June 20, 1944. J. O. BALLINGER ET AL 2,351,904

TRANSLATOR

Filed July 31, 1941 2 Sheets-Sheet 1

Fig. 1.

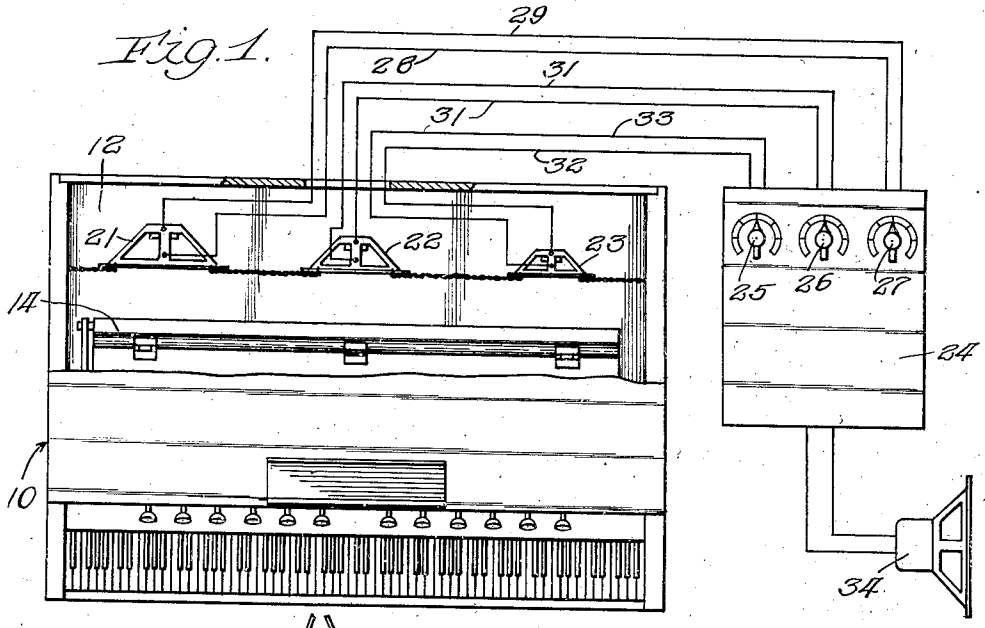
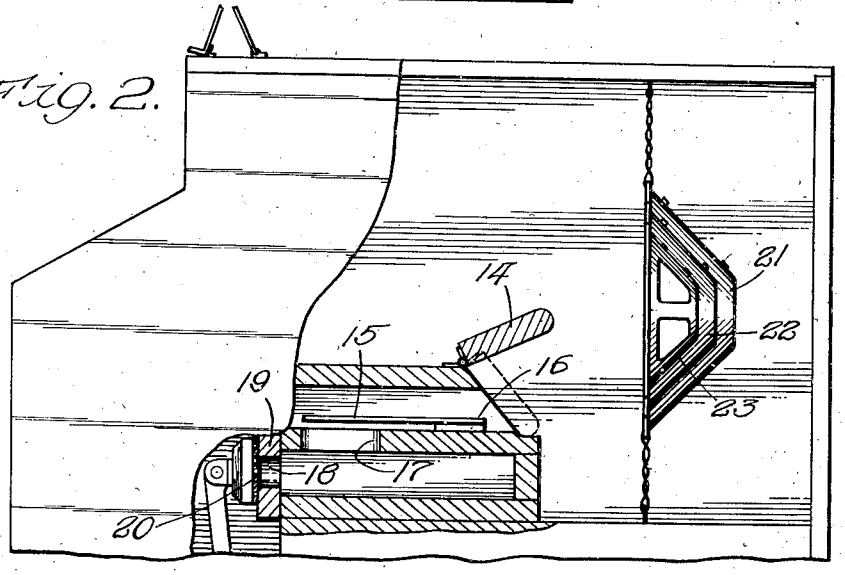


Fig. 2.



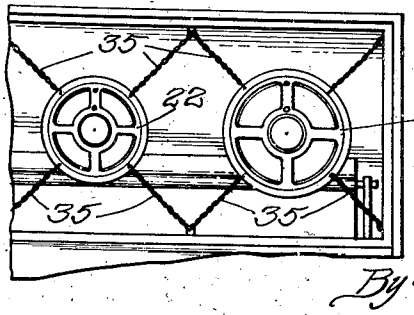


Fig. 3.

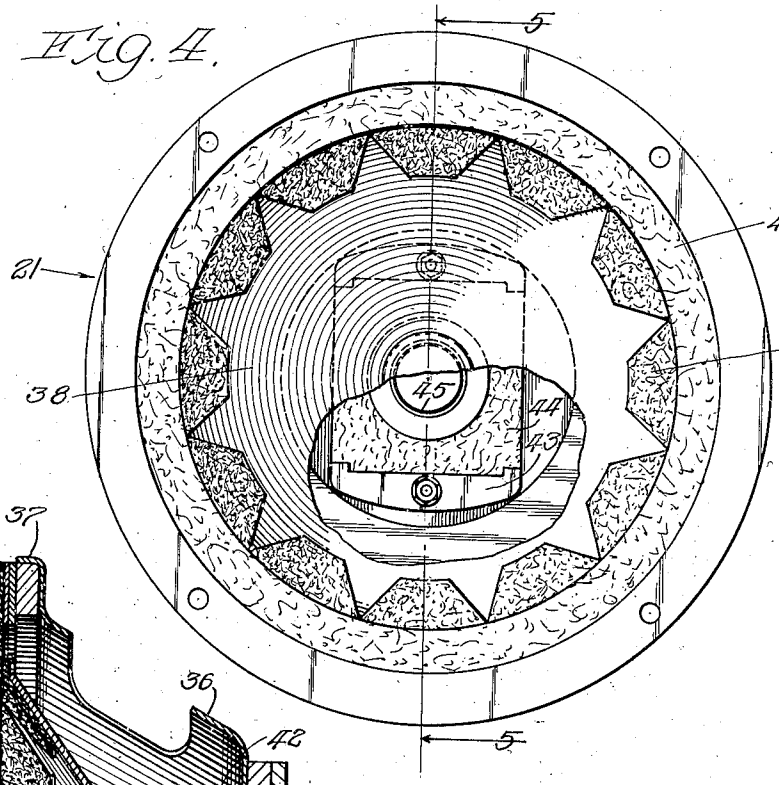
Inventors.
Jesse O. Ballinger,
Edward B. Worthington,
By Chadbourne, Wiley, Davies & Kimball, Attys.

June 20, 1944. J. O. BALLINGER ET AL 2,351,904

TRANSLATOR

Filed July 31, 1941 2 Sheets-Sheet 2

Fig. 4.



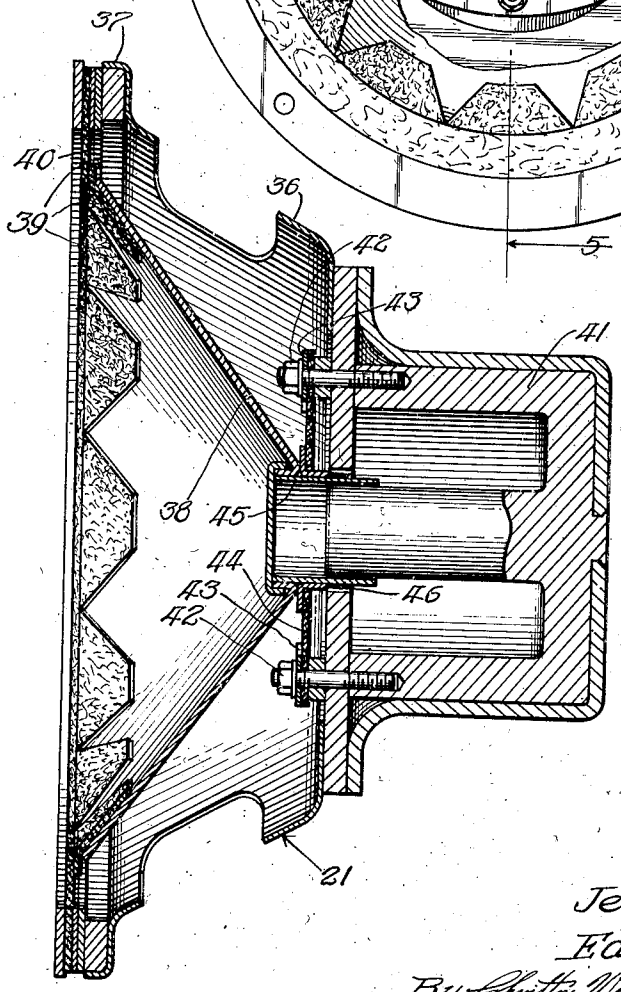


Fig. 5.

Inventors
Jesse O. Ballinger,
Edward B. Worthington
By Christy, Wiles, Davies & Reinhold, Attys.

Patented June 20, 1944 2,351,904

UNITED STATES PATENT OFFICE

2,351,904

TRANSLATOR

Jesse Ora Ballinger, Batavia, and Edward B. Worthington, Maywood, Ill.; said Worthington assignor to said Ballinger

Application July 31, 1941, Serial No. 404,920

4 Claims. (Cl. 179—115.5)

This invention relates to a translator, and more particularly to a device for translating sound waves into generally similar electrical waves having somewhat modified characteristics.

This application is a continuation-in-part of our copending application Serial No. 299,790, filed October 17, 1939, which was in turn a substitute for our application Serial No. 155,302, filed July 23, 1937.

Certain generators of musical sound waves, particularly in the audible frequencies below one thousand cycles per second, generate sound waves containing certain undesired and unpleasat partials, so that true and faithful amplification of such waves to considerable volume results in a sound which is very unpleasant to the ear. Examples of such generators are free floating reeds, chime bars or tubes, and short piano strings of the type found in a spinet piano, for example. A free floating reed produces a sound which is fairly pleasing so long as it is kept at very low volume levels, since the unpleasant partials are of much weaker amplitude than the true harmonic partials; but if such a tone is considerably amplified, as to fill a church or hall, the weaker unpleasant partials make the tone a grating one, highly unpleasant.

We have devised means for translating sound waves from such tone generators as those mentioned above having certain undesired partials, the translating means operating in such a manner as to practically wipe out all of the low amplitude undesired partials, also tending to eliminate sharp wave front impulses and to smooth the tone out to a wave form more nearly approximating a true sine wave. That is, the fundamental and desired harmonic partials are retained in the resultant electric current, so that the electrical waves are generally similar to the original sound waves, but they are modified slightly by the practically complete elimination of the unharmonic partials and by the smoothing out of slopes.

The resultant electrical waves or currents can then be amplified to any desired extent and transformed faithfully into sound waves, these sound waves being adapted to fill a church or hall with a pleasing tone rather than what would have been an unpleasant tone. Tones from the base reeds of a reed organ, for example, lose all of their undesired partials, pop tones, and the motor boating or death rattle frequently occurring upon termination of the action of such reeds, and the musical sound delivered by the loud speaker is a mellow pleasant one, which has, where desired, flute-like characteristics such that the average listener cannot distinguish it from the tones of a pipe organ. Our translator also finds great advantage with chimes, resulting in an output tone having the quality of that of a heavy bell; and with very short stringed pianos where, with proper use of a plurality of translators, tones can be achieved which are indistinguishable from those of a concert grand.

Our translator, therefore, is to be distinguished from the ordinary microphone or pick-up device in that it translates sound waves into electrical currents which, while they are generally similar, are modified by the elimination of very weak partials and by the smoothing out of sharp wave fronts in the sound waves. We have found that such a translator can be made by using a quite heavy diaphragm of material which is relatively dead vibrationally, and by supporting the diaphragm by means which is substantially devoid of characteristics tending to return the diaphragm to a given position when it is displaced therefrom by the sound waves. We find that a conical diaphragm is best, and when we speak of making it of material relatively dead vibrationally we mean that the material must be fairly heavy and have a low modulus of elasticity, so that the diaphragm tends to move as a unit, like a plunger, rather than to break up into various movements in various sections, as occurs with the conventional loud speaker diaphragm. We have found very heavy blotting paper to be an excellent material for the cone diaphragm. When we speak of the diaphragm as being supported by means which is substantially devoid of returning characteristics, we contemplate the use of supporting annuli of felt or very soft leather, as kid, not under any appreciable tension. During incidence of sound waves upon it the diaphragm of our translator is moved back and forth almost entirely by the portions of high and low air pressure in the sound waves. The ordinary diaphragm of a microphone, or of a speaker used as a microphone, is snapped back to its original position by the spring-like resilience of its mounting, whereas our diaphragm merely tends to float back and forth.

To carry the analogy to its limits, our diaphragm may be considered to act like a sheet of cardboard hung by a string, where it will be seen that as long as sound waves are incident upon it the movements of the cardboard sheet will be substantially entirely dependent upon

such waves, will tend to overrun or lag behind reversals in the sound waves, and will fail to move at all in response to the very weak partials. The usual pick-up diaphragm or vibrating member, on the other hand, is resiliently returned to its initial position, with spring-like snap, whenever it is displaced by the compression portion of a sound wave; and the vibrating member is usually made as light as possible so that, in combination with this snap return, it tends to faithfully follow all of the variations in the sound waves. While faithful reproduction is desirable in many circumstances, it is highly undesirable in the loud reproduction of tones given off by certain generators, as reeds, short strings, and tubes.

One feature of our present invention is that it provides desirable modificatons in translating certain sound waves into electrical currents; another feature of our invention is that it is particularly adapted to be used as a pick-up in connection with free floating reeds, tubes, and short strings, enabling the production of highly amplified pleasing tones from such sources; another feature of our invention is that it may be simply and cheaply constructed and used in association with conventional tone generating elements; other features and advantages of our invention will be apparent from the following specification and the drawings, in which:

Figure 1 is a diagrammatic view of our invention in combination with a reed organ; Figure 2 is a partial end view of the organ, partly broken away and with a reed cell in section; Figure 3 is a rear elevation of a portion of the reed organ with the back removed, showing two of the translating devices; Figure 4 is a front elevational view, partly broken away, of one of our translating devices; and Figure 5 is a transverse sectional view of the translating device, along the line 5—5 of Figure 4.

In the particular embodiment of our invention illustrated herewith a reed organ, indicated in general as 10, includes a rear mixing chamber 12 and a conventional shutter 14 for controlling the volume of sound from the reeds. The mixing chamber of a conventional reed organ would be lined with sound absorbent material, and when the shutter is open, as shown in Figure 2, the sounds of the reeds pass out into the mixing chamber and are picked up by translating devices incorporating our invention.

Referring now more particularly to Figure 2, a rather schematic showing of a reed cell shows a free floating reed 15 mounted at one end in a base 16, in turn mounted on one part of the reed cell, the free end of the reed being over an actuating opening 17 connecting to an opening 18 in the pallet board 19. This opening is controlled by a pallet 20 movably mounted and adapted to be actuated by a corresponding key on the keyboard of the instrument, so that depressing the key admits air from the windchest through the pallet board and the opening 17 to set the reed 15 into vibration. The vibration of the reed 15 sets up sound waves corresponding to the pitch and voicing of the reed, and these waves pass out through the opening in the end of the reed cell, controlled by the shutter 14.

Within the mixing chamber and to the rear of the reed cells and shutter, are mounted a plurality of substantially similar translators, here indicated as 21, 22 and 23. These translators include a conical diaphragm mounted for axial movement and carrying a voice coil near its apex, the voice coil being adapted to move in a fixed magnetic field so that movement of the diaphragm generates corresponding electrical waves or currents in the output leads from the voice coil. A multistage amplifier 24 is provided, this amplifier preferably being provided with three separate input stages and separate volume controls 25, 26 and 27. Translator 21 has its voice coil connected by the leads 28 and 29 to the input circuit controlled by the volume control 25; translator 22 is connected by the wires 30 and 31 to the input circuit controlled by the volume control 26; and translator 23 is connected by the wires 32 and 33 to the input circuit controlled by the volume control 27. It will be understood that these three inputs are combined in the amplifier 24, amplified to any desired extent (which may be controlled by a separate general volume control), and the resultant amplified currents translated as faithfully as possible into corresponding sound waves by the loud speaker 34.

While the translator 21 is exposed to vibrations or sound waves from any reed which happens to be playing, it is located adjacent the base end of the reed cell and is particularly designed to receive and translate the low frequency bass notes. In a particular reed organ which we have built and which we find operates very satisfactorily we employ a translator with an eight-inch diameter diaphragm adjacent the bass notes, a translator with a six-inch diameter diaphragm for the middle range (corresponding to the translator 22 in the drawings), and a translator with a five-inch diameter diaphragm adjacent the high treble notes (corresponding to the translator 23 in the drawings). We find that an eight-inch translator constructed in accordance with the details which we are hereinafter disclosing responds in a desirable manner to frequencies from thirty cycles per second up to and including about five hundred cycles per second; a six-inch diameter translator of our type gives the desired response to notes having a frequency in the range of one hundred fifty cycles per second to about two thousand cycles per second; and a five-inch diameter translator of our preferred type responds as desired to frequencies from about one thousand cycles per second to about seven thousand cycles per second. Because of the overlap in response ranges some notes would be picked up and translated efficiently by two of the translators, and very high harmonics of the lower notes might be translated by the translator designed for the high frequency range. In the main part, however, the low frequency notes are translated by the translator 21, the intermediate frequency notes by the translator 22, and the high frequency notes by the translator 23.

As may be best seen in Figure 3, the translators are preferably vibrationally insulated from the remainder of the organ, here being shown as mounted on twisted rubber strands 35. These serve to isolate the translators from undesired vibrations in the organ console, as vibrations of the motor driving the blower, or the like. The translators are intended to pick up and translate into modified electrical waves the sound waves which emanate from the reeds, and are as far as possible isolated from other vibrations. Any sound outside the organ is prevented from energizing the translators by the same internal lining of sound-insulating material which tends to keep the sounds of the reeds within the mixing chamber 12.

Inasmuch as all of the translators are prefer-

ably identical, only one translator will be described in detail, reference now being had particularly to Figures 4 and 5. As can be seen there, the translator includes a metal frame 36 provided with a peripheral flange 37. A conical or cone-shaped diaphragm 38 has its outer end attached (here through intermediate material 39) to an annular supporting ring 40 which is in turn carried by the peripheral flange 37. In the particular construction shown the material of the cone 38 is cemented to the intermediate member 39, which is in turn cemented to the inner edge of the annular member 40, the outer edge of this member being cemented to paper or cardboard rings cemented or otherwise fastened to the peripheral flange 37 of the metal frame of the translator. A permanent magnetic frame 41 is carried by screws 42 which also carries metallic members 43 to which is fastened the coil support annulus 44. As may be best seen in Figure 5, the diaphragm does not come to an actual apex, carrying a coil support 45 near its apex, this coil support having the windings 46 of the voice coil thereon. The output leads of the voice coil 46 would, of course, be the wires 28 and 29 earlier referred to and shown in Figure 1.

The diaphragm 38 should be quite heavy, and of material which is relatively dead vibrationally, so that the entire diaphragm tends to move as a unit without any flexure intermediate its ends. We have found that heavy blotting paper, or two layers of blotting paper cemented together, make a diaphragm having the characteristics which we desire. The supporting means for the diaphragm, comprising the members 40 and 44, should be of flexible material also relatively dead vibrationally, having substantially no modulus of elasticity, as felt or soft leather, like soft kid. These supporting parts should be mounted so that they are flabby, and not under tension. Under these conditions the diaphragm 38 and the voice coil carried by it are capable of considerable excursion without any substantial amount of restoring force because of the supports, the principal restoring force being gravity, so that the action of the diaphragm may be considered analogous to that of a pendulum. The movement of the voice coil in the fixed magnetic field created by the magnet 41 generates electrical waves corresponding to the movement of the diaphragm; but the diaphragm does not move in exact accordance with sound waves incident upon it. Because of its relatively great weight it has little or no response to partials of low amplitude, and it tends to start movement rather slowly and to continue movement after it is under way, so that the sharp wave front impulses of pop tones, or of motor boating, are smoothed out.

We have found that, in addition to the use of a mounting which is substantially devoid of the characteristics which tend to return the diaphragm to a position from which it is displaced, and the use of a diaphragm which is relatively dead and which does not break up during vibration, certain very definite weights and ratios must be maintained if our preferred form of action is to be achieved. Merely using a commercial loud speaker as a pick-up will not give the type of full rich flute-like tones which our translators give; and even if the mounting of a conventional loud speaker is changed to a felt or leather annulus, our results still will not be attained. The diaphragms of conventional loud speakers are of quite resilient and flexible paper, and are very light. For example, all of the moving parts of a conventional high quality five-inch diameter speaker have a weight of 1.20 grams; a six-inch speaker by the same manufacturer has moving parts with a total weight of 3.25 grams; and the eight-inch speaker of this manufacturer has a total weight of moving parts of 5.09 grams. Moreover, in all cases the weight is substantially equally divided between the voice coil and its mounting on the one hand and the diaphragm on the other hand. We have found that the weight of the moving parts of a translator (diaphragm, voice coil and mounting, and mounting rings) must be at least three times conventional weight for a given diameter loud speaker to accomplish the modification of wave characteristics which we desire; and the moving parts should preferably be about five times their normal weight. Moreover, we find that it is best to concentrate most of this weight in the diaphragm, so that the voice coil and its mountings preferably do not comprise more than one-quarter or one-third of the total weight. More specifically, we have found that a translator of the type which we have in mind must have a diaphragm with a weight of at least one gram per inch of diameter, and that the total weight of the moving parts of a translator embodying our invention must be at least one and one-half grams per inch of diameter and preferably two and one-half to three grams per inch of diameter.

In an ordinary reed organ keyboard where the notes cover a full range of from about sixteen cycles per second to eight thousand cycles per second, we have found that, while it is preferable to use pick-ups of our particular type in connection with all of the ranges, it is only necessary to use such pick-ups in connection with the lower ranges. That is, a bass reed tone, for example, will sound very unpleasant if faithfully amplified to a high level; while a very high reed note, from four thousand cycles up, does not sound particularly unpleasant if faithfully amplified. Accordingly, it will be understood that normally satisfactory results could be achieved by using one of our translators for the low range, and a high fidelity microphone or similar faithful pick-up for the middle and high ranges, although preferably a smaller translator of our type (as one having a six-inch diameter diaphragm) should be used for the middle range. Moreover, certain variations in result can be achieved by this mixing of the levels from the various pick-ups; but in all cases the gist of our invention lies in a translator which changes the sound waves from a generator having certain unpleasant characteristics into electrical waves which are modified more closely to a flute-like sine wave.

While we have shown and described certain embodiments of our invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims.

We claim:

1. A device of the character described for translating sound waves from a source of musical sound waves having certain unpleasant partials of relatively low amplitude into generally similar electrical waves having somewhat modified characteristics providing a pleasing musical tone, including: a relatively heavy conical diaphragm

adapted to be vibrated by the sound waves; annular supports for the diaphragm attached thereto near its base and apex, said annular supports being of flexible and inelastic material, whereby the diaphragm is only slowly returned to a neutral position when it is displaced therefrom; and a coil carried by the diaphragm near its apex and movable therewith, said coil being adapted to move in a fixed magnetic field to translate movements of the diaphragm into corresponding electrical waves, the moving parts having a total weight in excess of one gram per inch of diaphragm diameter, such weight being principally concentrated in the diaphragm.

2. Apparatus of the character claimed in claim 1, wherein the material of which the diaphragm is made is relatively dead vibrationally, whereby the diaphragm vibrates as a unit and discriminates against low amplitude and sharp wave front impulses.

3. A device of the character described for translating sound waves into generally similar electrical waves having somewhat modified characteristics, including: a relatively heavy circular diaphragm adapted to be vibrated by the sound waves; means for supporting the diaphragm for vibratile movement along its axis, said means being of such nature as to cause said member to only slowly return to a neutral position when it is displaced therefrom; and means carried by the diaphragm near its apex and movable therewith adapted to cooperate with fixedly mounted means to translate movements of the diaphragm into corresponding electrical waves, the moving parts having a total weight of at least one and one-half grams per inch of diaphragm diameter and such weight being principally concentrated in the diaphragm.

4. Apparatus of the character claimed in claim 3, wherein the moving parts have a total weight of approximately two and one-half to three grams per inch of diaphragm diameter.

JESSE ORA BALLINGER.
EDWARD B. WORTHINGTON.