

Oct. 28, 1941.

S. G. SEARS ET AL

2,260,727

CONTACT MICROPHONE

Filed July 12, 1938

2 Sheets-Sheet 1

Fig. 1

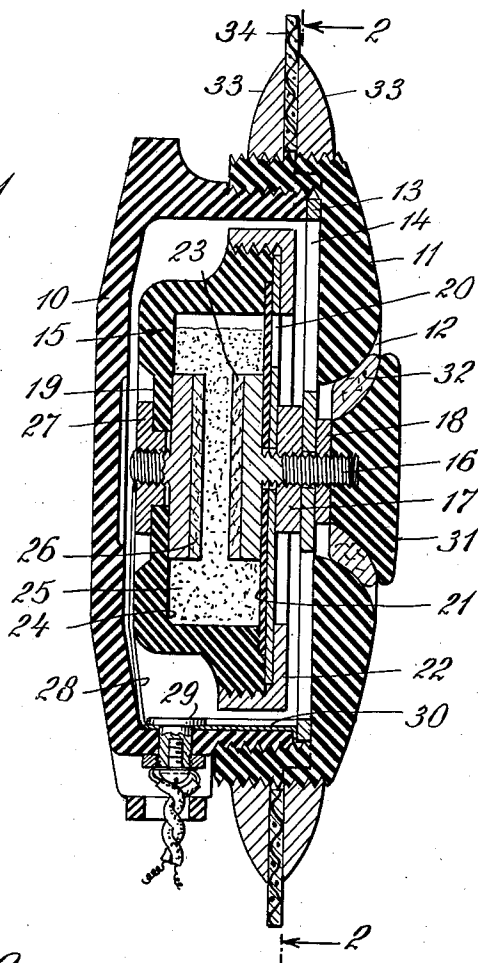
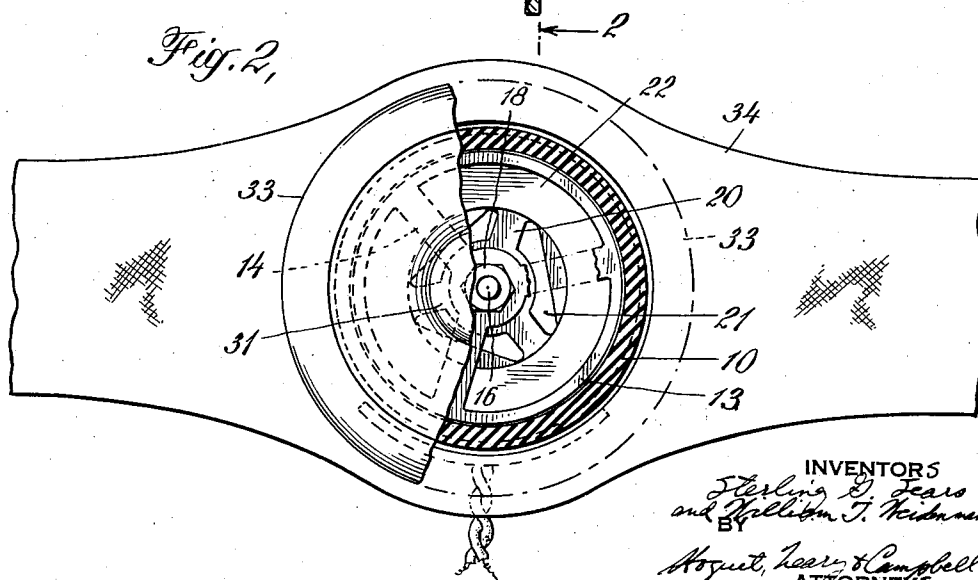


Fig. 2



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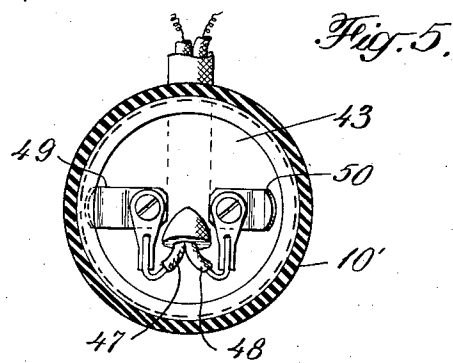
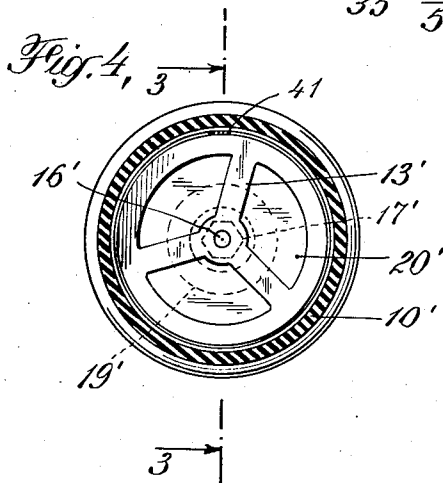
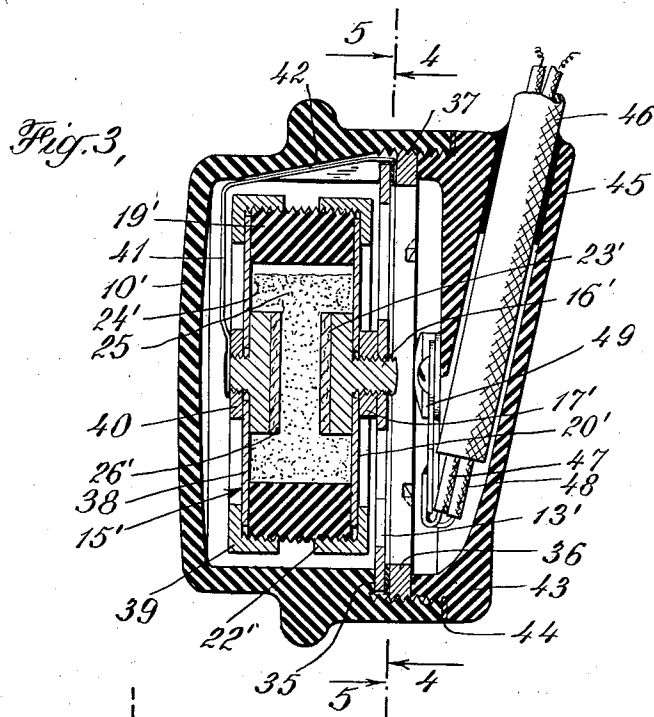
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2 Sheets-Sheet 2



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CONTACT MICROPHONE

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2 Claims. (Cl. 179—123)

This invention relates to microphones and has particular reference to microphones of the body contact type, whereby vibrations of the voice are reproduced directly from the throat, cheek or other part of the body, for telephone, radio or other uses.

Body contact microphones, of which the throat contact type has been the most commonly used, have been cumbersome, inefficient and so variable in performance or poor in reproducing quality as to be generally unsatisfactory. Nevertheless the body contact type microphone offers many advantages, providing its reproducing effectiveness and efficiency could be improved. Of the general class of body contact microphones, the throat type offers particular advantages, although its position introduces the additional objections that the vibrations of the throat are deficient in high frequency response, and are accentuated in the low frequencies by reason of the natural resonance of the vocal cords. Thus the prior throat contact arrangements produce a distorted nasal quality, which, though usually understandable with difficulty, require filters and the like for correcting the deficiencies in reproduction. This necessity for filters and the like disproportionately increases the size and cost of the equipment.

In accordance with the present invention, a body contact microphone is provided, which overcomes the objections to the prior devices: which efficiently reproduces the desirable vibrations of the generating medium, such as the throat, head, chest, back, etc.; which effectively isolates the desirable vibrations from interference and undesirable vibrations; which produces substantially uniform vibrations over an extended tone range without distortion due to overloading and the like, and with a quality comparing favorably with a direct speech or acoustic microphone without the need of filters, and which is rugged, moisture-proof, light and comfortable to wear.

In a preferred embodiment of the body contact microphone of this invention, a reaction type carbon granule microphone element, having relatively movable cooperating electrodes is movably suspended within a casing held on the throat or other speech-responsive portion of the body by suitable means, such as a flexible strap or band. In one form of the invention, a button connected to the element engages the throat for actuation by the speech vibrations. With this arrangement, the response of the element to low frequency vibration is small, while at higher frequencies the mass inertia of the free parts of the suspended element becomes more effective in re-

acting to the vibrations, and relative movement between the electrodes with consequent reproduction results. At still higher frequencies the inertia of one electrode assembly causes it, in effect, to remain stationary while the button-connected electrode vibrates at considerable amplitude in response to the vibrations.

In another form of the invention, the contact button is dispensed with and replaced by the entire casing, which is placed in contact with the throat or the like for bodily vibration thereby in response to speech. The microphone element is resiliently suspended in the casing and the electrodes are each resiliently supported for independent relative movement with respect to each other. With this arrangement, the weight of the casing is effective in suppressing vibrations of large amplitude and in transmitting vibrations of higher frequency to the modulating electrode. The inertia reaction response of the microphone element is substantially the same as was described in connection with the contact button form.

It will be seen that the body contact microphone of this invention is very efficient and effective for all purposes and has particular utility where it is inconvenient if not impossible to hold the direct speech or acoustic type of microphone before the lips, such as in an aeroplane, where the background noise level of engine and propeller vibration is high. Inasmuch as the throat vibrations are the most difficult to reproduce intelligibly, it follows that a body contact microphone which is effective at that point will be at least as effective in reproducing voice vibrations when in contact with other voice-responsive parts of the body, such as the cheek, head, chest, back and the like.

For a more complete understanding of the invention, reference may be had to the accompanying drawings, in which:

Figure 1 is an axial section through one form of the body contact microphone of this invention;

Fig. 2 is a cross-section through the microphone as seen along the line 2—2 of Fig. 1, a portion of the main supporting spider being broken away to illustrate the arrangement of the microphone element;

Fig. 3 is an axial section through another form of the invention, as seen along the line 3—3 of Fig. 4;

Fig. 4 is a transverse section as seen along the line 4—4 of Fig. 3, a portion of the main supporting spider being broken away to illustrate

the arrangement of the microphone element; and

Fig. 5 is a transverse section as seen along the line 5—5 of Fig. 3 illustrating the electrical contact arrangement on the interior of the back cover.

Referring to Fig. 1 of the drawings, numeral 10 designates a housing of suitable material, such as hard rubber, phenolic resin, metal, or the like, having a cap 11 threaded thereon provided with a central aperture 12. Clamped between the cap 11 and the bezel of the housing 10 is a spider 13, the radial spokes 14 of which provide the spider with a degree of axial flexibility. The spider 13 may have three spokes 14 and it freely supports the microphone element 15 within the housing 10 by means of a threaded stud 16 passing through the center of the spider 13, which is clamped between a nut 17 and a nut 18 on the stud 16.

The microphone element 15, thus floatingly mounted, comprises a casing 19, of insulating material such as hard rubber or the like, having an open front over which is clamped the axially flexible spider 20 and the flexible sealing gasket 21 by means of the clamp ring 22 threaded on the casing 19. The stud 16 which supports the microphone element 15 passes through spider 20 and gasket 21 and is conveniently secured to the front electrode 23 within the microphone chamber 24 containing carbon granules and a rear electrode 26 threaded on a nut 27 in the rear of the casing 19. As shown in Fig. 2, spider 20 is provided with spokes, preferably three, and the gasket 21 seals the spaces between them.

The nut 27 serves as a terminal for rear electrode 26 and is connected by a light flexible ribbon or wire 28 to one of the terminals 29 projecting through the housing 10, while the front electrode 23 is electrically connected by stud 16, spider 13 and ribbon or wire 30 to the other terminal 29. The ribbon or wire 28 offers no restraint to the bodily movement of the microphone element within housing 10.

The stud 16 projects beyond the clamp nut 18 through the center aperture 12 of the cap 11 and serves as a support for the applicator button 31, which is threaded thereon. Preferably interposed between the button 31 and the wall of the aperture 12 is a ring 32 of felt, rubber, or the like, which prevents the entrance of moisture or dust into housing 10.

For mounting the device on a helmet or other harness, a pair of clamp rings 33 are preferably threaded on the periphery of the cap 11. If the microphone is to be used for throat contact, for example, the rings 33 clamp the device on a suitable throat-encircling flexible band or strap 34 of leather, fabric, or the like. The band or strap 34 is fastened around the user's throat so that applicator button 31 engages the flesh of the throat with sufficient pressure to effect intimate operative contact between the button 31 and the flesh. The usual point of contact with the throat is at the side toward the front adjacent the thyroid cartilage, although other points on the throat and on the body may be utilized as desired, the intimacy of contact between the button 31 and the body part being essential in each case.

In operation of the form of the contact microphone of this invention illustrated in Figs. 1 and 2, the mere act of applying the device to the body usually results in deflection of the spider 13 and a bodily axial displacement of the microphone element 15 in the housing 10, due to the pressure of the applicator button 31 on the body, the de-

gree of such displacement being dependent upon the degree of the pressure. Usually this displacement is but slight, because too great pressure of the button 31 on the body will soon become

uncomfortable. It will be observed that this bodily displacement of the microphone element 15 due to pressure on button 31 does not alter the relation between the electrodes 23 and 26, so that any degree of pressure on button 31 in use cannot affect the performance of the microphone element 15 in its reproduction of the desired speech sounds. It will be understood that the microphone element 15 operates in the characteristic way of carbon granule microphones, in that the relative movement of the electrodes 23 and 26 rearranges the carbon granules 25 in chamber 24 so that the resistance to the flow of current between the electrodes is varied in proportion to their movement, which in turn is in accordance with the speech vibrations.

Very low frequency vibrations of the engaged body part in response to speech will cause the microphone element 15 to move substantially as a unit with little or no deflection of the inner spider 20, so that the relation between the electrodes 23 and 26 is not materially varied, with the result that little or no sound is reproduced. This is particularly advantageous where the microphone is arranged for throat use, since the vibrations of the throat are accentuated in the low frequencies, the major reproduction of which is undesirable.

When the vibration frequency is increased, the mass inertia of the casing 19, clamp ring 22 and rear electrode 26 assembly becomes more effective in reacting to the vibrations of the button 31, spiders 13 and 20 and front electrode 23 assembly. The inertia of the former assembly tends to cause it to remain stationary, so that relative movement between electrodes 23 and 26 and consequent reproduction of the speech takes place.

At still higher frequencies, including the very high frequencies, the casing 19, clamp ring 22 and rear electrode 26 assembly practically remains stationary due to its inertia, with the result that the amplitude of movement between the electrodes 23 and 26 is relatively large with consequent reproduction of the speech vibrations in accordance with their amplitude and frequency. Since the output of the microphone element 15 is in general proportional to the displacement of the electrodes 23 and 26 with respect to each other, except for the characteristics of carbon contacts, the device of this invention has an output characteristic which rises with increase in frequency. This makes the device particularly adaptable for reproducing throat vibrations which are deficient in high frequency response, since the device reproduces the higher frequency vibrations efficiently and suppresses or fails to respond efficiently to the over-accentuated low frequencies of the throat vibrations.

In the form of the invention illustrated in Figs. 3, 4 and 5, the applicator button of the arrangement of Fig. 1 is dispensed with and the entire housing 10' takes its place, being suitably supported by a helmet, or harness such as a band or strap for holding the front of the casing 10' in operative connection with the body part, such as the throat, head, chest, back, or any other body part which vibrates in response to speech of the user. In the arrangement of Figs. 3 and 4 the microphone element 15' is, in effect, reversed, i. e., the spider 13' which supports it freely in housing

10' is at the rear thereof, instead of in front as in Fig. 1, while the electrodes 23' and 26' become rear and front electrodes, respectively.

Considered in greater detail, in the form of the invention illustrated in Figs. 3 and 4, the axially flexible spoked spider 13' is securely clamped against a shoulder 35 within the housing 10' by means of a clamp ring 36 threaded into the rear of the housing 10'. An insulating gasket 37 is interposed between spider 13' and clamp ring 36, both of which form part of the electrical circuit to be described. A stud 16' threaded into the center of the spider 13' and connected to the rear electrode 23' secures the microphone element 15' upon the spider 13', the stud 16' passing through the axially flexible rear wall 20' of the element 15', which is clamped between the back of the rear electrode 23' and a nut 17' threaded on the stud 16' and serving as a spacer between spider 13' and wall 20'.

The rear wall 20' is secured to the casing 19' of the microphone element 15' by a clamp ring 22' threaded on the casing 19'. The opposite or front wall 38 of the microphone element 15' is likewise constituted by an axially flexible plate, secured in place by a clamp ring 39 threaded on the casing 19' and mounting the front electrode 26' by means of a nut 40 threaded on the stud of the electrode 26'. The chamber 24' within the microphone element 15' contains carbon granules 25' engaging the electrodes 23' and 26'. In the respect that both of its opposite electrode-bearing walls 20' and 38 are axially flexible, the arrangement of Fig. 3 differs from that of Fig. 1, in which only one such wall is flexible, namely 20, 21. The front and rear walls 38 and 20' may be imperforate, axially flexible plates as shown in Fig. 4 or they may be spoked spiders similar to spider 20 of Fig. 1 with the spaces between their spokes closed by flexible sheet gaskets like 21 in Fig. 1, depending upon requirements.

The electrical connections include a thin flexible ribbon or wire 41 connected at one end to the nut 40 of front electrode 26' and extending through a groove 42 in the housing 10' to overlie the insulating gasket 37 for electrical engagement by the metal clamp ring 36. The rear electrode 23' is electrically connected to spider 13' through stud 16'. The rear of the housing 10' is closed by a cap 43 threaded into the rear opening thereof over a water-tight gasket 44. Preferably the cap 43 is formed with an inclined conduit 45 into which the two-strand conductor 46 is water-tightly sealed. The two strands 47 and 48 of the conductor are electrically connected to contact springs 49 and 50, respectively, which are secured to the under surface of the cap 43 and which are arranged to respectively engage the clamp ring 36 and spider 13', respectively, the former being connected to the front electrode 26' and the latter to the rear electrode 23'. Connections between the microphone element 15' and the conductor 46 are accordingly simply completed by screwing the cap 43 in place.

In operation of the form of the invention exemplified by Figs. 3, 4 and 5, the device, suitably mounted on a helmet or harness, in a manner similar to that illustrated in Figs. 1 and 2, with the conductor 46 on the outside, engages the throat or other part of the body at the front surface of housing 10' with the intimate operative contact described. Thus applied to the body, there is no engagement between the body and the microphone element 15', no matter what the pressure of the housing 10' on the body. The microphone element 15' being freely suspended

in the casing 10' by flexible spider 13' is accordingly afforded a certain freedom of bodily axial displacement, and is not submitted even to the restraint afforded by the applicator button 31 of the arrangement of Figs. 1 and 2. Also there is no liability that the carbon will become electrically packed due to static pressures, and hence relatively inoperative.

As in the arrangement of Figs. 1 and 2, low frequency speech vibrations applied to the housing 10' cause the microphone element 15' to oscillate bodily by reaction on spider 13' with little or no relative movement between the electrodes 23' and 26'. As the frequency of vibration is increased, the mass inertia of the microphone element casing 19' the clamp rings 22' and 39, front wall 38 and front electrode 26' assembly causes it to react against the movement of the lighter rear wall 20' and rear electrode 23' assembly, resulting in relative movement between the electrodes 23' and 26' and consequent reproduction of the speech. Likewise at still higher frequencies the inertia reaction effect increases, the front end assembly of the microphone element 15' in effect, remaining stationary. The flexible front wall 38, with the front electrode 26', provide a tunable element permitting further control of the response range of the device, and enables the reinforcement or reduction of predetermined regions of the useful range.

In both forms of the device the relative weight of the microphone element 15 and 15' should be low and the stiffness of the springs 13, 13', 20, 20' and 38 should be relatively high, in order that a long tone range may be effectively handled by the device. Thus, by a suitable selection of the stiffness of these springs and adjustment of the mass or weight of the microphone element 15 or 15', suitable variation in the response characteristic may be achieved for throat use. For example, the weight of the microphone element 15' or 15 may be on the order of six grams, and the springs 20, 20' sufficiently stiff to cause the corresponding electrode resonance to be high in the frequency range to be reproduced. Similarly, springs 13, 13' should be relatively stiff so that the resonance thereof, weighted by the microphone element 15, 15', will be at the top of the frequency range to be reproduced. Also to increase the inertia reaction effect, housing 10' may be made heavier, as by loading.

A damping effect on the resonance of the springs is produced by the carbon granules in the microphone elements 15 and 15' and by the friction at the peripheries of the springs 13, 20, 20', 38. This friction damping may be increased if desired by interposing felt or other resilient material between the springs 13, 20, 20', or 38 and the corresponding engaging surfaces of the housing 10, 10' or casing 19, 19', as the case may be. This last expedient may be employed to increase the relatively low frequency response when the microphone is used on the head or cheek bone. Where the device is immediately over bone, a greater mass of the vibration responsive part of the device is permissible, since the bone effectively attenuates the low frequencies.

It will be observed that in both forms of the device of this invention, the electrodes 23, 26 and 23', 26' project well into the carbon 25, 25', modulating the material at approximately the center of the mass thereof, whereby the device is operative in all positions of use. Also, because the electrodes 23, 26 and 23', 26' are arranged for response movement in a direction parallel to the

body vibrations, and as the extraneous vibrations due to propeller and exhaust noises, or engine or machine sounds are negligible in that direction, the device responds but little or not at all to such extraneous disturbances. Furthermore, the device is so constructed as to be effectively tunable to suppress the undesirable extraneous noises, thus reducing the background noise to some thirty decibels below the average useful signal intensity, even under extreme conditions. Also, if properly constructed of selected materials, the device is unaffected by the high or low pressure or temperatures encountered in use.

Because the device of this invention may be employed effectively on any parts of the body which are responsive to local vibrations, it may be used as a stethoscope or the like, simply by adapting the response characteristic of the device to the desired service. The device may also be employed for machinery vibration detection or analysis, and may be applied with varying pressure to any part without altering its sensitivity or causing the carbon to pack. While a carbon type microphone element has been illustrated and described herein, other forms of microphone element may be used with equal facility, providing only that it contains an electro-mechanical element which moves or vibrates in response to the sounds or vibrations to be reproduced to proportionally vary or effect the development of an electrical current of proportional value. For example, an electromagnetic system with an air gap variable by the vibration responsive movement of an armature in place of electrode 23 or

23' and a pole or poles in place of casing 19 or 19' and/or electrodes 26 or 26', or other equivalents of the ribbon or condenser type microphone elements and the like.

While certain preferred embodiments of the invention have been illustrated and described herein, it is to be understood that the invention is not limited thereby, but is susceptible of changes in form and detail within the scope of the appended claims.

We claim:

1. In a body contacting microphone, the combination of a member adapted to be supported in operative connection with a voice-responsive body part for vibration thereby, a microphone element having opposite resilient walls, spaced electrodes on said walls, and resilient means in said member connected to one of said electrodes and supporting said element on said member for bodily movement relative to said member within at least part of the audible frequency range.

2. In a body contact microphone, the combination of a member adapted to be supported in operative connection with a voice-responsive body part for vibration thereby, a microphone element resiliently supported on said member and having opposite resilient walls extending substantially parallel to the vibrating body part, and electrically-cooperating electrodes connected to said walls for vibration thereby in response to vibration of said member by the body part for effecting corresponding electrical vibrations.

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