May 30, 1933. F. RIEBER 1,911,772

DIRECTIVE SOUND PICK-UP

Filed July 14, 1931

Fig. 1.

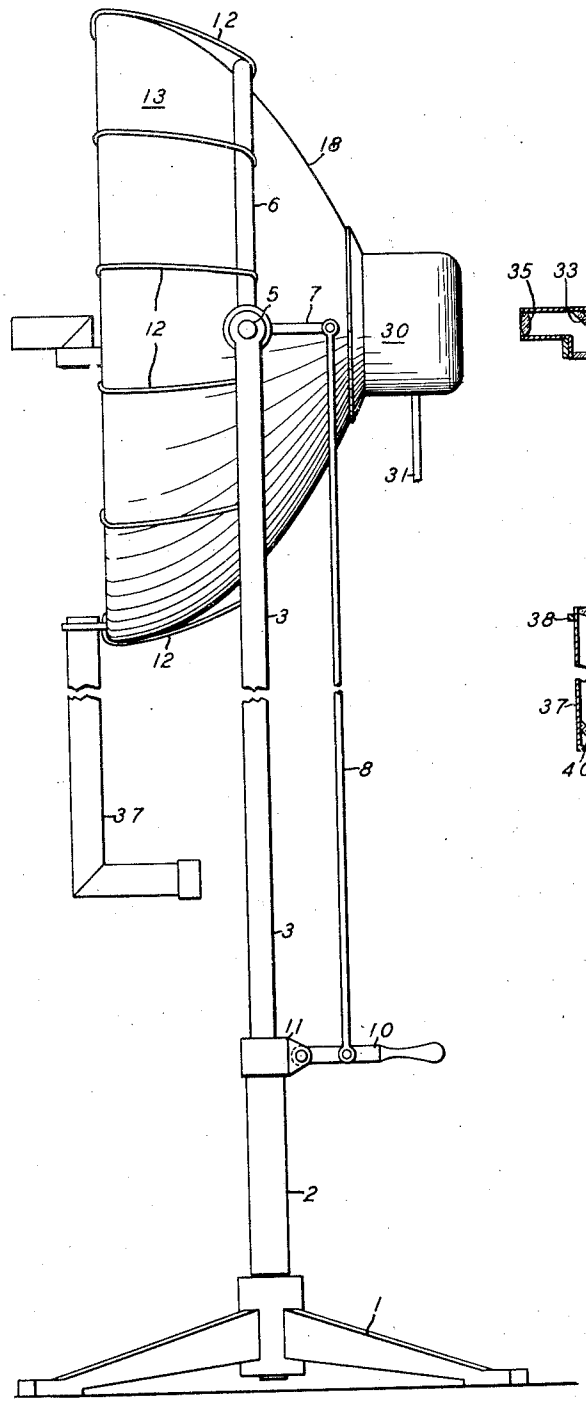
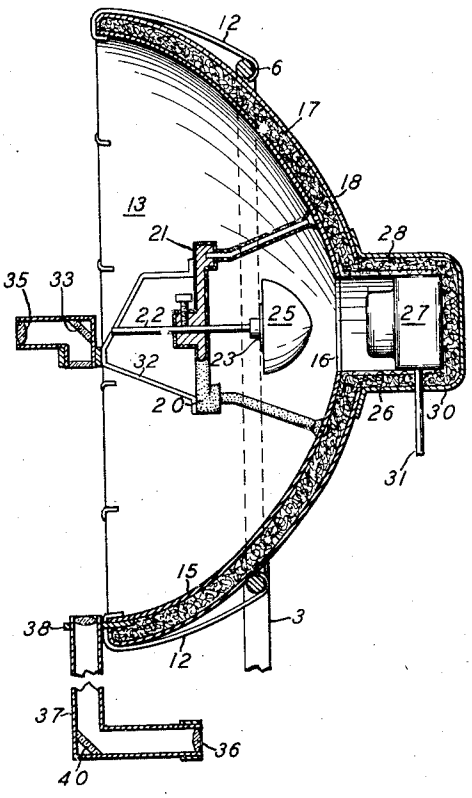


Fig. 2.



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UNITED STATES PATENT OFFICE

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DIRECTIVE SOUND PICK-UP

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My invention relates to sound pick-ups for the electrical recording or transmission of sound, and its broad purpose is to provide a pick-up wherein the ratios between direct and reflected sound of both high and low frequencies from a given source are adjusted to substantially the values of normal human perception.

Among the objects of my invention are: To provide a pick-up having substantially uniform response to direct sound of both high and low frequencies, while discriminating against reflected or secondary sound of high frequency; to provide a sound directive system which will intercept a portion of a received sound wave, concentrate said wave, and redirect it as a wave-front of smaller diameter and higher concentration in its direction of original travel; to provide a sound pick-up system wherein the advantages of a baffle may be combined with the advantages of a directive reflector; to provide a directive sound receiving system wherein the microphone is completely shielded from sound of both high and low pitch proceeding from the rear of the system; and to provide a directive sound receiving system which is completely adjustable in direction, both as to azimuth and altitude, and having means whereby it may be directed so that the sound source lies upon the axis of the pick-up.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of my invention herein described, as various forms may be adopted within the scope of the claims.

Referring to the drawing:

Figure 1 is a side elevation of a directive pick-up embodying my invention.

Figure 2 is a vertical axial sectional view, the plane of section being parallel to the plane of projection of Figure 1.

Since the early days of radio broadcasting, and particularly since the advent of talking moving pictures, it has been recognized that sounds picked up by microphone and reproduced by a loud speaking mechanism have a different quality from those perceived directly by an observer, and that there are certain sounds which it is difficult if not impossible to reproduce naturally. Such sounds as the jingling of keys, the rattling of paper, a slamming door, and various others, are so magnified and confused in the process of sound pick-up that every effort is made to avoid them. Moreover, because the microphone has appeared to be super-sensitive to the effect of reverberation, it has been customary to position the microphone as close as possible to a speaker or other source of sound, so that the directly received energy would so far over-balance the secondary sounds due to reflection from walls, furniture, etc., that the latter could be neglected.

In moving picture practice the microphone must ordinarily be concealed from the camera, and this has led to the necessity of mounting the microphones on booms which could be swung to follow the actors about the stage while keeping the microphone out of the field of view of the camera. The effect produced by this practice has been that to the ear, the speaker remains stationary, while to the eye, he appears to move about, and in cases where this was fatal to the desired illusion, changes in intensity of the sound have been accomplished by means of "faders", which attenuated the speech currents from the microphone to the desired level.

Attempts have been made to utilize parabolic reflectors to concentrate the sound from a particular source upon the microphone, thus partially excluding echoes and reverberations, and permitting freer motion of the speakers, but these attempts have only been partially successful owing to the fact that the frequency response of such a pick-up system has not been uniform, and that it has apparently discriminated greatly against sounds of lower pitch.

A typical sound reproduction problem arises in the case of speech in a room having normal reverberation, i. e., reverberation sufficiently low so that conversation may be carried on without noticeable strain or diffi-

culty in hearing. If a microphone is positioned in the place of one of the listeners to such a conversation, the reproduction from the microphone circuit will be so clouded with interference, reverberation, and general noise, as to make the conversation practically unintelligible, or at least extremely difficult to listen to. Again replacing the microphone by a listener, and this time covering or blocking one of his ears so that he is capable of monaural perception only, the same confusion and interference which were noted in the reproduction from the microphone pick-up obtain.

From this, and numerous other experiments, it becomes evident that the interferent sounds are not added or built up by the microphone, but that they actually are present to the same extent as picked up by the microphone, and affect the listening ear mechanically to the same degree. The binaural effect of the normal listener, however, enables that listener to disregard sounds proceeding from undesired directions, and to concentrate his attention upon the desired sound. Thus, although the interferent sounds affect the ear of the listener, they do not affect his perception. The mechanism involved in thus disregarding undesired sounds is obscure, but experiment shows that phase differences in the received sound as between the two ears of the listener play an important part in the operation. It follows that the directive effects relate almost wholly to sounds of sufficiently short wave-lengths to produce a marked phase difference as between the two ears, and that low pitched sounds are not directionally discriminated against.

If a directive pick-up be used which is equally effective directionally as regards sounds of both long and short wave-lengths, the reproduced sounds have an unnatural quality and are apparently lacking in tones of lower pitch, although the reverberatory effects are very largely excluded.

Considered broadly, my invention comprises a system of sound reflectors or concentrators which is highly directional as regards sounds of relatively high pitch or frequency, and decreasingly directional as regards sounds of lower pitch. In its preferred form the directive system comprises a paraboloidal primary reflector, which redirects the sound back in the general direction of its source, toward the focus of the parabola. Adjacent the focus is mounted a secondary reflector, preferably in the form of a convex paraboloid, whose focus is substantially coincident with the focus of the primary reflector. Sounds received from the primary reflector by the secondary reflector are again redirected in the direction of their original travel, but with a greatly concentrated wave-front, to the microphone which is mounted centrally of the primary reflector, preferably in an aperture therein which is screened from direct sound by the secondary reflector. Sounds whose wave-lengths are shorter than the diameter of the primary reflector are picked up and concentrated thereby as above mentioned. It is well known, however, that a reflector must be large in comparison to the wave-length it is receiving in order that reflection phenomena may predominate over diffraction phenomena. With increasing wave-lengths the effect described becomes less and less noticeable, while the sounds become more and more capable of bending by diffraction, around the secondary reflector and entering the microphone without being redirected. For such sounds the primary reflector acts as a baffle, so that the "pressure doubling" effect which is always present when the wave-lengths shorter than the diameter of the microphone impinge thereon, also becomes effective for sounds of long wave-lengths. Not only do long wave-lengths affect the microphone, but reflected sounds, curving by diffraction about the obstruction offered by the deflecting system, also react upon it and, to a certain extent, undergo the pressure doubling effect. The result is that the sounds of high frequency and short wave-lengths which reach the microphone are primary sounds only. As the wave-length increases there is an increasing ratio of secondary sound reaching the microphone. If the primary reflector be made with a diameter of, say, from 30 to 40 inches, and the secondary reflector from one-fourth to one-sixth the diameter, the sounds of all frequencies reaching the microphone bear approximately the same primary-secondary ratio as in ordinary binaural perception.

The usefulness of the apparatus described is not limited to the one case thus discussed in detail. It has been found that the sounds which are ordinarily extremely difficult to reproduce, such as striking matches, tearing paper, the sound of surf, and the many minor sounds which give "life" or back-ground to almost all activities, are produced at their natural value. The sound pick-up may be mounted at a considerable distance, in many cases 20 to 50 feet, and in some cases as much as a hundred yards, from the sound source, and an entire play or act may be taken without changing the microphone set-up. Actors may approach or retreat from the microphone, and the sound level changes only as it normally should in response to their movements. There is thus obtained an effective depth in the sound action which adds greatly to the illusion of reality.

The maximum effect of the pick-up system is obtained when the sound source lies directly upon the axes of the parabolic re-

flectors, but sounds originating but slightly off of the axis of the reflector system are received with but slightly less effect, the effectiveness of the pick-up dropping off rapidly with departure from the axis. There is thus obtained a "third dimensional" or lateral depth, which is capable of being used to great advantage. A periscopic sight, whose line of collimation coincides with the axis of the reflector system is preferably provided. If it be desired to make a single voice dominate a situation, the reflecting system may be pointed by the aid of this sight so that the mouth of the speaker lies exactly upon the axis. In this case, the voice of that particular speaker will rise somewhat above those even immediately adjacent him, while the suppression of the other voices is not sufficiently severe to be objectively noticeable.

A preferred embodiment of this invention is shown in the drawing, and will next be described in detail. A suitable tripod or foot 1 having a vertical column 2 carries a yoke 3 which is journaled within the column for rotation in azimuth. In the design shown, the combined height of the stand thus formed, extending from the foot of the tripod to the trunnion bearings 5 at the upper ends of the arms of the yoke, is approximately nine feet, but other models have been built and operated satisfactorily where the over-all height of the apparatus was approximately five feet.

Trunnioned in the bearings 5 is a ring 6, carrying a lever 7 which is joined by a link 8 to a hand lever 10. The hand lever is pivoted in a collar 11 secured to the stem of the yoke 3, so that the yoke may be rotated in the stand by swinging the handle, or the ring tilted vertically by raising or lowering the handle.

Secured to the ring 6 by a series of clips or lacings 12, is a paraboloidal primary reflector indicated by the general reference character 13. The reflector comprises an inner reflecting surface or shell 15, preferably formed with a central axial orifice 16. Covering the outer surface of the shell 15 is a sound-absorbing coating 17 of felt or similar material, which in turn is covered with a protecting covering 18, which may also be of metal or which may be of fabric if desired.

Mounted within the reflector is a bracket or support 20, covered with sound-absorbing padding 21, and arranged adjustably to support a stem or shaft 22 on the axis of the parabola. This shaft carries upon its inner end a flange 23 to which is secured the convexly paraboloidal secondary reflector 25. This secondary reflector may be made of wood, metal, or any suitably rigid material whose surface will act as a satisfactory sound reflector.

Covering the back of the orifice 16 is a container 26, within which is mounted a microphone pick-up of conventional type, preferably a condenser microphone 27. The sound-absorbent coating 17 is continued as a cover 28 over the container 26, and the container and coating are protected by a cap 30, provision being made for the entrance of the microphone cable 31.

Mounted on an extension 32 of the bracket 21, on the axis of the two paraboloids, is a mirror 33, mounted at 45° with the axis and the objective 35 of a periscope or periscopic sight, whose eye-piece 36 is carried by a tube 37 projecting downward from a bracket 38 mounted on the lower rim of the paraboloid. A second 45° reflector 40 completes the optical system of the simple periscope thus formed, whose line of collimation therefore lies upon the axis of the reflector system.

In operation, the secondary reflector 25 is usually adjusted so that its focus coincides with that of the primary reflector 15. The operator of the pick-up rotates the system in azimuth and tilts it in altitude until the periscope or sight indicates that the sound source lies upon the axis of the system or closely adjacent thereto.

When the pick-up is positioned at sufficient distance from the sound source so that fronts of arriving sound waves are substantially plane, the waves of relatively high frequency are redirected toward the focus of the primary reflector. Because of the mathematical properties of the parabola, the distance traveled by each portion the sound wave to the focus would be identical with the distance traveled to a plane the same distance behind the apex of the parabola that the focus is in front of it, and all portions of the wave-front therefore are in phase, or would be were they allowed actually to reach the focus. Before reaching the focus, however, they are redirected by the secondary reflector 25, which again renders the wave-front parallel and traveling in its original direction, but much concentrated, the energy originally distributed over the portion of the wave-front intercepted by the primary reflector being concentrated in a circle whose diameter is that of the secondary reflector. Again the paraboloidal form of the reflector assures that all portions of the waves arrive in phase at the microphone diaphragm. Those waves which would otherwise have reached this diaphragm without reflection are intercepted by the secondary reflector.

In the case of wave-lengths which are long in comparison with the diameter of the reflector, the phenomena of reflection is subordinated to diffraction phenomena. Such waves bend around the secondary reflector and act directly upon the microphone. Be-

cause the secondary reflector is preferably made of such diameter that its projection in the plane of the microphone is a circle of one quarter wave-length diameter with respect to the longest wave which it is desired to receive at full intensity, the pressure-doubling effect becomes effective and the reflector acts as a baffle, giving the microphone substantially the same efficiency for such wave-lengths as it has for the shorter ones. It is to be noted, however, that the effect upon the microphone for these low frequencies is only double what it would be were the baffle not present, instead of being approximately 36 to 1 as it is for the high frequencies, the secondary reflector being assumed to be one-sixth of the diameter of the primary reflector.

In the actual response to sound, however, the difference in order of response is not nearly as great as these figures would indicate. Secondary low frequency sounds are received from the walls of the room wherein the device is located, or from other surrounding structures, and are received by diffraction from these sources. Only sounds coming from directly behind the reflector system are completely cut off by a combination of baffle action and the insulation covering the microphone and reflector system from the rear.

The relationships described, corresponding to maximum sharpness of focus, are strictly accurate only for plane wave-fronts, i. e., for sounds originating far from the pick-up. If several actors, an orchestra, or other relatively large "sound source" is to be used, it is desirable that the pick-up field be made divergent, while if a single actor close to the pick-up must dominate the received sounds, a convergent pick-up field is of advantage. This flexibility is provided by the adjustability of the secondary reflector. Convergence of focus is secured by moving the latter away from the apex of the primary reflector, while divergence is secured by moving the apices of the reflectors together. Such adjustments need be very slight, and are accomplished empirically, the position of optimum effect being immediately perceptible to a monitor. The "depth of focus" is great, however, when the paraboloids are confocal, and it is seldom that the adjustment need be changed in recording a given situation.

I am aware that paraboloidal reflectors for sound are not, per se, new, having been described in my Patent No. 1,299,616, and by Aitken, Horn, and others, Horn in particular being concerned with the differentiation between primary or direct and secondary or reflected sounds. In so far as I have been able to ascertain, however, the necessity for secondary sounds of low pitch to impart naturalness is my own discovery, and none of the other inventors of whom I am aware has utilized a secondary reflector to redirect the reflected sounds in their original direction, giving the advantages above set forth.

I claim:

1. A directive sound pick-up comprising a microphone, a baffle surrounding said microphone and having a minimum extension therefrom equal to one-eighth of the wave length of the lowest pitched sound to be received, and means for insulating the back of said microphone from sound waves.

2. A directive sound pick-up comprising a paraboloidal reflector having a central opening therein, a microphone arranged within said opening so that the reflector constitutes a baffle therefore, sound absorbent material disposed to cover the back of said reflector and said microphone to shield said microphone from sound waves proceeding from behind said reflector.

3. In combination with a microphone and a reflecting system comprising a primary reflector for gathering and focusing the sound waves and a secondary reflector for redirecting said waves upon the microphone and mounted to intercept unreflected waves directed toward said microphone, means for directing the axis of said reflecting system toward a sound source, and sighting means including an optical reflector screened from said microphone by said secondary sound reflector.

4. In combination with a microphone and a directive sound reflective system therefor, a mounting for said reflective system adjustable in both azimuth and altitude, and sighting means for said system having a line of collimation substantially coincident with the axis of said reflective system.

5. In combination with a paraboloidal sound reflector and a microphone and a secondary reflector mounted coaxially therewith, a mounting for said paraboloidal reflector adjustable in azimuth and altitude, and sighting means having a line of collimation substantially coincident with the axis of said reflective system.

6. In combination with a paraboloidal sound reflector and a microphone and a secondary reflector mounted coaxially therewith, a mounting for said paraboloidal reflector adjustable in azimuth and altitude, and sighting means including an optical reflector screened from said microphone by said secondary reflector and having a line of collimation substantially coincident with the axis of said reflective system.

In testimony whereof, I have hereunto set my hand.

FRANK RIEBER.