

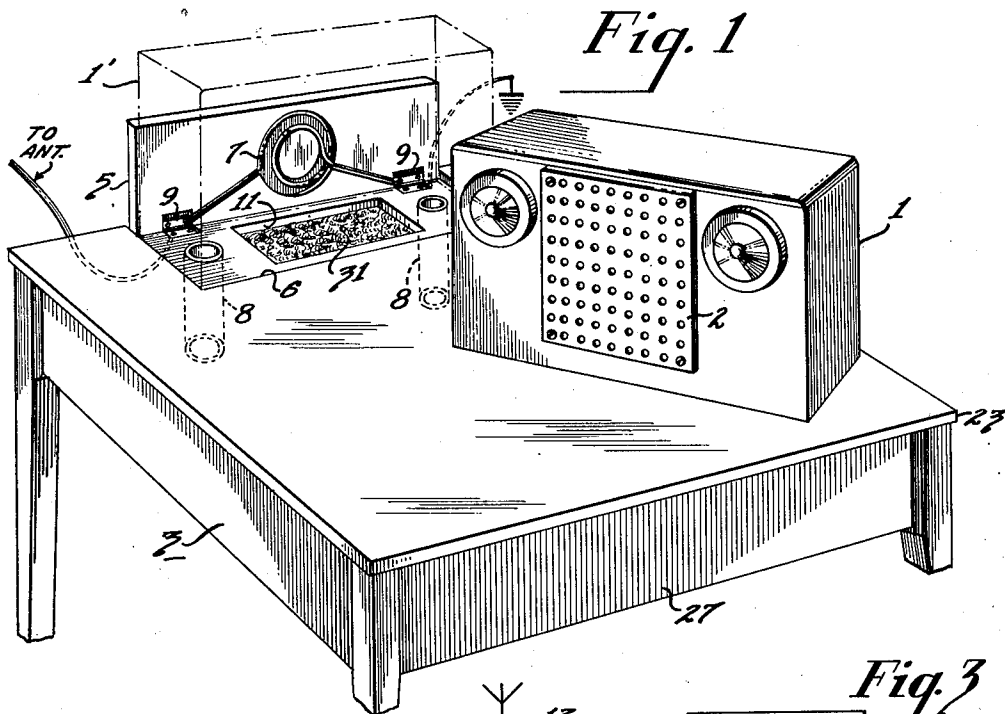
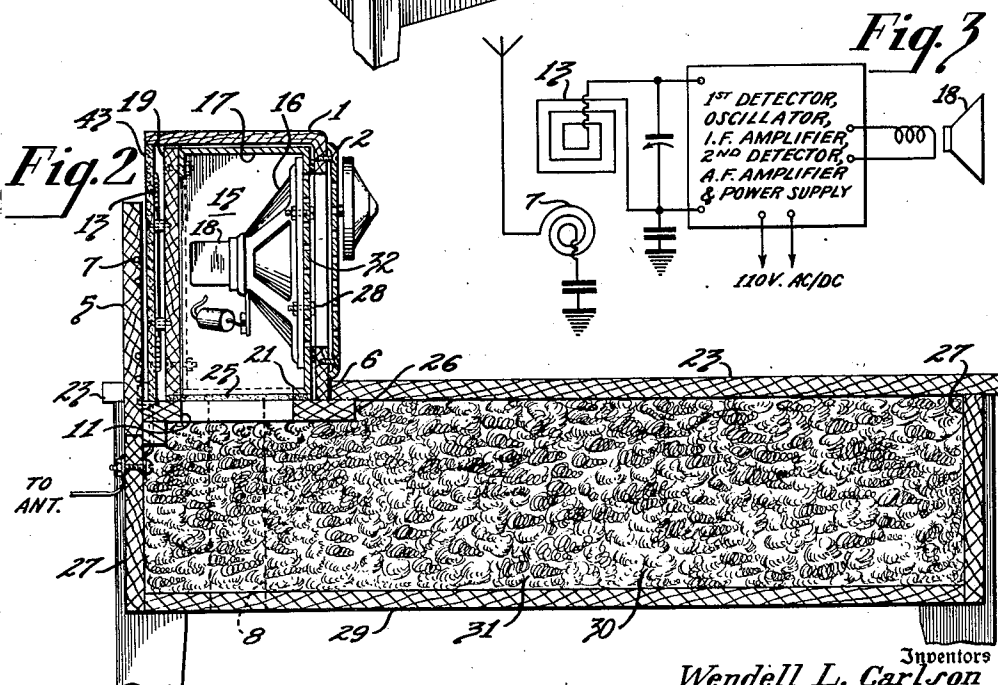
May 8, 1951

W. L. CARLSON ET AL
ACOUSTIC DIAPHRAGM AND BAFFLE

2,552,309

Filed Oct. 10, 1947

3 Sheets-Sheet 1



Inventors
Wendell L. Carlson
& Loy E. Barton

Attorney

May 8, 1951

W. L. CARLSON ET AL
ACOUSTIC DIAPHRAGM AND Baffle

2,552,309

Filed Oct. 10, 1947

3 Sheets-Sheet 2

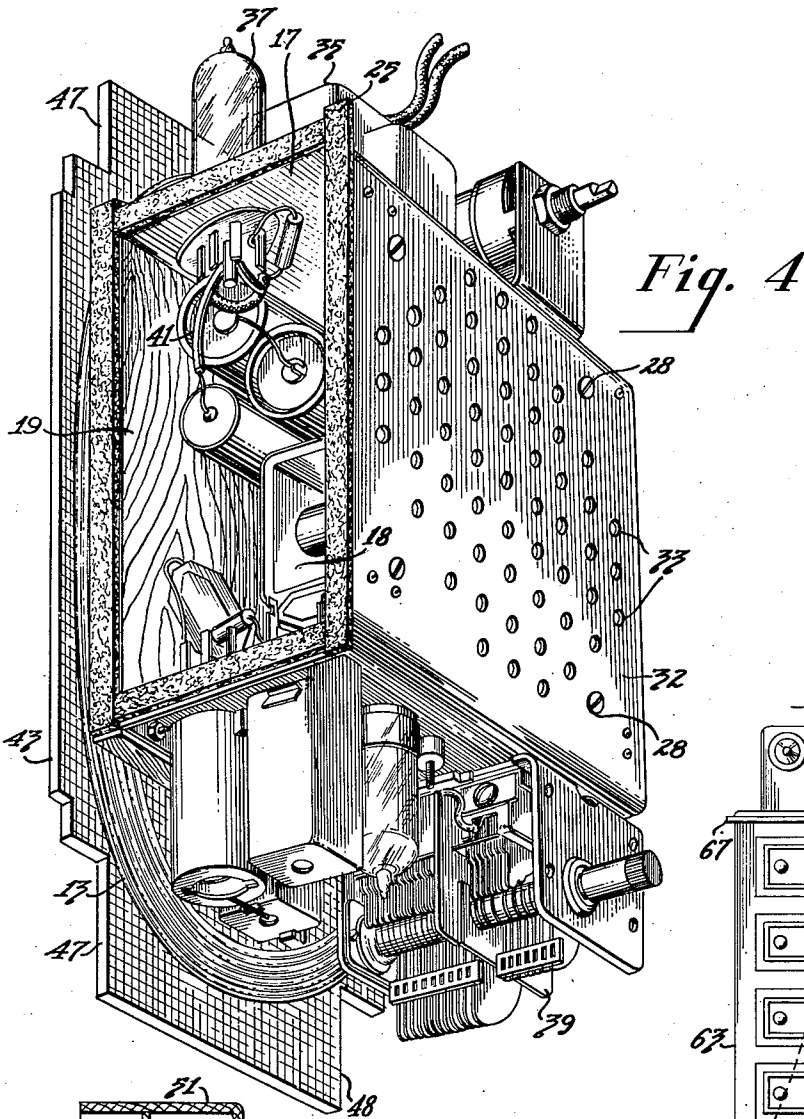


Fig. 4

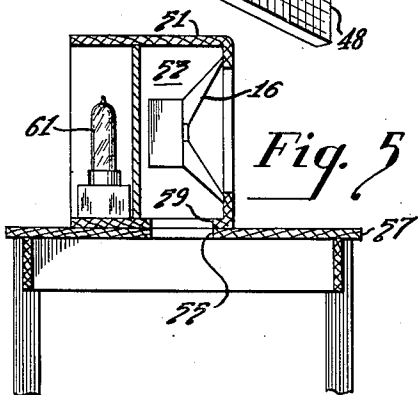


Fig. 5

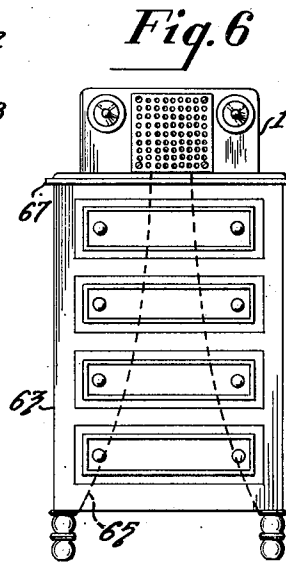


Fig. 6

Inventors
Wendell L. Carlson
& Loy E. Barton

W. L. Carlson

Attorney

May 8, 1951

W. L. CARLSON ET AL
ACOUSTIC DIAPHRAGM AND Baffle

2,552,309

Filed Oct. 10, 1947

3 Sheets-Sheet 3

Fig. 8

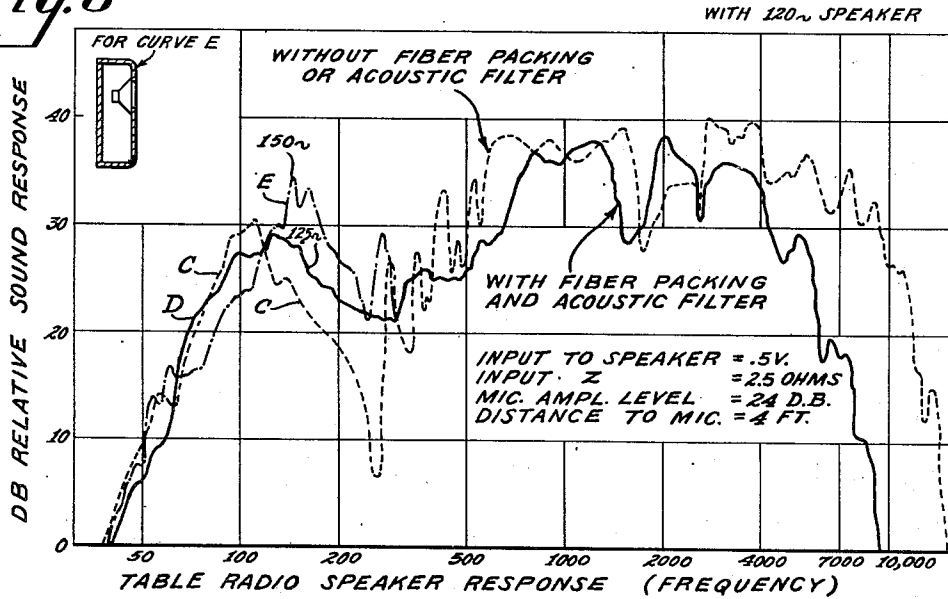
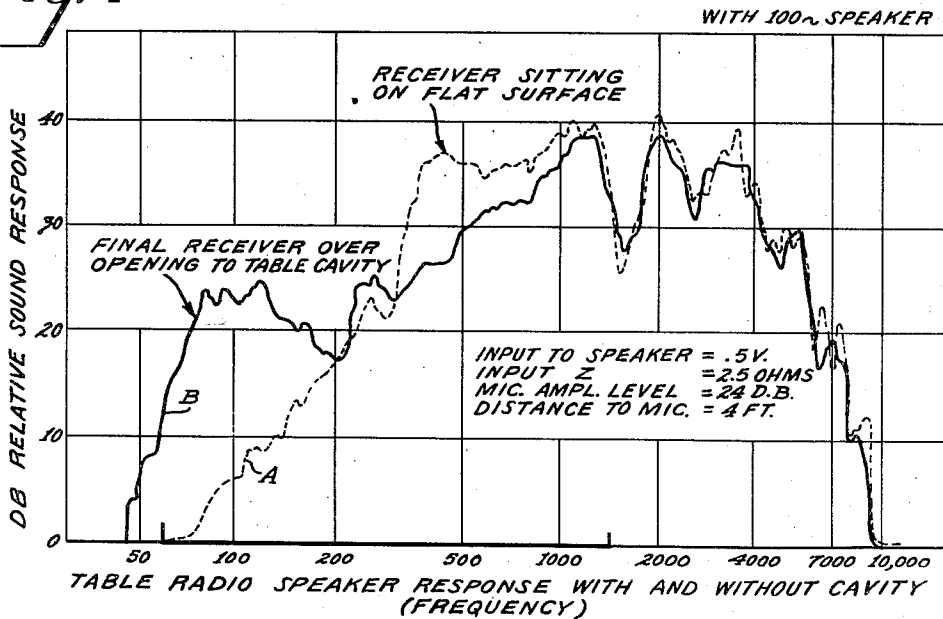


Fig. 7



Inventors
Wendell L. Carlson
& Loy E. Barton

Moore

Attorney

UNITED STATES PATENT OFFICE

2,552,309

ACOUSTIC DIAPHRAGM AND BAFFLE

Wendell L. Carlson and Loy E. Barton, Princeton,
N. J., assignors to Radio Corporation of America,
a corporation of Delaware

Application October 10, 1947, Serial No. 779,176

8 Claims. (Cl. 181—31)

1

This invention relates to radio receiving apparatus, and more particularly to an arrangement for improving the acoustic characteristics of the sound output from receivers of small size.

The most common objection to the small, table model receiver is its poor low-frequency response. Poor response is due largely to the small baffle for the speaker which allows the back and front waves from the speaker to cancel each other. The principal object of this invention is to overcome this defect without increasing the size or interfering with the portability of the receiver.

Those skilled in the art have long recognized the problem of obtaining low-frequency sound output from dynamic speakers using the very limited baffle area available in small cabinets. It has been proposed, and tried, to obtain a synthetic bass by accentuating the harmonics of the missing bass notes to give the ear the impression of bass response. Attempts have also been made to boost existing low frequencies by means of selective regenerative feedback in the electrical circuits. These arrangements have not proven sufficient.

The best arrangement heretofore proposed has consisted in enclosing the cabinet to the rear of the speaker for the purpose of preventing out-of-phase interference between the front and back waves from the diaphragm, as in the case of an infinite baffle, disclosed in Olson et al. copending application Serial No. 545,872, filed July 19, 1944; now Patent 2,490,466. In the latter case, it is necessary to use a specially constructed dynamic speaker, characterized by a highly compliant suspension, having a much lower than normal natural resonance to allow for the stiffness added by the confined air in the small rear enclosure to the compliance of the diaphragm suspension. It has generally been considered impractical, if not impossible, to reproduce frequencies lower than the natural resonance of the speaker, that is, below the point where the speaker diaphragm is mass controlled, in the stiffness controlled region. This is true regardless of the size of the baffle, contrary to the general supposition that low frequency reproduction is limited only by the baffle area used.

In accordance with the invention, the low-frequency response of sound reproducing apparatus using an ordinary dynamic speaker is extended by enclosing the space to the rear of the speaker except for a restricted opening in the base and removably placing the opening over a corresponding opening in a table top or cabinet having an acoustic device, the back wave being

2

fed through the openings into said device. The invention is based upon three assumptions: (1) That, in the home, small table model receivers are usually located more or less permanently on a piece of furniture such as an end table; (2) that a special table or the like could be provided especially for this purpose and so constructed in combination with the receiver as to increase the effective baffle area or otherwise to increase the reproduction of low frequency over what the small receiver is capable of reproducing alone; and (3) that it is desirable at times to move the small receiver to other locations in the room or house without difficulty, using it as an ordinary table model with ordinary performance.

Another object of the invention is to provide a small, portable radio receiver having unusual performance when used in one location in combination with auxiliary apparatus, which may readily be disassociated from said auxiliary apparatus and transported to other locations for operation as a complete, small receiver with at least usual performance.

Another object of the invention is to provide means for obtaining from an ordinary small, table model radio receiver an extended range of low-frequency sound output comparable to that obtained with a relatively large receiver and without using a special speaker of lower resonant frequency than usual.

A further object of the invention is to provide an inexpensive low-pass acoustic filter for a radio receiver, preferably using some of the existing apparatus as parts of the filter, for reducing high audio-frequency disturbances.

A still further object of the invention is to provide a supporting table stand or cabinet for a table model radio receiver, constructed to improve the fidelity of the sound output as well as to increase the radio-frequency input to the antenna built within the receiver, particularly for operating within shielded buildings, when the receiver is used with the table.

Other objects of the invention and details of structure will be clear from the following description, taken in connection with the accompanying drawings, in which:

Fig. 1 is a view in perspective of a radio receiver and table comprising a preferred embodiment of the invention, the dotted lines showing the normal operating position of the receiver, and portions of the table legs being cut away;

Fig. 2 is an elevational view partly in cross-section, of the apparatus shown in Fig. 1, with the receiver in operating position on the table;

Fig. 3 is a simplified electrical circuit diagram of the apparatus shown in Fig. 1;

Fig. 4 is an enlarged view, in perspective, of the chassis of the radio receiver shown in Fig. 2;

Fig. 5 is a side elevational view, partly in section, of a species of the invention;

Fig. 6 is a front elevational view of another species of the invention; and

Figs. 7 and 8 are actual characteristic curves of performance taken of the apparatus of Figs. 1 and 2.

Referring to Fig. 1, a radio receiver 1, made in accordance with the invention, is shown on top of a table 3, also embodying the invention, the normal operating position of the radio receiver being shown in dotted lines 1'. The table is provided with a hinged lid 5, which may be closed when the radio receiver is not used in combination therewith, to present a substantially smooth table surface. For improving signal reception, a coil of wire 7 is embedded in the surface of the hinged lid and is connected, through the hinges 9, to antenna and ground, respectively, or in some cases to a dipole antenna. When the radio receiver is placed over the opening 11, for reasons hereinafter described, the loop antenna of the receiver, shown at 13 in Figs. 2 and 3, is adjacent the coil 7 for increasing the signal pickup. The latter feature is particularly desirable in shielded locations where a loop antenna loses its effectiveness and where an outside antenna is necessary. While only one turn 7 is shown, and while this would operate materially to increase signal pickup, actually several turns were used to obtain sufficient inductance to resonate the antenna circuit below the broadcast band.

For the purpose of obtaining an increased reproduction of low audio-frequency sound waves, and materially extending the low-frequency end of the range, a loudspeaker 13, of the moving coil, dynamic type, shown in Fig. 2, is provided, which has a natural resonance, as measured in a large baffle, substantially below the useful audio frequency range to be reproduced. The loudspeaker includes a direct acting diaphragm 16, and a highly compliant suspension system for the diaphragm whereby the diaphragm is controlled by mass reaction. The loudspeaker is mounted in a closed and acoustically sealed compartment 15 made up of a sheet metal housing 17 and a rear enclosure wall 19, preferably of plywood. The compartment is sealed around the rear surface region of the diaphragm 16, except for an opening 21 in the bottom thereof which is arranged to communicate with a corresponding opening 11 near the top of the table when the radio receiver is positioned in a recess 6 above a sub-top 26, as shown. A felt gasket 25 provides an acoustic seal between the rear compartment 15 of the speaker and a closed cavity 30 below the table top formed by the top 23, bottom 29, and side walls 27. In effect, there are two compartments coupled acoustically through openings 11 and 21.

The felt gasket 25 may be cemented to the chassis upon the base around opening 21, as shown in Fig. 4, or it may be cemented to the sub-top member 26. In the former case, the compartment 15 is sealed when the receiver is mounted upon any flat surface. In the latter case, there is leakage around the lower edge of the opening 21 through the ventilating openings 47 (Fig. 4) in the cabinet back 43 when the receiver is operated upon an ordinary flat surface. The leakage may be increased, if de-

sired, by spacing the receiver base above the surface, as by means of a few books or by feet, in either of the two cases, depending upon results desired. The low-frequency response changes in the former case as the base opening is raised above a flat supporting surface, changing from a sealed, small back enclosure to a partially open rear enclosure. The felt seal may be entirely omitted, as in Figs. 1 and 2, it having been found that beneficial results still are obtained by spacing the openings 21 and 11 a small distance apart.

For the purpose of minimizing resonant peaks and eliminating anti-resonant dips, shown below 1000 cycles in dotted lines in Fig. 8, the table cavity is filled with sound damping material 31, such as fibre glass, loosely packed. Other ways of damping known to the art may be used if desirable, for example that shown in Carlisle et al. Patent 1,837,755, disclosing coupled compartments but involving a different acoustic function. The cavity has little or no effect on the response above 1000 cycles.

In accordance with the invention, the cubical contents of the rear speaker enclosure or compartment and the table top cavity bear a certain desired relation, the latter being much greater than the former. In an actual working model made in accordance with the invention, the cubical content of the region to the rear of the speaker diaphragm, that is, the enclosed air, was about 40 cubic inches, whereas the cubical content of the cavity was around 900 cubic inches. The latter volume may be increased for speakers having lower speaker resonant frequency. The speaker resonance in this case was 120 cycles (Fig. 8), as measured in operation with a very large baffle. The throat opening at 21 and 11 bears a certain relation to the cubical contents of the communicating chambers and the diaphragm area. The table cavity inside dimensions are 16" x 16" x 3½", and the table was 23 inches high. In the model mentioned, the area of the throat or housing opening was about the same as the diaphragm area and measured about 2.25" x 5". Experiments were made with the throat opening smaller, and it was found that the effect was to lower the low-frequency resonance point, but there was some loss in amplitude of response. The speaker housing dimensions are, height 5", width 5", and depth 2¼". The cabinet dimensions are, height 5¼", width 10¼", and depth 3½".

Referring to Fig. 4, which shows the invention in greater detail, the metal chassis or plate 32 to which the speaker is secured at points 28, in front of the speaker diaphragm, is provided with a plurality of small holes 33 of the order of ⅛" in diameter, spaced about ½" from each other for the purpose of providing an acoustic filter in combination with a grille 2 (Figs. 1 and 2), preferably also made of metal and having holes of similar size and spacing. The diameter of the holes and the thickness of the metal determine the acoustic inertance. The spaced perforate plates provide a low-pass filter for effectively cutting off undesired higher audio frequencies, including "monkey chatter," from an adjacent channel, high frequency hiss, and static bursts, as shown to the right in Fig. 8. The dotted line curve C shows the effect of the output response without the filter and the solid line curve D shows the effect of the filter. The filter has little effect upon the low-frequency response if the holes are about the size shown, or larger,

The perforate plate 32 serves also during production to protect the conical paper diaphragm from injury, such as often occurs in cases where the diaphragm is unprotected on the chassis during production, and in use the plate 32 may take the place of a grille cloth.

It will be observed that certain of the radio components are mounted upon the chassis within the speaker compartment and others are mounted on the outside thereof. The tubes 37 and other heat radiating elements are mounted on the outside of the chassis. The tuning condenser 39 and other components are also mounted on the outside, but for other reasons. Certain of the connections to the tubes are made on the inside of the chassis, within the compartment, as shown at 41, for example.

The loop antenna 13 is preferably cemented to an insulating composition board 43 which forms the rear enclosure wall for the cabinet of the receiver 1. The loop and mounting board 43 are preferably spaced from the rear of the chassis to reduce losses. It will be noted that the rear wall of the chassis is made of plywood or other insulating material to reduce losses into the loop circuit.

It will be observed that the closure board 43 is cut away at the corners, at 47 and 48, to provide openings for the purpose of circulating air to cool the heat radiating elements on the chassis within the spaces between the chassis end walls and the cabinet. When the small receiver is mounted on an ordinary surface, for example, as shown by the receiver 1 in Fig. 1, the air enters the openings at 47 at the bottom of the cabinet and leaves through openings 48 at the top of the cabinet. When, however, the receiver is placed in normal operating position upon the table, as in Fig. 1 (dotted lines 1') and Fig. 2, the lower openings at 47 are closed by the proximity to lid 5. Tubular members 8 have been provided for the entrance of cooling air in place of the covered openings at 47. The tubular members 8 extend all the way from the top to the bottom surface of the closed cavity in the table, while preserving the acoustic seal within the cavity.

Referring to Fig. 5, an earlier species of the invention, enhanced results were obtained with an increased baffle effect between the front and rear surfaces of the diaphragm, by providing in a cabinet housing 51 an enclosed rear compartment 53 for the speaker, similar to that shown in Fig. 2, arranged to communicate with an opening 55 in a table top 57 through a corresponding opening 59 in the bottom of the speaker compartment. As in the other case, the heat radiating elements, such as the amplifier tubes 61, were mounted outside of the speaker compartment for the purpose of air cooling.

An improvement over the arrangement of Fig. 5 can be obtained by the use of a horn, as shown in the modification of Fig. 6. In this arrangement, a table or cabinet 63 of appropriate ornamental design is provided with a horn 65 extending vertically downwardly from the top 67 to the base of the table or cabinet, as shown in dotted lines. A small radio receiver 1, with an enclosed speaker, as shown in Figs. 1 and 2, is mounted over the throat of the horn in the top of the cabinet. This arrangement results in a substantial extension of the low-frequency end of the operating range. The horn is not critical in design, although an exponential type is to be preferred. While this arrangement is sat-

isfactory, it is expensive and requires more room than that shown in Fig. 1. Applicants are aware that High patent 1,794,597, dated March 3, 1931, broadly discloses an exponential horn coupled to the rear surface of a speaker diaphragm. In order to make the structure of Fig. 6 more compact, as in Fig. 1, the horn may be made up into a labyrinth construction, as taught by High.

Referring to the characteristic curves of Fig. 7, the dotted line curve A shows the operation of the small receiver with the bottom opening 21 closed, as used on any ordinary table or surface. The speaker used for this measurement had a natural resonance of 100 cycles, as determined with a very large baffle. Curve B shows the substantial improvement in the extended low-frequency end of the range when used with applicant's invention. In view of the increased low-frequency response, it was found desirable to improve certain of the circuit components, such as the output transformer to the speaker, which was redesigned to handle the increased low frequencies.

Referring to the curves in Fig. 8, curve C in dotted lines shows, in the region below 1000 cycles, the undesired peaks and dips occurring in the cavity without the sound damping material. The full line curve D shows a slight reduction in the first peak and a substantial elimination of the first bad dip in curve C. These curves were made with a speaker having 120-cycle natural resonance as measured in a very large baffle, for example, the wall of a room. The 100-cycle speaker used in the case of Fig. 7 was damaged and it was necessary to obtain another speaker of the same type to complete the tests. It had a different natural period.

Curve E, the low-frequency portion only being shown, was taken with the same speaker as in the case of curves C and D, but operating in a single, large, sealed rear cavity or compartment. In this case, the speaker was mounted in a hole cut in the top wall 23 of the table cavity, with the opening 11 closed. The compartment 15 was not involved. A comparison with curve D shows that the low-frequency resonance is about 25 cycles higher. This shows the beneficial results from the two coupled compartments made in accordance with the invention, as distinguished from a single, large, rear compartment.

From the above, it is apparent that, as a result of the invention, substantially improved results are obtainable with a small, table model radio receiver using a standard design of speaker when combined with a table or other support which is made to extend the low-frequency end of the range. At the same time, the small receiver may readily be carried to other locations and operated in the normal manner as a small radio receiver with the usual acoustic characteristic output. The receiver may be fully portable, as in the case of A. C./D. C. battery operation.

In accordance with the invention, a substantial improvement can also be realized when using a small receiver with a sealed rear enclosure and extra-low frequency speaker, as in the above mentioned Olson et al. patent. In one aspect, the invention is an improvement over said Olson et al. patent. For example, if the speaker, preferably of the folded edge type, disclosed in said Olson et al. patent, has a low natural resonance of, say, 40 cycles, and is mounted in the sealed enclosure, the stiffness introduced by the small enclosure raises the resonant point to around 70

cycles. When such an enclosure, preferably larger than that in the above figures, is provided with the above disclosed base opening and other features shown in Figs. 2 and 4, and mounted upon the table embodying the invention, in communication with the large cavity, as in Fig. 2, there is much less stiffness introduced into the diaphragm suspension system and the net result is a lower resonance, say around 50 to 60 cycles. In such a case, the operation of the small set, with a special low-frequency response speaker, operated upon a plane surface with sealed rear enclosure, is better than normal as to low-frequency response, but when mounted on the table and coupled with the cavity according to the invention, the performance is exceptional. While the main purpose of the invention is to improve the operation of an ordinary small set, with an ordinary speaker, the invention is not limited thereto in that substantial improvement results in applying the invention to a small set with a speaker of special acoustic design.

What we claim is:

1. In a sound reproducing device, the combination with a loud speaker having an acoustic diaphragm of the direct acting type of a housing for said diaphragm, said housing having an acoustically closed compartment therein for enclosing the rear surface of said diaphragm and having an opening in one surface thereof for the passage of sound waves originating from said diaphragm rear surface, and a support for said housing, said support including a walled enclosure defining an acoustically closed cavity of substantially larger cubical content than said compartment, one wall of said enclosure having an opening therein in registry with said housing opening.

2. The invention as set forth in claim 1 wherein damping material is included in said acoustically closed cavity for substantially reducing resonance peaks and dips in the frequency response characteristic of the low-frequency end of the range.

3. The invention as set forth in claim 1 wherein said housing includes a walled enclosure for the front surface of said diaphragm, one wall of said enclosure having a plurality of spaced small holes therein to provide a low pass filter effect.

4. The invention as set forth in claim 1 wherein said speaker has a natural resonance, as measured in a large baffle, substantially below the useful audio-frequency range to be reproduced by said device.

5. The invention as set forth in claim 1 wherein said housing opening is comparable in area to that of said diaphragm.

6. The invention as set forth in claim 1 wherein said support includes means providing an air passage communicating with the interior of said housing independently of said walled enclosure

opening for providing circulation of air in said housing.

7. In combination, an acoustic apparatus comprising a table having a top provided with an opening, a relatively portable sound producing device comprising an acoustic diaphragm of the direct acting type, a housing for said device defining around the region rearwardly of said diaphragm a compartment acoustically closed except for a base opening, and means providing a closed acoustic cavity of relatively larger cubical content than said compartment, said means being carried by said table and coupled with said compartment through said openings for conducting sound waves from the back of said diaphragm through said openings to enhance the reproduction of low frequency sound waves.

8. In a sound reproducing device, the combination with a loud speaker of the moving coil type having a direct acting diaphragm and a highly compliant suspension system for said diaphragm whereby said diaphragm is controlled by mass reaction substantially below the useful audio frequency range to be reproduced by said device, of a walled enclosure defining a relatively small compartment enclosing the rear of said diaphragm, said enclosure having an opening in one wall thereof, and a support for said compartment having an enclosure defining a cavity of substantially larger cubical content than said first-mentioned compartment, said cavity being acoustically sealed except for an opening disposed in a wall of said enclosure, said last-mentioned opening being in registry with said first-mentioned opening whereby the effective enclosure for the rear of said diaphragm is substantially increased.

WENDELL L. CARLSON.
LOY E. BARTON.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,443,688	Hurd	Jan. 30, 1923
1,693,470	Thomas	Nov. 27, 1928
1,677,509	Hallberg	July 17, 1928
1,705,778	Munroe	Mar. 19, 1929
1,715,831	Hahnemann	June 4, 1929
2,031,500	Olney	Feb. 18, 1936
2,065,751	Scheldorf	Dec. 29, 1936
2,067,582	Sperling	Jan. 12, 1937
2,072,035	Hayenga et al.	Feb. 23, 1937
2,129,184	Roy	Sept. 6, 1938
2,160,283	Roberts	May 30, 1939
2,160,284	Roberts	May 30, 1939
2,224,919	Olson	Dec. 17, 1940
2,277,525	Mercurius	Mar. 24, 1942
2,315,896	Dumas	Apr. 6, 1943
2,337,213	Topping, Jr.	Dec. 21, 1943