

Jan. 28, 1941.

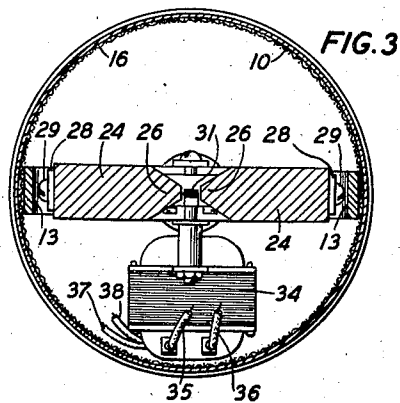
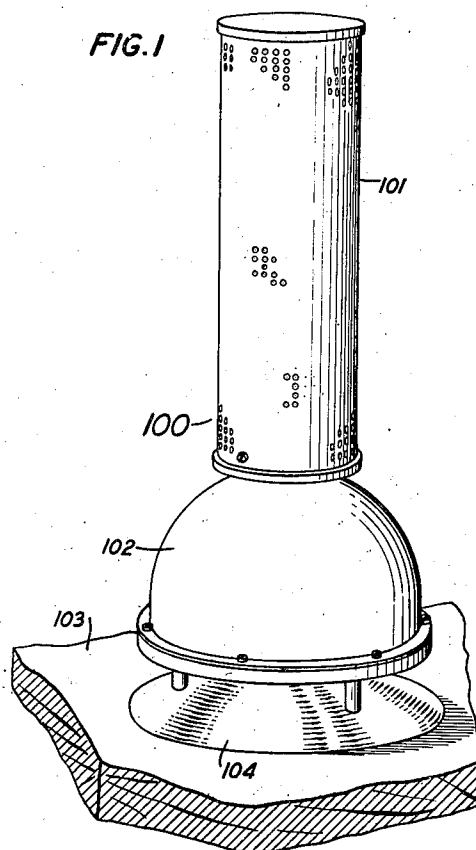
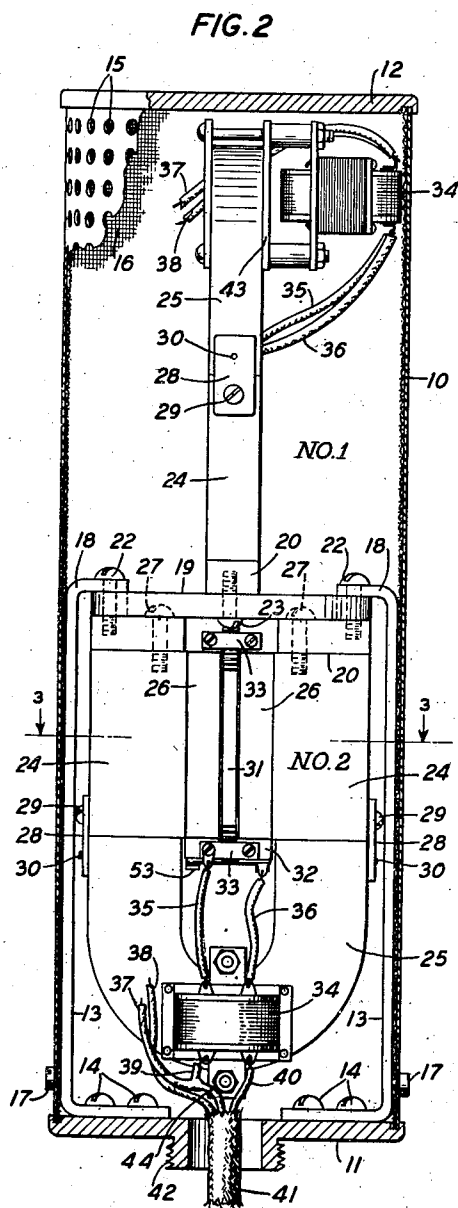
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2,230,104

ACOUSTIC DEVICE

Filed Dec. 20, 1938

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FIG. 4

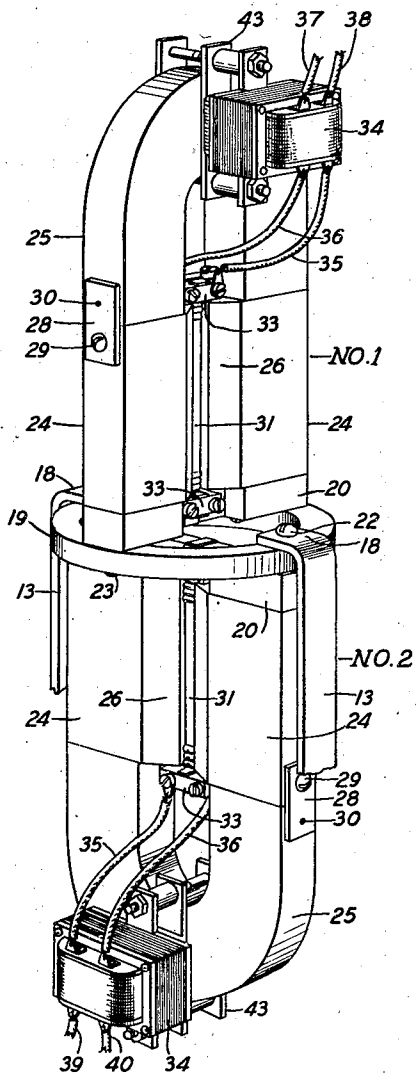


FIG. 6

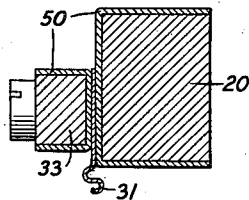


FIG. 7

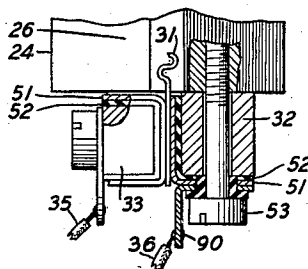
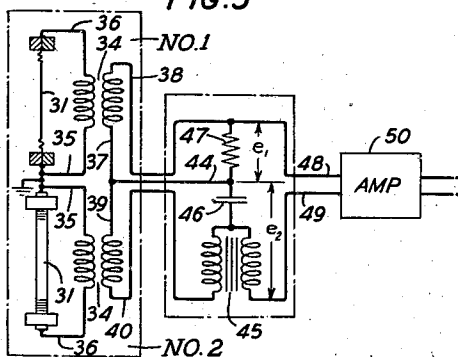


FIG. 5



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2,230,104

ACOUSTIC DEVICE

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Application December 20, 1938, Serial No. 246,792

17 Claims. (Cl. 179—1)

This invention relates to acoustic devices and more specifically to electroacoustic transducers suitable for two-way telephone conference systems. More particularly, it relates to certain relative arrangements of transmitter and loud-speaker means and to forms of transmitter means peculiarly adapted for such arrangements.

In loud-speaker two-way telephone conference systems, it has been found important to have large acoustic transmission loss between the loud-speaker and transmitter at each station. If the loud-speaker and transmitter are located on the conference table, as seems desirable from several considerations, the transmitter should be equally sensitive to speech of all conferees around the table, while discriminating against sounds from the loud-speaker.

One object of this invention, therefore, is to insure good transmission and reception for each member of a telephone conference group at each conference station.

A further object of this invention is to obtain a transmitter means having a desired polar response characteristic.

In accordance with one feature of this invention, the transducer unit comprises pressure gradient or velocity transmitter means and a loud-speaker located at a point of minimum transmitter sensitivity and oriented to radiate as much as possible away from the transmitter.

A further feature of the invention resides in a transducer unit constructed in accordance with the foregoing feature in which the transmitter means comprises a plurality of transmitter elements arranged in a vertical line with their axes of maximum sensitivity in angular relation to each other, the outputs of one or more of the elements being modified as to magnitude and/or phase relation.

Another feature of this invention pertains to the use of ribbon-type velocity transmitter units for the transmitter elements.

An additional feature of this invention resides in a transmitter including two ribbon velocity transmitter units with vertically aligned ribbon diaphragms, having their planes angularly related, and means connected to the ribbon diaphragms to modify the outputs of the units as to phase and magnitude.

A further and more specific feature of this invention relates to a transmitter means employing two ribbon diaphragms in line vertically with the planes of the ribbon diaphragms at right angles and with the output voltage of one

ribbon unit shifted substantially 90 degrees in phase by an electrical network.

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 appended drawings, in which:

Fig. 1 is a general perspective view of a transducer unit illustrative of this invention and a portion of the table top on which it rests;

Fig. 2 is an elevational view of a transmitter constructed in accordance with this invention with its casing broken away to show the interior structure;

Fig. 3 is a section on line 3—3 of Fig. 2;

Fig. 4 is a perspective view of the transmitter shown in Fig. 2 with the casing removed and part of the supporting brackets broken away;

Fig. 5 is a wiring diagram showing how the transmitter may be connected to amplifier means through a suitable network; and

Figs. 6 and 7 are sectional detail views showing how the ribbon is clamped and one way of making electrical connections thereto.

Referring now to the drawings, in Fig. 1, 100 denotes the transducer unit comprising a transmitter 101 and a loudspeaker 102 resting on a conference table, a portion of which is shown at 103. As will be apparent from the drawings the speaker 102 radiates toward the table and its sound output is distributed therearound by the arched or convex member 104. This arrangement insures a uniform distribution of sound around the loud-speaker in a generally horizontal direction.

If the transmitter 101 comprises a single ribbon velocity unit with the ribbon vertical, the foregoing arrangement gives minimum acoustic coupling between loud-speaker and transmitter. This is due to the well-known low sensitivity of this type of transmitter to sounds in the plane of its ribbon diaphragm. However, this characteristic directivity is objectionable since it does not permit uniform pick-up in a horizontal plane. This difficulty inherent in the single ribbon unit is overcome in accordance with one feature of this invention by employing a plurality of ribbon elements, vertically in line with the planes of the ribbon diaphragms at angles with respect to each other, and means for modifying the phase and/or magnitude of the output of certain of the ribbon units. Thus, various pick-up patterns in a horizontal plane may be provided. Such patterns may be made generally elliptical for a long conference table or circular for a square or round

table. Other desired patterns may be formed by proper arrangement of the angles between the ribbon planes and with suitable modification of the output of certain ribbon units as to phase and/or magnitude.

In the embodiment of the invention illustrated, the transmitter means comprises two ribbon diaphragms vertically in line with their planes mutually perpendicular. The output of one ribbon is shifted in phase by substantially 90 degrees with minimum attenuation. The other ribbon has its output attenuated without phase shift to the same degree as the first in order to match the two outputs. Such an arrangement provides a substantially circular field in the horizontal plane with maximum discrimination against zenith and nadir sounds.

Referring again to the drawings and more particularly Figs. 2, 3 and 4, 10 denotes a cylindrical casing or housing of brass or the like for enclosing the transmitter. The ends of casing 10 are closed by two circular members 11 and 12 of brass or other suitable material. The closure 11 acts as a base for the transmitter and has brackets 13 mounted thereon. The brackets 13 may be secured to the base 11 by screws 14 or other suitable means. The member 11 may be provided with a projecting bushing 42 for accommodation of the cable 41 and for attaching the transmitter to the loud-speaker casing. It is desirable under some conditions to employ material, such as soft rubber, in the connection between the transmitter and loud-speaker housings. Such an expedient inhibits the transference of mechanical vibrations between the housings.

The casing 10 is perforated with a plurality of openings 15 for the passage of sound waves. A lining 16 of fabric, such as silk cloth, covers the openings 15. The closures 11 and 12 are grooved to receive the ends of the casing 10 which are secured therein by soldering or like means. Suitable fastening means, such as screws 17, secure the casing 10 to the brackets 13.

The top ends of brackets 13 are turned inwardly, as shown, at 18, to provide supports for a mounting ring 19 of non-magnetic material, such as brass. Bridging members 20 are diametrically mounted, on opposite sides of the ring 19 and at right angles to each other. The lower bridge member 20 and ring 19 are fastened together and secured to portions 18 of the brackets 13 by screws 22. The upper bridge member 20 is attached to ring 19 by means of screws, one of which is shown at 23. The upper and lower transmitter units are mounted on upper and lower bridge members 20 respectively.

Inasmuch as the two transmitter units are of the same construction, the same reference characters are applied to like parts of each. For convenience of description the upper unit may be designated as No. 1 and the lower unit as No. 2. Each unit includes a magnetic structure comprising a pair of pole-pieces 24 of iron or the like and a magnet 25 of suitable magnetic material, such as an alloy comprising cobalt 12 per cent, molybdenum 16 or 17 per cent and the remainder iron.

The pole-pieces 24 have reduced portions 26, best seen in Figs. 2 and 4, and are mounted in parallel relation with the portions 24 in juxtaposition to define an elongated air-gap. Fastening means, such as screws 27, secure the pole-pieces to a bridge member 20. The magnet 25 is attached to the pole-pieces 24 by tabs or plates

28. The plates 28 may be secured to the pole-pieces 24 by screws 29 and spot-welded to the magnet as at 30.

A ribbon diaphragm 31 is mounted in the air-gap between pole-pieces 24. The ribbon is clamped at one end in a recess of bridge member 20 and at the other end to the support 32 by a clamp 33 as shown in detail in Figs. 6 and 7. The support 32 is secured to the ends of portions 26 of the pole-pieces 24 by screws 53.

As shown in Fig. 6, the end of the ribbon that is attached to bridge member 20 is in electrical connection therewith, being clamped between sheets 50 of silver foil or the like, which sheets are in electrical contact with members 20 and 33. The silver foil provides low ohmic connection to the ribbon and also acts as a cushioning means to avoid damage to the ribbon in clamping. The other end of the ribbon is clamped in a similar manner between sheets 51 of silver foil which are insulated from members 32 and 33 by sheets 52 of insulation.

The ribbon 31 is preferably of aluminum foil and may be transversely corrugated near its ends only. The central portion of the ribbon may be stiffened by virtue of its curved cross-section as indicated in Fig. 3.

The ends of the ribbon, as illustrated in Fig. 5, are connected to the primary winding of a transformer 34 by conductors 35 and 36. As shown in Figs. 2 and 7, both connections may be made adjacent one end of the ribbon. The connection from conductor 35 is to clamp 33 and then via the pole-pieces 24 to the grounded end of the ribbon at bridge member 20. The conductor 36 may be connected to the ribbon through a tab 30, clamped against the insulated silver foil 51 by insulated screw 53, as shown in Fig. 7.

Connection to the external circuit may be made by conductors 37 and 38 for unit No. 1 and by conductors 39 and 40 for unit No. 2. The conductors 37 and 39 may, for convenience, be spliced to a common conductor 44 at a point adjacent the lower transformer and conductors 38, 40 and 44 taken out in a shielded three-conductor cord 41 through the bushing 42.

The transformers 34 are mounted on the magnets 25 by suitable clamping brackets 43.

Referring now to the wiring diagram, Fig. 5, it will be seen that each ribbon diaphragm 31 is connected by the conductors 35 and 36 to the primary winding of a transformer 34. The secondary winding in unit No. 2 is connected by conductors 40 and 39 and common conductor 44 to a phase shifting network, comprising inductor 45 and condenser 46. Conductors 38, 37 and 44 connect the transformer secondary winding in unit No. 1 to attenuating means such as resistor 47. The combined output is conducted to amplifier 50 by wires 48 and 49. The attenuating means 47 is designed to substantially match the attenuation of the phase shifting network in order that the two outputs may be properly combined.

Inductor 45 comprises two coil portions, serially connected and inductively coupled to each other with a tap between the two portions for the condenser connection. The inductance and capacitance of network elements 45 and 46 should be of such values that their impedances are substantially equal for a frequency intermediate the highest and lowest frequencies of the transmitter range. The impedances of the inductor 45 and the condenser 46 are made small with

respect to the impedance of the transmitter elements.

In a transmitter constructed in accordance with this invention, the output voltage of one ribbon diaphragm unit combined with that of the other after it has passed through the phase shifting network, is independent of the direction in the horizontal plane from which the energizing sound originates, as is shown by the following equations. The ribbon diaphragms, for convenience, may be designated as No. 1 and No. 2 in accordance with the unit designation of the prior description. If e_1 represents the instantaneous voltage from ribbon No. 1 measured across resistor 47 and e_2 the instantaneous voltage at the output of the phase shifting network which is connected to ribbon No. 2, as indicated in Fig. 5, then according to the known properties of the ribbon transmitter

$$e_1 = E_1 \cos \theta \cos \omega t \quad (1)$$

$$e_2 = E_2 \cos (\phi - \theta) \cos (\omega t - \phi) \quad (2)$$

where

E_1 and E_2 = maximum instantaneous potentials,

θ = the angle between the normal to ribbon No. 1 and the direction in the horizontal plane under consideration,

ϕ = the angular rotation of the plane of ribbon No. 2 with respect to that of ribbon No. 1,

and

ϕ = the phase shift of the voltage of ribbon No. 2 introduced by the electrical network.

If ϕ and ϕ are made 90 degrees Equation 2 becomes

$$\begin{aligned} e_2 &= E_2 \cos (90 - \theta) \cos (\omega t - 90^\circ) \\ &= E_2 \sin \theta \sin \omega t \end{aligned} \quad (3)$$

Making $E_1 = E_2 = E$, the combined instantaneous voltage e for the two ribbons is then:

$$\begin{aligned} e &= e_1 + e_2 = E_1 \cos \theta \cos \omega t + E_2 \sin \theta \sin \omega t \\ &= E \cos (\omega t - \theta) \end{aligned} \quad (4)$$

It is evident that the magnitude of the voltage represented by the coefficient E in Equation 4 is independent of the angle θ in the horizontal plane from which the sound originates. At the same time zenith and nadir sounds are discriminated against because each ribbon diaphragm is insensitive to sound from a direction in the plane of the ribbon diaphragm and, therefore, the combined voltage of the two ribbon diaphragm units for these sounds is small. Thus, the polar sensitivity pattern in a horizontal plane is a circle while the pattern in any vertical plane through the ribbon is similar in form to a figure 8.

To obtain the above results it is necessary that the voltage output of one ribbon be shifted 90 degrees in phase with respect to the other. If the two ribbons at right angles are connected in series without a phase shifting means, a polar sensitivity pattern similar to that for one ribbon is attained. The two transmitter voltages combine in a manner to cause insensitivity in a plane 45 degrees to that of each of the two ribbon planes.

The foregoing discussion of the operation of the transmitter assumes exactly 90 degrees phase shift in the electrical network. Such a constant phase shift with small and uniform insertion loss is difficult to obtain over a wide frequency range. It has been found, however, that a network such as shown in the wiring diagram, Fig. 5, produces

a close approximation to that desired with tolerable loss values.

As heretofore stated, other horizontal pick-up patterns may be obtained by suitable arrangements of the transmitting elements and the phase and magnitude modifying means. For example, elliptical patterns with desired major and minor axes may be produced by several arrangements. One such arrangement comprises two sound responsive elements with 90-degree relative rotation, 90-degree phase shift of one and unequal sensitivities. Another arrangement comprises two elements with 45-degree relative rotation, 45-degree phase shift of one and equal sensitivities. A third arrangement uses three elements, one with 45-degree and another with 90-degree rotation, 45-degree and 90-degree phase shifts, respectively, and equal sensitivities.

Although specific embodiments of the invention have been shown and described, it is to be understood that they are illustrative and not limiting the scope of the invention as defined in the appended claims.

What is claimed is:

1. A loud-speaker-acoustic pick-up device comprising a unitary structure including a sound pick-up means having an axis of low sensitivity, a loud-speaker located on said axis and oriented to radiate away from said pick-up means, and means associated with said loud-speaker for distributing a substantial portion of its output over a plane perpendicular to said axis of low sensitivity.

2. A transducer unit comprising an acoustic transmitter capable of picking up sounds from all directions in a horizontal plane therethrough and substantially insensitive to nadir sounds, a loud-speaker mounted beneath said transmitter and oriented to radiate downwardly, and means below and spaced from said loud-speaker for distributing its sound output uniformly therearound in substantially a horizontal plane.

3. A transducer unit comprising an acoustic transmitter means of the pressure gradient type, so oriented as to discriminate against zenith and nadir sounds, a loud-speaker mounted under said transmitter means and radiating downwardly, and convex baffle means under and spaced from the speaker for diverting its sound output uniformly into a generally horizontal path.

4. An acoustic transmitter including sound pick-up means and electrical phase shifting means so constructed and arranged that the transmitter responds to sounds from all directions in a horizontal plane in accordance with a predetermined sound direction pick-up pattern, but is substantially insensitive to zenith and nadir sounds.

5. An acoustic transmitter including sound pick-up means and electrical phase shifting means, so constructed and arranged that the transmitter responds to sounds from all directions in a horizontal plane, in approximately the same degree, but is substantially insensitive to zenith and nadir sounds.

6. An acoustic transmitter comprising a plurality of pressure gradient transmitter units mounted in line vertically and having their axes of maximum sensitivity at angles to each other, output modifying means associated with one or more of said units, and means for combining the modified outputs, whereby said transmitter means is sensitive to sound in all directions in a horizontal plane in accordance with a predetermined

pick-up pattern but is relatively insensitive to zenith and nadir sounds.

7. An acoustic transmitter comprising a plurality of pressure gradient transmitter units having conductive ribbon diaphragms, said diaphragms being axially in line and having their planes at predetermined angles, and means connected at one or more of said ribbons for modifying the phase and magnitude of its output voltage.

8. An acoustic transmitter comprising two pressure gradient transmitter units having conductive ribbon diaphragms, said diaphragms being axially in line and having their planes mutually perpendicular, and means connected to one ribbon to shift the phase of its output voltage substantially 90 degrees.

9. An acoustic transmitter including sound pick-up means and electrical output modifying means so oriented and connected that the polar diagram of transmitter sensitivity to sound direction in a horizontal plane through the pick-up means is substantially elliptical and is substantially a figure 8 for any vertical plane through the pick-up means with maximum discrimination against zenith and nadir sounds.

10. An acoustic transmitter including sound pick-up means and electrical phase shifting means so oriented and connected that the polar diagram of transmitter sensitivity to sound direction in a horizontal plane through the pick-up means is substantially circular and is substantially a figure 8 for any vertical plane through the pick-up means with maximum discrimination against zenith and nadir sounds.

11. An acoustic transmitter comprising a two-ribbon pressure gradient sound pick-up device, a phase shifting network and an attenuating means, the ribbons being axially in line with their planes mutually perpendicular, the network being connected to shift the output of one ribbon 90 degrees in phase, and the attenuating means connected and proportioned to reduce the magnitude of one ribbon output below that of the other, and means for combining the outputs of the two ribbons whereby said transmitter means responds substantially equally to sound in an elliptical field extending in a generally horizontal direction, but discriminates against zenith and nadir sounds.

12. An acoustic transmitter comprising two pressure gradient type transmitter units having ribbon diaphragms, said units being mounted on a common support and so oriented that the ribbon diaphragms are axially in line with their planes mutually perpendicular, means responsive to the output of one unit to shift the phase of its voltage substantially 90 degrees with low loss, means responsive to the output of the other unit to introduce a loss substantially equivalent to that in the phase shifting means but without shifting the phase of its voltage, and means for combining the modified outputs of the two units.

13. An acoustic transmitter as defined in claim 12 in which the phase shifting means comprises an inductor having two inductively coupled, serially connected winding portions, and a capacitor connected to the junction of said winding portions.

14. An acoustic transmitter including a two-ribbon pressure gradient sound pick-up device and a phase shifting network, the ribbons being axially in line with their planes mutually perpendicular and the network being connected to shift the output of one ribbon substantially 90 degrees in phase, and means for combining the outputs of the two ribbons, whereby said transmitter responds substantially equally to sounds in a generally horizontal direction, but discriminates against zenith and nadir sounds.

15. An acoustic transmitter comprising sound pick-up means including two transmitter units having bi-directional sound pick-up characteristics, means connected to the output of one of said units to shift the phase thereof substantially 90 degrees, and means for combining the shifted output of said one transmitter unit with the output of the other unit, said transmitter units being so oriented with respect to each other that the transmitter means is substantially equally responsive to sounds from any direction in or near a given plane through the sound pick-up means, but discriminates against sounds from a direction perpendicular to said plane and in line with the pick-up means.

16. An acoustic transmitter comprising two bi-directional transmitter units mounted on a common support with their axes of maximum sensitivity at right angles to each other, means for modifying the output of one of said transmitter units by shifting its phase substantially 90 degrees, and means for combining this modified output with that of the other transmitter unit, whereby said transmitter means is non-directional as to sounds in a horizontal plane passing therethrough but is substantially insensitive to zenith and nadir sounds.

17. An acoustic transmitter comprising a supporting structure including a base, bracket means mounted on said base and having arms extending therefrom, a supporting ring mounted on the extremities of said arms, and two diametral bridge members attached to said ring on opposite sides thereof and at right angles to each other, two pairs of spaced parallel pole-pieces, each pair defining an air-gap and attached to one bridge member, a magnet means associated with each pole-piece pair, and a ribbon diaphragm mounted in each air-gap, said diaphragms being axially in line and with their planes mutually perpendicular.

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