

Aug. 25, 1970

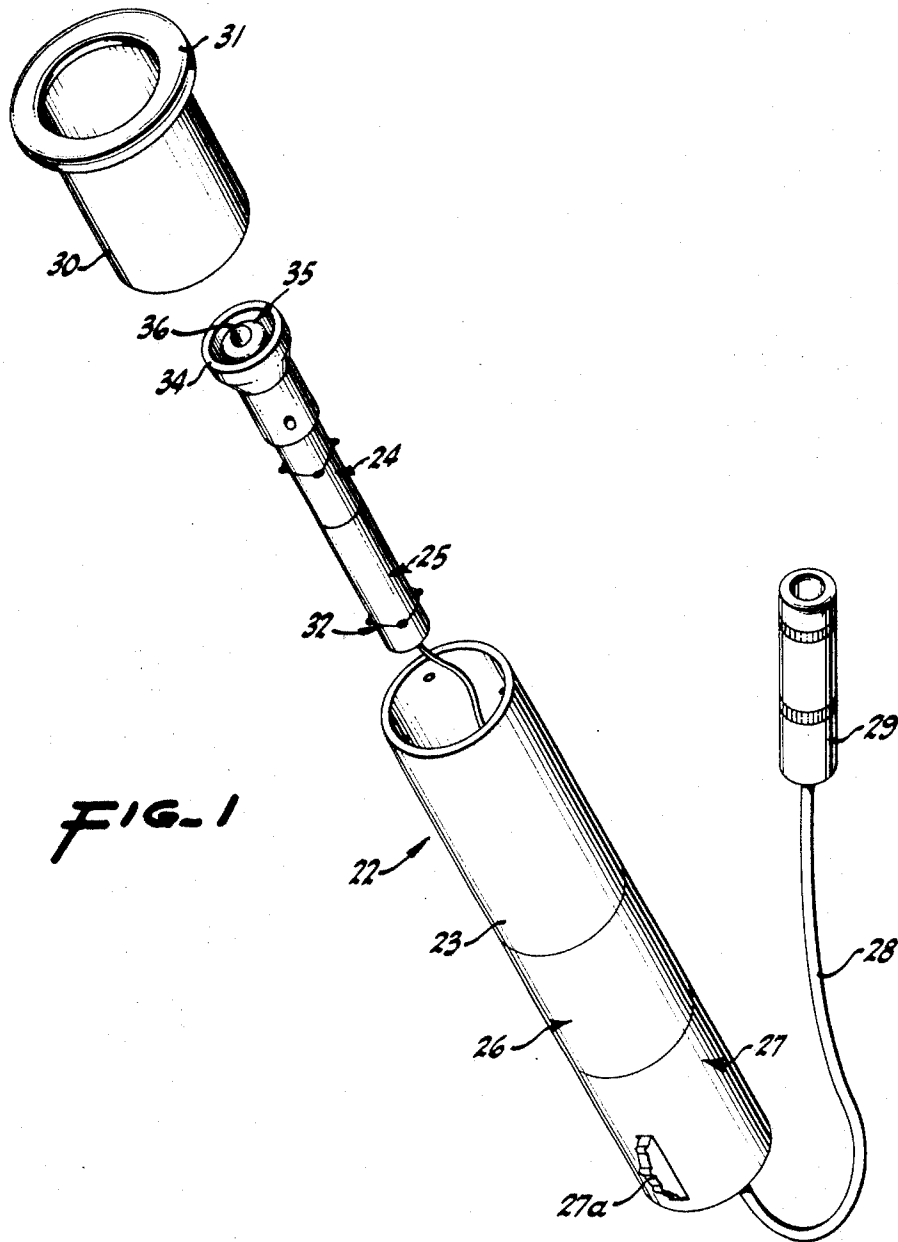
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3,525,810

MICROPHONE ASSEMBLY FOR USE IN A STETHOSCOPE

Filed Dec. 5, 1966

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

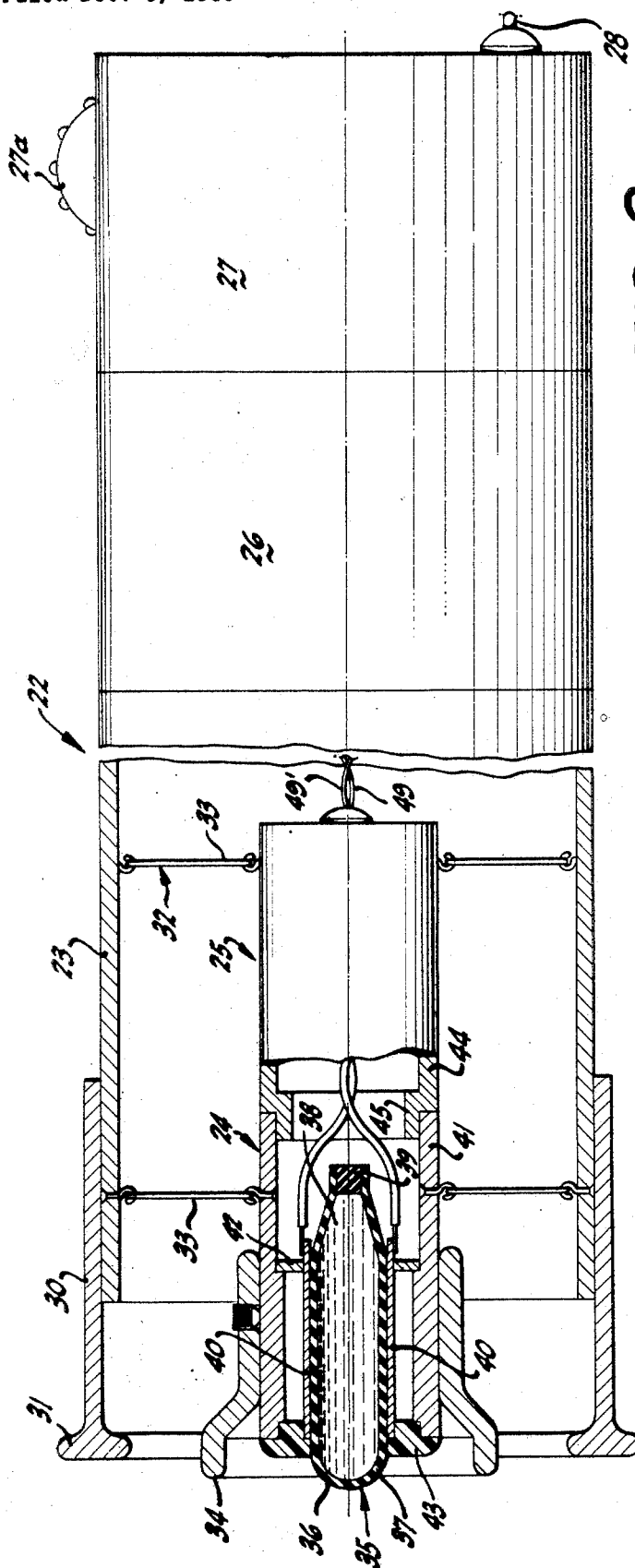


FIG-2

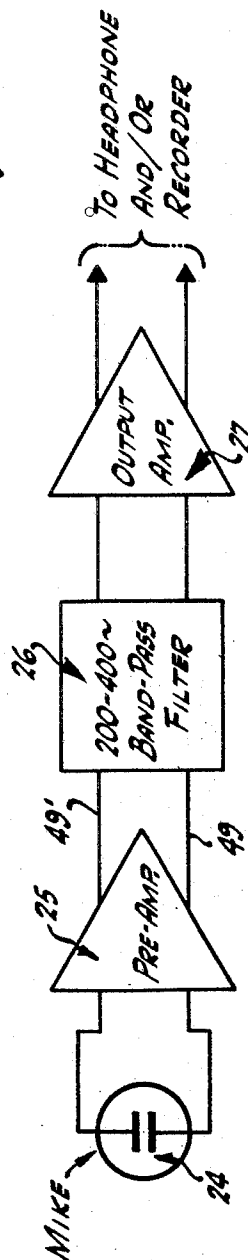


FIG-6

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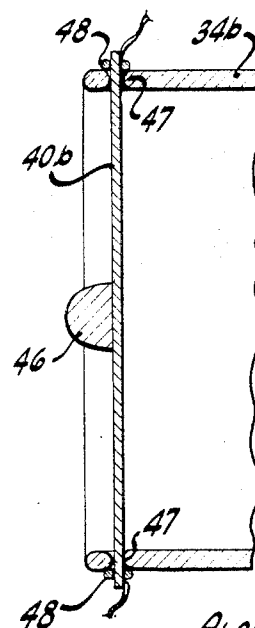
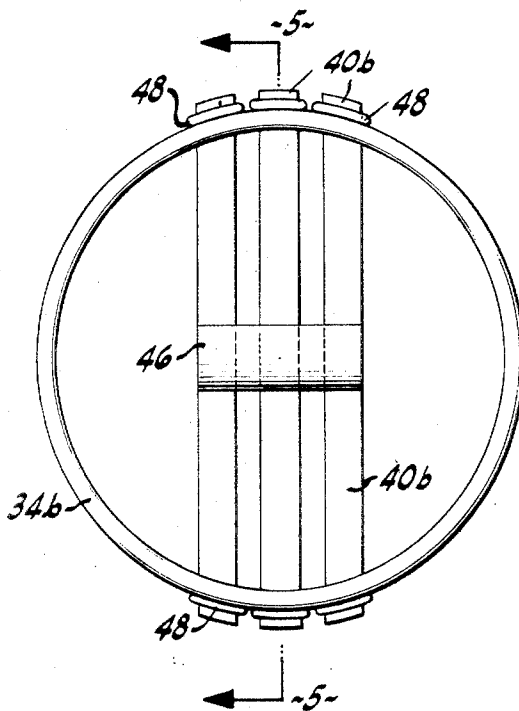
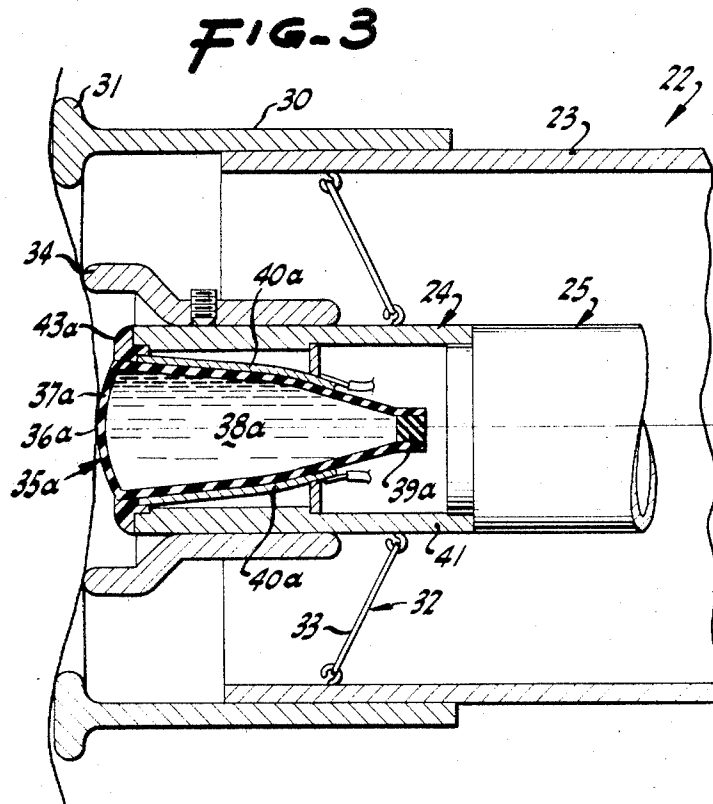
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MICROPHONE ASSEMBLY FOR USE IN A STETHOSCOPE

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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

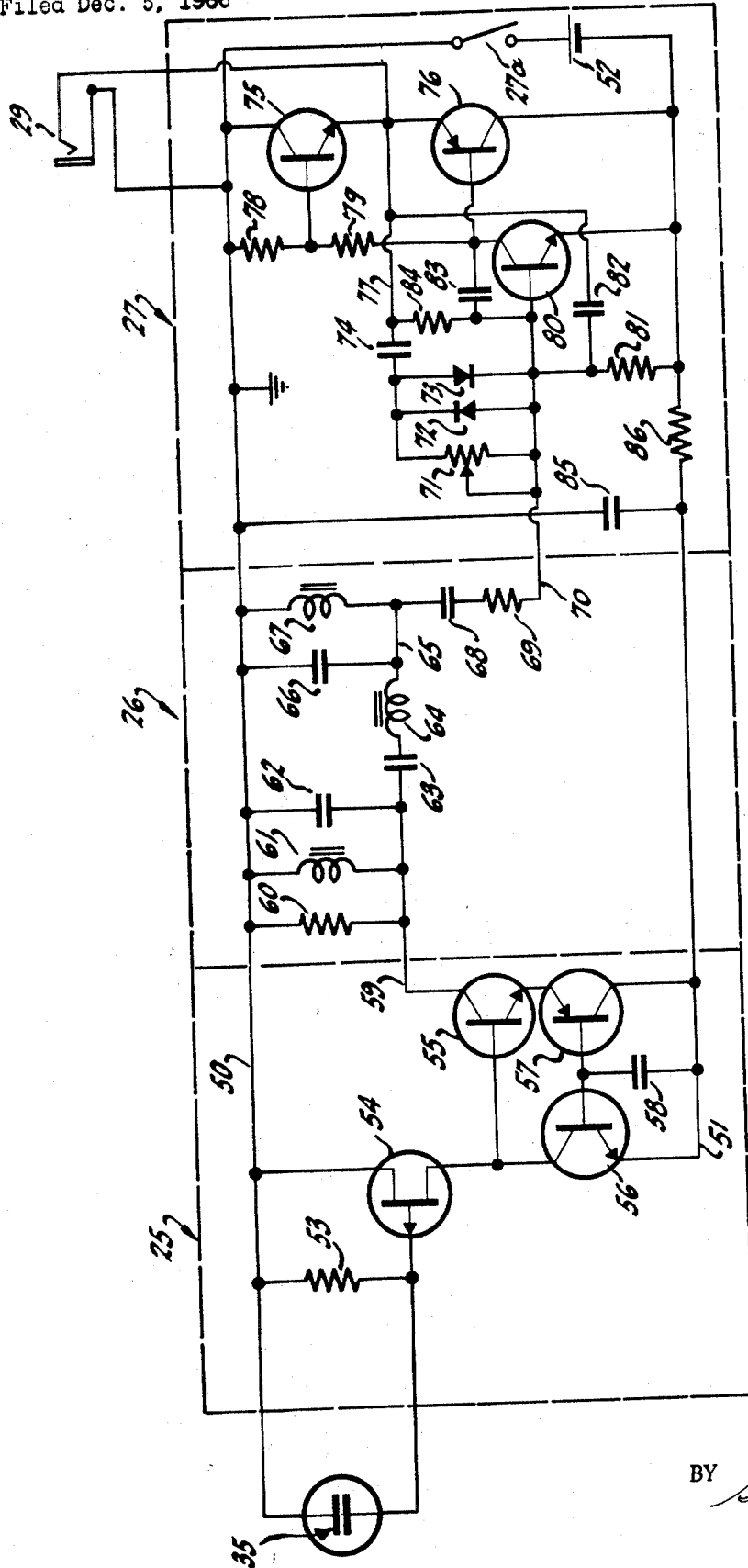


FIG. 7

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MICROPHONE ASSEMBLY FOR USE IN A STETHOSCOPE

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Int. Cl. A61b 5/02

U.S. Cl. 179—1

15 Claims

ABSTRACT OF THE DISCLOSURE

A microphone assembly for use in a stethoscope. A sound sensing means including a deformable fluid-filled casing is resiliently supported within an outer casing so as to project outwardly beyond the outer casing in its normal position. Upon movement of the outer casing into engagement with a body surface, the deformable casing is displaced inwardly against the biasing force of the resilient support for providing firm contact with the body surface. A sleeve connected to and surrounding the sensing means is additionally provided to limit the magnitude of the force with which the fluid-filled casing can engage the body surface for preventing excessive deformation thereof. A plurality of transducer elements are mounted on the deformable casing for converting the received sound energy into electrical energy.

This invention relates to sound-sensing apparatus and, more especially, to a microphone responsive to energy in the audible frequency range and operative to amplify to a useful level at least certain frequency components within such range. The apparatus has particular utility as an electronic stethoscope to be employed by medical personnel in auscultation—i.e., listening for and the observation of sounds within the body.

The invention will be discussed in detail herein in the embodiment of a stethoscope, and in this connection it may be noted that stethoscopes of various types have been used extensively in the medical sciences for observation of sounds throughout the entire body, including those sounds originating in the cardiovascular system, to determine whether there is present any sound suggesting the existence of an abnormal condition. So far as is known, those stethoscopes in actual use, as well as those proposed, have substantially no value in diagnosing certain cardiovascular abnormalities such as arterial stenosis, especially of the coronary artery, and for diseases of this type diagnosis most often depends upon the observation of physiological changes and clinical symptoms usually indicative, in the case of stenosis, of the late stages thereof.

One of the primary reasons for such limitation on the use of conventional stethoscopes is that sounds produced by early or mild stenosis, especially of the coronary artery, have an exceedingly low intensity, and their presence has only been recently recognized (see copending patent application Ser. No. 571,037, filed Aug. 8, 1966); and another such reason is that stenosis-caused sounds are so related to the ordinary heart sounds in a time sense, as respects the cardiac cycle, that they are dominated and overpowered by such ordinary sounds and, therefore, remain indistinguishable therefrom. Additionally, the intensity of such stenosis-caused sounds is so low that extraneous factors, such as room noise, skin scratch, movement of the technician, and even normal muscular movement of the patient, are sufficient to obliterate the sounds.

In view of the foregoing, an object, among others, of the present invention is to provide sound-sensing apparatus in which the sound sensor or pick-up component is

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mechanically isolated from response-producing extraneous factors (such as room noise, movements of the patient or of the diagnostician, etc., when the apparatus is used as a stethoscope), and in which the sounds which it is desired to detect are isolated from and made audible over other sounds occurring at approximately the same time so that when the apparatus is used as a stethoscope, the stenosis-induced sounds are isolated from the normal heart sounds and made audible to the technician.

Additional objects and advantages of the invention will become apparent from the following discussion of an exemplary embodiment of the invention illustrated in the accompanying drawings, in which:

FIG. 1 is an exploded perspective view of a stethoscope embodying the invention;

FIG. 2 is a longitudinal sectional view of the stethoscope;

FIG. 3 is an enlarged longitudinal sectional view illustrating a stethoscope having a modified sensor component in engagement with the chest wall;

FIG. 4 is a broken longitudinal sectional view of a further modified sensor component;

FIG. 5 is an end view in elevation taken along the line 5—5 of FIG. 4;

FIG. 6 is a block diagram of the electronic circuitry associated with the stethoscope; and

FIG. 7 is a schematic circuit diagram thereof.

The embodiment of the invention illustrated in FIGS. 1 and 2 is specifically intended for use as a stethoscope operative to detect low intensity murmur indicative of a stenosed artery. The instrument is denoted in its entirety with the numeral 22 and includes a generally cylindrical casing 23 providing a housing and support for the various components of the stethoscope. Such components include a sound pickup section 24, a pre-amplifier section 25 unified with the sound pickup section, a band-pass filter section 26, and an output amplifier and power pack section 27 equipped with an on-off and volume control switch 27a. The mechanical energy sensed by the sound pickup section 24 is converted into electrical signals which are transmitted to headphones (not shown) via conductors 28 and a connection jack 29.

The instrument 22 also includes an adjustable sleeve 30 forming a pressure control device for determining the position and force exerted by the sound pickup section 24 against the body surface of a patient. As is seen best in FIG. 2, the pressure control device 30 telescopically engages the casing 23 adjacent one end thereof and is slidably adjustable therealong. In this respect, the device 30 is coaxially circumjacent the shell 23 and engages the outer surface thereof with sufficient frictional force to maintain these components in various positions of adjustment. Evidently, a variety of arrangements may be employed to permit selective positioning of the device 30 along the shell 23 in addition to the frictional relationship described as, for example, releasable clamp means, set screws, a screw thread interconnection, etc. Adjacent its outer end, the device 30 has a radially enlarged flange 31 adapted to firmly seat against the body of a patient to define a positive and predetermined positional relationship of the sound pickup section 24 with the patient and to shield the pickup section from ambient noise.

The composite unit defined by the sound pickup section 24 and pre-amplifier section 25 is resiliently mounted within the shell 23; and in the specific structure being considered, such resilient mounting is effected by a spring suspension system generally denoted 32 and comprising a plurality of resilient elements interconnecting the unit 24—25 with the interior of the shell 23. As shown in the drawings, such resilient elements may be formed by a plurality of individual springs 33 angularly spaced from each other and extending radially outwardly from the

unit 24-25 adjacent both the forward and rear ends thereof for connection with the shell 23. In a very simplified form, the springs 33 may be strips of rubber each of which is fastened at one end to the unit 24-25 and at the other end to the casing or shell 23. The resilient suspension serves to center the unit 24-25 within the shell and to permit limited relative movements therebetween. In this latter respect, the suspension system tends mechanically to isolate the unit from the shell, and thereby attenuates the transmission of mechanical movement from the shell to the unit, which transmission adversely affects sound detection.

The suspension system 32 also resiliently urges the pickup section 24 into firm engagement with the patient's body, as shown in FIG. 3, whenever the pressure control device 30 is properly located along the shell 23. More particularly, if the flange 31 of the control device 30 is positioned somewhat rearwardly of the forwardmost surfaces of the sound pickup section 24 (which surfaces are defined by the outer ends of a cup-shaped bezel 34 and of a transducer 35) when the instrument 22 is at rest with the springs 33 unstressed, the unit 24-25 will necessarily be displaced rearwardly whenever the flange 31 of the pressure control device 30 is brought into firm abutment with the chest wall or other body surface of a patient.

Evidently, the suspension system will be stressed by such relative displacement between the device 24-25 and shell 23, and such stress will apply a force to the device 24-25 tending to return it to its normal position. The resilient restoring force defined by the suspension system will urge the outermost surface of the bezel 34 and of the transducer 35 into firm abutment with the patient. The magnitude of such force applied by the suspension system to the bezel and transducer can be varied selectively by altering the position of the control device 30 along the shell 23; and, in this respect, if the control device 30 is moved rearwardly along the shell, the seating force applied by the suspension system to the unit 24-25 will be increased; and if the device 30 is moved outwardly along the shell 23, such seating force will be reduced.

The transducer 35 is a contact transducer adapted to be brought into engagement with the patient, and it functions to sense the sound or mechanical energy transmitted thereto through the body structure of the patient from his cardiovascular system. In effecting this result the tip or sound-sensitive portion of the transducer engages the body surface of the patient and is responsive to the sound-energy transmitted thereto. The details of the transducer 35 are shown in FIG. 2 and reference will now be made thereto in discussing such details.

The contact portion of the transducer 35 includes a capsule 36 which, in the form shown, comprises a resilient membrane or casing 37 of elongated configuration filled with an essentially incompressible fluid, such as water, oil, or other suitable liquid. The membrane 37 is deformable and may be comprised of a variety of materials that permit deformation such as rubber (natural or synthetic) or one of the well known plastic materials as, for example, polyethylene. Evidently, the capsule 36 includes the membrane 37 and the liquid filler 38 which may be admitted into the membrane in any convenient manner such as via the closure-equipped end portion 39 shown which is inserted into the end of the membrane and secured thereto by adhesive.

Disposed along the outer surface of the membrane 37 are a plurality of electro-mechanical elements 40, each of which is relatively narrow in the transverse direction and is elongated longitudinally so as to extend along the membrane 37 and provide a substantial surface area in engagement therewith. The elements 40 are somewhat in the nature of barrel staves and are oriented in side-by-side juxtaposition along the adjacent edges thereof so as to substantially encompass a portion of the capsule 36. The elements 40 are able to flex or deflect radially outwardly along the intermediate sections thereof when

sound energy is imparted to the capsule and which sound energy tends to distort the capsule by causing radial expansion thereof. The elements 40 in the specific embodiment illustrated are ten in number and are piezoelectric generators. Such generators are available commercially and are sold by the Clevite Company, Piezoelectric Division, under the trade name "Bimorphs" or "Multimorphs." Each of these generator elements 40 is adhesively secured to the outer surface of the membrane 37; and, in an electrical sense, the generator elements are connected in series and the aggregate output thereof drives the aforementioned preamplifier section 25.

The capsule 36 is mounted within support structure forming a part of the pickup section 24 and, as shown in FIG. 2, such support structure comprises a generally cylindrical shell or casing 41 into which the capsule 36 is inserted. The capsule is constrained in a fixed position (except for the permissible deformation as described hereinbefore) by an annular spider or support collar 42 coaxially circumjacent the generator elements 40 along one end thereof and fixedly engaging the same as by means of an adhesive connection therebetween. The collar 42 along the outer edge thereof is fixedly secured to the casing 41. Adjacent its forward end, the capsule 36 is supported by a collar or end closure 43 coaxially circumjacent underlying end portions of the generator element 40 and adhesively or otherwise secured thereto. The closure collar 43 is also fixedly related to the shell 41 and, accordingly, the two collar components 42 and 43 fixedly define the position of the capsule 36 with respect to the casing 41 since they prevent longitudinal and radial displacements of the capsule with respect to the casing.

The casing 41 may be formed in a plurality of interconnected segments, as shown, for the purpose of facilitating assembly of the apparatus, and any appropriate mechanical arrangement may be used to permit interconnection of the various casing segments, such as a friction fit. In this respect and as shown in FIG. 2, the casing 41 providing the mounting for the capsule 36 may be releasably secured to the succeeding casing segment 44 as by means of the telescopic friction-type fastener structure 45 shown in FIG. 2.

The bezel 34 is a rigid element fixedly related to the casing 41 as by means of the set screw shown (which permits adjustment of the bezel) and, accordingly, the bezel is fixedly related to the capsule 36 and, in particular, to the outer tip thereof. Evidently, then, the maximum force with which the tip of the capsule 36 can be urged into abutment with the body surface of a patient is limited by the position of the bezel 34 because it serves as a positive stop terminating movement of the pickup section 24 of the instrument 22 in the direction toward the patient. More particularly, the bezel in functioning as a positive stop enables the instrument to be pressed into and maintained in firm engagement with the chest wall of a patient against the tendency of the instrument to undulate as a consequence of the movement imparted by the chest wall to the resilient tip of the capsule 36 which ordinarily projects slightly outwardly beyond the plane defined by the outer end or extremity of the bezel 34 to enable the capsule to be urged into firm engagement with the chest wall or other body surface of a patient.

It should be observed that the flange 31 of the pressure control device 30 is spaced rearwardly from the outer surface of the bezel 34 which enables the control device and instrument casing 23 to continue to move toward the patient until the flange 31 engages his body surface. Such continuation of movement of the pressure control device 30 after movement of the capsule 36 is yieldably arrested, causes the resilient spring structures 33 to be stressed, whereupon the forces of restoration intending to return such springs to their unstressed state, urge the capsule 36 into more firm abutment with the body surface of the patient. As a consequence thereof, the capsule 36 tends to deform slightly, which deformation will continue (as-

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suming the force defined by the springs 33 is sufficiently large) until the bezel 34 engages the patient. Upon such engagement of the flange 31, the capsule 36 can be deformed no further for any particular setting or adjustment of the pressure control device 30, and in no event can the capsule 36 be deformed beyond the maximum limit established by the bezel 34.

As is implicit in the foregoing description, the stethoscope is placed in use by positioning the transducer 35 at an appropriate location along the coronary artery, for example, adjacent a section therealong suspected of being stenosed. The transducer is firmly seated against the body surface at such location by moving the flange 31 of the pressure control device 30 into abutment with the patient because such abutment stresses the suspension system 32 and, as a consequence thereof, a resilient seating force is imparted to the transducer, as heretofore described. The transducer is then effectively shielded from ambient sound or noise, first, by the pressure control device 30, and, second, by the bezel 34, since each of these components encloses the transducer. The same two components also minimize, if not obviate, the occurrence of skin scratch by establishing a firm and positive relationship between the stethoscope and the patient; and because the sound pickup section 24 is resiliently supported with respect to the outer casing 23, the transmission of sound energy from the casing is materially attenuated in the resilient spring system.

The transducer 35 includes the liquid medium 38 which is essentially incompressible and, therefore, transmits sound energy sensed at the patient-engaging tip of the transducer with little diminution and at the speed of sound in the liquid to the sidewalls of the transducer. The sound energy developing at the tip of the transducer is believed to be propagated through the liquid medium 38 as a spherical wave front, but in any event is imparted to all of the electromechanical elements 40 which are deformed or stressed slightly as a consequence of the transmission of such sound energy thereto. Since the elements 40 are piezoelectric components, the electrical characteristics thereof are changed in correspondence with any such deformation and all of the changes are aggregated to produce an output signal because the elements are connected in series with each other. The output signals from the elements 40 are transmitted to the pre-amplifier 25 and are further processed in the electrical circuitry, as will be described hereinafter.

A modification of the stethoscope is illustrated in FIG. 3 and departs from the prior-described embodiment only as respects the configuration of the transducer component. As concerns this departure, the transducer 35 in the embodiment of FIG. 2 is an elongated component of generally cylindrical configuration, except for the end portions thereof, having a substantially uniform diameter or cross-sectional area all along such intermediate cylindrical section thereof. Contrasting therewith, the transducer in the embodiment of FIG. 3 has a somewhat conical configuration that progressively enlarges in cross-sectional area toward the outer patient-engaging end thereof; and, consequently, the opening in the support collar or end closure adjacent the patient-engaging end of the transducer is larger than in the prior embodiment to accommodate such greater cross-sectional area. In view of the evident similarities between the embodiments of FIGS. 2 and 3, the same numerals are employed to designate the respective corresponding components and as concerns the specific components of the transducer, the suffix *a* has been added to differentiate between the two embodiments.

A further modification of the stethoscope is illustrated in FIGS. 4 and 5 and departs from the prior-described embodiments by the manner in which the generator elements are supported. More particularly, in this respect, the generator elements in the embodiment illustrated in FIGS. 4 and 5 are respectively denoted with the numeral 40*b* and are elongated components disposed in spaced-

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apart parallel relation. Such generator elements 40*b* are generally planar, and along their outwardly facing surfaces are equipped with a metallic or other rigid bumper or patient-engaging component 46 adapted to be brought into direct engagement with the chest wall of the patient, as evidenced best in FIG. 4, to transmit movements therefrom to the generator elements.

The elements 40*b* are supported in a manner that permits relatively free deflection thereof, and a variety of structural arrangements may be used to provide such support for the generator elements so long as resistance afforded to free deflection of the elements is minimized. An exemplary support arrangement is illustrated in FIGS. 4 and 5 and constitutes the provision of a plurality of openings 47 in the peripheral edge portion of the bezel 34*b*. The openings 47 are arranged in aligned pairs, and each pair thereof passes a generator element 40*b* therethrough. In this connection, the openings are sufficiently large to permit relatively free movement of the associated generator elements with respect thereto in the direction of the longitudinal axes of such elements. In order to prevent the elements 40*b* from falling through the openings 47, stop members 48 may be secured to each element 40*b* adjacent the ends thereof exteriorly of the bezel 34*b*. Thus, the elements 40*b* are permitted to change length slightly upon inward deflection thereof with little frictional inhibition to such change.

The modified stethoscope shown in FIGS. 4 and 5 is substantially the same as in the prior embodiments except for the described change in the sound pickup section (i.e., the transducer and bezel), and in use is simply placed against the chest wall of a patient to bring the generator elements 40*b* into contact therewith. Sound transmitted via the bumper 46 from the chest wall to the elements 40*b* causes deflection thereof which is accompanied by changes in their electrical characteristics. As in such prior-described embodiments, the generator elements 40*b* are connected in series and are piezoelectric generators such as the aforementioned "Bimorphs" or "Multimorphs."

The instrument 22 is especially operative to select and isolate the low intensity murmur resulting from the presence of mild or early stenosis along the coronary artery from greater intensity sounds present in the cardiovascular system such as the ordinary "first" and "second" heart sounds associated with the cardiac cycle. In accomplishing this result, the instrument may be said to provide a generally logarithmic amplitude response in which the greater the intensity of the input sound, the smaller the amplification thereof relative to the large degree of amplification imparted to smaller-intensity input sound. Thus, in the particular instance being considered, the low intensity murmurs are amplified to a much greater extent than the higher-intensity second heart sounds, and to an additionally greater extent than the still higher-intensity first heart sounds.

The general electronic arrangement by which such selection and isolation is effected is illustrated in block diagram form in FIG. 7, and as indicated hereinbefore, the electronic components comprised by the stethoscope include a pre-amplifier section 25, a band pass filter section 26, and an output amplifier section 27. The pre-amplifier section 25 is physically located with the sound pickup section 24 which is especially advantageous in that it enables the exceedingly low intensity sounds sensed by the pickup or probe (transducer) to be amplified to a level or intensity that permits transmission to the balance of the circuitry through unshielded conductors.

Unshielded wires or conductors are much smaller than their insulated counterparts and are significantly more flexible, which flexibility thereof is effective to reduce the transmission of undesirable mechanical or acoustical energy therealong (hand tremors and skin scratch, for example) from the various casing components of the stethoscope to the suspended sound pickup section 24.

The unshielded wires connecting the pre-amplifier section 25 to the filter section 26 are illustrated in FIGS. 2 and 6 and are denoted for identification with numerals 49 and 49'.

Referring now specifically to FIGS. 7, the sound-sensing probe is illustrated in the form of an electrical element and is located exteriorly of the pre-amplifier section 25 which is enclosed by broken lines. For convenience, the probe is taken to be the transducer 35 heretofore described and is denoted with the same numeral. The pre-amplifier section 25 is connected across the positive and negative lines 50 and 51 of a power supply which is, in the circuit illustrated, in the form of a battery 52 providing a potential across such circuit of approximately 4.2 volts. The aforementioned on-off switch 27a is interposed in the line 50, as shown.

Connected across the transducer 35 so as to receive output signals therefrom is the pre-amplifier circuitry 25 which includes a biasing resistance 53, one side of which is connected to the positive voltage line 50 and the other side to the input element of a field-effect transistor 54. The transistor is operated at high gain and is characterized by having relatively low noise at high impedance and low frequency. The source element of the transistor 54 is in the nature of a cathode and is connected to the positive voltage line 50. The gate element of the transistor is analogous to a control grid in its function and receives the signal output from the transducer 35. The output signal from the transistor 54 is taken from the anode-like drain thereof which is connected in common to the base of an output transistor 55 and collector of a constant current source transistor 56 connected in series between the transistor 54 and negative voltage line 51.

The pre-amplifier network defined in part by the transistors 54, 55 and 56 further includes a current control transistor 57 connected in series between the transistor 55 and the negative voltage line 51. The base of the transistor 56 is connected directly to the base of the transistor 57, and a capacitance 58 provides an AC path between the base elements of the transistors 56 and 57 and the negative side of the power supply.

With respect to its operation, the pre-amplifier section 25 is characterized by having low electrical noise in the frequency range of 200 and 400 cycles per second and is operative to amplify the minute signals generated by the transducer 35 in response to the exceedingly low level sound or murmur transmitted thereto and to provide on the output signal line 59 of the pre-amplifier signals of sufficient magnitude to permit transmission thereof to the remotely located filter section 26 via the unshielded conductors 49 and 49'.

The filter section 26 is characterized by passing signals in the frequency band of approximately 200 to 400 cycles per second aid in the particular form shown, is a 3-pole Chebychev filter having approximately one decibel of ripple in the pass band. The filter section as shown includes a resistance 60 forming the resistive load for the preamplifier transistor 55, and connected in parallel with the resistance 60 are an inductance 61 and capacitance 62. All of these elements are connected between the signal line 59 and the positive voltage line 50 from the power supply. The filter further includes a series connected capacitance 63 and inductance 64 which are interposed in the signal line 59 with the inductance 64 terminating in a junction 65 to which is connected one side of a parallel connected capacitance 66 and inductance 67, the other side of which is connected to the voltage line 50. The junction 65 is also connected to one side of a capacitance 68, the other side of which is connected in series to a resistance 69 which terminates in an output signal line 70 providing the input to the amplifier section 27.

The various components comprising the filter 26 func-

tion in the usual manner to selectively pass signals within a particular band or frequency range while blocking signals on either side of such band. In the particular case being considered, the pass band is 200 to 400 cycles per second because experience has indicated that the exceedingly low intensity murmur indicative of stenosis is essentially confined to such range, and the filter provides nearly optimum selection, both in terms of transient response and selectivity.

The output amplifier 27 amplifies the signal delivered thereto from the filter 26, and in this respect it constitutes a power amplifier for driving head phones (not shown) adapted to be connected to the amplifier by means of the jack 29. The amplifier 27 has a logarithmic amplitude response which tends to attenuate the large amplitude signals while providing a high gain for the low amplitude signals which, in the present instance, constitute the low intensity heart murmurs indicative of coronary stenosis.

The input to the amplifier 27 appears on the signal line 70, and the amplifier circuit is seen to include a potentiometer 71 providing the volume adjustment for the instrument. The potentiometer 71 is arranged in parallel with reversely connected diodes 72 and 73 which provide a regulation network. A blocking capacitance 74 is connected between one juncture of the diodes 72 and 73 and the emitter elements of a pair of output transistors 75 and 76, the emitters of which are connected in common to one side of the capacitance 74 at a junction 77. The collector element of the transistor 75 is connected directly to the positive voltage line 50 and the base element is connected to the juncture of a pair of series-related resistance 78 and 79 providing a voltage divider network.

The opposite side of the resistance 79 is connected to the base element of the transistor 76, the collector of which is connected directly to the negative voltage line 51 and also to the collector element of a transistor 80 defining the input stage of the amplifier. The emitter element of the transistor 80 is connected directly to the negative voltage line 51, and the base of the transistor is connected to such voltage line through a resistance 81. The base element is also connected to the aforementioned signal line 70 as is a capacitance 82 which provides an AC path from the junction 77 to the negative voltage line 51 via the resistance 81. The collector element of the transistor 80 is coupled back to the base thereof through a capacitance 83, and a resistance 84 is connected between the base of the transistor 80 and the emitter elements of the transistors 75 and 76.

It will be noted that the positive line 50 from power source 52 is grounded and that a smoothing capacitance 85 is connected between the voltage lines 50 and 51 and a line resistance 86 is connected in series with then egative line 51.

The amplified output signals for delivery to the head phones appear at the connection jack 29 and, as indicated hereinbefore, represent a logarithmic amplification of the input signals appearing on the line 70 such that the low intensity murmurs characteristic of coronary stenosis are amplified significantly in relation to sounds of other frequencies that may comprise a part of the input signal. In terms of order of magnitude, the low intensity signals may be amplified from 5,000 to 10,000 times.

For purposes of presenting a specific example of component values in typical illustrative circuits, the following may be considered:

- Resistance 53—22 meg ohms
- Transistor 54—2N2844
- Transistor 55—2N3565
- Transistor 56—2N3565
- Transistor 57—2N3251
- Capacitance 58—47 micro farads

Resistance 60—10K ohms
 Inductance 61—7.96 henrys
 Capacitance 62—0.161 micro farads
 Capacitance 63—0.040 micro farads
 Inductance 64—7.9 henrys
 Capacitance 66—0.161 micro farads
 Inductance 67—1.96 henrys
 Capacitance 68—47 micro farads
 Resistance 69—10K ohms
 Potentiometer 71—10K ohms
 Diode 72—FD6193
 Diode 73—FD6193
 Capacitance 74—4.7 micro farads
 Transistor 75—2N3565
 Transistor 76—2N3638A
 Resistance 78—47K ohms
 Resistance 79—5.1K ohms
 Transistor 80—2N3565
 Resistance 81—62K ohms
 Capacitance 82—0.027 micro farads
 Capacitance 83—560 pico farads
 Resistance 84—160K ohms
 Capacitance 85—47 micro farads
 Resistance 86—330 ohms

It should be appreciated that the specific circuit values set forth imply no criticality and can be varied greatly depending upon internal and external parameters, the choice of transistors, the specific function intended for the circuit in any environmental setting, etc.

The logarithmic amplification characteristic of the amplifier 27 is attributable to circuit factors thereof and, in particular, to the diode elements 72 and 73 connected in the feedback circuit of the amplifier 27. One or the other of these diode elements is conducting in accordance with the polarity of the input signal appearing on the line 70 whenever the magnitude of the input signal exceeds a predetermined value, and the diodes, therefore, tend to limit the magnitude or permissible value of the input signal to the transistor 80. Consequently, the lower intensity signals are transmitted to the transistor 80 with substantially no diminution resulting from the action of the diodes while larger magnitude signals are limited by the action of the diodes. As explained heretofore, the filter 26 has a pass-band in the range of about 200 to 400 cycles per second, and the amplifier 27 is tuned so as to particularly accommodate signals within such range. Therefore, the low intensity murmurs characteristic of a stenosed artery are amplified to a significantly greater extent than signals falling outside of such range. Not only does this amplification selectivity enhance audibility and detection of the low intensity murmurs, but it also prevents the much greater intensity heart sounds from being amplified to an extent where they would cause discomfort, if not injury, to the diagnostician.

The pressure control device 30 is readily moved along the casing 23 so as to permit the diagnostician to adjust the instrument in accordance with the body contour of the patient, the requirements of any particular area being investigated, and his own auditory sensitivity; and ordinarily, the effectiveness of the sound transmission to the transducer 35 will be increased as the degree or force of engagement of the transducer 35 with the patient is increased. Thus, as the pressure control device 30 is moved rearwardly along the casing 23, the magnitude of the sound appearing at the jack 29 (or earphones) will increase.

While in the foregoing specification embodiments of the invention have been described in considerable detail for purposes of making a complete disclosure of the invention, it will be apparent to those skilled in the art that numerous changes may be made in such detail without departing from the spirit and principles of the invention.

What is claimed is:

1. A microphone assembly for use in a stethoscope comprising:

(a) abutment means for engaging a body surface to define a determinate positional relationship therewith;

(b) sensing means, movable with respect to said abutment means, for engaging said body surface to detect sound energy transmitted by said body surface;

(c) resilient support means for biasing said sensing means toward a normal position projecting outwardly beyond said abutment means for initial engagement with said body surface, said sensing means being displaceable inwardly against the biasing force of said resilient support means upon movement of said abutment means into engagement with said body surface following initial engagement of said sensing means therewith;

(d) transducer means for converting the sound energy transmitted to said sensing means by said body surface into electrical energy for subsequent amplification; and

(e) stop means connected to said sensing means for engaging said body surface subsequent to said sensing means but prior to said abutment means upon said movement of said abutment means into engagement with said body surface.

2. A microphone assembly as recited in claim 1 wherein said stop means comprises an annular sleeve surrounding said sensing means.

3. A microphone assembly as recited in claim 1 and further comprising a casing, said resilient support means being connected to said casing and said sensing means for resiliently supporting said sensing means relative to said casing.

4. A microphone assembly as recited in claim 3 wherein said abutment means is carried by said casing and is adjustably movable with respect to said casing.

5. A microphone assembly as recited in claim 3 wherein said resilient support means comprises a plurality of springs spaced apart with respect to each other for supporting said sensing means relative to said casing at a plurality of spaced locations.

6. A microphone assembly as recited in claim 1 wherein said sensing means comprises a resilient membrane defining a chamber therein containing a fluid medium, said resilient membrane being deformable in response to sound energy transmitted thereto by said body surface.

7. A microphone assembly as recited in claim 6 wherein said transducer means comprises a plurality of transducer elements connected to said resilient membrane, deformation of said resilient membrane in response to sound energy transmitted thereto, imparting a corresponding deformation to said transducer elements for conversion of said sound energy into electrical energy.

8. A microphone assembly as recited in claim 1 and further comprising a preamplifier connected to said transducer means for receiving output signals therefrom, and conductors connecting said preamplifier to external circuitry, said conductors being unshielded and flexible for preventing transmission therethrough of mechanical vibration to said sensing means.

9. A microphone assembly as recited in claim 8 and further comprising a casing, said resilient support means being connected to said casing and said sensing means for resiliently supporting said sensing means relative to said casing, and further comprising filter and amplifier means carried by said casing and connected to said preamplifier through said conductors.

10. A microphone assembly as recited in claim 9 wherein said amplifier is characterized by having a logarithmic response providing high gain for low intensity input signals thereto and low gain for high intensity input signals thereto.

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11. A microphone comprising:

(a) sensing means for engaging a body surface, said sensing means comprising a resilient casing defining a chamber therein containing a fluid medium, said resilient casing being deformable in response to sound energy transmitted thereto by said body surface; and

(b) a plurality of transducer elements mounted on said resilient casing, said transducer elements comprising a plurality of elongated members oriented in a side-by-side relationship around a portion of the outer surface of said casing for presenting a substantial surface area in engagement therewith, deformation of said resilient casing imparting a corresponding deformation to said transducer elements for conversion of said sound energy into electrical energy.

12. A microphone as recited in claim 11 wherein said fluid medium is a substantially incompressible liquid.

13. A microphone as recited in claim 11 wherein said plurality of elongated members are electrically connected in series.

14. A microphone comprising:

(a) an elongated, generally cylindrical, elastic casing defining a chamber therein containing a fluid medium, said casing having a longitudinal axis and being radially deformable about said axis in response to sound energy transmitted thereto; and

(b) a plurality of elongated transducer elements directly mounted on the outer surface of said casing in

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a side-by-side relationship around the longitudinal axis thereof, so as to substantially encompass said casing, the elongated dimension of said transducer elements being aligned with said longitudinal axis, radial deformation of said casing producing a corresponding deformation of said transducer elements for conversion of said sound energy into electrical energy.

15. A microphone as recited in claim 14 wherein said transducer elements are mounted on said casing by an adhesive.

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