Oct. 20, 1942. H. F. OLSON 2,299,342

ELECTRO-ACOUSTICAL APPARATUS

Filed Nov. 30, 1939 2 Sheets-Sheet 1

Fig. 2.

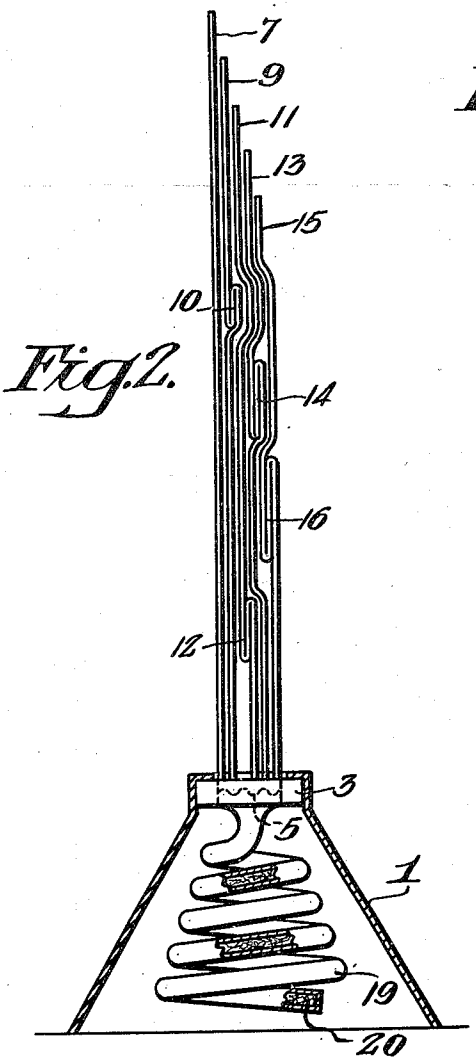

Fig. 1.

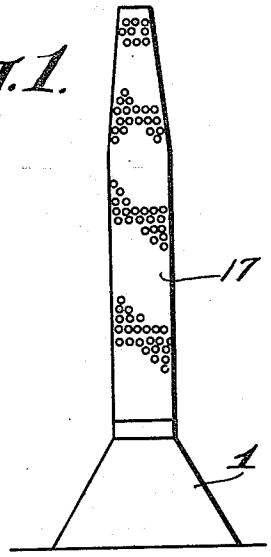

Fig. 3.

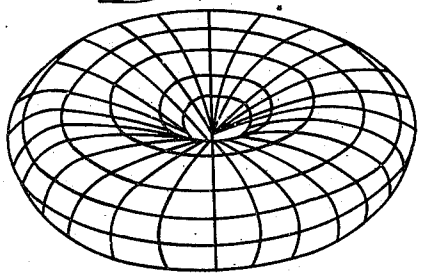

Fig. 4.

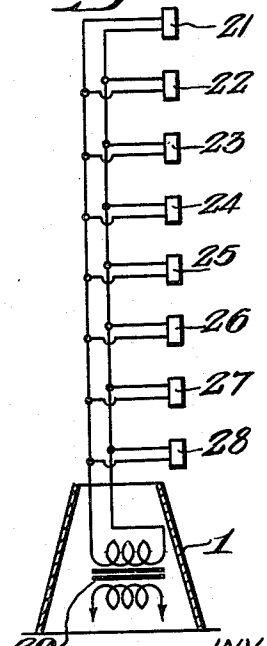

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Fig. 5.

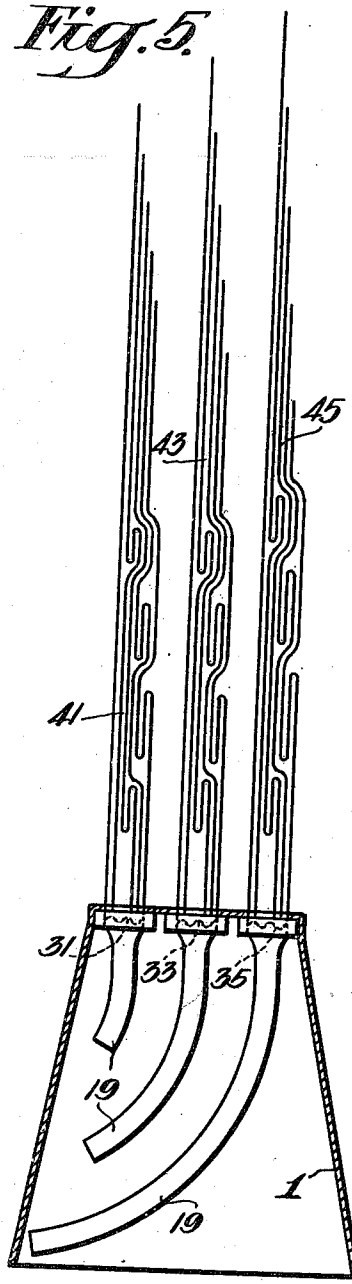


Fig. 6.

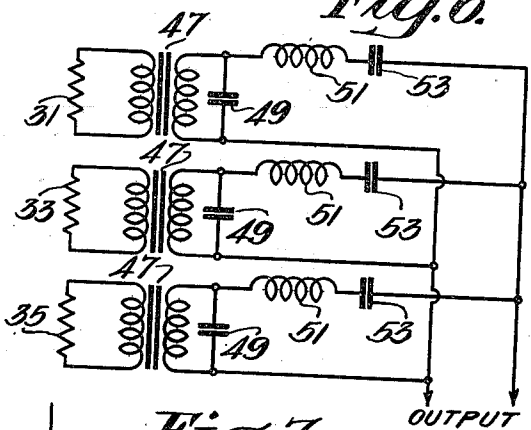


Fig. 7.

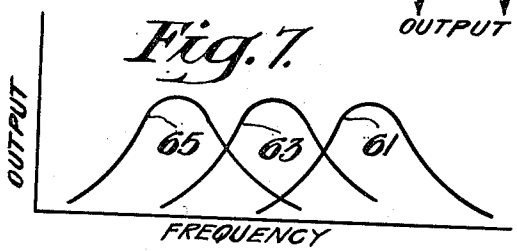
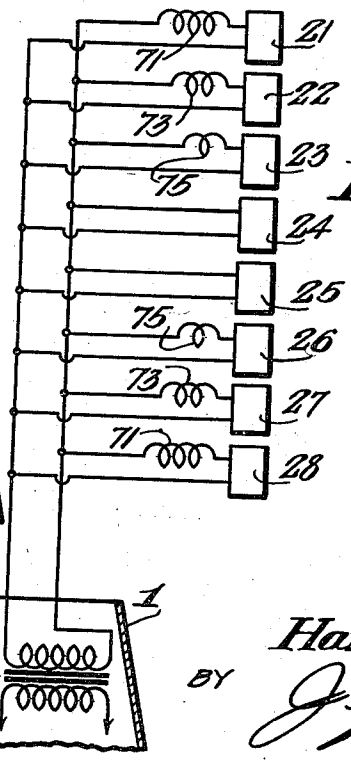


Fig. 8.



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2,299,342

UNITED STATES PATENT OFFICE

2,299,342

ELECTROACOUSTICAL APPARATUS

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Application November 30, 1939, Serial No. 306,954

11 Claims. (Cl. 179—121)

This invention relates to electroacoustical apparatus, and more particularly to a microphone of the line type in which the directional characteristics are symmetrical with respect to the microphone axis in a predetermined plane and wherein the maximum pickup is confined to substantially that plane.

In certain types of sound pickup, such, for example, as in sound broadcasting, the sources of sound are confined to substantially a single horizontal plane. The deviation from this plane is usually very small, being the difference between a person standing or sitting down. The same is true of an orchestra where the level of the instruments does not vary appreciably from an average horizontal plane. As a consequence, there is no point in employing a nondirectional microphone which picks up sound from all directions and therefore picks up sound reflected by the ceiling and floor. For this reason, the bidirectional velocity microphone has been employed almost exclusively for sound collection in radio broadcasting. When oriented to pick up sound in radio broadcasting, the velocity microphone does not pick up sound from the ceiling or floor. However, in a horizontal plane, the velocity microphone also varies as the cosine of the angle of the approaching sound wave. In other words, in the plane of the ribbon of a velocity microphone, the pickup is zero. This feature of the velocity microphone is useful for balancing orchestras, for eliminating unwanted sound, etc.

In certain types of sound collection, it is desirable to pick up sound in all directions in a horizontal plane, it being extremely important, at the same time, to eliminate sounds from the floors and ceiling. In other words, it is very desirable that the microphone which picks up the sound shall have a relatively sharp directional characteristic which discriminates against undesirable sounds, but which will pick up all the desired sound in a predetermined plane throughout a 360° angle, and it is the primary object of my present invention to provide a novel microphone which will accomplish this result.

More particularly, it is an object of my present invention to provide an improved directional microphone which is especially suitable for use in radio broadcasting, sound reinforcing systems, etc., where it is desirable to have maximum pickup in substantially a predetermined plane, but no pickup, or at least a minimum of pickup, outside of this plane.

Another object of my present invention is to provide an improved microphone as aforesaid which has a directional characteristic independent of the frequency of the sound picked up thereby.

It is also an object of my present invention to provide an improved line microphone as above described which is compact in construction, easily portable, and highly efficient in use.

According to one form of my present invention, the system consists of a number of vertically extending pipes or tubes of equal length with their pickup ends open and arranged on a line. The pipes are equipped with progressive bends so that their open ends will lie progressively nearer a ribbon element or the like to which the pipes are coupled and which is used for transforming the sound transmitted down the pipes into corresponding electrical variations. The acoustic paths from the opening of each pipe to the ribbon element are, however, the same in each case because the pipes are all of equal length. The ribbon element is terminated in a damped pipe which constitutes an acoustical resistance. Sound waves travelling in a horizontal plane will reach the open, or pickup, ends of each of the pipes substantially simultaneously, and, since the pipes are all of equal length, they will reach the ribbon element simultaneously and in phase.

According to another form of my invention, it is not necessary to use pipes and a ribbon element as above described, but several sound wave responsive elements arranged on a line can be used. These elements may comprise Rochelle salt or condenser units which are arranged vertically one above the other in suitably spaced relation and which are coupled to a common coupling circuit connected to a suitable amplifier.

To render either of the above-described systems independent of frequency, it is possible, in the case of the first-described modification of my present invention, to provide several lines of different lengths, the high frequency lines being made short and the low frequency lines being made long. The length of the lines should be inversely proportional to the frequency to obtain uniform directional characteristics, and the output of each line is fed through a filter system which discriminates against different frequencies within a preselected range, so that the output of each line is allocated to the proper frequency band. In the case of the second modification described above, suitable filter circuits may be coupled to certain ones of the pickup devices, the several filter circuits being effective

ver different ranges to provide frequency discrimination in a manner similar to the above.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, together with additional objects and advantages thereof, will best be understood from the following description of several embodiments thereof, when read in connection with the accompanying drawings, in which

Figure 1 is an elevation of one form of my invention as set up for use,

Figure 2 is an enlarged view thereof, partly in section, and with the cover removed,

Figure 3 shows the directional characteristic of this microphone,

Figure 4 shows a modification of my invention,

Figure 5 shows a variation of the first form of my invention by means of which uniform response for all frequencies is obtained.

Figure 6 is a wiring diagram illustrating a filter system that may be employed in connection with the modification of my invention shown in Figure 5,

Figure 7 shows the response curve of the system shown in Figure 4, but arranged with a filter system such as shown in Figure 6, and

Figure 8 shows a modification of the system shown in Figure 4, but arranged with a filter system to provide uniform response for all frequencies.

Referring more particularly to the drawings, wherein similar reference characters designate corresponding parts throughout, I have shown, in Figs. 1 and 2, a microphone comprising a hollow base or pedestal 1 carrying a casing or the like 3 in which is mounted a vibratile member or ribbon 5 arranged to operate in a suitable magnetic field and adapted to convert acoustical energy into electrical energy in well-known manner. Extending vertically from the casing 3 so that they are coupled to the upper surface of the ribbon 5 are a plurality of open-ended tubular elements or pipes 7, 9, 11, 13 and 15, the pipes being surrounded by and enclosed within a perforated cover or casing 17 which is supported on the base 1.

The pipes 7, 9, 11, 13 and 15 are all of the same length, but the pipes 9, 11, 13 and 15 are provided with uniformly progressively varying bends 10, 12, 14 and 16, so that the open ends of all of the pipes lie along a straight line with the pickup ends of the pipes 9, 11, 13 and 15 successively nearer the ribbon element 5 than is the pickup end of the pipe 7. The lower surface of the ribbon element 5 is terminated in an acoustical resistance which may be constituted by a coiled pipe or tube 19 of relatively large diameter coupled to the casing 3 and filled with tufts or felt or the like 20, the acoustical resistance which terminates the ribbon 5 having a value substantially equal to the surge resistance of the tubes or pipes 7, 9, 11, 13 and 15 and large compared to the mass reactance of the ribbon 5. Preferably, the total cross-sectional area of the tubular elements 7, 9, 11, 13 and 15 is substantially equal to the cross-sectional area of the large pipe 19 to minimize reflection at the junction or casing 3, particularly when the acoustic impedance of the ribbon 5 is small compared to the acoustic resistance offered by the pipe 19. In this respect, the construction of my present microphone is similar to that disclosed and claimed in my copending application Serial No. 237,960, filed October 31, 1938, now Patent No. 2,228,886, granted Jan. 14, 1941.

The over-all height of this microphone may be of the order of six to eight feet. Since the sound path from the opening of each of the pipes 7, 9, 11, 13 and 15 to the ribbon 5 is constant, it is apparent that sound travelling in a horizontal direction from a source to one side of the microphone which is substantially equidistant from all of the pick-up points will strike the pickup end of each tubular element at the same time and will therefore be conducted simultaneously to the ribbon 5 in phase, the ribbon 5 transforming the sound which travels down the tubular elements into corresponding electrical variations or pulsations. The directional characteristic of this microphone is shown in Fig. 3, the axis of the microphone coinciding with the axis of the three-dimensional curve shown in Fig. 3, and it will be noted that the directivity of the microphone is confined to a plane normal to the microphone axis.

In the modification of my invention shown in Fig. 4, instead of employing the tubes 7, 9, 11, 13 and 15 for picking up the sound, I employ a plurality of pickup devices 21 to 28, inclusive, which are arranged vertically along a line in spaced relation to each other and which are suitably supported on the base or pedestal 1, the devices 21 to 28 being substantially equidistant from a sound source to one side of the microphone. The pickup devices 21 to 28 may comprise small Rochelle salt units, condenser units, or the like, and they are connected in parallel relation, their outputs being coupled to a suitable amplifier (not shown) by means of a coupling transformer 29 which may be housed within the base 1. The operation of this form of my invention is, in general, the same as that described above insofar as the simultaneous picking up of the sound by all of the units and its conversion into electrical energy is concerned.

The two modifications of my invention thus far described have characteristics which vary with frequency, becoming relatively sharp at the higher frequencies. This, in general, is an undesirable characteristic. To overcome this objection, I provide the modifications shown in Figs. 5 and 8.

In the modification shown in Fig. 5, I provide three ribbons 31, 33 and 35 on the base 1 and couple to each of them three separate lines 41, 43 and 45 of tubular elements, each similar to that described above in connection with Fig. 2. However, the lines 41, 43 and 45 are made progressively longer, the line 41 being shortest and being effective for the higher frequencies, the line 45 being longest and effective for the lower frequencies, and the line 43 being of intermediate length and effective for the intermediate frequencies. The lengths of these lines should be inversely proportional to the frequency to obtain uniform directional characteristics, and the outputs of the lines are fed to a filter system such as shown in Fig. 6. This filter system may include, in connection with each line and its associated ribbon, a coupling transformer 47 across the secondary of which is connected a capacitance 49 and in series with which there may be provided an inductance 51 and a second capacitance 53. The values of the capacitances 49 and 53 and the inductance 51 will be different in each case, of course, and all of the circuits are connected together to a common output circuit, as

shown. Thus, the output of each of the lines 41, 43 and 45 is limited to a relatively narrow frequency band shown, respectively, by the curves 61, 63 and 65 of Fig. 7. In this way, the over-all directional characteristic of the microphone can be made independent of the frequency.

Similar arrangements may be provided for the modification shown in Fig. 4 to make the length of the line inversely proportional to the frequency, as in the case of the modification just previously described. To this end, there may be provided in circuit with certain of the devices 21 to 28 (for example, the devices 21, 22, 23, 26, 27 and 28) inductances 71, 73 and 75, each of different value. This arrangement will provide a response characteristic for the system like that shown in Fig. 7.

Although I have shown and described several embodiments of my invention, it will be apparent to those skilled in the art that many other modifications are possible. I therefore desire it to be understood that I do not wish to limit myself except insofar as is made necessary by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. In combination with a source of acoustical energy, a line microphone including a plurality of pickup elements all arranged on a single line and an output member coupled to said elements, said elements being so constructed and arranged relative to said source and said output member that the energy picked up by each of said elements in a predetermined plane is delivered to said output member simultaneously and in phase.

2. A line microphone comprising, in combination, a plurality of pickup elements all displaced along a single line and adapted to pick up acoustical energy simultaneously in a predetermined plane, means for converting said picked up energy into electrical variations, and means for simultaneously conducting the energy picked up by each of said elements to said means in phase.

3. In electroacoustical apparatus, the combination of a member adapted to be actuated by acoustical waves, and a plurality of tubular elements associated with said member and arranged to direct acoustical waves to said member, said tubular elements being of equal length and having their ends open and all arranged on a single line.

4. In electroacoustical apparatus, the combination of a member adapted to be actuated by acoustical waves, a plurality of tubular elements associated with said member and arranged to direct acoustical waves to said member, said tubular elements being of equal length and having their ends open and all arranged on a single line, and certain of said tubular elements being provided with bends therein whereby their open ends lie closer to said member along said line than the open ends of certain other of said elements.

5. In electroacoustical apparatus, the combination of a member adapted to be actuated by acoustical waves, a plurality of tubular elements associated with said member and arranged to direct acoustical waves to said member, said tubular elements being of equal length and having their ends open and all arranged on a single line, and certain of said tubular elements being provided with bends therein of progressively varying length whereby the ends of said bent elements lie at different distances from said member along said line.

6. In electroacoustical apparatus, the combination of a member adapted to be actuated by acoustical waves, a plurality of tubular elements associated with said member and arranged to direct acoustical waves to said member, said tubular elements being of equal length and having their ends open and all arranged on a single line, and means providing an acoustical resistance terminating said member.

7. In electroacoustical apparatus, the combination of a base, a member mounted on said base and adapted to be actuated by acoustical waves, a plurality of tubular elements associated with one surface of said member and extending upwardly therefrom, said tubular elements being of equal length and having their ends open whereby they are adapted to pick up acoustical waves and direct them to said member simultaneously and in phase, said open ends all lying along a single line, and a tubular member associated with the other surface of said first-named member, said tubular member being housed within said base and being filled with a material, constituting an acoustical resistance.

8. The invention set forth in claim 7 characterized by the addition of a perforated casing carried by said base and surrounding said tubular elements.

9. In electroacoustical apparatus, the combination of a plurality of line microphones each comprising, in combination, a member adapted to be actuated by acoustical waves, a plurality of open-ended tubular elements associated with one surface of said member and arranged to direct acoustical waves to said member, the tubular elements of any one of said microphones being of equal length but being of different lengths in each line and the open ends of the tubular elements of each microphone all lying, respectively, along a separate, single line, and means coupled to the opposite surface of each of said members providing an acoustical resistance terminating said members.

10. The invention set forth in claim 9 characterized by the addition of a hollow pedestal and characterized further in that said members are mounted on said pedestal with said tubular members rising upwardly therefrom, and characterized further in that said acoustical resistances include pipes enclosed with said pedestal.

11. The invention set forth in claim 9 characterized by the addition of electrical frequenuy discriminating circuits coupled to each of said members, each of said circuits being effective over a different range.

HARRY F. OLSON.