Jan. 7, 1941. W. R. HARRY ET AL 2,227,580

ACOUSTIC DEVICE

Filed June 30, 1938 2 Sheets-Sheet 1

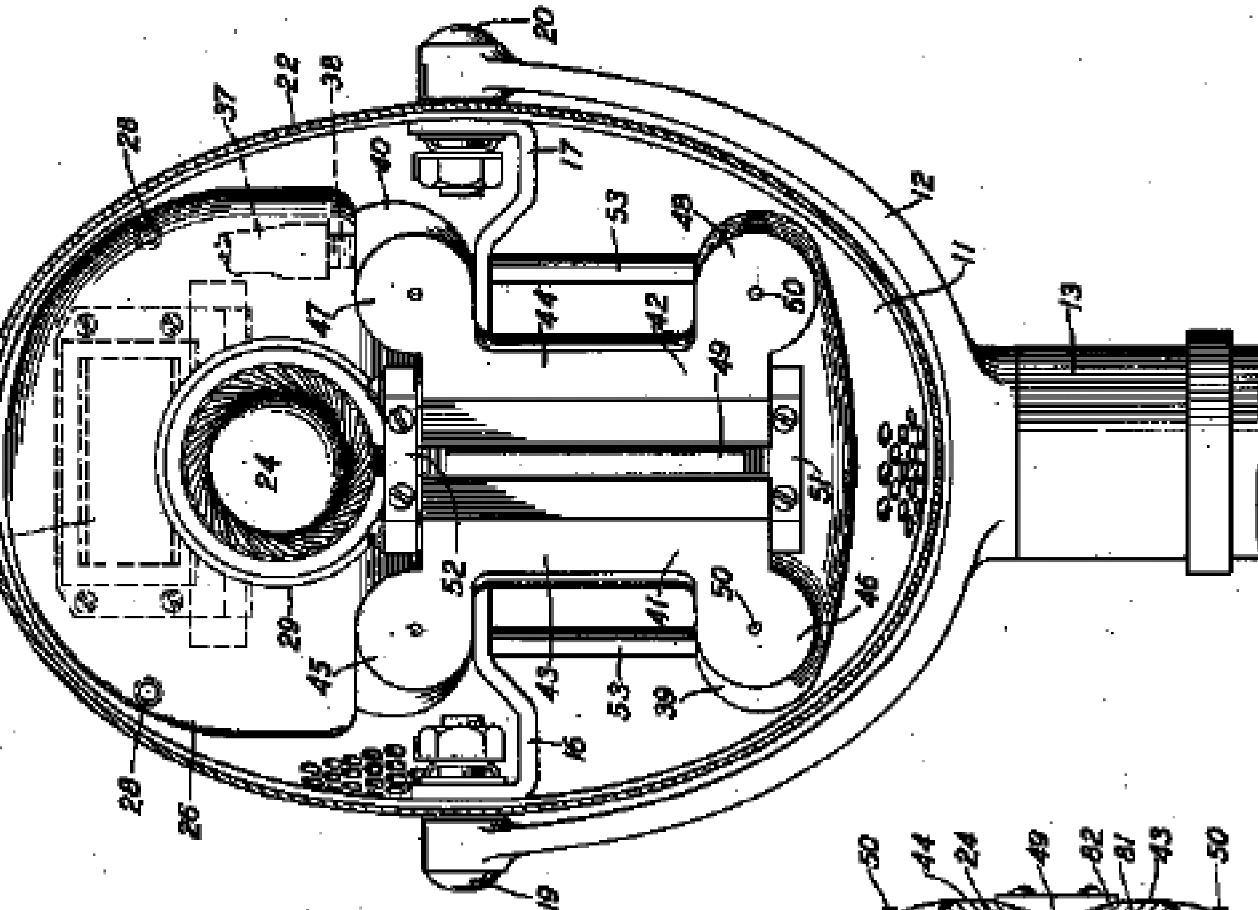


FIG. 2

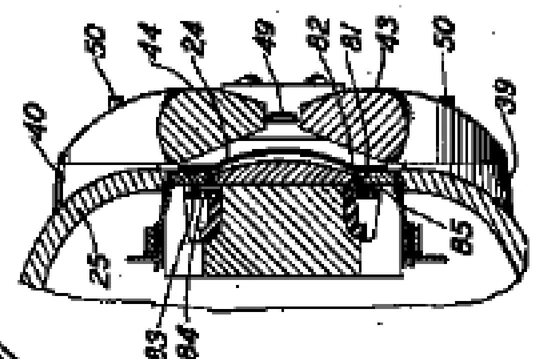


FIG. 5

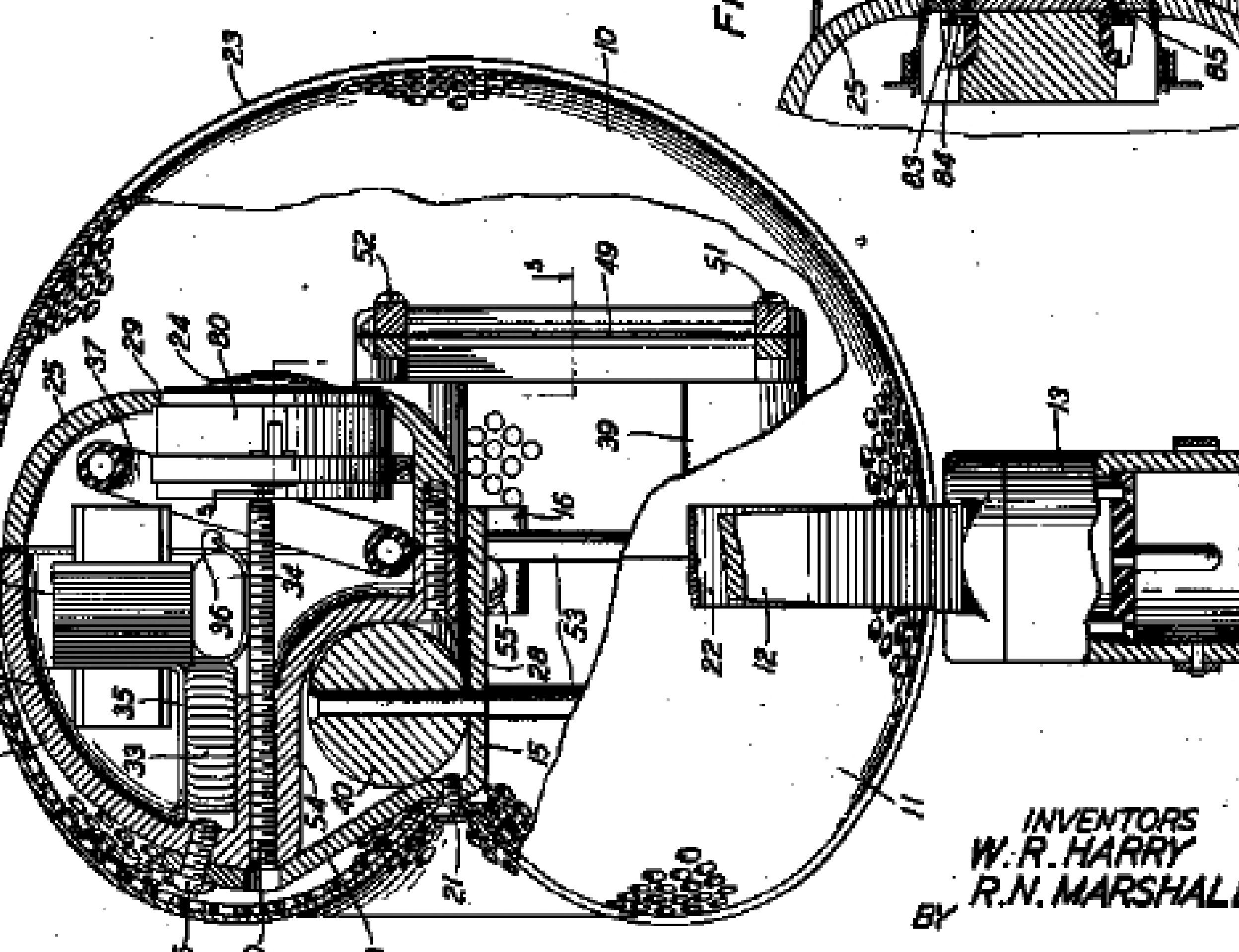


FIG. 1

INVENTORS
W. R. HARRY
R. N. MARSHALL
BY
Walter C. Kiesel
ATTORNEY

Jan. 7, 1941. W. R. HARRY ET AL 2,227,580

ACOUSTIC DEVICE

Filed June 30, 1938 2 Sheets-Sheet 2

FIG. 3

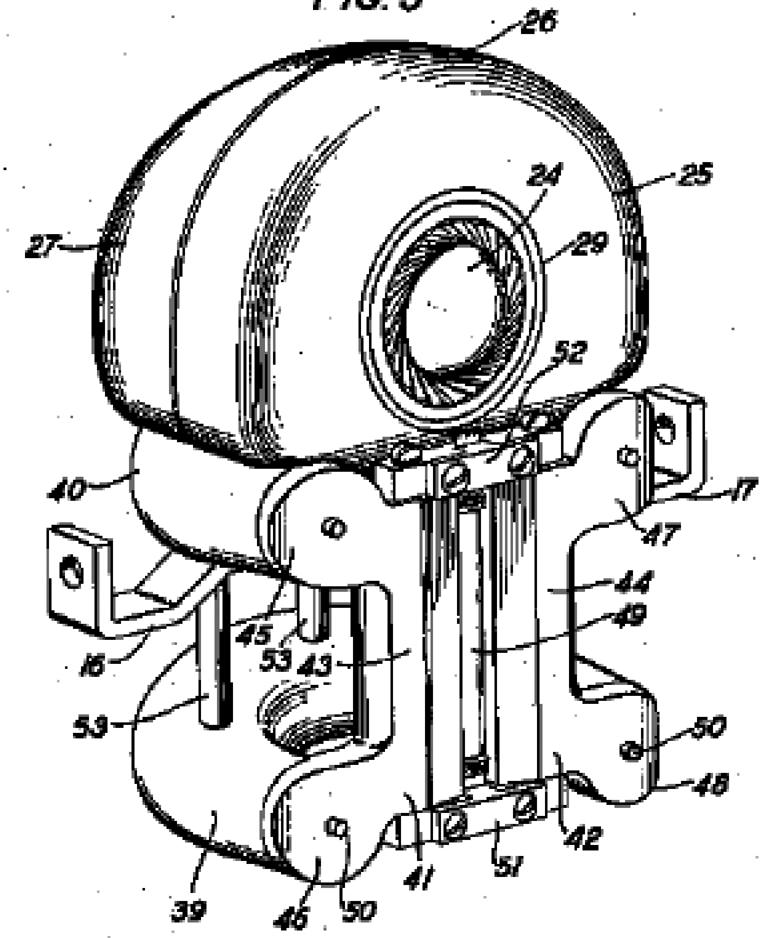
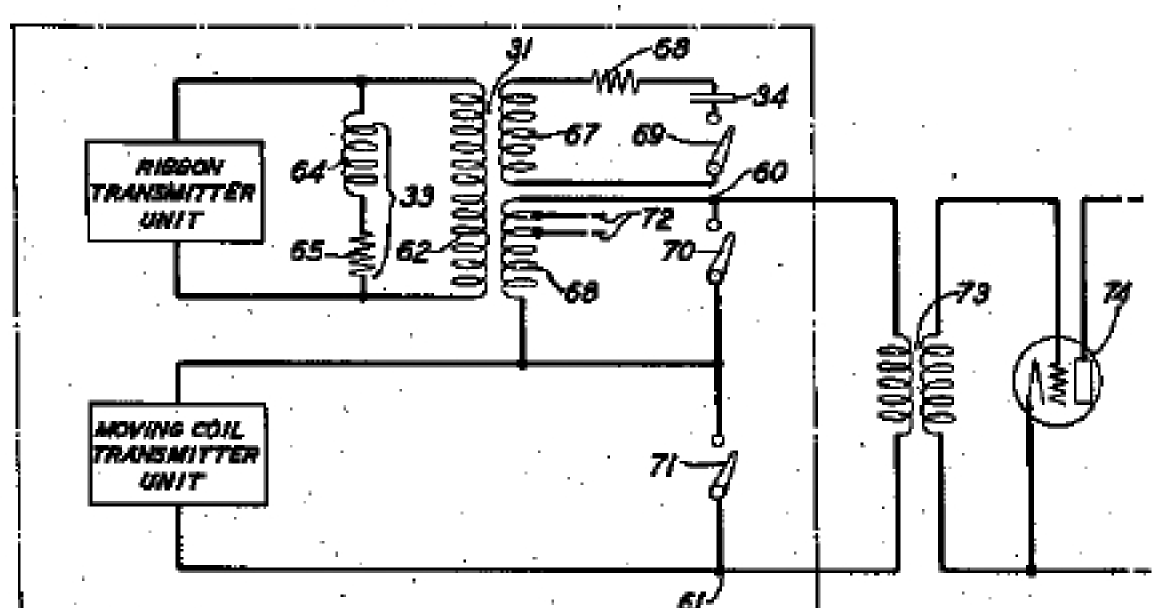


FIG. 4



INVENTORS: W. R. HARRY
R. N. MARSHALL

BY

Walter C. Kiesel

ATTORNEY

Patented Jan. 7, 1941

2,227,580

UNITED STATES PATENT OFFICE

2,227,580

ACOUSTIC DEVICE

William R. Harry, New York, N. Y., and Robert N. Marshall, Maplewood, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application June 30, 1938, Serial No. 216,634

13 Claims. (Cl. 179—1)

This invention relates to acoustic devices and more particularly to acoustic transmitters having a higher response level to sound from a limited range of directions than to sound from outside of this range.

One object of this invention is to translate sound waves into electrical energy with high efficiency and fidelity throughout a wide range of frequencies.

Another object of this invention is to obtain, for an acoustic transmitter, a substantially unidirectional response characteristic over a very wide range of frequencies.

Another object of this invention is to reduce or substantially minimize diffraction effects in acoustic transmitters.

A further object of this invention is to overcome objectionable phase shift effects in an acoustic transmitter including a pair of microphone units of different types.

Still another object of this invention is to reduce the size of composite acoustic transmitters and to produce a compact easily fabricable structure.

In one illustrative embodiment of this invention, an acoustic transmitter comprises a pressure gradient microphone unit, commonly known as a velocity microphone, and a pressure microphone unit, which may be of the moving coil type. The pressure gradient unit, wherein both sides of the diaphragm are exposed to the sound field, is bidirectional in character from the standpoint of response. The pressure unit, only one surface of the diaphragm of which is exposed to the sound field, is substantially non-directional throughout an extended portion of the low frequency range, for example, up to frequencies of the order of three thousand cycles, and is fairly unidirectional at higher frequencies. Means including a chamber or cavity are provided at the rear of the diaphragm of the pressure unit to produce an impedance, primarily resistive, to obtain a uniform response over a wide frequency range, the chamber or cavity being of such character that its stiffness reactance is substantially negligible as compared with the resistance, throughout the frequency range of interest.

In accordance with one feature of this invention, the pressure gradient and pressure unit are so coordinated that in cooperation they define an acoustic transmitter having a uniform response characteristic throughout a desired limited range of sound wave directions. More specifically the two units are so coordinated that a substantially unidirectional response effect obtains, the response being a maximum to sound waves emanating from a source directly in front of the composite transmitter and zero to waves emanating from a source directly behind the transmitter. The response to sources at intermediate points is such that the curve indicative of the response of the transmitter, determined by a plot of response against angle, is a cardioid. In order that the desired characteristics obtain, the relative phase and magnitude of the voltages produced by the two units in accordance with sound waves are in a particular relation throughout the frequency range to be translated.

In accordance with another feature of the invention, the exterior surfaces of the transmitter elements are made generally convex so that diffraction effects on sound waves approaching either diaphragm are minimized.

In accordance with a further feature of this invention means are provided for producing equalization of the combined responses of the two microphone units throughout the range of frequencies to be translated whereby a uniform substantially unidirectional response throughout this range is obtained.

In accordance with still another feature of this invention, the equalizing means are included within the impedance chamber or cavity to the rear of the diaphragm of the pressure unit whereby a relatively simple, compact structure of small size is achieved.

The invention and the foregoing and other features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawings in which:

Fig. 1 is a side view of a transmitter illustrative of one embodiment of this invention, portions being shown in section and portions of the outer shield or casing being broken away;

Fig. 2 is a front view of the transmitter with the front portion of the shield or casing removed to show the internal structure;

Fig. 3 is a perspective view of the transmitter units included in the transmitter shown in Figs. 1 and 2;

Fig. 4 is a circuit diagram illustrating the electrical association of the various elements of the transmitter; and

Fig. 5 is a view in section, along line 5—5 of Fig. 1, illustrating details of the microphone units.

Referring now to the drawings, the transmitter there illustrated comprises a perforated shield or casing having front and back portions 10 and 11, respectively, and pivotally mounted on a yoke 12 extending from a suitable standard, a portion of which is shown at 13. Mounted within the shield or casing is a support or bracket member 15 having oppositely extending arms 16 and 17 and an angular portion 18. The arms 16 and 17 have bent orificed end portions for attachment to the yoke 12 by suitable fastening means, such as bolts 19 and 20. The shield portion 11 is secured to the support or bracket member 15 by a screw or equivalent means 21. The shield is also supported by the fastening means 19 and 20 in cooperation with the yoke 12 and the bracket arms 16 and 17. Two bands 22 and 23 of metal or other suitable material may extend around the outside of the screen to strengthen it.

The pressure microphone may be a moving coil unit including a diaphragm 24, a magnet assembly 80 and a driving coil 81 mounted in the front portion 25 of a casing 26. The driving coil 81 is located in an air-gap 82. An acoustic resistance comprising a ring 83, having perforations 84, covered with a fabric 85, is mounted behind the air-gap 82, as may be seen in Fig. 5. The back portion 27 of casing 26 is secured to the front 25 by fastening means, such as screws 28. The moving coil unit is tightly secured against a shoulder in an opening 29 by a screw 30 threaded through the back portion 27 of the casing 26 and bearing against the unit.

The casing 26 is substantially air-tight except for connection to the atmosphere through the low frequency equalizing means. This means is shown as a resilient tube 37, which may be of rubber. One end of tube 37 is open to the outside air through a fitting 38 and the other end communicates with the interior of the casing 26.

The moving coil unit has a high mechanical impedance and, therefore, requires but a small cavity or chamber to the rear of the diaphragm to provide a terminating impedance of the magnitude requisite to assure a uniform response. This impedance, as noted heretofore, is primarily resistive, the cavity being of such size and character that the stiffness reactance is substantially negligible in comparison with the resistance throughout the desired range of frequencies. The acoustic impedance of the moving coil unit is determined principally by the cavity or chamber mentioned and the tube 37.

A transformer 31 is secured, by screws or similar means (not shown), to a pair of parallel ribs extending from the back wall of the casing portion 27. One of these ribs is shown at 32 in Fig. 1. An inductance coil 33 and a condenser 34 are held in place by a securing means, such as a clip attached to the transformer and having arms 35 and 36.

The ribbon velocity microphone may comprise a pair of U-shaped permanent magnets 39 and 40, such as shown in Fig. 3. These magnets, which may be of substantially circular section, may be arranged approximately in parallel relation to each other and at substantially right angles to pole-pieces 41 and 42. The pole-pieces have parallel portions 43 and 44 forming an air-gap for a ribbon diaphragm 49, and ears or projections 45, 46, 47 and 48 for attachment to the pole portions of magnets 39 and 40. The pole pieces may be attached to the magnets by suitable means such as pins 50 or by welding. The ribbon diaphragm 49 is mounted between the pole-piece members by support means 51 and 52, and may be transversely corrugated for only a small portion near its ends. The part between the corrugations is stiffened by virtue of its transverse curvature, as shown in Fig. 5. The material from which the ribbon is made may be any suitable conductor material capable of being worked to a very thin section. A preferred material is aluminum foil of about .00025 inch thickness. If desired, the ribbon may be transversely corrugated near one end only. Such a ribbon may be substituted for the one previously described and give substantially equivalent performance. Ribbons of the shape and thickness described reduce wind disturbances considerably. It is possible to employ successfully a ribbon having a greater stiffness than is ordinarily found in microphone ribbons because of the use of the low frequency equalizing means to be later described.

To maintain the magnets 39 and 40 in spaced relation and to strengthen the structure a plurality of rods 53 are provided. These may be secured to the magnet in any suitable manner as by welding, riveting and the like.

The casing 26 is formed with a recessed portion 54 which fits around magnet 40 whereby a very compact composite structure is obtained. The diaphragms of the two microphone units are thereby located close together, thus minimizing phase difficulties.

The bracket member 15 has its main portion fastened to the bottom of casing 26 by screws, one of which is shown at 55 in Fig. 1. The angular portion 18 is secured to the back part 27 of casing 26 by a screw 56. A portion of magnet 40 is clamped between bracket 15 and recessed portion 54 of casing 26. The two microphone units and the bracket member are thereby firmly secured together.

It will be noted, particularly from Figs. 3 and 5, that the exterior contour of the elements of the units is generally convex, with no sharp corners nor edges. Although these surfaces in the form illustrated are generally curved, they may comprise a plurality of substantially plane intersecting surfaces provided the angles of intersection are greater than about 120 degrees. This avoidance of sharp corners and edges greatly reduces diffraction effects on sound waves approaching either microphone unit.

A circuit whereby the parts of the transmitter may be interconnected is shown in Fig. 4. The parts enclosed in broken lines are those of the assembled transmitter having output terminals 60 and 61. The ribbon microphone unit is connected to the primary 62 of the three-winding transformer 31. The inductance coil 33 of Fig. 1 is shown in the wiring diagram as inductance 64 and resistance 65 connected across the ribbon unit. In the device 33 the resistance may be incorporated in the winding. The condenser 34 is connected across the tertiary winding 67 of transformer 31. The resistance 68 is that of the winding 67. The moving coil microphone is connected to terminals 60 and 61 in series with the secondary winding 68. Switches 69, 70 and 71 may be employed for a purpose to be described.

A plurality of taps 72 are shown on the secondary winding 68. These may be employed, if necessary, to obtain a substantially exact output voltage match between the microphone units.

The terminals 60 and 61 of the transmitter are connected by way of a transformer 73 to suitable amplifier means represented by its first tube 74.

The impedance 33 (inductance 64 and resistance 65) which is shunted across the ribbon microphone unit is a low frequency damping means for this unit. The value of this impedance and that of the acoustic impedance of the moving coil device are so adjusted that the relative responses are substantially equal at low frequencies.

The network connected to the tertiary winding 67 of transformer 31 is for high frequency equalization. The effect of this network is to make the ribbon microphone response correspond closely to that of the moving coil unit up to about three thousand cycles per second. For frequencies above three thousand cycles per second, the network acts as a filter to gradually cut out the ribbon unit as the frequency increases. Since the moving coil unit becomes increasingly directive above three thousand cycles per second, the unidirectional characteristic of the transmitter is maintained.

A particular function of the tertiary winding 67 of the transformer 31 is to allow the use of a high frequency filter condenser of small size. The impedance of the ribbon microphone circuit is made such that it matches the pressure microphone impedance. For such impedance a filter condenser of the proper reactance would be physically large as compared with other elements of the transmitter. By transforming to a higher impedance a smaller condenser could be used but a second transformation down to the matching impedance would be necessary, thus requiring an extra transformer. In accordance with this invention, by using a tertiary winding having an impedance that is high relative to that of the secondary and connecting the capacitative elements thereto, a small condenser will serve. Thus a great saving in size and weight is achieved. For example, without the tertiary winding 67 the condenser 34 (see Fig. 1) which is of the order of .2 microfarad with a tertiary-secondary impedance ratio of 20 to 1, would have to be of about 4 microfarads. Such a condenser would be approximately 20 times as large as condenser 34.

The switches 69, 70 and 71 previously mentioned may be employed to increase the versatility of the device. If switch 70 is closed and switch 71 left open the transformer secondary 68 is short-circuited and the ribbon unit is cut out. This leaves the moving coil unit alone in service. If, on the other hand, a bidirectional transmitter is desired, switch 71 is closed and switches 69 and 70 left open. The moving coil unit is then cut out and the high frequency equalizing network rendered inoperative. For normal unidirectional operation switch 69 is closed and switches 70 and 71 are left open.

The transmitter described in the foregoing translates sound waves with efficiency and fidelity and has an average directional discrimination of about 20 decibels between 0 degree and 180 degrees sound incidence over the range from fifty to ten thousand cycles per second. It is both small and light in weight for a device of its character and efficiency.

Although the invention has been disclosed with reference to a specific embodiment it will be understood that it is not restricted thereto but is limited in scope by the appended claims only.

What is claimed is:

1. An acoustic transmitter comprising a casing including a reduced portion and containing a moving coil pressure type transmitter unit and a ribbon diaphragm, velocity type transmitter unit including a pair of U-shaped permanent magnets having common elongated pole-piece members between which is mounted a ribbon diaphragm, one of said magnets embracing and closely fitting the reduced portion of said casing, thereby allowing compact assembly of the two units.

2. A composite acoustic transmitter comprising a bidirectional microphone and a second microphone, said second microphone comprising a moving coil unit mounted in a casing, said casing providing a substantially closed air chamber behind said unit, and means for equalizing the responses and combining the outputs of the two microphones, said means including a transformer, a condenser, an inductor and an acoustic impedance comprising a low frequency equalizing tube.

3. A composite acoustic transmitter comprising a bidirectional microphone and a second microphone, said second microphone comprising a moving coil unit mounted in a casing, said casing providing a substantially closed air chamber behind said unit, and means for equalizing the responses and combining the outputs of the two microphones, said means including a transformer, a condenser, an inductor and an acoustic impedance, said equalizing means being housed within the air chamber portion of said casing.

4. A composite acoustic transmitter comprising a ribbon velocity microphone unit, a moving coil pressure microphone unit, and a high frequency corrective network for the ribbon microphone, said network including a condenser and a transformer for matching the impedances of the two microphones, said transformer including a primary, a secondary and a tertiary winding, said tertiary winding being connected to said network and having an impedance ratio with said secondary winding such that the condenser capacity necessary for correction is low, whereby said condenser is physically small relative to the microphone units.

5. A composite acoustic transmitter assembly comprising a ribbon velocity microphone, a moving coil pressure microphone, a pair of output terminals, an inductance coil, a condenser, a transformer having a primary, a secondary and a tertiary winding, said transformer having its primary winding connected to the output of the ribbon microphone, its secondary winding connected serially with the moving coil microphone and the output terminals, and its tertiary winding connected to said condenser, said inductance coil being connected in shunt with said primary winding and a casing for said moving coil microphone, said casing comprising an acoustic impedance and also the housing for the transformer, inductance coil and condenser.

6. An acoustic transmitter having a unidirectional sound pick-up characteristic, said transmitter comprising a velocity microphone unit, a pressure microphone unit, and equalizing means including electrical and acoustic impedances for equalizing the high and low frequency responses of said units, said pressure unit having a diaphragm, a coil attached to said diaphragm, magnetic structure cooperating with said coil and a substantially closed chamber behind said diaphragm and coil, said chamber comprising part of the acoustic portion of the equalizing means and also housing all of the remaining equalizing means.

7. A sound pick-up device comprising a moving coil pressure microphone unit and a ribbon diaphragm velocity microphone unit, said velocity unit including a pair of U-shaped permanent magnets mounted at approximately right angles

to the plane of the ribbon diaphragm, said pressure unit having its casing recessed to interfit with one of said magnets, thereby allowing the respective diaphragms of the two units to be located sufficiently close together to minimize relative phase difficulties.

8. A unidirectional acoustic transmitter comprising a velocity microphone unit and a pressure microphone unit, said velocity unit comprising two U-shaped permanent magnets and a thin ribbon diaphragm mounted between parallel pole-pieces, the pole-pieces each being secured at either end to a pole portion of one of the magnets, said magnets being of generally circular cross-section and extending at right angles to the plane of said ribbon diaphragm, and said pressure microphone comprising a moving coil unit mounted in a casing, the casing having a reduced portion fitting within one of the U-shaped magnets to provide a compact unitary transmitter structure.

9. A unidirectional electroacoustic transmitter in which a pressure and a velocity microphone unit are combined, said transmitter including electrical impedance means connected across the velocity microphone terminals and acoustic impedance means comprising a tube connected to the pressure microphone for substantially equalizing the low frequency response of the two microphones.

10. A unidirectional acoustic transmitter comprising a ribbon velocity microphone and a moving coil pressure microphone combined in a unitary structure, said ribbon microphone having an electrical impedance shunted across its terminals and said moving coil microphone having an acoustic impedance connected thereto, the relative values of said impedances being such as to so equalize the low frequency responses of said microphones that they combine efficiently for unidirectional response.

11. In combination, a moving coil pressure type transmitter unit, a ribbon diaphragm velocity type transmitter unit, a casing for said pressure unit, said casing having a recess for receiving a portion of the velocity unit therein, and means for combining the outputs of said units so that the combination has a substantially unidirectional response characteristic.

12. A unidirectional acoustic transmitter comprising a ribbon velocity microphone and a moving coil pressure microphone, said velocity microphone including a pair of parallel pole-pieces defining an elongated air-gap, a ribbon diaphragm mounted in said air-gap, and a pair of substantially parallel U-shaped magnets of circular section secured at substantially right angles to said pole-pieces, said pressure microphone including a moving coil unit, a casing enclosing said unit and defining an air chamber therebehind, said casing being generally convexly curved exteriorly and having a portion shaped to fit within and partly around one of the U-shaped magnets, means for equalizing the responses of the two microphones comprising electrical and acoustic impedance elements, all of said impedance elements being housed in the pressure microphone casing, and an exteior perforated casing enclosing said transmitter.

13. A velocity microphone comprising a ribbon diaphragm of the order of .00025 inch thickness and having a compliant portion adjacent at least one end and a stiffened portion intermediate its ends, and a low frequency damping means comprising an electrical impedance shunted across said diaphragm.

WILLIAM R. HARRY.
ROBERT N. MARSHALL.