LOUDSPEAKER DIAPHRAGM AND DRIVER

Filed Sept. 22, 1964 2 Sheets-Sheet 1

FIG. 1

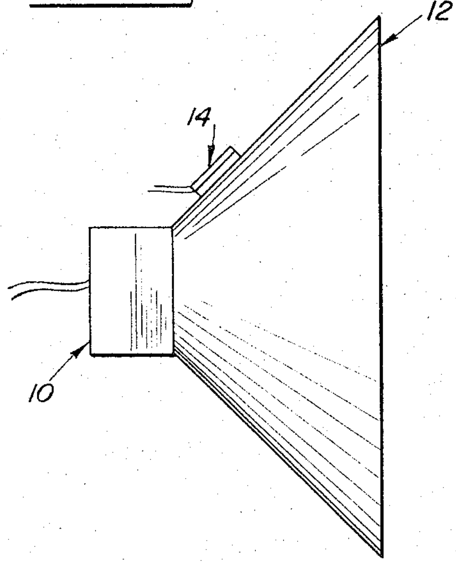


FIG. 4

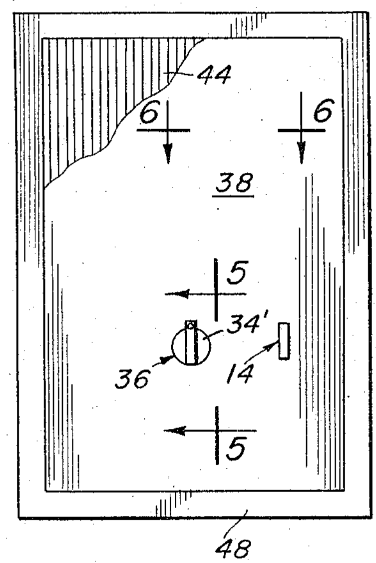


FIG. 2

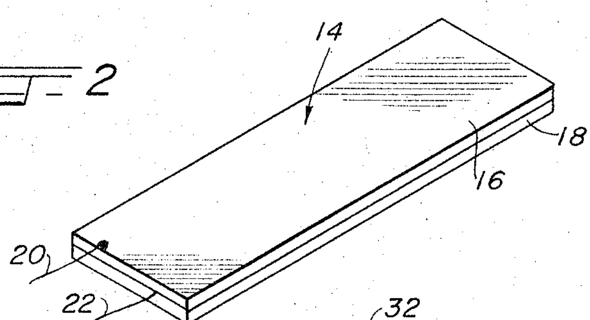
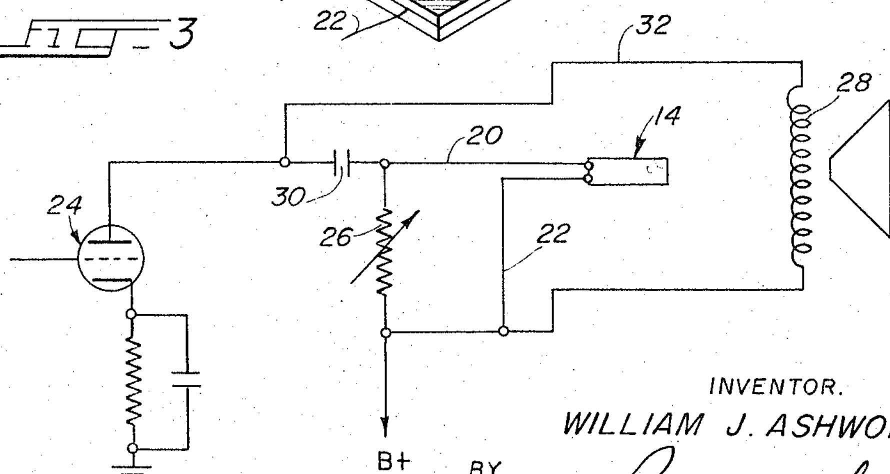


FIG. 3



INVENTOR.
WILLIAM J. ASHWORTH

BY Rummler & Snow
Attys.

LOUDSPEAKER DIAPHRAGM AND DRIVER

Filed Sept. 22, 1964 2 Sheets-Sheet 2

FIG. 5

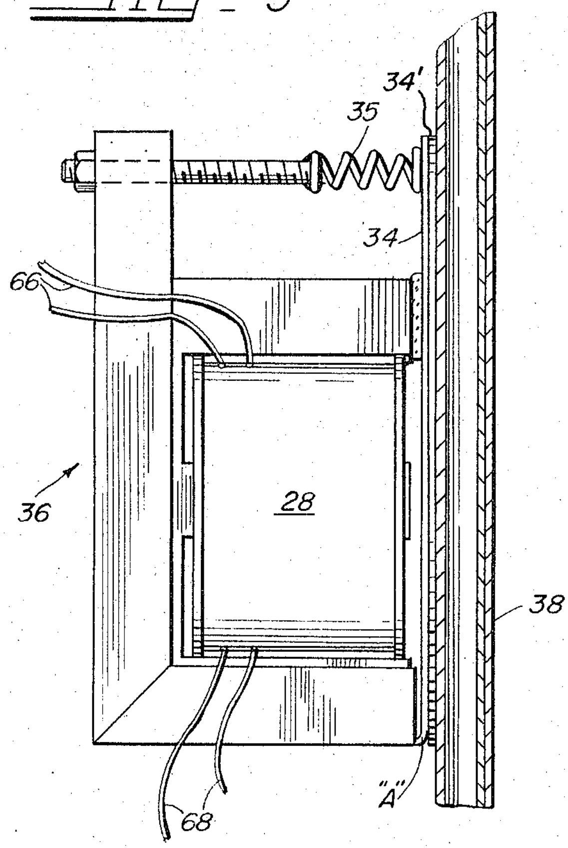


FIG. 6

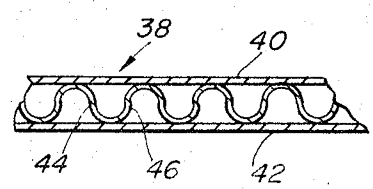
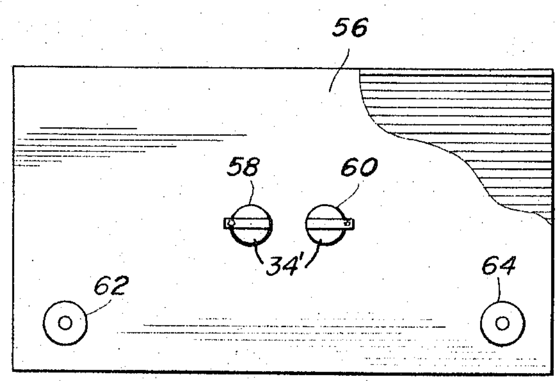


FIG. 7



INVENTOR.
WILLIAM J. ASHWORTH
BY

Attys.

United States Patent Office 3,366,748
Patented Jan. 30, 1968

3,366,748
LOUDSPEAKER DIAPHRAGM AND DRIVER
William J. Ashworth, New Albany, Miss., assignor to Artnell Company, Chicago, Ill., a corporation of Delaware
Filed Sept. 22, 1964, Ser. No. 398,270
6 Claims. (Cl. 179—109)

ABSTRACT OF THE DISCLOSURE

A transducer for converting electrical impulses into sound wherein the diaphragm is a flat corrugated paperboard panel onto which the armature of an electromagnetic driver is bonded in face to face relation and a second driver, for performing a tweeter function, such as a piezoelectric crystal, is also attached to the panel and connected to the output of an audio amplifier in parallel relation with the electromagnetic driver. A modification comprises a pair of electromagnetic drivers mounted back-to-back at the center of a corrugated board panel and connected with respectively different channels of a stereo audio amplifier.

Loudspeakers are generally separated into two broad types that are distinguishable by the operation of their drivers. The type most commonly used is referred to as the dynamic type. The dynamic driver is powered by a movable coil around or surrounded by a permanent magnet with the coil solidly attached to the diaphragm of the loudspeaker. Thus when an electrical current is passed through the coil the forces acting between the current and the magnetic field of the magnet cause the coil to move, which, in turn, moves the diaphragm. The coil of a dynamic driver must be of small mass, so that it is highly reactive to the magnetic field. Therefore, it requires a high current and thus requires a step-down transformer. The natural feed back in such a transformer has the disadvantage in this instance of producing some distortion in the reproduction of sound. In manufacturing dynamic speakers close tolerances are required which increase their cost. But dynamic type speakers have gained wide usage because of their ability to produce frequency responses of substantially constant intensity throughout a broad range of the audible frequency wave spectrum.

The other common type of loudspeaker driver is the electromagnetic type in which the diaphragm is attached to an armature that is reactive to an electromagnet. The amount of current passing through the electromagnet determines its attraction for the armature and hence the impulses transmited to the diaphragm. Although the electromagnetic type of loudspeaker is less expensive to make because it does not require a step-down transformer or the close manufacturing tolerances of the dynamic type, it had a much narrower range of operation at a constant intensity and was therefore not used except in rare instances.

An improved electromagnetic driver capable of reproducing low frequency responses without requiring an excessive amount of driving power and equally capable of producing good higher frequency responses is disclosed in my copending patent application Ser. No. 377,941 filed June 25, 1964, now Patent No. 3,334,195. Along with being capable of producing sound over a broad range of frequencies at substantially constant intensity, the electromagnetic driver disclosed in my said application is comparatively inexpensive to construct without detracting from the quality of the sound reproduced.

The competition among loudspeaker manufacturers has made the cost of production and assembly a necessary consideration. Before the improved electromagnetic driver, a reduction in the cost of production could be made

only at a sacrifice to the quality of sound the loudspeaker would produce. The improved electromagnetic driver provided a loudspeaker driver that was less expensive to produce than the dynamic type driver but retained the high quality of sound reproduction. Since the disclosure of the improved electromagnetic driver, further testing and research has led to the development of improved loudspeaker systems that will even further decrease the expense of production of loudspeaker units while yet retaining and, in some instances, improving the quality of sound reproduction.

One of the larger expenses in producing a complete loudspeaker assembly is in providing a transducer system that is equally responsive with a constant intensity throughout the normal range of the audible frequencies. Ordinarily, this requires at least two separate drivers with their respective diaphragms. One driver and diaphragm is designed to provide constant intensity over a broad band of the lower frequency range such as from approximately 50 cycles per second to 2000 cycles per second. This speaker is commonly referred to as a "woofer." The other driver and diaphragm is designed to provide a constant intensity of sounds over a broad bank of higher frequencies starting at about 2000 cycles per second and continuing to operate at constant intensity up to approximately 8000 cycles per second. This speaker is commonly referred to as a "tweeter" and the combination of the "woofer" and "tweeter" provides a complete loudspeaker assembly. Upon reproduction of the sounds, through the two speakers, the effect is as if all the sounds were produced by a single speaker.

In the field of technology concerned with sound reproduction there are known crystals of certain minerals that have the characteristic of developing an electrical potential difference across their poles when any pressure is applied to them that deform them, with the strength of the potential difference being determined by the amount of deformation. Because of this characteristic they are often used to transduce the air pressure variations developed by sound waves, due to expansion and compression of the air, into electrical impulses. And conversely, if electrical impulses are delivered to the poles of such a crystal, the crystal will become proportionally deformed. Crystals exhibiting this phenomena are called piezoelectric crystals and are widely used in the field of sound reproduction.

The piezoelectric crystals can be made with various shapes and sizes to fit the demands of various purposes. They are light in weight and highly reactive, with an immediate response to any applied voltage. Thus, they are ideally suited to be used as a driver for the higher frequency or "tweeter" speaker. Also because they are relatively light weight, it is possible to attach them directly to the diaphragm of a "woofer" speaker without appreciably increasing the weight of the diaphragm or effecting its reaction to the impulses delivered to the diaphragm by the primary driver. With the construction of a "woofer" speaker with a piezoelectric crystal attached to its diaphragm, a simple, less expensive "tweeter" and "woofer" combination would be provided with both drivers pulsing a common diaphragm, thereby eliminating the expense of one diaphragm and the expense of a more complex tweeter driver, usually found in a complete loudspeaker assembly.

Thus it is an object of this invention to provide an inexpensive loudspeaker unit that will reproduce sound at a substantially constant intensity throughout the range of audible frequencies by attaching two drivers, having different ranges of sound reproduction, to a common diaphragm.

It is another object of this invention to provide a piezoelectric crystal and another driver, of either dynamic type or electromagnetic type, connected in parallel to the output an electrical signal amplifier, for actuating a common diaphragm.

Another element of expense in a loudspeaker unit is the fabrication of a suitable diaphragm to provide sound reproduction as free from distortion as possible. The diaphragm most commonly used is a conical-shaped structure of a special parchment that is light weight but relatively stiff and containing circumferential ribs providing a stepped contour, thereby acting like a bellows when the diaphragm is vibrated. Although this type of diaphragm has proved highly satisfactory it has been found, through experimentation, that a diaphragm of common corrugated paper-board and cardboard, of the type widely used in packaging, solidly attached to the armature of the improved electromagnetic driver, provides sound reproduction of equal quality at much less expense. It has also been found through experimentation that the piezoelectric crystal driver can be attached directly to a corrugated cardboard diaphragm and will reproduce the sounds of the higher frequency with equal quality of those produced when using the more expensive conventional parchment diaphragm.

It is thus another object of this invention to provide a simple, inexpensive, and easily fabricated loudspeaker having a diaphragm of common corrugated cardboard; and to provide such a speaker comprising a single corrugated paper-board panel for stereophonically producing the sound generated by two separate signal sources.

A still further object of this invention is to provide a complete, inexpensive, loudspeaker unit comprising a single diaphragm of corrugated cardboard, vibrated by a piezoelectrical crystal driver to reproduce the higher frequencies of the audible range and vibrated by an improved electromagnetic driver for the lower frequency sound reproduction.

Another object of the present invention is to provide two improved electromagnetic drivers and two piezoelectric crystal drivers electrically connected to provide two separate "tweeter" and "woofer" combinations attached to a single corrugated cardboard diaphragm, with each combination of drivers responsive to a different source of electrical impulses, to produce a stereophonic effect.

Further objects and advantages of the invention will become more obvious as reference is made to the following drawings and in which:

FIGURE 1 is an elevational schematic drawing of a common loudspeaker driver and conical diaphragm showing a piezoelectric crystal attached to the diaphragm for reproducing sounds in a higher range than that of the simple driver diaphragm assembly.

FIG. 2 is an enlarged perspective view of a piezoelectric crystal suitable for use in the combination of FIG. 1.

FIG. 3 is a circuit diagram showing the piezoelectric crystal connected to a signal source in parallel with an electromagnetic or dynamic driver.

FIG. 4 is an elevational rear view of an improved arrangement of electromagnetic and piezoelectric crystal driver means attached to a flat cardboard diaphragm.

FIG. 5 is an enlarged sectional view of the same as taken on line 5—5 of FIG. 4.

FIG. 6 is an enlarged fragmentary sectional view of the corrugated cardboard diaphgram taken along line 6—6 of FIG. 4.

FIG. 7 is an elevational rear view showing two piezoelectric crystals and two electromagnetic drivers attached to the back side of a single corrugated cardboard diaphragm and arranged for stereophonic sound reproduction.

Referring first to FIG. 1, a typical loudspeaker unit is shown that is intended to represent a speaker of any construction which includes a driver **10** of either a dynamic or electromagnetic type and a diaphgram **12** of any suitable construction and shape, the conventional conical type diaphgram being shown.

As shown, a piezoelectric crystal **14** is rigidly attached to the outer surface of the diaphgram **12** by a suitable bonding agent that cements them securely together in face to face engagement so that deformation or vibration of the crystal **14**, when an electric impulse is applied to its poles, will be transmitted directly to the diaphragm **12** causing the diaphragm to vibrate accordingly. The axis of the crystal **14** is oriented on the diaphragm **12** so that the impulses produced by the crystal **14** have the greatest component of their force in a direction parallel to the force of the dynamic or electromagnetic driver **10**.

The piezoelectric crystal unit, as seen in FIG. 2 is a conventional construction comprised of two plates **16** and **18** of Rochelle salt bonded together in a face to face relationship to provide a unitary rectangular construction approximately ⅝-inch in width, 1⅝ inches in length and ¹⁄₁₆-inch in thickness.

In bonding the two plates **16** and **18** together the axes of the plate cuts are offset. Thus as a voltage is applied to the electrode leads **20** and **22** of the plates **16** and **18** each plate deforms in a different direction, the difference depending upon the orientation of the plate axes, and a twisting or bending action of the entire unit or combination results. Whether the crystal unit **14** twists or bends is predetermined by the orientation of the axis of the respective plates **16** and **18** but when the crystal unit **14** is used as a speaker driver it is preferred that the electrical impulses cause the crystal **14** to twist and thereby eliminate the reactive force, which the crystal has too small inertia to absorb and which accompanies the direct impulsive force.

The magnitude of the twist of the crystal **14** is directly proportional to the amount of voltage applied to the electrodes of the plates **16** and **18**. Thus the more voltage applied through the leads **20** and **22**, the greater the entire crystal **14** will twist, which in turn creates a greater impulse to the diaphragm **12** and thereby determines the volume of the sound produced. Therefore, the volume of the sound can be controlled by controlling the voltage of the electrical impulses applied to the leads **20** and **22** of the plates **16** and **18**.

Referring to FIG. 3, the last stage of the amplifying and sound reproduction circuit is shown as it is connected to the drivers of a loudspeaker assembly comprising a "woofer" and a "tweeter," the "tweeter" being the piezoelectric crystal **14**. As shown, a variable resistor or potentiometer **26** is connected across the leads **20** and **22** of the crystal **14** and the crystal **14** is connected in parallel with a coil **28**, between the output stage of the amplifier **24** and B+. As before mentioned, the coil **28** can be either the primary winding of a step down transformer to power a dynamic driver or the winding of an electromagnet in the electromagnetic driver. A capacitor **30** is inserted between the power lead **32**, coming from the amplifier **24**, and the crystal **14** to block the passage of the constant voltage direct current from the amplifier to the crystal **14** thereby assuring an unstressed position of zero potential from which the crystal **14** is pulsed.

This circuit provides power to the drivers of the speakers in the following manner: The output tube of the amplifier **24** is a source of constant direct current that is controlled by an intermittent higher voltage applied to the grid of the output tube **24**. The constant current flows through the power line **32** and into the coil **28**. If the coil **28** is the primary coil of a transformer the constant current will not energize the secondary winding, thus a dynamic type driver would not be actuated. But if the coil **28** is a coil on an electromagnet, such as is herein shown on the driver **36**, the armature **34** of the electromagnetic driver **36** is attracted against a spring **35** that can be adjusted to provide the desired zero output position. (See FIG. 5.)

The intermittent voltage applied to the amplifier grid causes a pulsating current above the constant current to flow through the power lead 32. This pulsating current causes a pulsating magnetic attraction between an electromagnet and its armature or can be transferred through a transformer to pulse a dynamic type driver if such is used. In either case the driver is reactive to the pulses of the output tube 24. Also, the increased current of the pulse breaks down the capacitor 30 and allows current to pass to the crystal 14 thereby producing corresponding pulsation of the crystal driver 14.

Referring now to FIGS. 4 and 5 a loudspeaker unit is shown comprising an electromagnetic driver 36 and a flat corrugated paper-board or cardboard diaphragm 38. The corrugated board for the diaphragm 38 as seen in FIG. 6 is the common type of corrugated board having two outer or cover sheets 40 and 42 rigidly held in a spatial relationship by an inner sheet 44 having a corrugated or wavy contour providing ribs or flutes 46 with the outer sheets 40 and 42 adhere to the crests and bases of the flutes 46. A corrugated cardboard that has proved to be highly satisfactory as a diaphragm was fabricated from 38-pound kraft paper for the outer sheets 40 and 42 and 26-pound kraft medium paper for the inner sheet 44. This corrugated board was 3/16 inch thick, contained 36 flutes per foot of width, and is classified as "175 pound test."

Again referring to FIGS. 4 and 5 the electromagnetic driver 36 is shown mounted on the cardboard diaphragm 38, just described, with the flutes 46 extending vertically the height of the diaphragm 38 and the armature 34 of the driver 36 extending parallel with the flutes. The flutes 46 in combination with the cover sheets 40 and 42 increase both the beam strength and the column strength of the diaphragm without appreciably increasing the weight. The beam strength is increased more in the longitudinal direction than in the transverse direction of the flutes so that the greatest resistance to bending is around a transverse line perpendicular to the flutes 36 and lying within either of the outer sheets 40 and 42. Thus it would require more force to bend the diaphragm 38 across the flutes 46 than it would to bend it parallel with them although the flutes 46 with the cover sheets do provide increased strength in this direction also. The greatest column strength is the direction parallel with the flutes 46.

At this point it should be understood that the electromagnetic driver 36 is of a construction such as is described in my beforementioned Patent 3,334,195 wherein the armature 34 comprises an integral flat plate 34 prime of any convenient shape, preferably circular, and the driver 36 is mounted to the diaphragm solely by means of the plate 34 which has its outer face surface bonded to the surface of the diaphragm by cementing.

The weight of the electromagnetic driver 36 as attached to the diaphragm 38 has a vertical component and a bending moment that must be supported by the diaphragm 38. The driver is thus mounted on the diaphragm 38 so the bending moment is around a transverse line perpendicular to the flutes 46 and the vertical component is parallel with the direction of the flutes 46 and, therefore, both components of the weight of the speaker are supported by the directional rigidity provided by the central corrugated core 44.

Extensive testing has shown that the strength of the corrugated cardboard diaphragm 38 above described is more than sufficient to support the weight of an electromagnetic driver embodying a one-half inch laminated iron E type frame having a 5000 turn primary winding without causing the diaphragm to bend or buckle. Diaphragms of various rectangular and oblong shapes, some 12 x 18 inches and larger in size, have been successfully employed in this manner, the shapes being oblong in that they are longer than they are wide.

The electromagnetic driver 36 is generally oriented on the diaphragm so that its armature hinge A is transversely perpendicular to the flutes 46 and thus the impulses delivered by the driver 36 to the diaphragm 38 vibrate the diaphragm 38 mainly in the longitudinal direction. The rigidity of the diaphragm 38 provided by the greater beam strength of this direction eliminates any whipping motion of the diaphragm 38 as it vibrates and the presence of the frame 48 in which the diaphragm is peripherally supported, obviates any marginal flutter or chatter.

Along with the orientation of the electromagnetic driver 36 with respect to the direction of the flutes 46, the placement of the driver 36 on the diaphragm 38 with respect to the dimensions of the diaphragm is also important to produce the best distortion-free response. It has been found through experimentation that least dissonance is produced by the diaphragm 38 when the driver is mounted centrally in the lateral dimension and its vertical position is approximately 1/3 of the diaphragm length from the bottom edge as shown in FIG. 4. This position is found by having the diaphragm 38 reproduce a combination of two notes that have a wavelength differential ratio of two to three and the driver is moved around on the diaphragm 38 to the point where the least dissonance is emitted by the diaphragm in reproducing this combination.

The method just referred to is similar to the method of tuning musical instruments whereby two notes having a wavelength differential of two to three, which is called the perfect fifth interval, are produced simultaneously and the instrument is manually adjusted by a person trained in this field so that this combination of notes creates the least dissonance. Thus, the speaker unit is tuned to the same combination creating the least dissonance that is actually produced by the instrument itself, or combination of instruments, when other notes than the ones for which the instruments are tuned are combined. The phenomenon that the least dissonance is produced when combining two notes having a wavelength differential of two to three explains the phenomenon that the least dissonance is reproduced by the diaphragm when the driver is placed in a position substantially 2/3 of the height down from the top.

Another speaker assembly is shown in FIG. 7 and provides a means whereby a single cardboard diaphragm 56, of the type previously described, is used with a combination of electromagnetic drivers 58 and 60 and dynamic type "tweeters" 62 and 64 to reproduce sounds stereophonically.

The electromagnetic drivers 58 and 60 which here function as "woofers" are centrally mounted on one face of the diaphragm 56 in a coplanar back to back relationship and with the armature hinge axes approximately one inch apart so that each driver 58 and 60 produces vibrations in its respective half of the diaphragm 56 with any interfering vibrations of the two halves damping each other in the space separating the electromagnetic drivers. The flutes 46 of the diaphragm 56 extend horizontally or in the long direction of the diaphragm so that the armature hinges axes of the electromagnetic drivers are perpendicular to them for the same reasons as previously explained. The "tweeters" 62 and 64 are each mounted toward a respective end of the diaphragm 56 preferably opening to the face of the diaphragm at corner portions thereof since they function independently of the diaphragm. In such a system each dynamic "tweeter" is preferably driven from a secondary winding on the electromagnetic respective "woofer," as indicated in FIG. 5 wherein the leads 66 are from the primary winding and the leads 68 are from the secondary.

It will be understood that in the "stereo" system shown in FIG. 7, each combination of "tweeter" and "woofer" will be connected to a separate source of electrical impulses so that each half of the diaphragm 56 is driven independently of the other to produce different sounds without any interference from the other. In this manner the one combination of electromagnetic driver 58 and "tweeter" 62 will produce sounds independent of the other combination of drivers 60 and 64 and two independent loudspeaker systems can be operated to drive a single diaphragm.

The loudspeaker combination shown in FIG. 4 includes a "tweeter" crystal **14**, which is cemented face-to-face against the back side of the corrugated board diaphragm in the area thereof between the electromagnetic driver **36** and one margin of the diaphragm. The precise location of the crystal "tweeter" is not believed to be critical since only a relatively small portion of the diaphragm is effected by the crystal and its operation to reproduce the higher sound frequencies is independent of the operation of the diaphragm as a whole under the influence of the electromagnetic driver, or "woofer," **36**. In this case, of course, the electrical connection to the amplifier **24** will be as shown in FIG. 3 and the secondary winding may be omitted or tapered-off.

The main advantages of the present invention reside in the reduced cost of a loudspeaker construction by employing the improved, low cost electromagnetic driver previously disclosed in conjunction with a low cost diaphragm constructed of ordinary corrugated cardboard. Another cost saving advantage is achieved through the use of a piezoelectric crystal as a driver for the higher audible frequency range thereby eliminating the need for a more complex and expensive dynamic driver; and also by eliminating the expense of a second diaphragm since a crystal driver can be attached directly to the diaphragm used with a dynamic or electromagnetic driver for simultaneously producing the higher frequency sounds.

The combination of a tweeter, electromagnetic driver, and cardboard diaphragm not only lends itself to other various cost saving arrangements, as in providing a speaker unit for reproducing sound stereophonically from one diaphragm, but also this invention considerably extends the range of sound reproducing system designers by eliminating the need for accommodating the separate speaker elements heretofore required.

Although several embodiments of this invention have been herein shown and described it will be understood that details of the structures shown may be altered or omitted without departing from the spirit of the invention as defined by the following claims.

I claim:

1. A transducer for converting electrical impulses into sound comprising,

(a) a diaphragm for imparting sound producing impulses to the ambient air and consisting of a generally oblong panel of corrugated paper board,

(b) means for delivering audio frequency impulses to said diaphragm including an electromagnetic driver means and a crystal driver attached to said diaphragm in face to face relation therewith,

(1) said electromagnetic driver means having a flat plate armature attached to the said panel in face to face relation therewith and oriented to vibrate about an axis extending parallel with the surface of the said board and normal to the corrugations thereof,

(2) said crystal driver comprising two piezoelectric crystals of predetermined size, bonded together in a face to face relationship with the axes of said piezoelectric crystals biased with respect to each other, and

(c) means for electrically actuating said electromagnetic driver and charging the poles of said piezoelectric crystals in accordance with the varying frequency of the output of an audio frequency amplifier.

2. A transducer for converting electrical impulses into sound comprising,

(a) a diaphragm for delivering sound producing impulses to the ambient air,

(1) said diaphragm comprising a sheet of corrugated paperboard, and

(b) means for delivering high frequency and low frequency impulses to said diaphragm including a magnetically actuated driver having an armature comprising a flat plate and a piezoelectric crystal each bonded to said diaphragm in face to face relation therewith and electrically connected to a source of audio frequency electrical impulses, the armature of said magnetically actuated driver being oriented to vibrate about an axis extending parallel with the surface of said paper board sheet and normal to the corrugation thereof.

3. A transducer for converting electrical impulses into sound comprising,

(a) a diaphragm for delivering sound producing impulses to the ambient air,

(1) said diaphragm comprising a sheet of corrugated board, and

(b) means for imparting audio frequency vibrations to said diaphragm including a plurality of electromagnetic drivers and a plurality of crystal drivers,

(c) said drivers being attached to said diaphragm in a paired relationship of an electromagnetic driver and a crystal driver such that each such pair of drivers will deliver impulses to a predetermined different portion of said diaphragm,

(d) each electromagnetic driver and crystal driver pair being electrically connected to the output of a different channel of a stereo audio frequency amplifier.

4. A loudspeaker comprising

(a) a panel of corrugated board,

(b) an electromagnetic driver having an operating coil and a vibratory armature comprising a flat plate mounted for actuation by said coil in response to a varying electromotive force therein,

(1) said armature plate being bonded to said panel in face to face relation therewith and disposed for oscillation about a fixed axis lying parallel with the adjacent face of the panel and transverse the panel corrugations, and

(c) means for connecting said operating coil with the output current of an amplifier of varying audio frequency electrical signals.

5. A loudspeaker according to claim 4 wherein the panel is of oblong form and a second electromagnetic driver is mounted on said panel adjacent the first mentioned driver, said drivers being disposed adjacent the center of the panel with the armatures thereof in end to end relation extending oppositely from adjacently disposed oscillation axes, and the respective operating coils of said drivers are adapted for connection with respective channels of amplified audio frequency electrical signals.

6. A loudspeaker comprising,

(a) a flat oblong panel of corrugated board having its corrugations extending in the longitudinal direction,

(b) a pair of electromagnetic drivers each having an operating coil and an armature extending transversely of the coil axis,

(1) each armature being bonded to one face of the panel adjacent the center thereof,

(2) each armature being hingedly attached to the respective driver for vibratory oscillation about an axis lying parallel with the plane of the panel and transverse the corrugations thereof, and

(3) the oscillation axes of said armatures being disposed adjacent the center of the panel with the armatures extending oppositely therefrom in the longitudinal direction of the panel, and

(c) means for connecting each of the driver operating coils with a respective source of amplified audio frequency electrical signals.

(References on following page)

References Cited

UNITED STATES PATENTS

1,620,367	3/1927	Lion	181—32
1,666,198	4/1928	Dressel	179—115
1,679,194	7/1928	Widmann	179—115
1,828,513	10/1931	Smythe	181—32
2,078,385	4/1937	Kato	179—115
2,453,521	11/1948	Marquis	179—109
2,640,889	6/1953	Cherry	179—110
2,912,605	11/1959	Tibbetts	310—9.1
3,062,926	11/1962	Roncii	179—115

WILLIAM C. COOPER, *Primary Examiner.*

KATHLEEN H. CLAFFY, *Examiner.*

A. A. McGILL, *Assistant Examiner.*