April 13, 1965 W. J. ASHWORTH 3,178,512

ELECTRICAL SOUND REPRODUCING DEVICE

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FIG 2

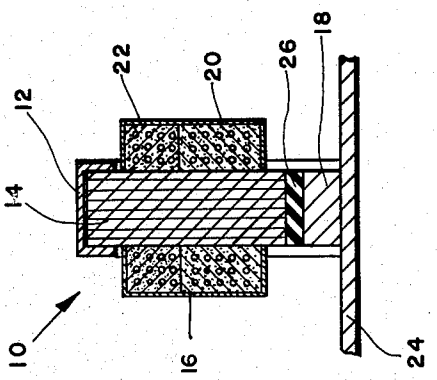


FIG 1

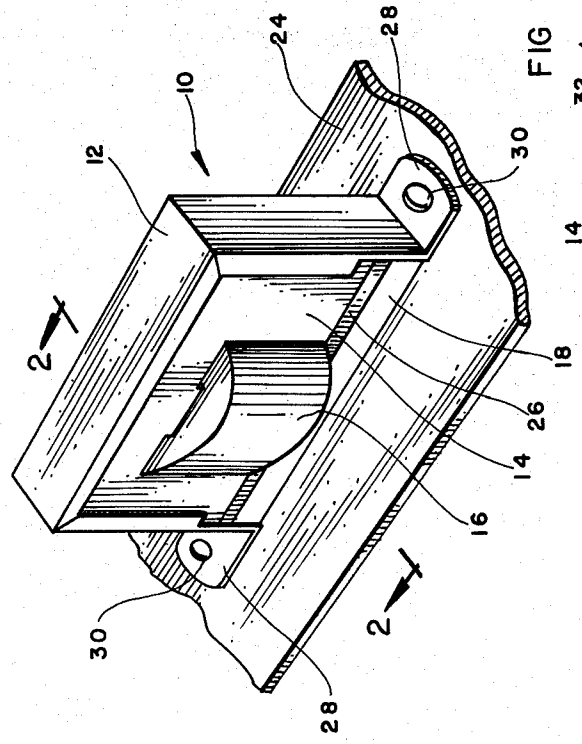
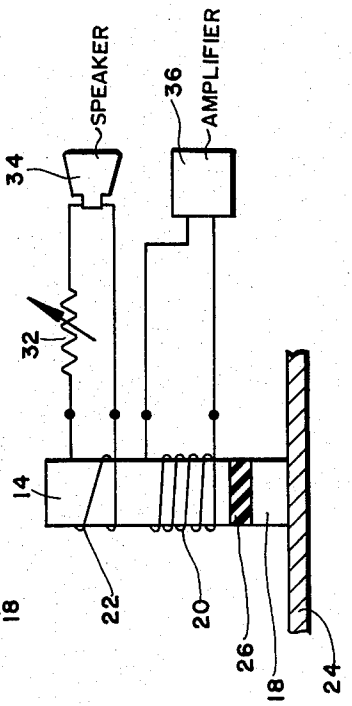


FIG 3



INVENTOR.
WILLIAM J. ASHWORTH
BY
Rummler & Snow

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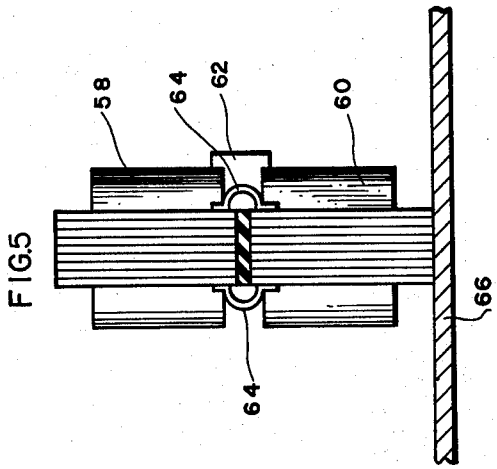

FIG.5

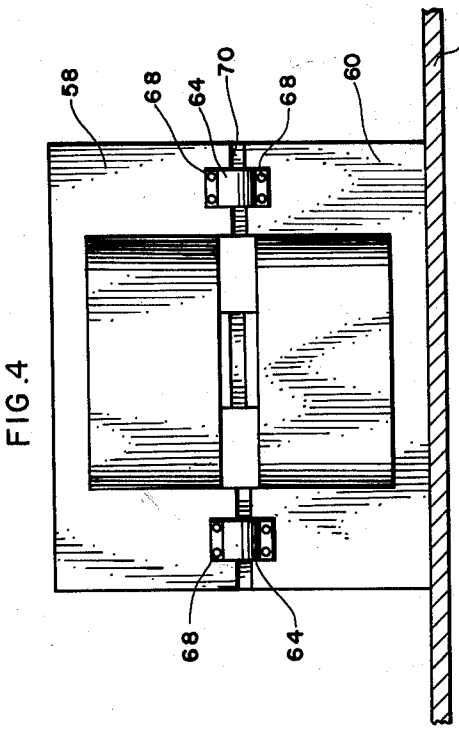

FIG.4

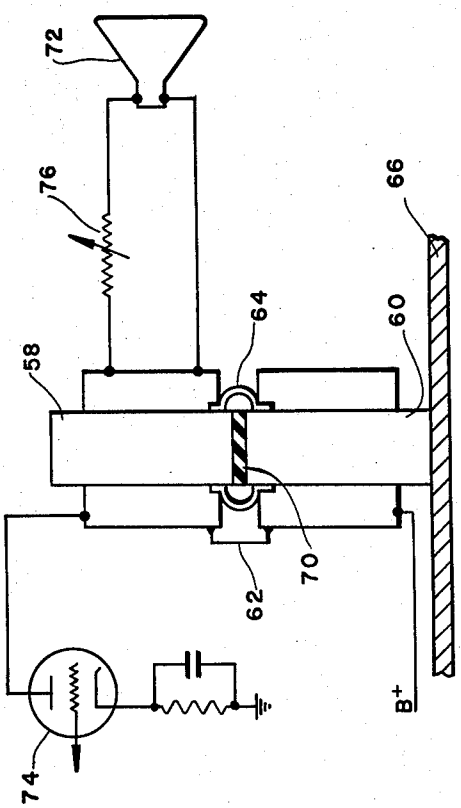

FIG.6

INVENTOR.
WILLIAM J. ASHWORTH
BY
Rummler & Snow

April 13, 1965 W. J. ASHWORTH 3,178,512

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FIG. 8

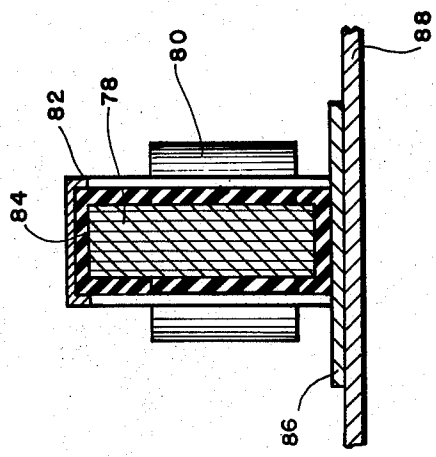
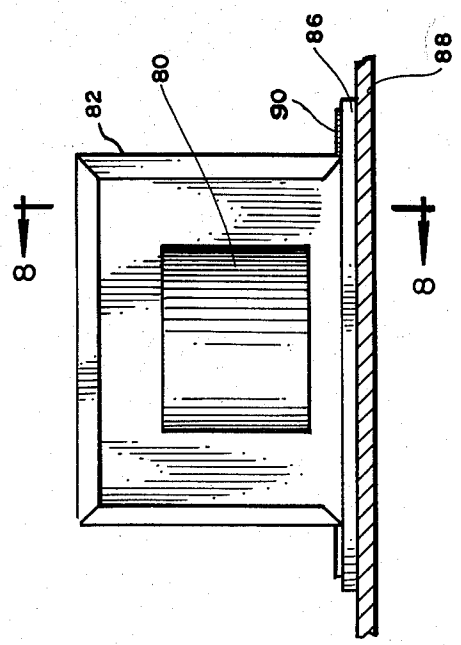


FIG. 7



INVENTOR.
WILLIAM J. ASHWORTH
BY Rummler & Snow

United States Patent Office 3,178,512 Patented Apr. 13, 1965

3,178,512

ELECTRICAL SOUND REPRODUCING DEVICE

William J. Ashworth, New Albany, Miss., assignor to Artnell Company, Chicago, Ill., a corporation of Delaware

Filed Aug. 23, 1962, Ser. No. 218,914
8 Claims. (Cl. 179—1)

This invention relates in general to electrical sound reproducing devices and in particular to a signal responsive actuating unit for the reproduction of the base tones in electrical sound reproducing equipment.

This application is a continuation-in-part of my application Serial No. 97,551, filed March 22, 1961, for Electrical Sound Reproducing Device, now abandoned.

Considerable work has been accomplished over a long period of time in an endeavor to develop an efficient and economical electrical sound reproducing system for such items as radios, phonographs, television sets, speaker systems, etc. Many combinations and arrangements of speakers, as well as speaker construction, have been utilized in an endeavor to obtain a desired rich sound or true tone pality. As tone quality improved, the manufacturing cost per unit increased since it became necessary to utilize a greater number of complex and precision component parts to attain this improved quality.

To derive an acceptable quality tone economically, several attempts have been made to build a transducer with an efficiency high enough to produce vibrations of sufficient intensity to actuate a sounding board when driven by a low power electrical signal. Generally, these prior transducers did not produce sufficient drive to actuate a sounding board at such a low power signal.

It is therefore, the primary object of this invention to provide an improved electrical sound reproducing device whereby a wall of an enclosure such as a radio, phonograph, TV, etc., can be vibrated efficiently to emit audible sound waves, such as music or speech, in proportion to the electrical signal transmitted to the device.

A specific object of this invention is to provide an improved electrical sound reproducing device for actuating a sounding board at sound levels within the range of a human ear by means of a substantially low power electrical signal.

Another object of this invention is to provide an improved electrical sound reproducing device that utilizes a standard output transformer, normally used to connect the output stage of an audio amplifier to a loud speaker, for driving an armature by means of the primary coil to reproduce base tones in a sounding board and which employs the secondary coil of the transformer to drive a conventional dynamic speaker for reproducting treble tones.

A further object of this invention is to provide an improved sound reproducing device which serves both as an output transformer and as a transducer to couple separate means for reproducing the base and treble tones.

Another object of this invention is to provide an improved sound reproducing device which directly reproduces the lower or base frequency range of rounds while simultaneously driving a conventional loud speaker to reproduce sounds in the upper frequency range.

A still further object of this invention is to provide an improved sound reproducing device which eliminates a speaker normally required for audible reproduction of the lower sound frequency range by utilizing a portion of the

enclosure in which the device is mounted as a sounding board.

Other objects of the invention will appear from the following description taken in connection with the accompanying drawings showing specific embodiments of my invention and in which:

FIGURE 1 is a fragmentary perspective view in front elevation of one form of the sound reproducing device of this invention;

FIG. 2 is a cross-sectional view of the device of this invention shown in FIG. 1 as taken along the line 2—2 of FIG. 1;

FIG. 3 is a pictorial schematic illustrating the electrical connection to the device of this invention;

FIG. 4 is a view in side elevation illustrating still another embodiment of this invention;

FIG. 5 is an end view of the embodiment shown in FIG. 4;

FIG. 6 is a schematic illustrating the electrical connection to the embodiment of this invention as shown in FIGS. 4 and 5;

FIG. 7 is a view in side elevation of the preferred embodiment of this invention; and

FIG. 8 is a sectional view of the same as taken along the line 8—8 in FIG. 7.

By way of generalization, for a better understanding of the detailed description of the various embodiments of the invention to follow, the device is primarily characterized by the unique mounting and structural arrangements of an ordinary audio amplifier output transformer to provide an armature for attachment to a sounding board so as to produce audible sounds in the low and middle tone ranges proportional to the electrical signal normally transmitted to the transformer. Another salient feature of the device of this invention lies in the connection of a speaker to the secondary winding of the transformer with the device being driven through the primary windings from an ordinary audio output amplifier, thus utilizing the output transformer of the amplifier as an electro-mechanical transducer actuated by a lower power electrical signal to reproduce the base tones, and as the power source for a conventional speaker for reproducing the treble tones.

Referring now to the drawings and more specifically to FIGS. 1, 2 and 3, and embodiment of the sound reproducing device of this invention, indicated generally by the numeral 10, is illustrated and provides four main sections; a housing 12, a core 14, a coil 16 and an armature 18.

The entire construction is substantially formed from a standard output transformer generally used for connecting the output stage of an audio amplifier to a loud speaker, the armature 18 replacing the usual transformer "I" or yoke bar. As best seen in FIG. 2, a standard E-shaped laminated iron transformer core 14 has a coil 16 wound around the center pole, the coil 16 comprising two separate sections providing a primary high impedance winding 20 and a secondary low impedance winding 22.

The armature 18 is formed from a rigid magnetic material and may have a rectangular configuration of substantially the same width as the end surface of the core 14. The armature is fixedly secured, by any suitable means, to a plate or panel 24 which functions as a sounding board. Panel 24 may be the side wall of a radio, phonograph, TV set or a portion of the enclosure in which the sound reproducing device is to be mounted.

A thin strip of elastic material 26, such as rubber, is disposed on the upper surface of the armature 18 to serve

as a spacer element between the armature and the poles of the core **14**, eliminating the possibility of metal to metal contact as will be readily understood as the description continues.

The core **14**, having the coil **16** positioned about the center pole of the core, is positioned above the armature **18** with the ends of the poles facing the armature and seating on the elastic spacer member **26**. To maintain the core **14** in alignment and positioned over the armature **18**, the frame **12** is provided about the edges of the core. As best seen in FIG. 2, the frame **12** provides a partial enclosure, but may be of any suitable configuration or arrangement, to functionally retain the core in juxtaposition with the armature. Frame **12** provides extending bracket members **28** adjacent the lower edge thereof through which screw members **30** may pass for securing the device to the panel **24**.

Referring now briefly to FIG. 3, the sound reproducing device **10**, as just described, has a variable resistor **32** connected in series with the secondary windings **22** and a voice coil of a conventional loud speaker as indicated by the numeral **34**. The primary windings are connected to an audio amplifier **36** from which the driving power is transmitted.

With the sound reproducing device **10** properly mounted against a cabinet side wall or on a panel **24**, an electrical signal of varying intensity may be passed through the coil **16**. As the signal is transmitted through the coil **16**, a magnetic field is set up about the core **14** which will tend to cause relative movement between the armature and the core and subsequently cause the assembly to vibrate in direct relation to the varying intensity of the electrical signal fed to the coil **16**.

It is readily understood that with the high intensity of the magnetic field and the weight and spaced relation of the armature and the core, the panel **24** will be vibrated with such intensity that sounds will be emitted with substantially the same intensity as normally emitted from a conventional loud speaker when utilizing a greater amount of driving power. The elastic member **26**, disposed between the armature and the ends of the poles of the core **14**, serves as a cushion to prevent metal to metal contact as the assembly vibrates during operation.

The sound reproducing device **10** will reproduce audible frequencies up to about the mid range frequency of the human ear which substantially covers all of the base tones. By combining the device **10** with the speaker **34**, which is intended for the high or treble tones above 3,000 cycles, the entire frequency range of the human ear may be covered.

By regulation of the variable resistor **32**, the higher tones from the speaker may be increased or decreased in volume or amplitude in relation to the base tones produced by the device of this invention.

Referring now to FIGS. 4, 5 and 6, another alternate embodiment of the sound reproducing device of this invention is illustrated and as readily seen in FIG. 6, the device is driven from a power signal through a primary coil with a speaker or tweeter connected to a secondary winding in substantially the same manner as previously described for the other embodiments.

This embodiment utilizes two transformer E frames, **58** and **60**, each of which has a primary winding and at least one of which has a secondary winding. Transformer frame **58** is positioned directly above the transformer frame **60** with the poles and primary coil of frame **60** being reverse to the poles and coils in frame **58** whereby poles of unlike polarity will be adjacent to one another when the primary coils are energized. The two primary coils are electrically connected by a line **62** which joins the two coils serially in opposed relation with each other.

A pair of resiliently flexible clips **64** are mounted on each side of the two legs or lateral pole pieces to maintain the transformer frame **58** in juxtaposition over the

frame **60**. Each clip has a leg secured to the respective upper and lower poles by any suitable means such as the screws **68**.

A resilient spacer member **70** is disposed between the ends of the opposing poles of the two transformer frames to eliminate metal to metal contact between the two units and at the same time adding resiliency during operation to increase the force transmission between the two frames and thereby afford a greater vibration amplitude on a sounding board or panel.

This embodiment of the device may be readily preassembled, requiring only subsequent positive securement of the lower transformer frame **60** to a sounding board or panel **66**, the frame **60** thus functioning as the armature for the driver **58**. A speaker **72** is connected to the secondary winding of the upper transformer **58** with the primary coil or winding connected to the output of an amplifier **74**. Speaker **72**, as previously described for the other embodiments, functions for the higher frequency tones only and is controlled by a variable resistor **76** connected in series with the speaker **72**. The primary coil of the lower frame **60** is also connected directly to a B+ supply.

In operation, the upper transformer **58** will be vibrated against the lower transformer **60**, as the varying current passes through the two primary coils, with a force sufficient to be transmitted to the sounding board or panel **66**, thus amplifying audible tones of lower frequency in proportion to the signal supplied to the two primary coils.

If a single ended tube is to be used in conjunction with the device, sufficient current will pass through, even though there is no signal, to provide a constant magnetic field in both the transformers **58** and **60** to pull them together. The A.C. signal adds and subtracts from the constant magnetic field to eliminate second harmonics and improve the ultimate results.

If the device is to be used in conjunction with a push-pull circuit, a third coil or winding should be added to each of the transformers and connected in series to the B+ supply to produce a constant magnetic field or, if desired, suitably placed permanent magnet laminations may be used to provide the desired constant magnetic field, thus eliminating the necessity of a third coil.

Turning now to FIGS. 7 and 8, the preferred embodiment of this invention is illustrated, the coils being adapted for electrical connection to a reproducing unit in the same manner as that shown in FIG. 3. This embodiment also utilizes a conventional E-shaped transformer core **78** having a coil **80** made up of a secondary and a primary winding mounted on the center pole. As shown, the transformer is encompassed by a yoke **82** which serves as a guide, as will be readily understood as the description continues, and may be of any suitable configuration, such as the thin peripherial frame shown in the drawings.

As best seen in FIG. 8, a resilient member **84** is disposed completely about the transformer between the yoke **82** and the core **78** in sandwich relationship. The resilient member **84**, formed from any suitable flexible material, maintains the transformer frame in spaced apart relationship from the yoke **82** and permits movement of the frame relative to the yoke and the armature **86** to produce vibration that is transmitted to a sounding board **88** in direct relation with the varying signal passing through the primary winding of the coil **80**.

The yoke **82** is firmly fastened to the base plate or armature **86** which is in turn rigidly secured to the sounding board or panel **88**. The armature **86** is preferably of a mass that will not saturate magnetically. In any case, the optimum mass of the material in the armature should be approximately the mass of the "I" or flux path bridge bar that would normally be present in the conventional output transformer designed for the amplifier driving the device of the present invention. The armature may be secured to the sounding board by any suitable means with the yoke **82** being provided with ears **90**

which may receive bolts (not shown) to secure the yoke to the armature **86**. As readily seen in FIG. 8, the resilient member **84** also extends between the poles of the core **78** and the armature **86**.

As previously mentioned, this preferred embodiment of the device is electrically connected to a reproducing unit in the manner shown in FIG. 3. The primary winding is connected to an audio amplifier output to receive a driving signal and the secondary winding is connected to and drives a tweeter and loads the primary winding to lower the frequency of the circuit and prevent high voltage discharge in or on the output tube of the amplifier. It being readily understood, the entire frame **78** vibrates and is resiliently spaced from and retained in position by the yoke **82** as the frame moves upwardly and downwardly in response to an electrical signal imposed upon the primary winding, the force of impact upon the armature **86** being transferred directly to the sounding board or panel **88**.

To those skilled in the art, it is readily understood that the device of this invention completely eliminates the necessity of a diaphragm for base tones and when connected with an ordinary tweeter, a complete range of tone reproduction is accomplished of quality normally experienced with expensive reproducing units using 12 to 15 inch speakers for the base tones.

The novel arrangement of the component parts plus the new use of the standard transformer that would normally be used in the audio amplifier, materially reduces the manufacturing cost of the sound unit and, with the device of this invention operating directly from the ordinary plate output of the common amplifier, produces excellent results without any increase of the power normally required for the operation of conventional speaker systems.

It will be readily understood that the device of this invention also may be utilized to a great advantage with units equipped with reverberating devices. Since the device of this invention reacts only to the lower frequencies and not through the higher frequencies, the device may be advantageously mounted in an area spaced from the speaker unit so that lower tones would be heard coming from a different place than the higher tones, thereby creating a sound similar to an echo.

It is to be understood that, although the invention has been illustrated and described with specific reference to various embodiments thereof, details of the constructions and arrangements shown may be altered or omitted without departing from the spirit of the invention as defined by the following claims.

What is claimed is:

1. A sound reproducing device comprising a sounding board, an armature fixed to said sounding board, electromagnetic means mounted in juxtaposition with said armature for reacting therewith in response to a variable electrical signal, and means supporting said electromagnetic means for vibratory movement relative to said armature, said electromagnetic means comprising the E frame of an audio amplifier output transformer having primary and secondary coils mounted on the center pole thereof, and said secondary coil being operatively connected with the voice coil of a dynamic speaker.

2. In combination with a sound reproducing system for converting electrical signals into audible sound, said system including an audio amplifier and a speaker, a sound reproducing device comprising a sounding board, an armature member secured to the sounding board, a transformer E frame including a coil having a primary winding and a secondary winding, means supporting and retaining the transformer frame in alignment with the armature and for relative movement of one with respect to the other, and resilient cushion means disposed between said armature and said transformer to prevent metal to metal contact between them and yet transmit force from one to the other proportional to the intensity of a variable electrical signal passing through the primary winding of said coil, said secondary winding being connected to the voice coil of said speaker, and said primary winding being connected directly to the output stage of said audio amplifier.

3. A sound reproducing system for converting electrical signals into audible sound comprising a sounding board, a first transformer frame having its back edge secured to the sounding board, a second transformer frame mounted on said first frame in an inverted spaced apart relation with the respective poles opposed and aligned with each other, resilient means connecting said frames together and holding them in spaced apart relation, said transformer frames having primary windings thereon electrically interconnected in opposing series with each other and in circuit with a signal source to effect relative reciprocal movement of the second transformer frame and said first transformer frame and to thereby vibrate the sounding board with a force proportional to the intensity of the signal transmitted from the signal source.

4. The sound reproducing system as defined in claim 3 wherein one of said transformer frames mounts a secondary winding for energization by the respective primary winding, and wherein a speaker is operatively connected with said secondary winding.

5. A sound reproducing system for converting electrical signals into audible sound comprising a sounding board, a first transformer E frame having its back edge rigidly secured to the sounding board, a second transformer E frame disposed in inverted pole to pole alignment with said first frame, a plurality of spring clips disposed and secured on both sides of the respective poles to secure said second transformer frame in magnetically operative spaced apart relation with said first transformer frame, said transformer frames each having a primary winding on its center pole and said windings being electrically interconnected in opposing series relation and to a signal source to effect reciprocal movement of the second transformer frame relative to said first transformer frame and thereby vibrate the sounding board with a force proportional to the intensity of the signal transmitted from the signal source.

6. A sound reproducing system for converting electrical signals into audible sound comprising a sounding board, a first transformer E frame including a primary winding on the center pole thereof, said first transformer frame having its back edge secured to the sounding board, a second transformer E frame including a primary winding on its center pole, means for securing said second frame in an inverted spaced apart pole to pole alignment with said first frame, resilient cushion means mounted between the opposing ends of said poles, said primary windings being electrically interconnected to one another in opposing series relation and to a signal source to effect magnetically a reciprocal movement of one transformer frame relative to the other to thereby vibrate the sounding board with a force proportional to the intensity of a signal transmitted from the signal source, a secondary winding on the center pole of one of said E frames, and a speaker operatively connected with said secondary winding for reproducing sounds in the range above that of the sounds produced by said sounding board.

7. An electrical sound reproducing system comprising an audio amplifier, an output transformer for said amplifier adapted to actuate a relatively movable armature member and having a primary winding operatively connected with the output stage of said amplifier, a sound board, means for attaching the armature member to the sound board, means for mounting said transformer in operative relation with said armature member, a secondary winding on said transformer, and a speaker operatively connected with said secondary winding.

8. An electrical sound reproducing system comprising an audio frequency amplifier, an output transformer for said amplifier comprising an E frame and an iron bar

disposed across the ends of the E frame legs, said bar being disposed for relative movement with respect to the transformer E frame, said transformer having primary and secondary windings, a sound board, means for attaching the bar of said transformer to said sound board, means for supporting said E frame in operative relation with the bar and for relative movement in a plane common therewith, means operatively connecting said primary winding with the output stage of said amplifier, and a speaker connected in driving relation with said secondary winding.

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ROBERT H. ROSE, *Primary Examiner.*