

Feb. 10, 1953

E. T. FLEWELLING

2,627,931

MEANS FOR IMPROVING FREQUENCY RESPONSE OF SOUND SYSTEMS

Filed Dec. 3, 1949

3 Sheets-Sheet 1

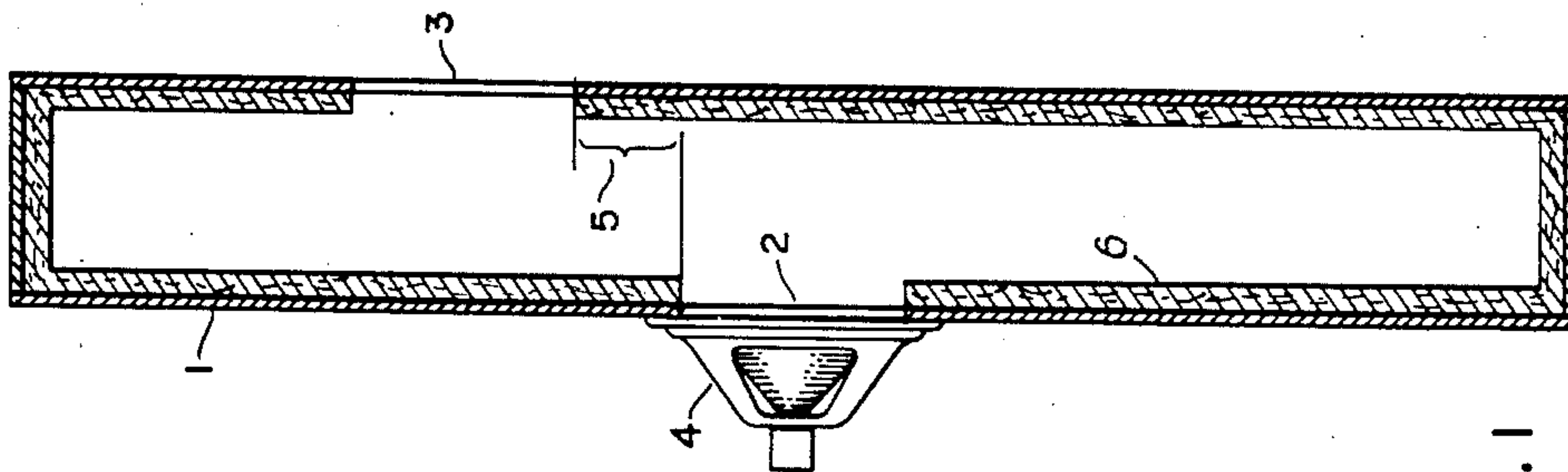


FIG. 1

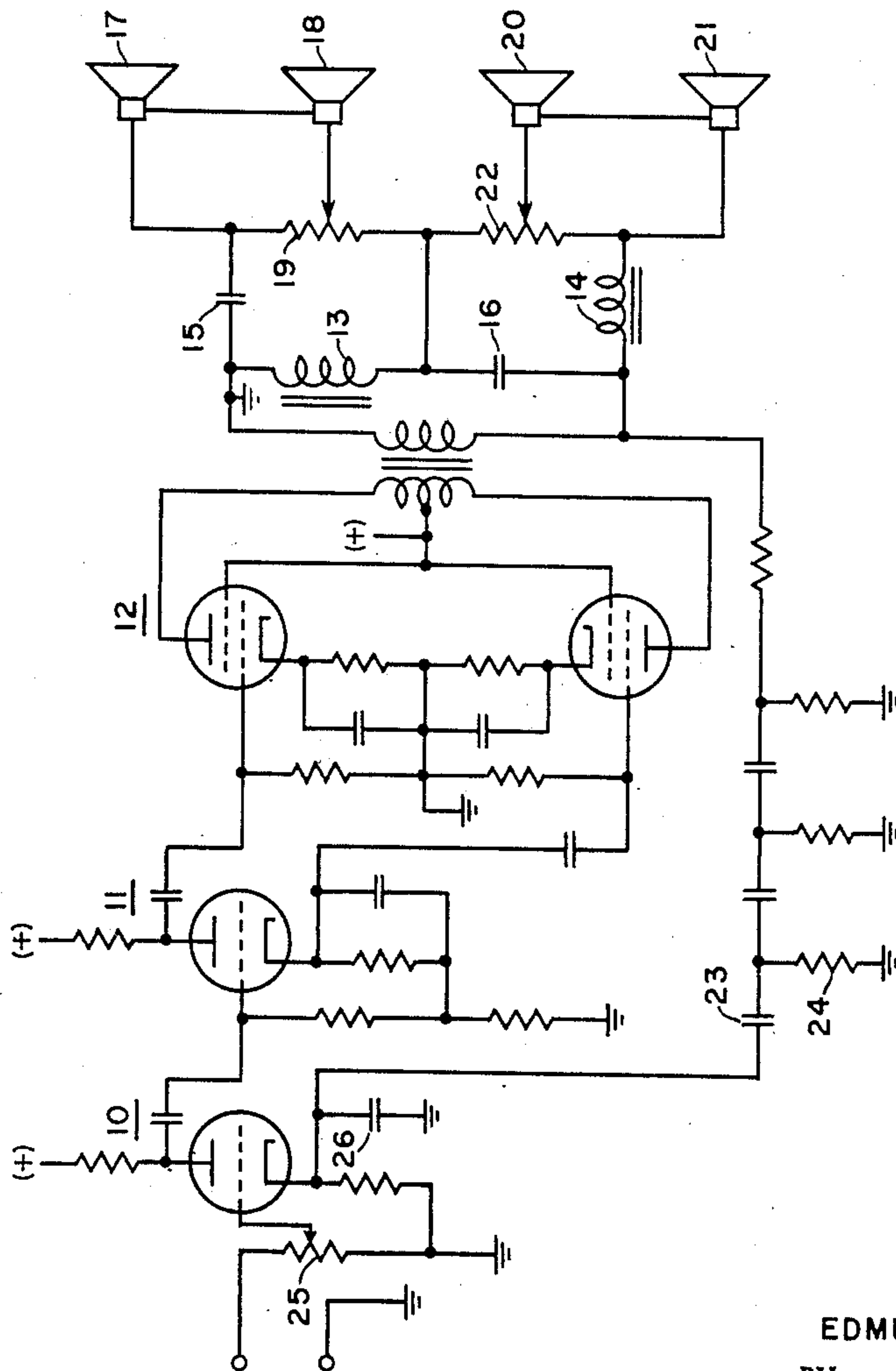


FIG. 2

INVENTOR.
EDMUND T. FLEWELLING
BY *J. L. Bowser*
ATTORNEY

Feb. 10, 1953

E. T. FLEWELLING

2,627,931

MEANS FOR IMPROVING FREQUENCY RESPONSE OF SOUND SYSTEMS

Filed Dec. 3, 1949

3 Sheets-Sheet 2

FIG. 3

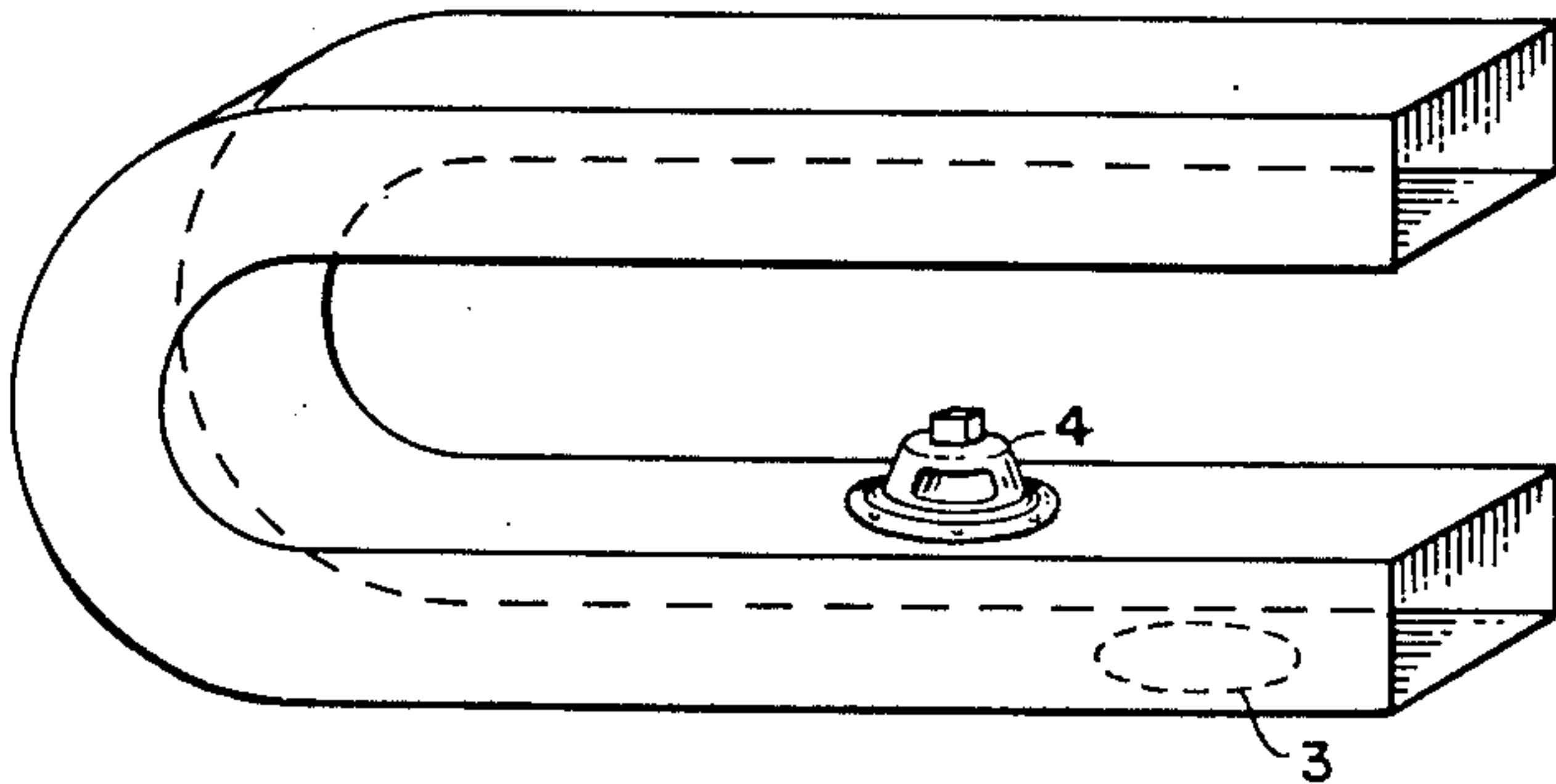
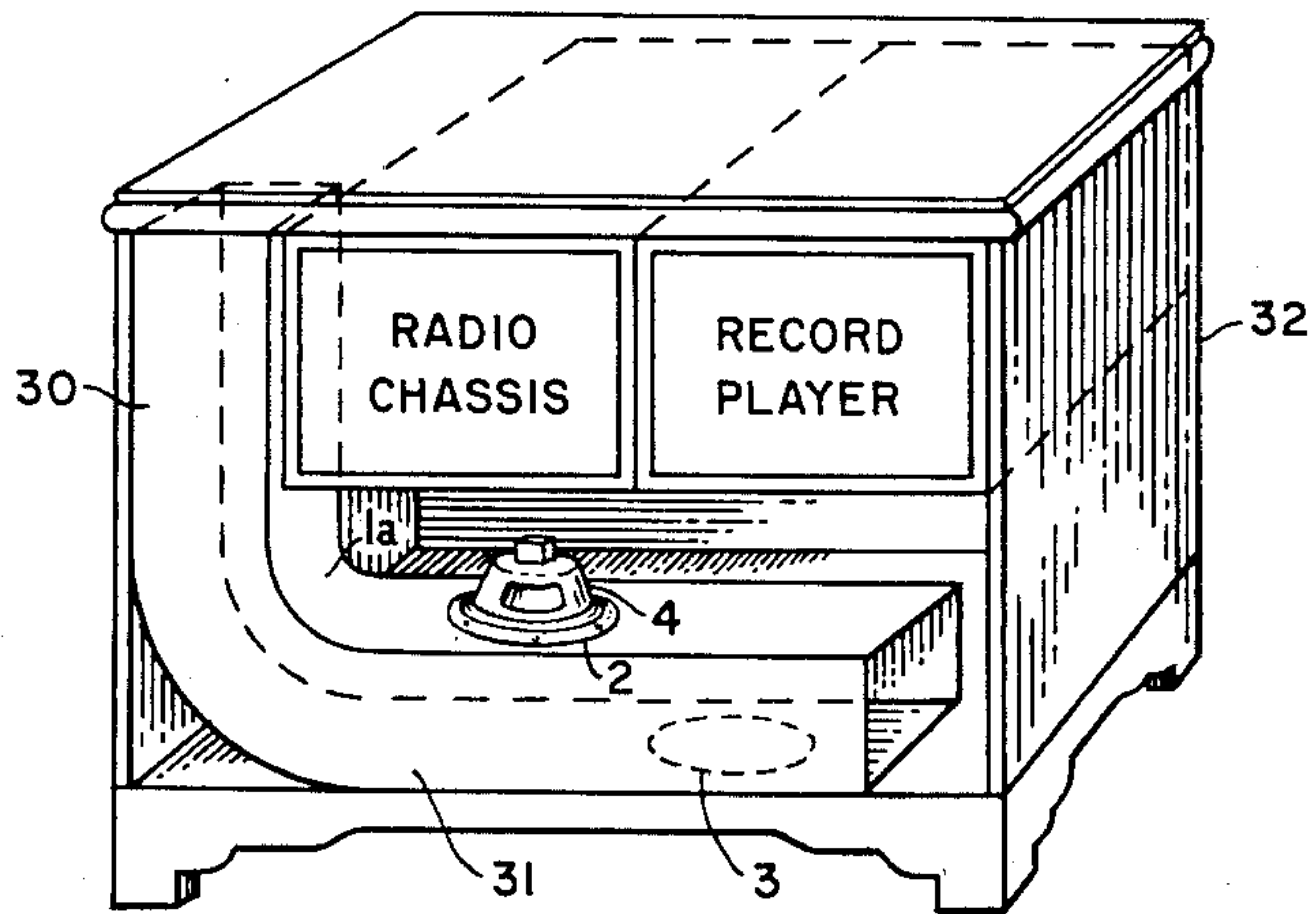
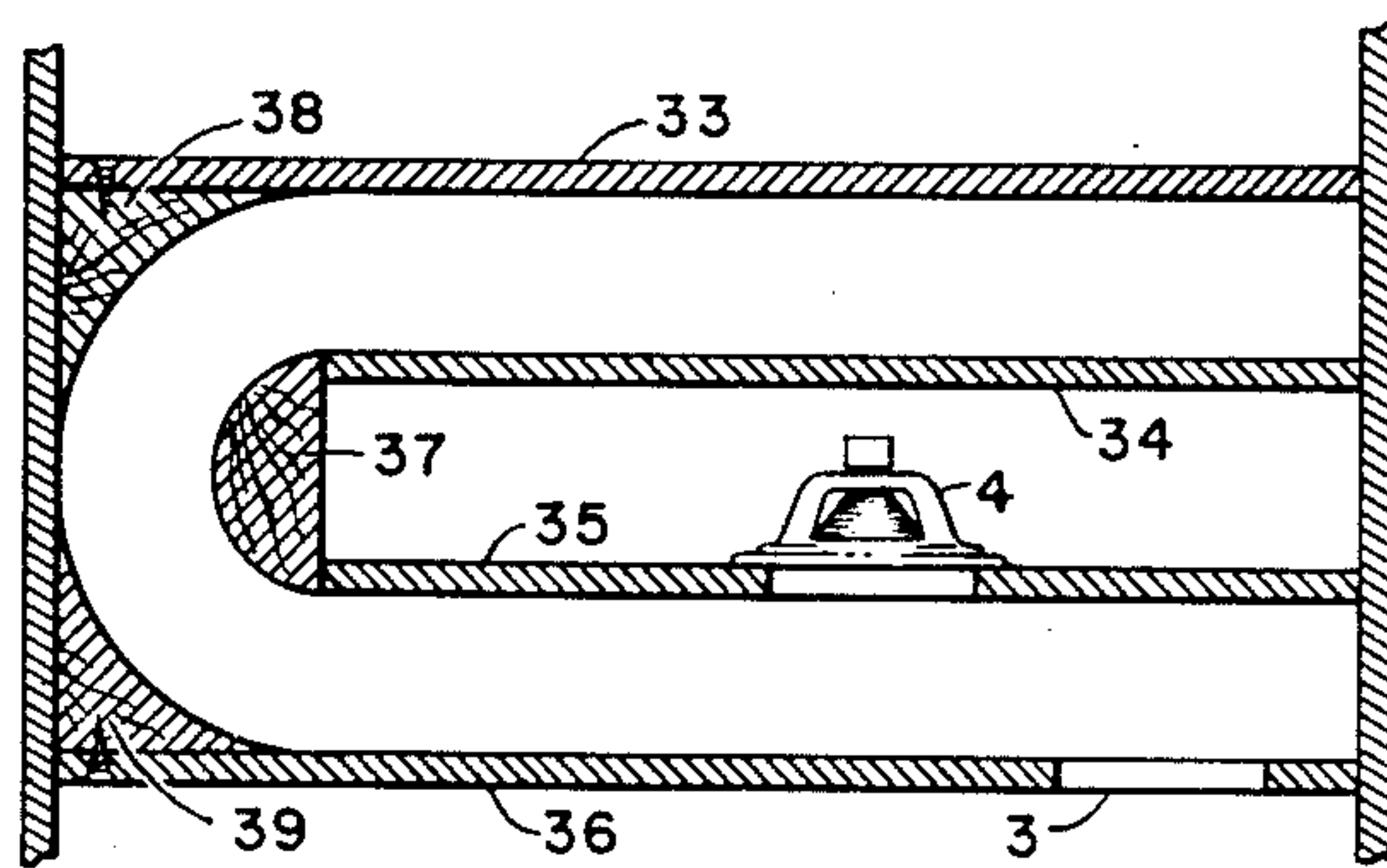


FIG. 4

FIG. 5



INVENTOR.
EDMUND T. FLEWELLING
BY *J. L. Bowser*
ATTORNEY

Feb. 10, 1953

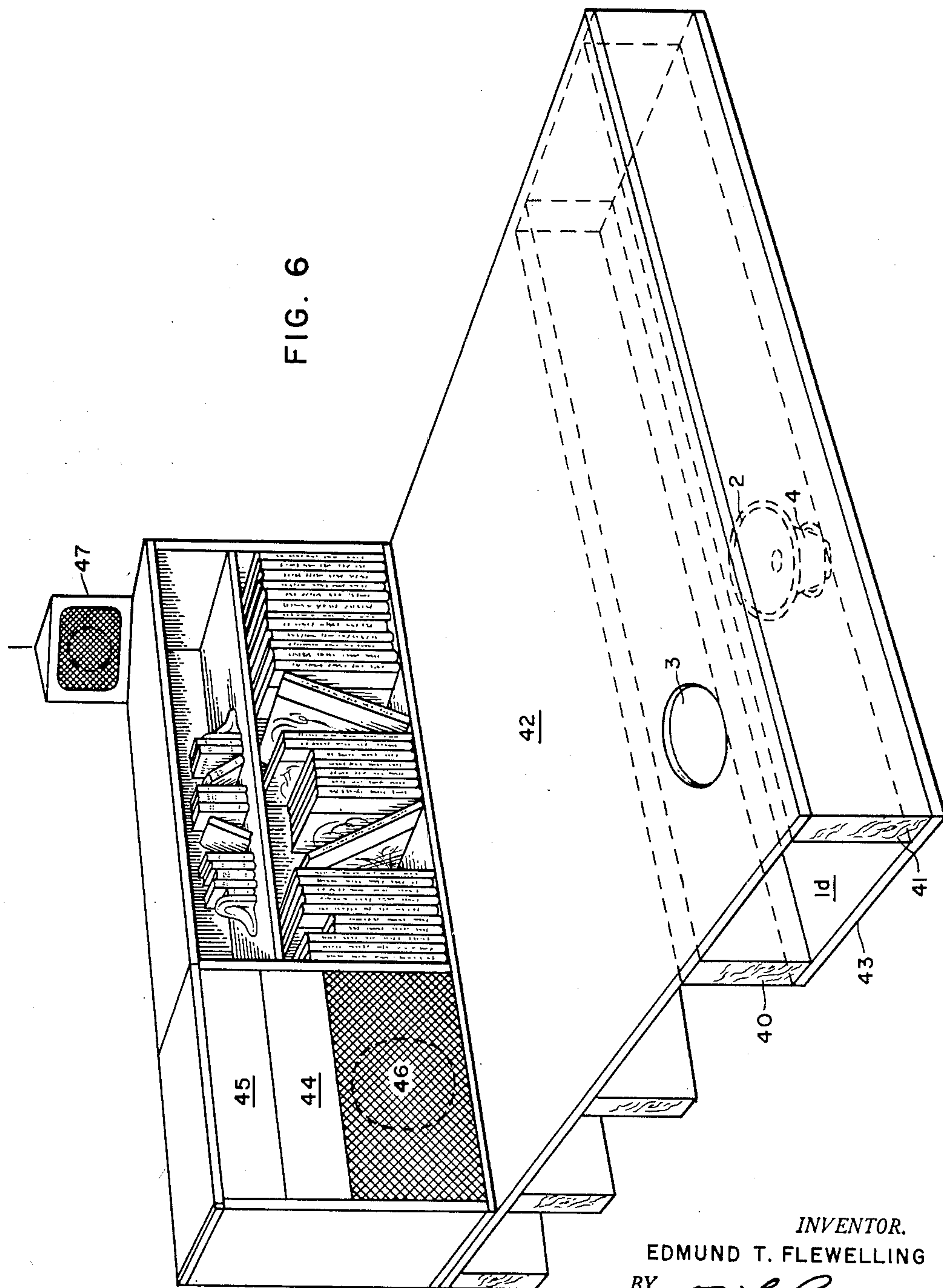
E. T. FLEWELLING

2,627,931

MEANS FOR IMPROVING FREQUENCY RESPONSE OF SOUND SYSTEMS

Filed Dec. 3, 1949

3 Sheets-Sheet 3



INVENTOR.
EDMUND T. FLEWELLING
BY *J. L. Bowes*
ATTORNEY

UNITED STATES PATENT OFFICE

2,627,931

MEANS FOR IMPROVING FREQUENCY
RESPONSE OF SOUND SYSTEMSEdmund T. Flewelling, Ashburnham, Mass., as-
signor to Stromberg-Carlson Company, a cor-
poration of New York

Application December 3, 1949, Serial No. 131,035

19 Claims. (Cl. 181—31)

1

This invention relates to sound systems and more particularly to means for improving the frequency response of sound systems, whether installed in homes, buildings of other types, or combined with a radio receiver or a record player or both.

Heretofore, many suggestions have been made for the improvement of sound reproduction from records, radio receivers, and the like. Because of transients and intangible factors difficult to analyze, previous systems with which I am familiar have, to a greater or lesser degree, failed of accurate and natural reproduction over an extended frequency range. In particular, because of distortion in one form or another and non-uniformity in the boosting of adjacent bands of frequencies, the lower frequencies have not been reproduced in a satisfactory manner by the methods of "bass boost" known to me.

Therefore, it is an object of my present invention to provide a new and improved sound system which faithfully reproduces music and other sounds over an extended frequency range and, in particular, with respect to the lower frequencies.

It is another object of my invention to provide a new and improved sound system for use in the reproduction of sound from sound recordings whether incorporated with a radio tuner in a radio cabinet or with an amplifier, or built into a home or other building.

Still another object of my invention is to improve the frequency response of loudspeakers such as are ordinarily used with radio receivers and record players and especially when installed in school rooms, homes, moving picture theaters, and the like.

Another object of my invention is to provide a new and improved sound system having broad resonance characteristics, especially with respect to low frequency response, whereby there result no narrow-band, excessive, bass-boost effects.

A further object of my invention is to provide a new and improved sound system for the reproduction of sound from recordings in which a natural-sounding response is obtained and in which extraneous noises, such as needle scratch, for example, are reduced to a minimum.

Still another object of my invention is to provide means in a sound system to correct for loudspeaker distortion and to properly load a loudspeaker or loudspeakers.

Still another object of my invention is to provide a sound system embodying an audio frequency amplifier and acoustic apparatus which

2

provides a pleasing overall frequency response with relatively small driving power.

Still another object of my invention is to provide a sound system which faithfully reproduces the lower frequencies down to the order of 20 cycles.

In order to accomplish the foregoing objects, I have combined an audio frequency amplifier of predetermined desirable characteristics with an air column described hereinafter. The acoustic portion of my sound system comprises a speaker and the aforementioned air column. The cross-sectional area of the column is made approximately equal to the area of the speaker diaphragm. The column is provided with two longitudinally-spaced-apart openings of substantially the same area. The loudspeaker is suitably mounted in one of these openings whereby the speaker drives across the air column as distinguished from driving through a horn or similar air column as has been done in the past. The area of each of the openings is preferably substantially the same as the area of the speaker diaphragm and the cross sectional area of the air column. I employ an amplifier with negative feedback in order to cancel out undesired effects in the higher frequency regions.

In the preferred form of my amplifier there are utilized at least two loudspeakers in the output or voice coil circuit. Each speaker is fed through a condenser-choke coil circuit in such a manner that one speaker reproduces the higher frequencies and another speaker responds principally to the lower frequencies. A volume control is connected across the voice coil of each speaker or group of speakers in such a manner as substantially to leave unchanged the frequency response of the associated speaker or speakers but to vary the volume or loudness of the associated speaker or speakers. In this manner compensation is provided for pre-emphasis of high or low frequencies of a phonograph recording and also allows the operator of the system to express his preference for the upper and lower frequency ranges. An overall volume control of conventional type may be employed and is used to control the absolute volume after suitable adjustment of the relative volumes of low and high ranges of frequencies.

Substantial results are obtained with the use of my air column, whether or not the amplifier shown and described herein is employed. However, to match the bass response of my system, it is believed that a conventional amplifier system should have bass boost of the order of forty to

forty-five db, and feed into an exponential horn of adequate size. These expensive requirements are obviated by the combination described herein.

Further objects and advantages of my invention will become apparent as the following description proceeds, and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of my invention, reference may be had to the accompanying drawing in which Fig. 1 is a diagram illustrating the principles and arrangement of an air column embodying the principles of my invention; Fig. 2 is a schematic diagram of an amplifier embodying the principles of my invention and useful in the proper reproduction of sound; Fig. 3 illustrates the application of my invention to a radio and record player; Figs. 4 and 5 illustrate modifications of the air column which are particularly useful when my sound system is installed in radio cabinets or the like; and Fig. 6 illustrates the application of the principles of my invention to a home or other building.

The principles of my invention will be understood from a consideration of Figs. 1 and 2. With respect to Fig. 1 there is shown a rectangular column 1. There are provided spaced-apart openings 2 and 3 in opposite walls of the column. The adjacent edges of the openings are longitudinally spaced apart as shown. In opening 2 there is mounted, in any suitable manner, a loudspeaker 4 in such a manner that when energized by suitable signals, the speaker 4 drives across the air column 1 as shown in Fig. 1. The speaker may be mounted as shown or reversed so that the speaker is entirely within the column and the large end of the diaphragm faces outwardly. With this arrangement it is seen that the back of the loudspeaker is completely separated from the front of the speaker and there is no conflict or confusion between out-of-phase return waves.

I have found that best results are obtained when the cross-sectional area of the column, the area of the diaphragm of loudspeaker 4 and the areas of openings 2 and 3, are approximately the same. For example, if a twelve-inch speaker, which has a diaphragm of approximately ten and one-half inches diameter, is used, a column 1 having a width of fourteen inches and a depth of six inches performs satisfactorily when the length of the column is of the order of six to ten feet long.

The column may be constructed as a separate cabinet, may be installed in the walls or floor of a building, as for example between the floor joists in a home, or in a radio cabinet, for example. It will be understood that the walls or joists of a building, or the sides and bottom or top of a cabinet may comprise walls of the column itself.

I have found that the separation of the openings 2 and 3 is not critical although the openings should not be directly opposite and I prefer to have the longitudinal distance between adjacent edges of the openings indicated by numeral 5 not exceed the approximate diameter of the opening.

I have found that the length of the column is not critical although the low frequency response improves as the length is increased. I have found that a column of the order of six to eight feet long gives a substantially pure waveform undistorted response at low levels down to approximately 20 cycles when employed in conjunction with a twelve-inch speaker, i. e., the length of the column is preferably of the order of six times the

diameter of the speaker diaphragm and is preferably not less than four times the diameter of the diaphragm. I have also found that columns as short as six inches to two feet in length prove useful at the higher frequencies.

The material from which the column is made may be of any material such as cardboard, wood, etc., although improved results are obtained if sound absorbing material is used, or if the column is lined with sound absorbing material, such as fibrous material 6, for example, or if the column is filled with sound absorbing material such as rock wool. The provision of sound insulating material reduces cross-reflection within the column and reduces or eliminates sharp resonances therein.

Furthermore, the air column may be of any shape and of any cross-sectional arrangement, although I prefer that the cross section shall not deviate to any great extent from a square. In this connection, however, the matching of acoustical impedances is important and the impedance match of any section of the column to another section must be gradual for best results. Preferably, the column and the openings must maintain a uniform cross-sectional area and any changes of direction of the column or changes in cross-sectional area should be by means of rounded corners and gradual tapers, respectively.

I prefer to provide openings in opposite walls of the column, but it is within the scope of my invention to place the respective openings in adjacent walls or even in the same wall or side of the column. Both ends of the column may be closed, or one end of the column may be closed and the other open.

Reference is made to Fig. 2 for illustration and description of a suitable amplifier for use with my sound system.

In the particular form illustrated there are shown first and second stages 10 and 11 of amplification utilizing tubes of the triode type and an output stage 12 employing two electron discharge devices or tubes of the screen grid type connected in push-pull.

The output circuit comprises a pair of choke coils 13 and 14 and a pair of capacitors 15 and 16. Capacitor 15 is connected in one side of the output circuit and choke coil 14 is connected in the other side. Choke coil 13 and capacitor 16 are connected in series across the output circuit. There is illustrated the use of four loudspeakers connected in two sets. The first set of loudspeakers 17 and 18 is connected across a potentiometer 19. The resistance portion of potentiometer 19 is connected across choke 13 and capacitor 15. Similarly, the second set of loudspeakers 20 and 21, either or both of which may be used with air column 1 in the manner shown by speaker 4 as indicated in Fig. 1, is connected across the potentiometer 22 which in turn is connected across capacitor 16 and choke coil 14. With this arrangement potentiometers 19 and 22 serve as volume controls for the speakers 17, 18, and 20, 21, respectively, and enable adjustment of the relative volume levels of the sets of loudspeakers which respond generally to the upper and lower frequency ranges, respectively.

The amplifier shown in Fig. 2 is provided with negative feedback. The feedback circuit comprises a high pass filter including three capacitance-resistance sections. Each section comprises a capacitor 23 connected in series in one side of the feedback circuit and a resistor 24 connected in shunt on the input side of the capacitor.

5

I have found that three sections give satisfactory results if each of the capacitors is 0.1 microfarad in capacity and each resistor is of 30,000 ohms resistance.

In order to provide overall volume control I have illustrated the use of a variable resistance 25 in the grid circuit of the electron discharge device included in stage 10 of the amplifier.

It is thus seen that I prefer to employ a plurality of loudspeakers and each set of speakers is preferably arranged to reproduce principally frequencies in a range less than the complete response range. Inasmuch as a plurality of speakers is used there may also be used a plurality of columns inasmuch as a column may be provided for each speaker. I have found that commercial loudspeakers provide reasonably satisfactory results.

In Fig. 3 there is illustrated a column 1a having two portions 30 and 31 bent or folded to 90 degrees with respect to each other in order to fit the column into the rear portion of a radio cabinet 32 of conventional shape and size. In order to provide proper impedance matching the bend in the column 1a is made in the form of a gradual curve. In this arrangement the upper end of the column is closed by the top of the cabinet but the other end remains open. The loudspeaker 4 drives across the column through an opening 2 in the upper side of the column and the audition opening 3 is in the bottom of the cabinet. With this arrangement the side and bottom walls form part of the column.

Fig. 4 illustrates a folded arrangement of a sound column and Fig. 5 illustrates in some detail the constructional details of one form of a folded air column such as that shown in Fig. 4. The side walls, not shown, may be sheets of suitable material and the four horizontally disposed walls 33, 34, 35 and 36 may similarly be formed from sheet material. The inner curve may be provided by rounding a suitable block 37 of wood or the like and securing it in a suitable manner to the inner horizontal walls 34 and 35. The outer curve may be provided by utilizing two suitably shaped inserts 38 and 39 of suitable material fastened in any desired manner in the upper and lower corners as illustrated.

In Fig. 6 there is illustrated a typical installation of my invention in a home. As shown, an air column 1d is formed between joists 40 and 41 of the floor 42 of a room in a home. The floor 42 forms the upper wall of the column and the lower wall 43 is formed by suitably securing sheet material to the bottom edges of the joists 40 and 41. The loudspeaker 4 for providing the low frequency response in the order of 20-400 cycles is suitably mounted at the opening 2 in the lower wall of the column and the audition opening 3 is formed in the floor of the room. While there is shown a full opening 3, it is believed obvious that a suitable grill or a plurality of small openings, or the like, would be provided in an actual installation.

I have illustrated a radio tuner 44 and record player 45 disposed in the room illustrated although, of course, any other desired arrangement may be employed. I have found that a loudspeaker 46 of the "tweeter" type illustrated as mounted below the radio tuner is useful when speech or singing is being reproduced and it is desired to provide a "center of interest" by giving the listener the impression that the sound is being emitted from a predetermined point. I have found that desirable results are obtained by

6

locating other speakers in various locations about the room. For example, I have shown a third loudspeaker 47 in a corner of the room. By variously placing the speakers a pleasant diffusion of sound is provided.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention in its broader aspects. For example, the column may be filled with insulating material, such as rock wool, for example, in which case it is preferred to place a screen across each opening to maintain the insulating material in place. I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim is:

1. Means for use in a sound reproduction system for providing a broad-resonance low-frequency response over an extended range of low frequency signals including an elongated structure defining an air column, said structure having a substantial length with respect to its lateral dimension, said structure having two non-overlapping openings displaced longitudinally with respect to and on opposite sides of said column and a loudspeaker mounted at one of said openings in such a manner as to drive across said column, the second of said openings comprising a sound emitting port, the cross-sectional area of each of said openings being of substantially the same order of magnitude, and the distance between adjacent edges of said openings not exceeding the approximate effective diameter of said loudspeaker.

2. The device of claim 1 in which one end of said column is closed.

3. The device of claim 1 in which both ends of said column are closed.

4. The device of claim 1 in which said column contains sound absorbing material.

5. The device of claim 1 in which the length of said column is of the order of six times the effective diameter of said speaker.

6. The device of claim 1 wherein the length of said column is not less than four times the effective diameter of said speaker.

7. The device of claim 1 in which said column is folded.

8. The device of claim 7 in which the folds of said column are uniform and gradual so that said column is of substantially uniform cross-sectional dimensions throughout the entire effective length of said column.

9. The device of claim 1 wherein the second of said openings and the back of said loudspeaker are open to the air with a substantially unobstructed sound wave passage therebetween.

10. The device of claim 1 and baffle means extending outwardly from said structure for increasing the distance between said two openings, whereby the destructive interference between the front and back waves of said speaker is reduced thereby minimizing phase cancellation.

11. Means for use in a sound reproduction system comprising a structure defining an air column having two openings longitudinally displaced on opposite sides of said air column, and means including a sound radiating surface arranged to radiate into one of said openings, the cross-sectional area of said air column and of each of said openings being substantially the same as the area of said radiating surface.

12. The device of claim 11 in which one end of said air column is closed.

13. The device of claim 11 in which both ends of said column are closed.

14. The device of claim 11 in which said air column contains sound absorbing material.

15. The device of claim 11 in which the length of said air column is in the order of six times the effective diameter of said sound radiating surface.

16. The device of claim 11 in which the length of said column is not less than four times the effective diameter of said sound radiating surface.

17. The device of claim 11 in which the distance between the adjacent edges of said opening does not exceed the approximate effective diameter of said loudspeaker.

18. In a building including a plurality of walls, a sound system comprising; a loudspeaker having a sound emitting surface, means for enclosing an elongated air column having a substantial ratio of length to width within at least one of said walls, said air column having a pair of non-overlapping longitudinally displaced openings on opposite sides of said air column, said loudspeaker being disposed at one of said openings to drive across said column, the second of said openings comprising a sound emitting port, the cross-sectional area of each of said openings being substantially the same and the distance between the adjacent edges of said openings not exceeding the approximate effective diameter of said sound emitting surface.

19. In a building including a plurality of walls, a sound system comprising; a loudspeaker having a sound emitting surface, means for enclosing an elongated air column having a substantial ratio of length to width within at least one of said walls, said air column having a pair of longitudinally displaced openings on opposite sides of said air column, said loudspeaker being disposed

at one of said openings to drive into said column, the second of said openings comprising a sound emitting port, the cross-sectional area of each of said openings, of said air column and of said sound emitting surface being approximately the same.

EDMUND T. FLEWELLING.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
782,582	Schmeltz	Feb. 14, 1905
1,912,454	Hutter	June 6, 1933
1,932,343	Holland	Oct. 24, 1933
1,953,135	Staunton	Apr. 3, 1934
2,097,289	Olson	Oct. 26, 1937
2,143,175	Waite	Jan. 10, 1939
2,179,840	Bucky	Nov. 14, 1939
2,205,804	Wells	June 25, 1940
2,229,702	Larsen	Jan. 28, 1941
2,313,098	Shepard	Mar. 9, 1943
2,491,982	Kincart	Dec. 20, 1949
2,514,267	Watkinson	July 4, 1950

FOREIGN PATENTS

Number	Country	Date
447,749	Great Britain	May 18, 1936
102,888	Australia	Dec. 23, 1937

OTHER REFERENCES

Read et al., "The Recording and Reproduction of Sound," article in "Radio and Television News," December 1948 (pages 48-50, 120, 122 and 124).

Drisko, "Getting the Most Out of a Reflex-Type Speaker," article in "Audio Engineering," July 1948.