise levels up to 120 decibels. Useful in military, helicopter, fire and police operations.

20 Claims, 8 Drawing Figures

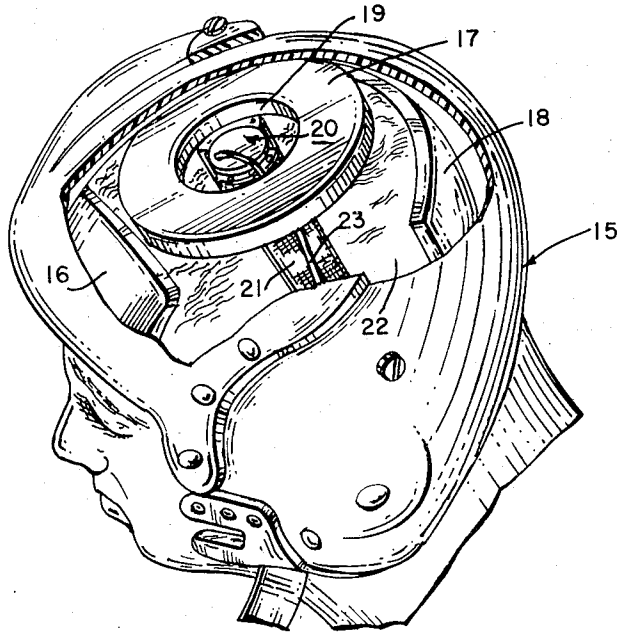


FIG. 1

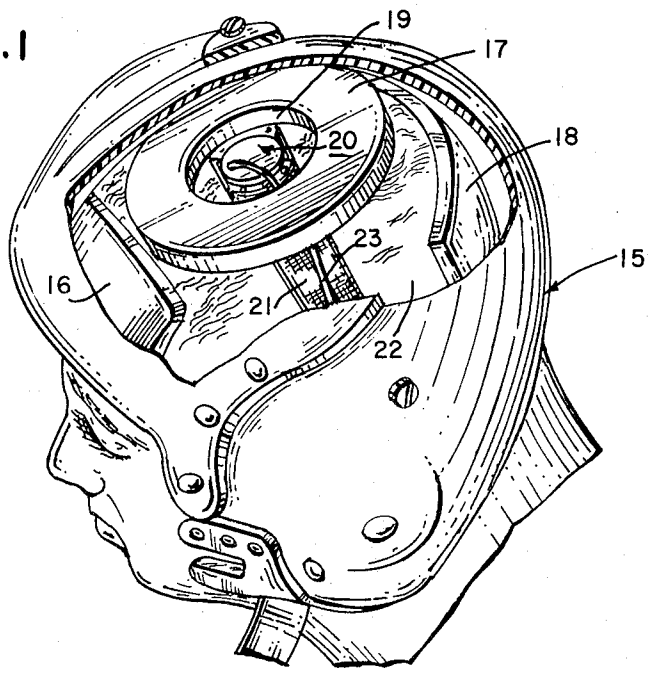
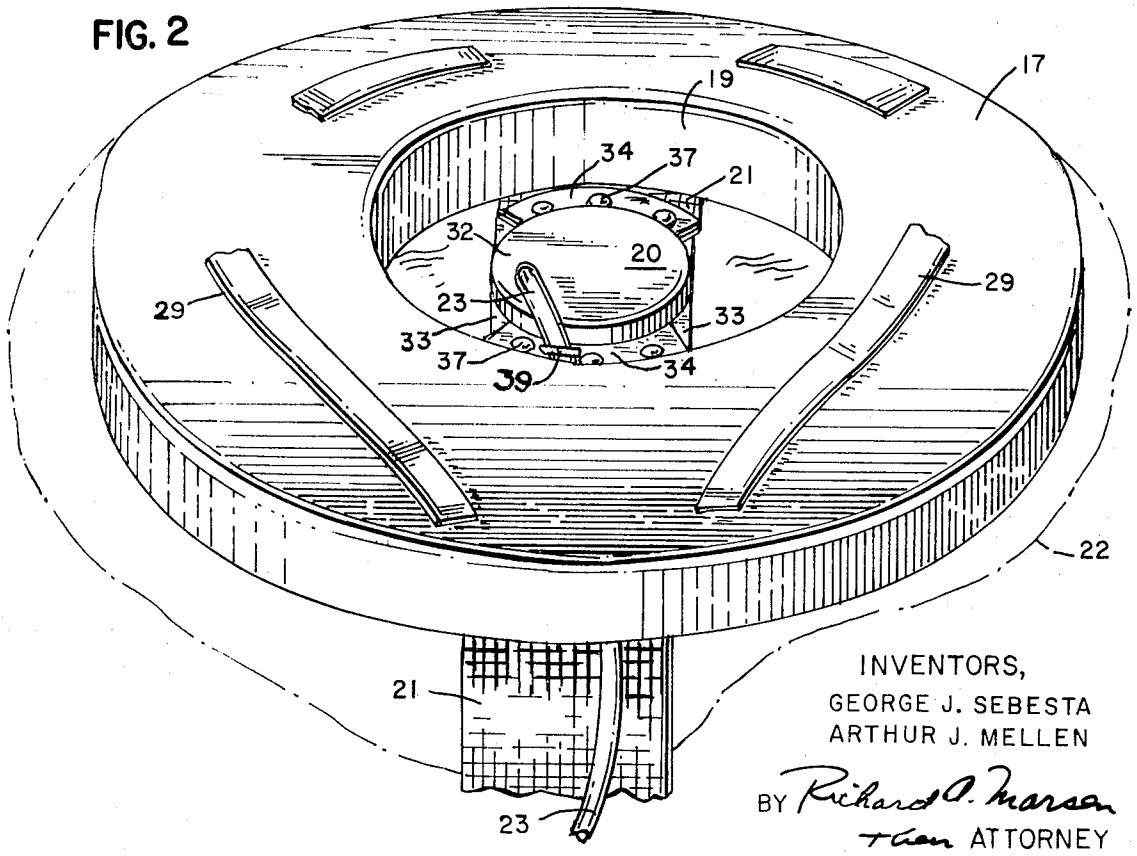


FIG. 2



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FIG. 3

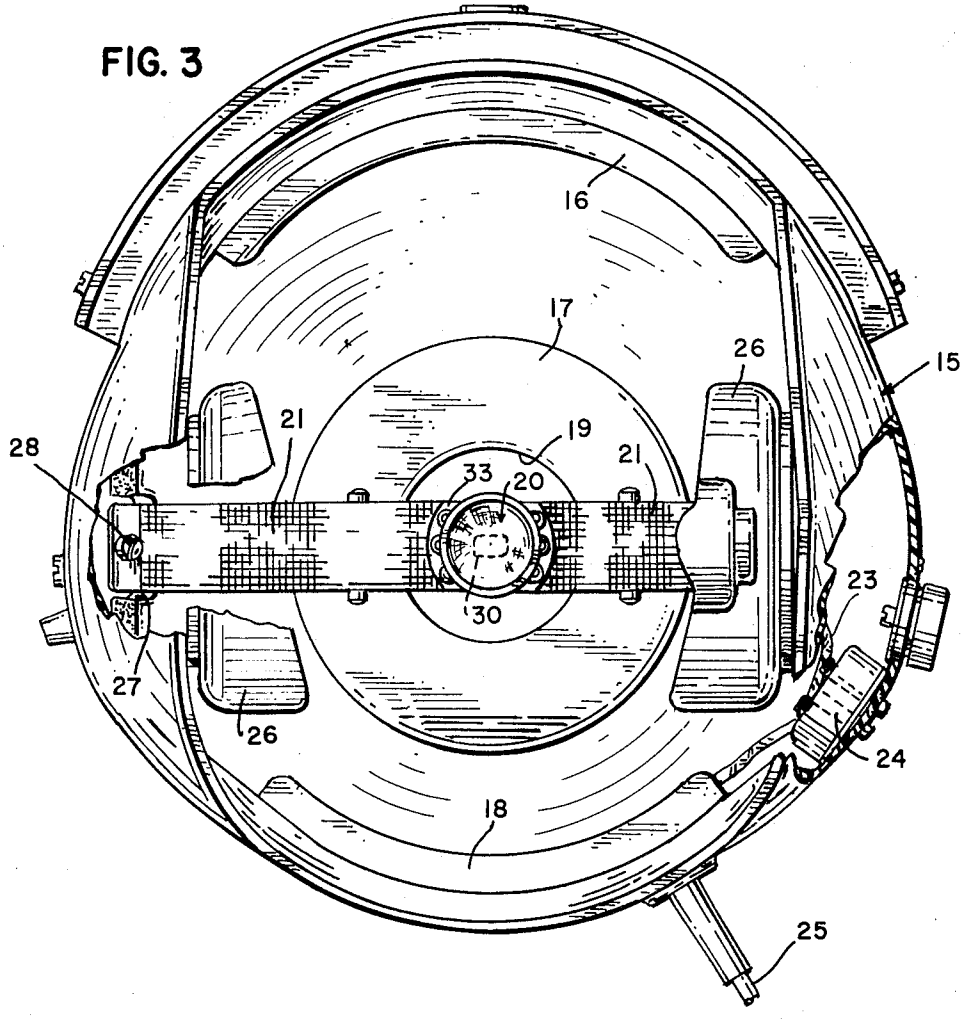
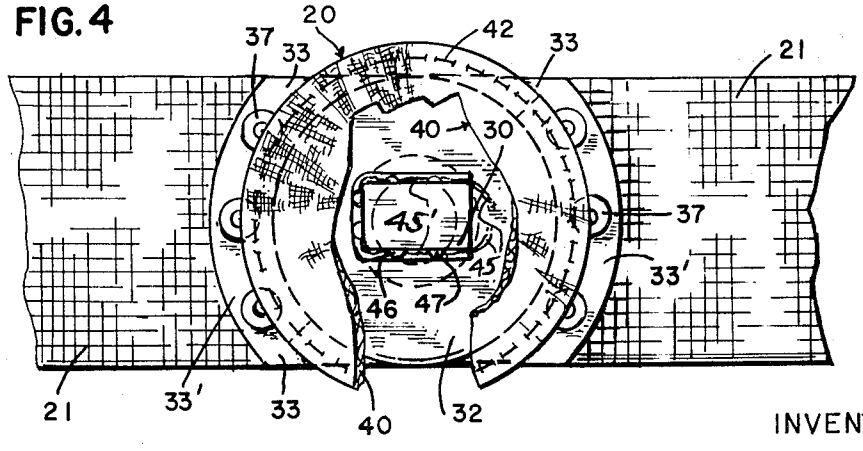


FIG. 4



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FIG. 5

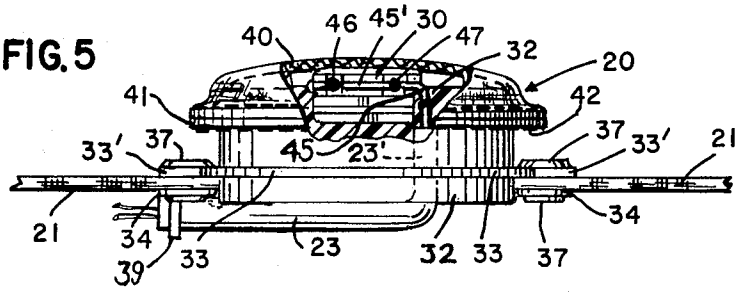


FIG. 6

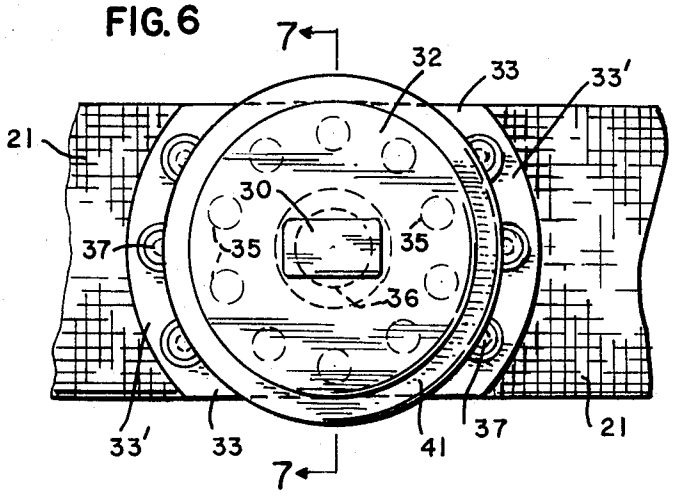


FIG. 7

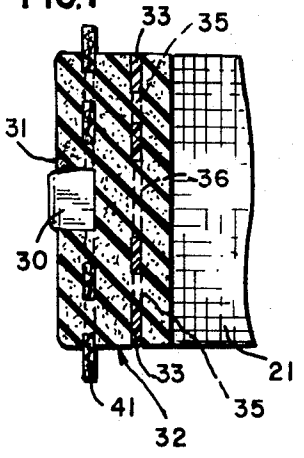
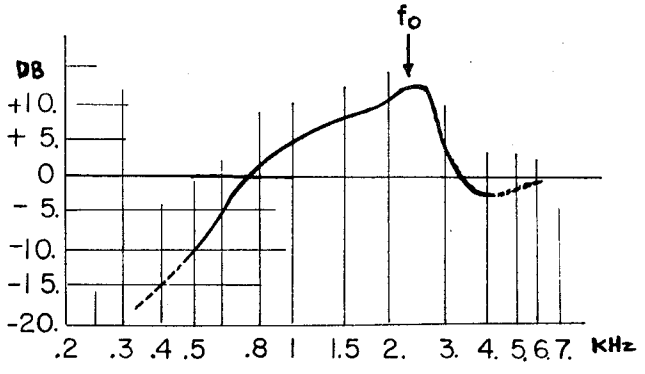


FIG. 8



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HEAD CONTACT MICROPHONE SYSTEM

This application is a continuation of Ser. No. 678,974, filed Oct. 30, 1967 and now abandoned.

This invention relates to speech microphone systems operable in contact with the head; and more particularly to novel mounting arrangements that inhibit extraneous noise transmission to the microphone, for good performance under severe ambient wind and noise conditions.

There are a number of very noisy and/or windy situations in which a good speech microphone system is essential. An important need is aboard helicopters, particularly during battle for vital communication while subjected to propeller winds of 100 knot velocity and/or ambient noise up to 120 decibels. Noise-cancelling microphones are ineffective in the presence of high winds or air turbulence, and furthermore encumber due to their position in front of one's face. Firemen and motorcycle police find the microphone system hereof most useful. Pilots in general, soldiers, and many other types of users are contemplated therefor.

The microphone system of the present invention overcomes the afore-mentioned problems. An inertial microphone is imbedded in a member of very pliant material, in turn suspended in the helmet in a novel arrangement that protects it from turbulent air and suppresses ambient noise transmission therethrough to the microphone. The microphone is mounted inside the helmet for comfortable contact with the head of the user. Noise absorbed by one's head is transmitted to the microphone through the skull at a lower order of magnitude. Such transmitted noise has been found to be substantially neutralized by corresponding noise reaching the microphone housing through the helmet in sufficiently out-of-phase relation. The microphone array hereof leaves one's hands and face unencumbered, and provides good speech intelligibility despite the presence of strong wind or noise. The invention system is light in weight, unobtrusive, and is maintained in operable condition during the normal wearing of the helmet.

The above and further features, advantages and objects of this invention will become apparent from the following description of an exemplary embodiment thereof, illustrated in the accompanying drawings, in which:

FIG. **1** illustrates the contact microphone system hereof, in position on the head, with the helmet cut away thereat.

FIG. **2** is an enlarged view of the microphone suspension, as used in the helmet of FIG. **1**.

FIG. **3** is an interior view of the helmet of FIG. **1**, illustrating the microphone assembly in plan.

FIG. **4** is an enlarged plan view of the microphone suspension arrangement at its head-contacting face, with its covering layer partially broken away.

FIG. **5** is an enlarged elevational view of the microphone assembly, partially broken away, corresponding to its showing in FIG. **4**.

FIG. **6** is a plan view of the microphone mounting, without its cover.

FIG. **7** is a cross-sectional view through the microphone mounting, taken along the line **7—7** of FIG. **6**.

FIG. **8** is a subjective characteristic performance curve of the microphone system hereof.

A typical pilot helmet **15** is shown in FIG. **1**, cutaway to illustrate the contained microphone system in operative contact with the head. The sun-visor is omitted for clarity. Helmet **15** has a firm outer shell, and a plastic liner. Foam urethane pads **16, 17, 18** at the front, middle and rear, comfortably support the helmet on the head. Middle pad **17** has its central portion **19** open to accommodate microphone assembly **20** therein. The microphone assembly **20** is thus shielded from direct impingement of turbulent air, by the helmet top and the surround of foam rubber **17, 19**. Pad **17** may be of soft elastomer or other comfortable-to-press yet sound-inhibiting material.

The microphone assembly **20** is operatively supported centrally in the helmet by flexible mesh straps **21, 21**. When the helmet is in normal position, the straps **21, 21** conform to the top of the head (**22**), and press the assembly **20** into proper and comfortable contact therewith. FIGS. **1** and **2** show the back of microphone assembly **20** from which its output electrical leads **23** extend to a miniature amplifier **24**, the output of which is conducted externally at **25**, see FIG. **3**. Conventional earphones **26, 26** are suitably supported in the helmet, and connected through to external cable **25**, as is understood by those skilled in the art. The end of each strap **21** is anchored at a side of the helmet by a clamp **28**. The adjacent styrene foam liner of the helmet is notched out to accommodate the strap support for assembly **20**, as shown in FIG. **3**.

Surround **17** is of doughnut form, and microphone assembly **20** is recessed in its opening **19**. Pad **17** is attached to the top inside part of the helmet by contact adhesive strips **29, 29**. It is important to provide an electrical connection between the cable **23** and the microphone **30** in such a manner to mechanically filter vibrations and sound transmission therebetween. The shielded cable (**23**), is relatively stiff and capable of picking-up and physically conducting noise and live vibrations. By thus suitably isolating its mechanical transmission to the microphone **30**, we suppress an important source of noise from the system output, as will be set forth. The surround **17** creates a field protected region in its center **19** for the microphone (**30**) that is held in head-contacting assembly **20**. The upper boundary of this region is the stiff plastic top of the helmet **15**; the under boundary is the head (**22**). Exterior air turbulance and wind is thereby kept from the microphone assembly **20**, and external ambient noise is attenuated thereat by the order of 25 decibels. Desirably, the open region within pad **17** may be filled with a cylindrical pad of soft elastomer material to further reduce the field noise for assembly **20**. The inertial microphone per se (**30**) is mechanically filtered from its electrical cable (**23**), as aforesaid.

An important factor of this invention for the suppression of ambient noise from the resultant speech signal output, is the method and character of mounting the inertial microphone per se with the assembly **20**. Essentially, microphone **30** is imbedded in a very pliant and flexible material (**32**) that in turn is carefully supported as a practical assembly for rugged use. The pliant bed **32** is made of a very soft composition that greatly inhibits conduction of noise therethrough to the microphone, while permitting its firm head contact for speech actuation. The material of bed **32** is highly absorbtive of vibration and sound energy. The air

shielded region within surround (17), and the highly pliant bed (32) for the inertial microphone, combine to provide remarkably intelligible speech communication despite external ambient turbulant air and noise conditions. The unique and effective inertial microphone bed (32) hereof, and its support, will now be described.

The transducer 30 is set into outer face 31 of bed 32, shown in cylindrical shape. Microphone 30 is of rectangular form, and is implanted into very soft elastomer bed 32, with its head-contact face protruding a little amount, as by 0.005 to 0.010 inch (see FIG. 7). It is advantageous that the inertial transducer (30) be small in size and light in weight in the invention assembly and system, and yet be sufficiently sensitive for good signal-to-noise output. A suitable microphone is described in the copending patent application Ser. No. 116,260, filed Feb. 17, 1971 which is a continuation of Ser. No. 650,776 filed on July 3, 1967 for "Inertial Reaction Transducer," now abandoned, and assigned to the same assignee. Its exemplary dimensions are 0.440 inch × 0.220 inch × 0.165 inch; its weight, about 1 gram. It is an inertial transducer of the electromotor type. Other inertial microphone types or sizes may of course be used instead. A transducer of such small mass has been found to provide a good match of mechanical impedance between it and the head, regardless of whether hair is interposed. This results in low attenuation of sound vibrations from the head to the transducer.

The elastomer bed 32 of the exemplary assembly (20) is a highly plasticized polyvinyl chloride, sold under the trademarks "Koroseal" and "Korogel." This material has excellent vibration suppression characteristics, being highly dissipative and absorptive of vibrations throughout the sound spectrum. Such compound is manufactured by the Perma-Flex Mold Company in Columbus, Ohio under license by the B. F. Goodrich Company. Their No. 15 material is excellent in noise suppression but is crumbly. Their No. 6 compound is used in the exemplary assembly hereof. It has sufficient cohesiveness to be stably molded into a body of requisite size, and hold well together with a mounting ring, as will be set forth. The No. 6 "Koroseal" is extremely soft; being in the 30 to 35 range as measured on a Shore Durometer A scale. The soft exemplary bed 32 is 1.0 inch in diameter and 0.5 inch thick.

The highly pliant elastomer bed 32 thus thoroughly surrounds the four sides and the rear face of transducer 30, and thereby substantially reduces the intensity of ambient noise impinging on these surfaces of the microphone. The soft elastomer 32 not only exerts significant sound and vibration damping action, but also alters the magnitude and phase of vibrations originating outside the head that do reach the transducer 30 through it. The apparent net effect is the further minimization of extraneous noise from the transducer output, by balancing-out such vibrations that reach it otherwise. Satisfactory signal-to-noise communication results, despite high external air turbulance as due to 100 knot wind velocities, and noise levels to 120 decibels of "pink-noise" fields.

The very pliant pad 32 is suspended by a plate 33 of phenolic material held molded together with the pad, and extending from its periphery. Plate 33 is positioned near the pad's rear surface, inwardly about 0.100 inch. Plate 33 contains a series of apertures 35, 35 and a central hole 36 through which the elastomer extends, for practical mechanical attachment therewith. A pair of ears 33', 33' extend from plate 33 for firm connection with the straps 21, 21. Toward this end, an arcuate anchor 34 is used to press an end of each mesh strap 21 against a plate ear 33', and is secured therewith by rivets 37. The plate 33 is resiliently positioned in the helmet 15 by the flexible straps 21, 21 and presses the soft elastomer pad 32 towards the head (22), with the contact-face of transducer 30 in inertial operative relation therewith, see FIGS. 1 and 2. The mounting plate 33 exerts mainly a compressive force on the soft bed 32 when in use upon the head, and thus renders the assembly 20 stable even in rugged usage.

The said "Koroseal" elastomers are highly plasticized with chemicals which have the effect of softening and/or dissolving a number of materials and compounds with which it may be placed in contact. A covering 40 is provided on the operative face of bed 32 that prevents chemical action to the head. Cover 40 also serves to isolate the transducer per se from the head. Chamois leather has been found to be inert to the "Koroseal" material. A chamois cap 40 is secured to the bed 32 through a second ring 41 molded therewith about 0.100 inch inwardly from its transducer side. Mount-ring 41 is a soft annulus made of fabric impregnated with rubber. The annular edge of ring 41 is sewn together with the edge of circular chamois cap 40 by stitching 42.

The chamois cap 40 has the property of transmitting head vibration to the transducer 30 with negligible attenuation. In the exemplary assembly 20 its thickness is of the order of 0.025 to 0.035 inch. The soft attachment ring or annulus (41) for the cap (40) isolate vibrations of the harder suspension ring (33) therefrom through the compliance of the annulus. Other inert sheet material may suitably be used instead of chamois for the cap 40, as of soft elastomer, Dacron, etc. Also, such cap 40 may be satisfactorily held in position on bed 32 through an annulus (41) or equivalent extending insert in bed 32 of "Dacron" sheeting or other material; or merely linked to plate 33 by several pliant strands. Further, the plate 33 may be of flexible material, rather than stiffer phenolic.

The output leads 23 electrically connect with those (45) from transducer 30. The local transducer leads are initially (45') secured to the case of the transducer at several spots indicated at 46, 47 in FIG. 5. This provides strain-relief for leads 45 that in turn connect to output cable 23. A strain-relief mode for transducer leads 45, 45' is illustrated in FIG. 7 of the aforesaid copending patent application Ser. No. 116,260. Transducer output cable 23 has its initial portion 23' extend loosely through bed 32, see FIG. 5. The shielded cable 23 is connected to the fine wire leads 45 of the transducer 30 in a manner to mechanically filter-out vibrations from the cable to the transducer. Towards this end the fine wire leads 45 are soldered or otherwise connected with the corresponding wire ends of the cable 23 of the interior cable portion 23'. An external portion of cable 23 is anchored to a projecting ear 33' of mount plate 33, as by a strap indicated at 39. In this manner a U-loop is formed from cable 23 to transducer 30, inclusive of interior sections 23', 45. Vibrations conducted up through cable 23 are absorbed at the

plate 33 and highly dissipative bed 32, and are substantially further attenuated for the transducer at its fine wire leads 45 through the effective mechanical filter established through the U-loop.

The material used for the transducer mount or bed 32 is very important in accomplishing the objectives of the present invention. The transducer 30 is press-fitted therein, relying on residual elasticity of the bed to hold it in, or by a very thin layer of pliant adhesive. As hereinabove emphasized material 32 is highly absorbtive of sound and vibrational energy applied to it. The highly flexible supple "Koroseal" No. 6 composition satisfactorily performs the invention requirements for the bed 32: being sufficiently cohesive to form as a body (32); shaped or moldable with a mounting insert (33); and highly dissapative of sound and vibrational energy that impinges thereon. The latter absorbtive characteristic is preferably equivalent to that of human flesh. The shape and size of bed 32 are such as to sufficiently surround all the unexposed surfaces of the transducer (30) centered in its open side (31), so as to significantly attenuate ambient noise energy thereto. The "Koroseal" No. 6 material also alters the phase of residual ambient sound energy that reaches the transducer (30) through the bed (32), with advantageous result as aforesaid.

An illustrative subjectively determined response curve of the helmet head-contacting microphone system hereof is depicted in FIG. 8. There is a generally rising characteristic from about 300 to a peak at about 2,400 Hz (f_o), at approximately 9 db rise per octave. Speech intelligibility of such response has been found to be quite good. It is to be realized that such response results from mere contact of the transducer with top of head, where attenuation of the higher frequencies is rather pronounced. The rising frequency characteristic of FIG. 8, coupled with the steady roll-off from the peak frequency (f_o) to 3,800 Hz results in good speech pick-up inherently by the transducer (30) per se, with relatively low accompanying ambient noise. The overall system hereof is found to provide satisfactory intelligible speech communication while the wearer of the helmet arrangement hereof is in an ambient field of noise up to 120 decibels as aforesaid, and/or in the presence of turbulent air, as up to 100 knots velocity.

Although the present invention has been described with an exemplary embodiment, it is to be understood that variations thereof are feasible within the broader spirit and scope of the invention, and that it is not intended to be limited except as set forth in the following claims.

What we claim is:

1. A speech communication system adapted to be worn on the head comprising an inertial microphone, a member of elastic material that is dissipative of vibrational energy passed therethrough and that is substantially larger than said microphone, the said elastic member having a substantial head-contacting region, said microphone being surrounded in contiguous relation by the elastic member and being supported thereby at its head-contacting region, mounting means connected with said member for holding its said head-contacting region against the head and thereby maintain the microphone in stable vibratory coupling relation with the head during the communication mode, said mounting means being physically separated from the microphone with dissipative material of said member therebetween, whereby speech vibrations are effectively communicated from the head to said inertial microphone through its said coupling relation while ambient sound vibrations in the vicinity of the microphone minimally affect its response.

2. A speech communication system as claimed in claim 1, further including a cable with terminals extending to said microphone, fine wire leads of the microphone in circuit connection with said terminals, said cable and leads being arranged to inhibit vibrations in the cable from reaching the microphone.

3. A speech communication system as claimed in claim 1, further including a cap of soft material overlying the microphone for contact with the head, whereby head vibrations are transmitted substantially unattenuated through said cap to the microphone.

4. A speech communication system as claimed in claim 3, in which said cap is made of a chamois-like material.

5. A speech communication system as claimed in claim 3, in which said cap is made of chemically inert sheet material.

6. A speech communication system as claimed in claim 3, further including an element mechanically connected with said elastic member apart from said mounting means, said cap being fastened to said element.

7. A speech communication system as claimed in claim 1, further including a part set into said elastic member apart from its microphone setting, said mounting means being attached to said part and thereby hold the member and microphone to the head.

8. A speech communication system as claimed in claim 3, further including a part set into said elastic member apart from its microphone setting, said mounting means being attached to said part and thereby hold the member and microphone against the head, and an element mechanically connected with said member in spaced relation from both said microphone and said part, said cap being fastened to said element.

9. A speech communication system as claimed in claim 8, further including a cable with terminals extending to said microphone, fine wire leads of the microphone in circuit connection with said terminals, said cable and leads being arranged to inhibit vibrations in the cable from reaching the microphone.

10. A speech communication system as claimed in claim 3, in which said member is a soft elastomer in the 30 to 35 range as measured on a Shore Durometer A scale and highly dissipative of vibrational energy passed therethrough.

11. A speech communication system comprising a helmet, an inertial microphone, a member of elastic material that is absorptive of sound vibrations impinging therein, mounting means arranged to support said member within the helmet and out-of-contact therewith, said microphone being retained by said member substantially separated from said mounting means, said member being held in compression against the head by said mounting means when the helmet is worn and thereby maintain the microphone in stable vibratory coupling with the head during the communication mode, whereby speech vibrations of the wearer

are effectively communicated to said inertial microphone through its said coupling relation while ambient sound vibrations reaching the vicinity of the microphone minimally affect its response.

12. A speech communication system as claimed in claim **11**, in which said member is a soft elastomer in the 30 to 35 range as measured on a Shore Durometer A scale and highly dissipative of vibrational energy passed therethrough.

13. A speech communication system as claimed in claim **11**, in which said member is a highly plasticized polyvinyl chloride.

14. A speech communication system as claimed in claim **11**, in which said microphone is substantially smaller than said member and is imbedded centrally in the section of said member that faces the head, a portion of the microphone projecting just beyond said section for coupling with the head.

15. A speech communication system as claimed in claim **11**, in which said mounting means further includes straps anchored in the helmet, said member and microphone being thereby pressed to the head when the helmet is worn.

16. A speech communication system as claimed in claim **11**, further including a surround mounted at the inner top region of the helmet, said surround having an opening within which said member and the microphone are positioned by said mounting means for operative coupling with the head, whereby turbulent air within the helmet is substantially shielded from the microphone by said surround.

17. A speech communication system as claimed in claim **16**, in which said surround is made of soft sound-absorbing material.

18. A speech communication system as claimed in claim **11**, further including a cable with terminals extending to said microphone, and fine wire leads of the microphone in circuit connection with said terminals, said cable and leads being arranged to inhibit vibrations in the cable from reaching the microphone.

19. A speech communication system as claimed in claim **11**, further including a cap of soft material overlying the microphone for contacting the head, whereby head vibrations are transmitted substantially unattenuated through said cap to the microphone.

20. A speech communication system as claimed in claim **19**, further including an element mechanically coupled with said member apart from said mounting means, said cap being fastened to portions of said element.

* * * * *