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DIRECTIONAL SOUND TRANSMITTER

Filed May 17, 1962

Fig. 1

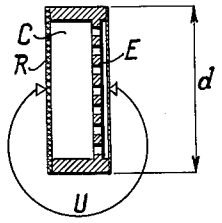


Fig. 2

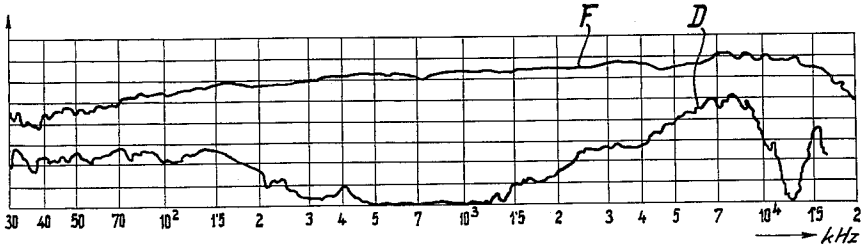


Fig. 3

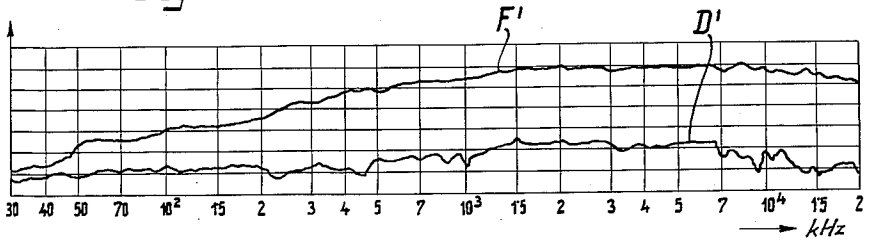


Fig. 4

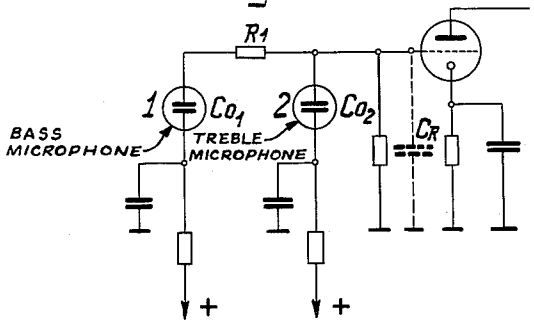
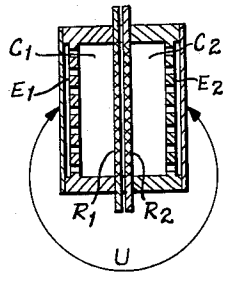


Fig. 5



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DIRECTIONAL SOUND TRANSMITTER

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5 Claims. (Cl. 179—1)

This invention relates to a directional sound transmitter which comprises at least two closely spaced condenser microphones, which are electrically connected together and feed a common amplifier.

Theoretical and practical investigations have shown that in systems in which the sound detour from the center of the front face to the center of the rear face of the diaphragm is equal to or larger than half the wavelength of the highest frequency to be transmitted, the frequency response in the case of sound incidence from the front side (sound incidence at 0°) and the attenuation in the case of sound incidence from the rear (sound incidence at 180°) are not satisfactory so that such sound transmitters no longer meet present-day quality requirements. It has been recognized that these disturbances are due to the fact that the sound detour from the front side to the rear side of the diaphragm is too large for high frequencies where individual systems are used. In a known design of such a sound transmitter comprising electrostatic transducers having a unilateral, cardioid, directional pattern, the capsule diameter of each individual system is about 2.2 mm. This capsule diameter equals approximately the sound detour. The frequency at which half the wavelength equals the sound detour from the front face of the diaphragm to the rear face thereof is 7.5 kilocycles per second. Measurements have shown that a considerable deterioration of the rear attenuation occurs below this frequency. Theoretically, this defect might be eliminated by a reduction of the diameter of the capsule. Whereas this would increase the critical frequency, it would involve an intolerable decrease in sensitivity if the 0° frequency response were left unchanged because the actuating pressure gradient decreases linearly with the diameter. On the other hand, an attempt to maintain the sensitivity constant will result in a decrease in sensitivity at low frequencies owing to the low acoustic frictional resistance which is permissible. Whereas such an electrostatic transducer having a diameter of, e.g., 8 mm., has a satisfactory rear attenuation (180° sound incidence), its 0° frequency response decreases considerably below 1000 cycles per second.

The invention teaches how the disadvantages of the previously used directional sound transmitters comprising at least two closely spaced condenser microphones can be avoided. For this purpose the invention proposes to provide the transmitter with at least one condenser microphone having a preferential response for the high frequencies and at least one condenser microphone having a preferential response for the low frequencies and to design the treble microphones to have a shorter sound detour than the bass systems.

According to another feature of the invention, the diameter of the treble microphones is so small that a natural drop will occur at the low frequencies and the critical frequency lies outside the range to be transmitted whereas the bass systems include electrical blocking means connected into the output or outputs of the bass systems for clipping the high frequencies inclusive of the critical frequency lying in the frequency band transmitted.

Another feature of the invention resides in that the treble microphones are directly connected to the input of the common amplifier whereas the bass microphones are

connected by series resistors to the treble microphones.

When it is desired that the sound transmitter should have a plurality of directional patterns, each individual system is provided according to the invention with two diaphragms.

The invention will now be described more fully with reference to the accompanying drawings, in which

FIG. 1 is a sectional view showing a conventional directional condenser microphone.

FIGS. 2 and 3 show different curves representing results of measurement,

FIG. 4 is an electrical circuit diagram of a sound transmitter according to the invention, and

FIG. 5 is a sectional view showing a conventional directional condenser microphone having two diaphragms.

The condenser microphone shown in FIG. 1 has a unilateral, cardioid directional pattern. It has the diameter *d*. Behind the perforated counter-electrode E, the volume C is disposed, which is confined at the rear side of the microphone by the acoustic frictional resistance R. U is the sound detour from the front side to the rear side of the microphone. In FIG. 2, F is the frequency response at 0° sound incidence and D is the rear attenuation at 180° sound incidence as a function of frequency of such a microphone having a diameter of 2.2 cm. It is apparent from this showing that the rear attenuation greatly deteriorates adjacent to 7 kilocycles per second, i.e., adjacent to the frequency at which the sound detour from the center of the front face of the diaphragm to the center of the rear face of the diaphragm is approximately half the wavelength. The frequency response is also slightly increased in this range.

An attempt to achieve an improvement by a reduction of the capsule diameter would not be successful alone because, as has been mentioned hereinbefore, it results in a decline at the low frequencies if the sensitivity is maintained constant. This is readily apparent from the curves shown in FIG. 3, in which the rear attenuation D′ can be considered satisfactory whereas the frequency response F′ shows an intolerable decline beginning at 1000 cycles per second.

According to the invention, sound in the frequency range to be transmitted is received by at least two microphones, and the microphones having a preferential response for the high-frequency range have a small sound detour whereas in the systems having a preferential response for the lower frequencies, the microphones have a much longer path from the center of the front face of the diaphragm to the center of the rear face of the diaphragm. In order to avoid with these microphones the undesired influence at the critical frequency, at which the sound detour is approximately half the wavelength, the frequency range transmitted by the bass systems must be clipped so that all frequencies of the treble range, inclusive of the range of the critical frequency, will not reach the input of the amplifier. This is effected most suitably by electrical means by connecting band pass filters or band elimination filters in the output of the bass systems. One or more resistance-capacitance networks will usually be sufficient. A particularly desirable arrangement is shown in FIG. 4, in which the capacitance of the capsule together with the input capacitance of the amplifier, which input capacitance is substantially constituted by the interelectrode capacitance of the amplifier, form a part of the filter required for a bass system. The treble system causes a decline in the response at the treble low frequencies owing to its dimensions and has a transmitting range which does not include the critical frequency so that this system does not require additional filters and can be directly connected to the input of the amplifier. The capacitance C_{02} of this microphone 2 together with the interelectrode capacitance C_r of the

tube form the capacitive component of a resistance-capacitance network having the resistance R_1. The bass microphone **1** having the capsule capacitance C_{01} is connected to this network. The resistance capacitance network thus formed is designed to have a limiting frequency at which the sensitivity of the treble microphone has decreased by approximately 3 decibels. Thus the point of division on the frequency scale has been defined.

In the embodiment shown in FIG. 4, the capsule capacitance $C_{01}=40$ picofarads, $R=8$ megohms and $C_{02}=10$ picofarads. These values resulted in a point of division at 1500 cycles per second.

The other circuit elements shown in FIG. 4 and having no reference characters serve in a manner known per se for supplying the polarizing voltages and for the A.C. connections.

Each of the two systems may be provided with two diaphragms so that each system has two oppositely directed cardioid directional patterns, which may be combined in known manner to form different directional patterns (omnidirectional, cardioid, bidirectional and intermediate patterns).

Such a two-diaphragm arrangement is shown in FIG. 5, wherein volumes C_1 and C_2 are disposed behind perforated counter-electrodes E_1 and E_2, respectively. The rear sides of the respective volumes C_1 and C_2 are limited by respective acoustic frictional resistances R_1 and R_2. The sound detour from one diaphragm to the other is indicated as U. The arrangement of FIG. 5 results in two kidney microphones having their main sensitivity directions directed toward each other.

What we claim is:

1. A directional sound transducer comprising, in combination, at least two closely adjacent condenser microphones each including diaphragm means having a front face with a zero degree sound wave incidence and a rear face with a 180° sound wave incidence, the sound waves incident upon the rear face of each microphone being phase displaced with respect to the sound waves incident upon the front face of the respective diaphragm, with the amplitude of phase displacement depending substantially upon the sound detour path which sound waves, incident upon the front face, must travel between the center of the front face and the center of the rear face, each microphone having a respective output; and a common amplifier having an input connected to all of said outputs; at least one of said microphones consisting of a treble condenser microphone, and at least one other of said

microphones consisting of a bass condenser microphone; the sound detour path from the center of the front face to the center of the rear face of said diaphragm means being shorter for said treble microphone than for said bass microphone.

2. A directional sound transducer as set forth in claim **1**, in which the length of said sound path for said treble microphone, relative to the length of the sound track for said bass microphone, being such that said treble microphone has a substantially decreased response to frequencies equal to and below a critical frequency at which said sound path for said bass microphone equals half the wavelength of sound, and which sound transducer further comprises electrical blocking means connected to the output of said bass microphone and clipping frequencies equal to and above said critical frequency.

3. A directional sound transducer as set forth in claim **2**, in which said blocking means comprise a resistance-capacitance network including the capacity of said treble microphone.

4. A directional sound transducer as set forth in claim **1**, in which the output of said treble microphone is directly connected to the input of said amplifier and the output of said bass microphone is connected by a series resistor to the output of said treble microphone.

5. A directional sound transducer as set forth in claim **1**, in which said diaphragm means of each of said microphones comprises two diaphragms to enable different directional patterns to be achieved.

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