April 21, 1964 L. P. HAGEY 3,130,275

MICROPHONE

Filed Oct. 15, 1962

FIG. 1

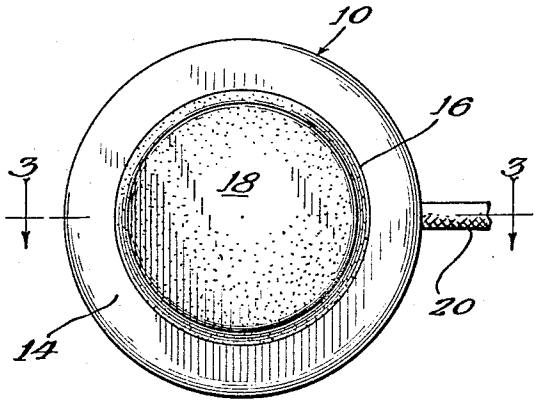


FIG. 2

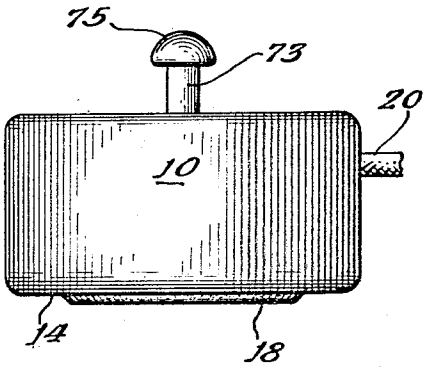
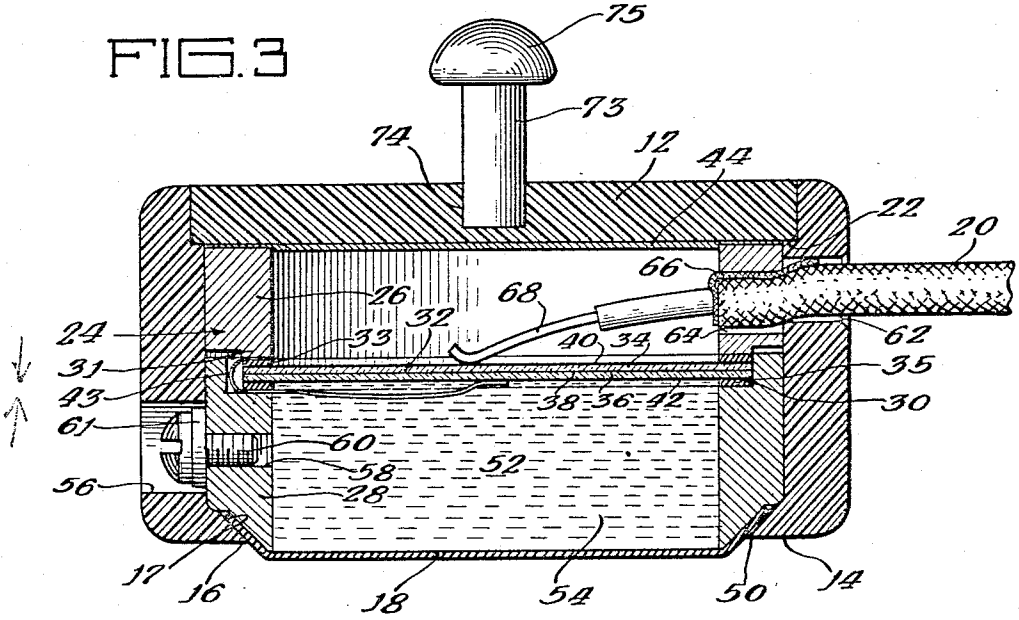


FIG. 3



Inventor:
Lee P. Hagey
By: Stone, Nierman, Dunmeister & Zummer
Attorneys

United States Patent Office 3,130,275 Patented Apr. 21, 1964

3,130,275

MICROPHONE

Lee P. Hagey, Buchanan, Mich., assignor to Electro-Voice, Incorporated, Buchanan, Mich., a corporation of Indiana

Filed Oct. 15, 1962, Ser. No. 230,578
3 Claims. (Cl. 179—110)

The present invention relates generally to microphones, and more particularly to microphones which are adapted for use in electrical stethoscopes.

Electrical stethoscopes have long been known to the art, Patent No. 1,791,932 to Miller disclosing such a stethoscope in 1931. An electrical stethoscope employs an electromechanical transducer which is mechanically coupled to the body of a person under investigation and which generates an electrical impulse. The electrical impulse is utilized to excite an amplifier circuit, and the output of the amplifier circuit is observed either visually or audibly.

A stethoscope should reproduce the sound generated by the body of the person under investigation without alteration, and should be relatively insensitive to gross body movements. This requires the microphone of the stethoscope to have a frequency response range adequate to reproduce the sounds generated by the human body and it further requires coupling of the microphone sensitive element to the body of the person under investigation. Microphones for use in electrical stethoscopes prior to the present invention have produced relatively small outputs, thus requiring expensive and generally bulky amplifiers. Further, the small output from prior microphones for use with electrical stethoscopes has tended to introduce distortion and other types of untrue sound reproduction. It is one of the objects of the present invention to provide a microphone for use in electrical stethoscopes which will produce high electrical output relative to the microphones that have existed for this purpose heretofore.

One of the difficulties in obtaining substantial output from a microphone for use in an electrical stethoscope is in obtaining adequate coupling between the sensitive element of the microphone and the skin of the person under investigation. Prior to the present invention, microphones were not provided with coupling mechanisms between the body of the person under investigation and the sensitive element of the microphone which would achieve adequate impedance matching. It is therefore a further object of the present invention to provide a microphone for use in an electrical stethoscope which is provided with a coupling element adapted to be placed in contact with the skin of the person under investigation for the purpose of matching the impedance of this person's skin to the mechanical impedance of the sensitive element of the microphone.

Prior to the present invention, there was a tendency to utilize magnetic structures in microphones for use with electrical stethoscopes. Such structures are mechanically heavier than desirable, more fragile than desirable, and relatively costly. It is a further object of the present invention to provide a microphone for use in electrical stethoscopes which is durable, simple in construction, and relatively inexpensive.

These and further objects of the present invention will become readily apparent to those skilled in the art from a further consideration of this specification, particularly when viewed in the light of the drawings, in which:

FIGURE 1 is a plan view of a microphone constructed according to the teachings of the present invention;

FIGURE 2 is a side elevational view of the microphone illustrated in FIGURE 1; and

FIGURE 3 is an enlarged sectional view taken along the line 3—3 of FIGURE 1.

As indicated in the figures, the microphone has a cylindrical shell **10** with a flat circular base **12** and a flat circular face **14**. The face **14** has a circular opening **16** with a conical surface **17** which is closed by a circular membrane **18** which protrudes from the face **14**. A two wire conductor cable **20** extends from the shell **10** for connecting the microphone to an amplifier in the conventional manner.

As illustrated in FIGURE 3, the flat base **12** of the microphone is formed by a circular disc which is cemented within a circular groove **22** at one end of the cylindrical shell **10**. The shell **10** and base **12** are constructed of electrically insulating material, such as Lexan plastic, nylon plastic, hard rubber, or some other plastic material. A cylindrical sleeve assembly **24** is disposed within the cylindrical shell **10** and in abutment therewith. The sleeve assembly **24** has an upper portion **26** and a lower portion **28**, both constructed of electrically conducting material such as brass. The lower portion **28** has a circular recess **30** confronting the upper portion **26** and the upper portion **26** has a shallow circular ridge **31** at its inner surface confronting the lower portion **28**. A circular piezoelectric ceramic element **32** is disposed between the ridge **31** of the upper portion **26** and the lower portion **28**. A gasket **33** of electrically insulating material is disposed between the upper portion **26** and the piezoelectric element **32**, and an identical gasket **35** is disposed between the lower portion **28** and the piezoelectric element **32**. The piezoelectric element **32** has a pair of ceramic discs **34** and **36** which are provided with a common electrically conducting coating **38** which secures the discs **34** and **36** together. In addition, the disc **34** has an electrically conducting coating **40** on the surface thereof opposite the coating **38**, and the disc **36** has an electrically conducting coating **42** on the surface thereof opposite the coating **38**. The two discs **34** and **36** are electrically polarized in opposite directions relative to the common coating **38**, so that displacement of the disc in a direction normal to the coating **38** results in the generation of electrical potentials of opposite sign on the coatings **40** and **42**. The coating **42** is connected to a leaf strip **43** of electrically conducting material, such as copper, which extends between the gasket **35** and the lower portion **28** and between the gasket **33** and the upper portion **26** of the assembly **24**, thereby forming an electrical connection between the coating **42** and the upper and lower portions of the assembly **24**.

A disc **44** of electrically conducting material has its periphery in electrical contact with the surface of the upper portion **26** of the sleeve **24** in abutment with the base **12**. The electrically conducting disc **44** and the upper and lower portions of the sleeve assembly **24** form an electrostatic shield about the ceramic element **32**. Also, the electrically insulating gasket **35** is cemented on the piezoelectric element **32** and on the lower portion **28** of the assembly **24** and forms a fluid tight seal therebetween.

The end of the sleeve assembly **24** opposite the base **12** terminates in a circular inwardly tapering ridge **50**, and the membrane **18** is cemented at its perimeter on the exterior surface of this ridge **50**. The membrane **18** is thereby disposed between the ridge **50** and the confronting surface of the opening **16** in the shell **10**. The membrane **18** is constructed of flexible material to transmit vibrations, and further is constructed of material with compliance, such as rubber.

The region between the membrane **18** and the disc **44** is a cavity, designated **52**, and this cavity is filled with a liquid designated **54**. It has been found that a light oil, such as silicone oil, is preferable for the liquid **54** in that it provides positive coupling for the transmission of sound waves from the membrane **18** to the piezoelectric element **32**. The membrane **18** must be flexible to

transmit sound waves to the body **54** of liquid, and the membrane **18** must have compliance in order to permit the cavity **52** to be thoroughly filled with the body **54** of silicone oil or other liquid.

The shell **10** is provided with an aperture **56** which is aligned with a threaded orifice **58** in the lower portion **28** of the sleeve assembly **24** to permit the cavity **52** to be filled with the body **54** of liquid. The orifice **58** is sealed by a screw **60** having a washer **61** after the cavity **52** has been filled.

The shell **10** is provided with a second aperture **62** which confronts a second orifice **64** in the upper portion **26** of the sleeve assembly **24**. The electrical conductor **20** extends through the aperture **62** and orifice **64**, and has a grounding shield **66** which is wedged between the cable **20** and the surface of the upper portion **26** of the sleeve assembly **24** to provide electrical connection to the coating **42** of the piezoelectric element **32**. The conductor **20** also has a center conductor **68** which is connected to the coating **40** of the piezoelectric element **32**, as by solder for example.

In order to provide a means for mounting the stethoscope microphone on a patient, a button **73** is inserted in a recess **74** in the flat base **12**. The button **73** has a head **75** spaced from the base **12**, and is utilized with a perforated tape (not shown) to strap the microphone in place on a patient.

When it is desired to use the microphone illustrated in FIGURES 1 through 3, the membrane **18** of the microphone is placed in contact with the surface of the skin of the person under investigation. Generally, a stethoscope is employed to listen to the heart and lung action of a person. Sound waves transmitted from the body of the person under investigation pass through the membrane **18** into the body **54** of liquid, and are thereafter transmitted to the piezoelectric element **32**. The piezoelectric element **32** is free to vibrate, thereby generating periodic electrical potentials of opposite sign on the coatings **40** and **42** of the element.

The shell **10** and sleeve assembly **24** have a combined mass far greater than the mass of the piezoelectric element **32**, so that movements of the patient result in movements of the entire microphone, but the piezoelectric element **32** is not placed under strain relative to the shell **10** and sleeve assembly **24**. Thus, operation analogous to an accelerometer is avoided.

The microphone will operate properly with the body **54** of liquid disposed on both sides of the piezoelectric element **32**. However, it is preferable to cement the perimeter of the piezoelectric element **32** on the groove **30** of the lower portion **28** of the sleeve assembly **24** to prevent the body **54** of silicone oil from passing to the other side of the piezoelectric element **32**.

From the foregoing specification, those skilled in the art will readily devise many embodiments of this invention within the intended scope of the invention. Further, a microphone constructed in the manner set forth above, may be utilized for purposes other than and in addition

to that of a stethoscope, for example, for the purpose of originating sound in the manner of a throat microphone, or microphone operating on some other portion of the body to originate sound. A microphone constructed in accordance with the foregoing specification may also be utilized for responding to sounds within a mechanical structure, such as a tank, or the like. It is therefore intended that the scope of the present invention be not limited by the foregoing disclosed embodiment, but rather only by the appended claims.

I claim:

1. A microphone comprising a cylindrical shell of electrically insulating material having a circular opening at one end, a cylindrical sleeve of electrically conducting material disposed coaxially within the shell having an opening confronting the opening of the shell, said sleeve having an upper portion and a lower portion spaced therefrom and disposed on a common axis, a flat circular piezoelectric element clamped at its perimeter between the upper and lower portions and extending across the sleeve, said element having two parallel adjacent flat discs and a common electrically conducting layer disposed therebetween, said element having a first and a second electrically conducting coating disposed on the flat surfaces thereof opposite the electrically conducting layer and said element being electrically polarized in opposite directions relative to the electrically conducting layer, the first of said coatings being electrically connected to the electrically conducting sleeve, means for sealing the portion of the interior of the sleeve between the opening thereof and the element against leakage of fluid including a flexible membrane extending over the opening thereof and sealed thereto, a body of liquid disposed within the sleeve and filling the portion thereof between the membrane and the piezoelectric element, said body of liquid mechanically coupling the piezoelectric element and the membrane, and an electrical cable extending through the sleeve and shell having a first conductor electrically connected to the sleeve and a second electrical conductor electrically connected to the second coating of the piezoelectric element.

2. A microphone comprising the elements of claim 1 wherein the means for sealing the interior of the sleeve against fluid leakage includes an electrically insulating gasket cemented between the piezoelectric element and the confronting surface of the sleeve.

3. A microphone comprising the combination of claim 1 wherein the sleeve is provided with openings at both ends of the cylindrical portion thereof and the opening remote from the diaphragm is covered with an electrically conducting disc.

References Cited in the file of this patent

UNITED STATES PATENTS

2,564,562	Chess	Aug. 14, 1951
2,571,899	Kroft et al.	Oct. 16, 1951
2,939,106	Mason	May 31, 1960
3,054,084	Parssinen et al.	Sept. 11, 1962