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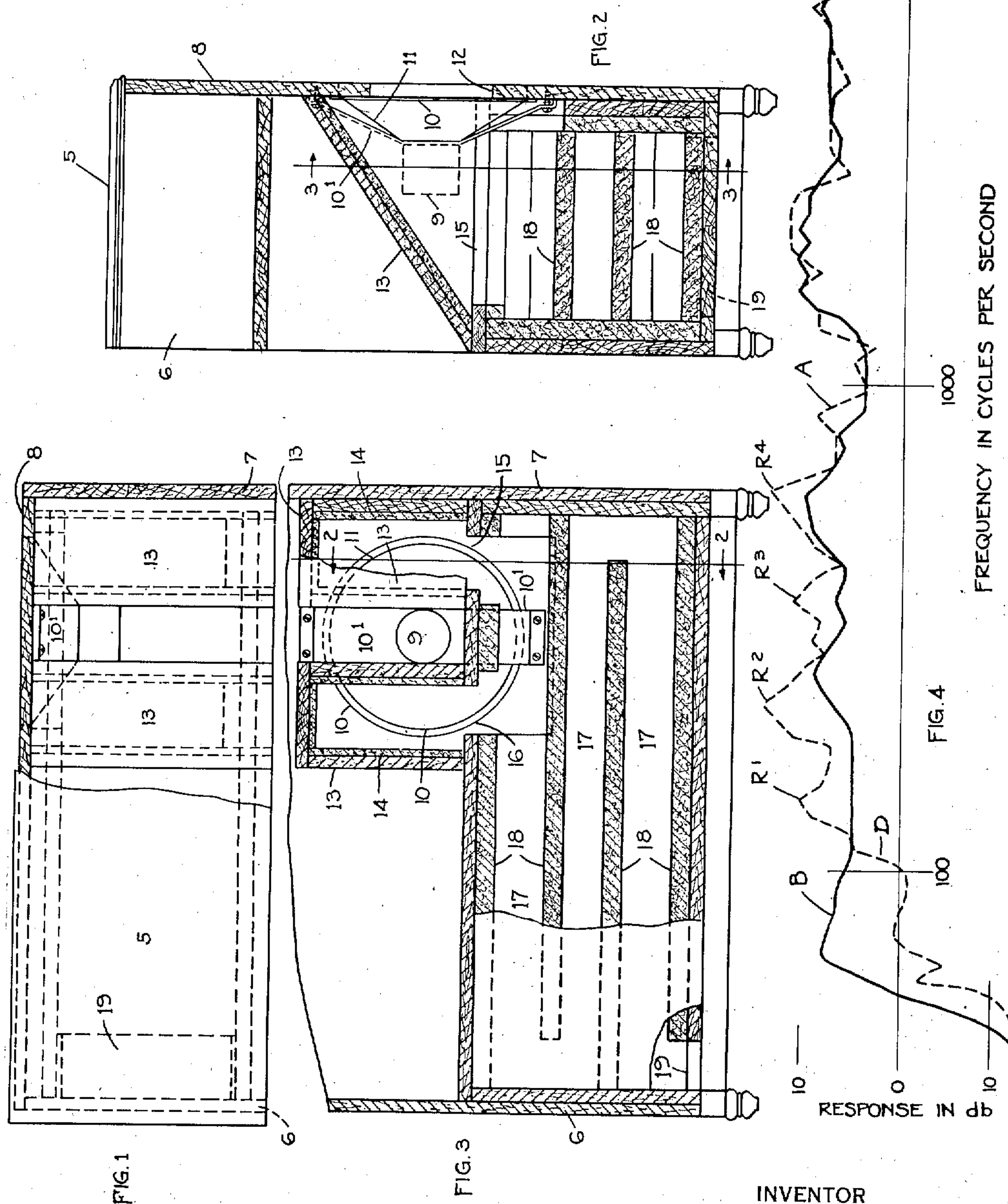
B. OLNEY

2,031,500

SOUND REPRODUCING SYSTEM

Filed Sept. 17, 1934

2 Sheets-Sheet 1



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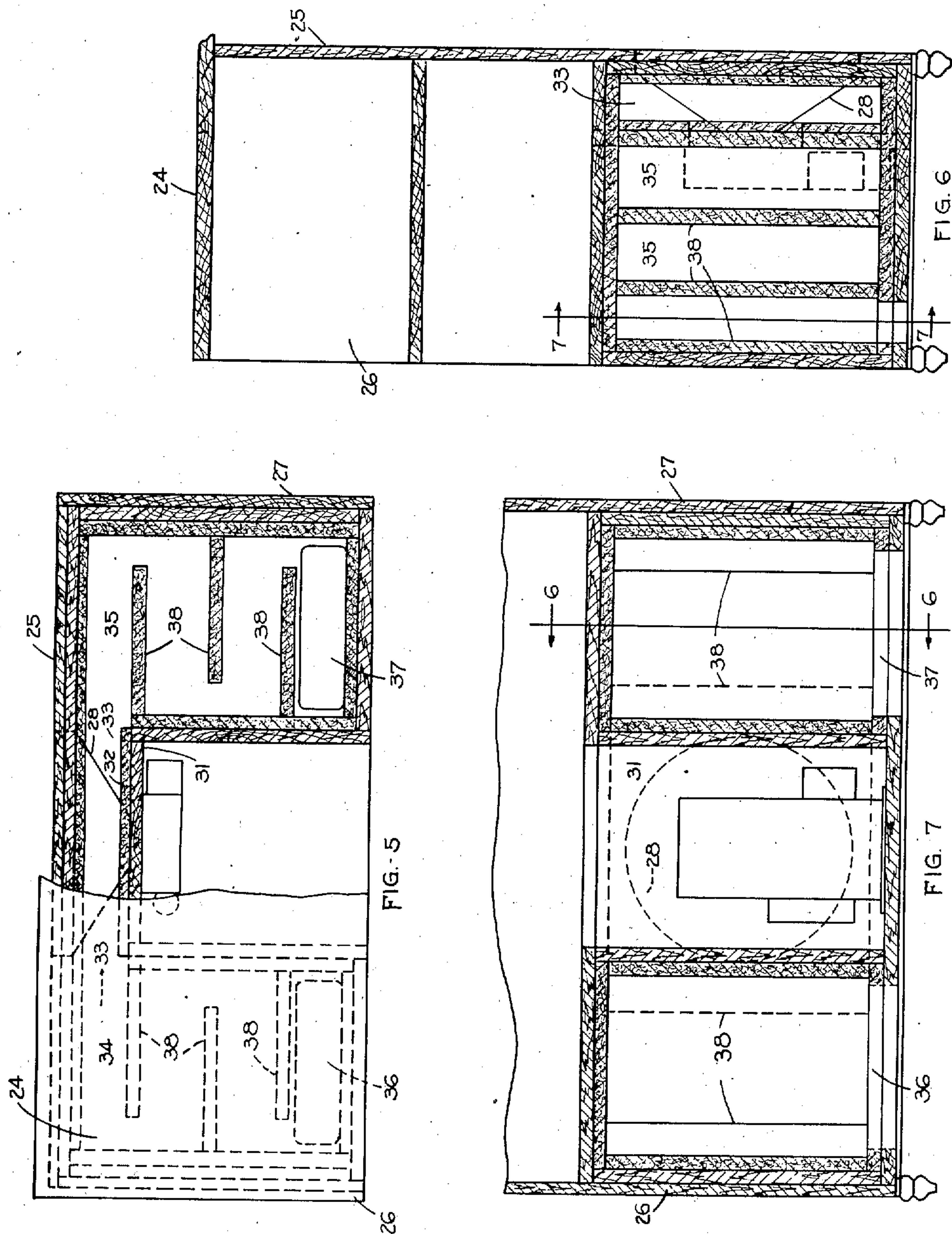
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SOUND REPRODUCING SYSTEM

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19 Claims. (Cl. 181—31)

This invention relates to sound reproducing systems.

When a loud speaker of the open radiator type such as a cone type loud speaker is mounted in a cabinet, the sound reproduction thereof is always marred by so-called cavity resonance which manifests itself in a disagreeable "booniness" and an apparent lowering of the pitch of speaking voices. This is due to the fact that a loud speaker cabinet, although open at a side or an end, otherwise encloses a column of air at the rear of the loud speaker and therefore acts like any well-known resonator in which the resonance is due to the reaction between the mass and the stiffness of a partially enclosed column of air. The resonant frequency and the intensity of resonance of such a cabinet varies with its position relative to the walls of the room and surrounding objects, the resonant frequency being lowered and the strength of the resonance being augmented when the back of the cabinet is placed close against a wall. While cavity resonance in a cabinet provided with an open radiator type of loud speaker may be minimized by careful cabinet design, in so far as applicant is aware, such resonance has never been completely eliminated.

It is recognized that a cone type loud speaker mounted in a baffle of limited size is very inefficient in handling power at low frequencies due to the fact that the loud speaker has an insufficient acoustic load at certain of the lower frequencies and consequently, at these lower frequencies, the loud speaker may chatter as a result of its moving coil striking the pole pieces of the speaker on relatively large surges of current in the moving coil such as occur when loud passages of music or the like are reproduced.

Commercial open radiator or cone types of loud speaker have a poor response at the lower frequencies, notably frequencies below one hundred cycles, so that bass voices and the music from bass instruments are only weakly reproduced thereby at such frequencies.

In accordance with the main feature of the present invention, means are provided in a sound reproducing system which substantially eliminates the air cavity resonance effect of a loud speaker cabinet forming a part of such system.

An additional feature of the invention relates to means in a sound reproducing system for suppressing or absorbing substantially all of the sound waves of higher frequencies transmitted from one surface of an exposed radiator such as a cone type loud speaker incorporated in said system while discharging into free air, certain un-

absorbed low frequencies transmitted from said surface.

A further feature of the invention relates to a loud speaker system provided with a conduit or passageway lined with sound absorbing material and having substantially the form of a labyrinth into which the sound waves radiated from one surface of a sound radiator of the loud speaker, are discharged.

Still a further feature of the invention relates to a loud speaker system provided with a conduit suitably lined with sound absorbing material and of such length as to resonate at those lower frequencies at which the loud speaker is an inefficient reproducer so that the low frequency response of the loud speaker is extended.

These and other features of the invention will appear from the detailed description and claims when taken with the drawings in which Fig. 1 is a fragmentary plan view of a cabinet containing the sound reproducing arrangement of the present invention; Fig. 2 is a vertical section section thereof taken substantially on the line 2—2 of Fig. 3; Fig. 3 is a vertical sectional view taken substantially on the line 3—3 of Fig. 2; Fig. 4 is a chart showing the differences in response of a given sound reproducing system with and without the arrangement disclosed in the foregoing figures; Fig. 5 is a fragmentary plan view of a cabinet containing a modified type of sound reproducing system; Fig. 6 is a vertical section view thereof taken on the line 6—6 of Fig. 7; and Fig. 7 is a sectional view taken substantially on the line 7—7 of Fig. 6.

While the invention may have various embodiments, one form thereof is illustrated in Figs. 1, 2 and 3 in which the sound reproducing system is housed in a cabinet made of wood or like material. This cabinet includes a top 5, sides 6 and 7, and a front or baffle 8, the rear and bottom of this cabinet being conveniently left open. A loud speaker of the open radiator type such as a dynamic cone type loud speaker 9 is mounted in the cabinet with the frame 10 (Fig. 3) of its diaphragm 11 closely engaging the margin of an opening 12 in the baffle 8 so that the front surface of the diaphragm transmits reproduced sound waves through this opening. It will be understood that in the construction just described, which follows current practice, the rear surface of the diaphragm transmits sound waves into the space within the cabinet. The top, sides and front or baffle of the cabinet form a partial enclosure which acts as a resonator for the sound waves transmitted from the rear surface of the dia-

phragm 11 and develops a series of undesirable fundamental resonances and harmonics thereof indicated by the peaks such as R1, R2, R3, R4 etc. represented by the broken line response curve A of Fig. 4. As a result of these resonances certain frequencies are reproduced with intensities out of proportion to the remaining frequencies. Such a sound reproducing system is also deficient in that it affords poor reproduction of the low frequencies notably those below one hundred cycles as indicated at D in the response curve A of Fig. 4. This poor reproduction at such low frequencies arises from the fact that it is impractical to provide a commercial cabinet having a sufficiently large baffle area to prevent the circulation of air from the front surface of the diaphragm to the rear surface thereof and vice versa. This poor reproduction at the mentioned low frequencies also arises from the fact that prior loud speakers having an open type of radiator, could not be provided with a sufficient acoustic load to prevent the moving coil of the diaphragm from striking the pole pieces of the actuating unit of the loud speaker on relatively large surges of current in the moving coil, such as occur in the reproduction of loud passages of music and the like. If the moving coil were permitted to strike the pole pieces in the manner just described, it would cause a rattling or chattering sound which would be highly unpleasant to the listener. In order to prevent such rattling of the loud speaker, it has been the common practice to provide such a rigid mounting for the moving coil thereof that this coil could not strike the pole pieces of the actuating unit. However, such a rigid mounting prevented the diaphragm from moving freely in response to the currents of lower frequency and consequently the sound reproducing system had a poor low frequency response.

In accordance with the present invention an arrangement is provided which eliminates the disadvantages of such former sound reproducing systems. While this arrangement may take various forms, as shown in Figs. 1, 2 and 3, it comprises a housing made in two parts designated 13, 13 which with the bracket 10' forming a part of the frame of the loud speaker completely encloses the rear surface of the diaphragm 11 so that none of the sound waves from the rear surface of this diaphragm are transmitted into the space within the cabinet. It will be noted that the interior of the housing comprising the parts 13, 13, is lined with felt 14 or other suitable sound absorbing material. The parts 12 and 13 respectively communicate with the conduit 17 through the slots or openings 15 and 16 which are symmetrically placed with respect to the rear surface of the diaphragm 11. Substantially all of the inner surfaces of this conduit are lined with a sound absorbing material 18 such as rock wool or other material of like characteristics. Since it is desirable to have the conduit 17 of relatively great length and since it is highly desirable in commercial cabinets that they be of relatively small size, the conduit is herein shown as being folded back and forth upon itself, in other words, it comprises a circuitous passageway. The conduit 17 discharges into free air through a slot 19 at the bottom of the cabinet, this slot preferably being positioned as acoustically remote as possible, consistent with the size of the cabinet, from the front surface of the diaphragm 11. This arrangement tends to prevent the circulation of air from the

front surface of the diaphragm to the rear surface thereof and vice versa.

It should be mentioned that the conduit is preferably made of uniform rectangular cross section since by this arrangement a maximum area of sound absorbing material can be brought in contact with sound waves in any given cabinet. The cross sectional area and the shape of the conduit and consequently, the size and shape of the orifice 19 have an important bearing on the operation of the system. In the first place, it is necessary that this cross sectional area be at least one-half the projected area of the diaphragm in order that the stiffness reactance of the air in the conduit may not become sufficiently great to interfere with the motion of the loud speaker diaphragm at low frequencies. This cross sectional area is also made large because of the fact that in a pipe of large proportions, the overtones are thrown somewhat out of tune with the pipe and are not readily excited therein. The cross section of the conduit and consequently, the shape of its orifice is in a form of an elongated slot which provides poor efficiency for the radiation of low frequency sounds. This reduces the radiation which occurs at the fundamental resonance of the conduit. As a result of the acoustically remote positioning of the orifice 19 with respect to the front surface of the diaphragm, the loss of low frequencies due to circulation between the two surfaces of the diaphragm is largely prevented. While there can be reasonable variations in the cross sectional area of the conduit and its length, it has been found empirically that a conduit having a cross-section of the form of a rectangle, the dimensional ratio of the sides of which is not less than 1:3.7 is satisfactory. The conduit preferably has a ratio of effective length in inches to its cross-sectional area in square inches of not greater than 1 to 3.5. The length of the conduit may be restricted in practice by the amount of room available in the cabinet with some sacrifice in results, but the ideal length however, is such that the fundamental resonance of the pipe occurs just below the frequency at which the loud speaker cabinet becomes increasingly ineffective as a baffle as diagrammatically indicated by the portion D of the response curve A of Fig. 4. By proper proportioning of the dimensions of the conduit, this resonance may be caused to extend, in a smooth manner, the response of the loud speaker at the lower frequencies where ordinarily the efficiency would be poor due to limitations in baffle size. The sound absorbing lining of the conduit together with the poor radiation afforded by the slot shaped orifice 19 prevent the fundamental resonance from being excessively strong and also serve to broaden this resonance considerably. As a result of adding the present invention to the cabinet previously referred to, the response of the sound reproducing system is transformed from its condition as indicated in the broken line response curve A of Fig. 4 to the condition indicated by the response curve B illustrated in full lines in this figure. From this chart it will be seen that the low frequency response of the system has been greatly extended in range and the resonant or peaked frequencies have been largely reduced so that the system affords a uniform or substantially straight line response over an extended frequency range.

It has been mentioned that the openings 15 and 16 in the housing are symmetrically placed with respect to the rear surface of the diaphragm.

This is done so that the diaphragm may not be driven out of line due to an unbalanced acoustic load.

It should also be mentioned that experiments thus far conducted indicate that the acoustical impedance presented to the rear of the diaphragm by the conduit 17, at very low audible frequencies has the characteristics of a mass reactance which is large as compared with that of said diaphragm including the acoustic load on its freely transmitting side, so that it is possible to greatly reduce the rigidity of the center mounting of the diaphragm 11 without its moving coil striking the pole pieces on relatively large surges of current. This reduced rigidity of the mounting permits the diaphragm to respond more freely at the mentioned lower frequencies. This acoustic impedance at one low audible frequency has the characteristics of a pure resistance while at audible frequencies higher than the last-mentioned frequency, this impedance has the characteristics of a compliance reactance associated with a resistance, the magnitude of the resistance component with respect to the compliance component becoming greater as the frequency increases and becoming predominant at the higher audible frequencies. These characteristics of the mentioned acoustic impedance together with the resonance of the conduit 17 at the lower frequencies explain the greatly improved lower frequency response of the present sound reproducing system.

In certain sound reproducing systems where it is desirable to provide a loud speaker having a diaphragm of greater diameter than that illustrated in Fig. 1, it may not be convenient to arrange the conduit in the manner shown in Fig. 3. Under such conditions, a modified form of the invention as shown in Figs. 5, 6 and 7 may be employed. As before the system is housed in a cabinet having a top 24, sides 26 and 27, and baffle 25 of well-known construction which cabinet can conveniently be open at the rear and the bottom. In this arrangement the loud speaker which includes the diaphragm or radiator 28, is suitably mounted behind the front or baffle of the cabinet with the front surface of the diaphragm transmitting sound waves generated thereby through the opening in the baffle. The rear surface of the diaphragm 28 is enclosed in a housing generally designated 31 which housing is suitably lined with felt 32. This housing has openings 33 and 33 respectively communicating with two separate conduits 34 and 35. Each of these conduits is lined with a sound absorbing material 38 such as rock wool or the like and is folded back and forth upon itself as a circuitous passageway in order to afford relatively great length for the conduit while still maintaining it in compact form. These conduits respectively open into free air through rectangular slots 36 and 37 in the bottom of the cabinet. This arrangement of these mentioned slots effects the discharge of the sound waves from the rear surface of the diaphragm as acoustically remote as possible from the front surface of the diaphragm as is consistent with a given cabinet size. Each of these conduits preferably has its dimensions comparable with those of the conduit of Figs. 1, 2 and 3.

Listening tests of the above systems show an entire lack of the customary boominess associated with cabinet loud speakers and it has been found that the naturalness of the reproduction has been greatly increased.

In addition to the improvement in reproduction described above, there are other advantages to be had from the use of the system of the present invention. The loud speaker cabinet may be placed tightly against the wall without changing its operating characteristics or it may be used, for example, on a stage where the acoustics at the back of the loud speaker may be poor and which would give inferior results with the loud speaker radiating freely from both sides of its diaphragm. On account of the loud speaker radiating from one side only of its diaphragm over the greater part of the frequency range, the standing wave pattern in the room due to the interference of sound waves is greatly simplified. Furthermore, since sound is not being discharged into the back of the cabinet, the likelihood of acoustic coupling due to the mechanical vibration of the vacuum tubes and condenser plates in the radio receiver chassis which is commonly mounted within the cabinet, is greatly reduced. For a like reason there is much less trouble from rattling of the cabinet and the radio receiver chassis parts, due to acoustic driving.

What I claim is:

1. The method of improving the sound reproduction of an open diaphragm type of loud speaker which comprises transmitting to the atmosphere substantially unmodified sound waves from one surface of said diaphragm, absorbing in a folded passageway by multiple reflection from the surface of material having a high degree of acoustic absorption, the major portion of the range of audio frequencies of sound waves transmitted from the other surface of said diaphragm, and simultaneously resonating a certain remaining portion of the frequency range of sound waves transmitted from said last-mentioned diaphragm surface.

2. The method of improving the sound reproduction of an open diaphragm type of loud speaker which comprises transmitting substantially unmodified sound waves to the atmosphere from one surface of said diaphragm, absorbing substantially all frequencies above 100 cycles transmitted from the other surface of said diaphragm, resonating certain of the unabsorbed frequencies radiated from the last-mentioned surface of the diaphragm, discharging the resonated frequencies at a point remote from the first-mentioned surface of said diaphragm, and utilizing the resonated frequencies to augment the response of the loud speaker at certain frequencies.

3. In combination with a loud speaker having an exposed radiating diaphragm and actuating means therefor, a housing enclosing one surface only of said diaphragm, the other surface of said diaphragm being in free and unrestricted communication with the atmosphere, and a sound damping conduit communicating with the interior of said housing and extending therefrom to free air at a point remote from the other surface of said diaphragm, said conduit comprising material having a high degree of acoustic absorption.

4. In combination with a loud speaker having an exposed radiating diaphragm and actuating means therefor, a housing enclosing one surface only of said diaphragm the other surface of said diaphragm being in free and unrestricted communication with the atmosphere and a folded sound absorbing conduit of substantial length communicating with the interior of said housing and extending therefrom to free air.

5. In combination with a cabinet having an

opening in one wall thereof, a loud speaker having an exposed radiating diaphragm one surface of which is arranged to transmit sound unrestrictedly through said opening to the atmosphere and actuating means for said diaphragm, a housing enclosing the other surface of said diaphragm and a sound damping structure within the cabinet defining a circuitous sound passageway extending from the interior of said housing to free air at a point located as acoustically remote as possible from the first mentioned surface of the diaphragm consistent with the size of the cabinet.

6. In combination with a loud speaker having an open type of radiating diaphragm and actuating means therefor, a housing enclosing one surface only of said diaphragm the other surface of said diaphragm being in free and unrestricted communication with the atmosphere, and a circuitous sound damping conduit communicating with the interior of said housing and extending therefrom to free air, the cross sectional area of said conduit being at least equal to one-half of the projected area of said diaphragm.

7. In combination with a loud speaker having an open radiating diaphragm and actuating means therefor, a housing enclosing one surface only of said diaphragm, the other surface of said diaphragm being in free and unrestricted communication with the atmosphere, and a circuitous sound damping conduit lined with sound absorbing material communicating with the interior of said housing and extending therefrom to free air.

8. In combination with a loud speaker having an open radiating diaphragm and actuating means therefore, a housing enclosing one surface only of said diaphragm, the other surface of said diaphragm being in free and unrestricted communication with the atmosphere, and a pair of sound damping conduits opening into said housing symmetrically with respect to said surface of said diaphragm and communicating with free air, said conduits having their inner surfaces treated with sound absorbing material.

9. In a sound reproducing system, a cabinet having an opening in one wall thereof, a loud speaker mounted in said cabinet and including a radiator of the type which radiates sounds from both of its surfaces, one of said surfaces radiating substantially unmodified sound to the free atmosphere only through said opening, and means including a conduit communicating with said other surface for discharging sound at a point outside of said cabinet, said conduit including sound damping material and having a length greater than the greatest dimension of said cabinet whereby sound radiated from the other surface of said radiator is not discharged within the enclosure of said cabinet.

10. In a sound reproducing system, a cabinet having an opening in one wall thereof, a loud speaker mounted in said cabinet and including a radiator the front surface of which radiates sound only through said opening in free and unrestricted communication with the atmosphere, and a folded conduit for resonating and conducting certain of the frequencies of the sound radiated from the rear surface of said radiator to a point acoustically remote from said front surface.

11. In a sound reproducing system, a cabinet having an opening in one wall thereof, a loud speaker mounted in said cabinet and including a radiator of the type which radiates sounds from both surfaces thereof, the front surface of said

radiator radiating unmodified sound only through said opening to the atmosphere, and a folded conduit for conducting sound radiated from the rear surface of said radiator to a point acoustically remote from said surface, said conduit being lined with acoustically absorbent material.

12. In a sound reproducing system, a cabinet having an opening in one wall thereof, a loud speaker mounted in said cabinet and including a diaphragm of the type which radiates sounds from both of its surfaces, the front surface of said diaphragm radiating unmodified sound to the atmosphere only through said opening, and a conduit of uniform cross section throughout its length for conducting sound radiated from the rear surface of the diaphragm to a point acoustically remote from the front surface thereof, said conduit being lined with acoustically absorbing material.

13. In a sound reproducing system, a cabinet having an opening in one wall thereof, a loud speaker mounted in said cabinet and including a diaphragm of the type which radiates sounds from both of its surfaces, one of said surfaces radiating unmodified sound to the atmosphere only through said opening, and a conduit of uniform cross section throughout its length for conducting sound radiated from the other surface of the diaphragm to a point acoustically remote from said opening, said conduit having a cross section of which the ratio of length to width thereof is greater than 1 to 3.7.

14. In a sound reproducing system, a cabinet having an opening in one wall thereof, a loud speaker mounted in said cabinet and including a diaphragm of the type which radiates sounds from both of its surfaces, one of said surfaces radiating unmodified sound to the atmosphere only through said opening, and a conduit of uniform cross section throughout its length for conducting sound radiated from the other surface of said diaphragm to a point acoustically remote from said opening, said conduit having a ratio of effective conduit length in inches to cross sectional area in square inches less than 1 to 3.5.

15. In a sound reproducing system, a cabinet having an opening in one wall thereof, a loud speaker mounted in said cabinet and including a radiator radiating unmodified sound from its front surface through said opening only, a folded conduit lined with sound absorbing material for discharging sound radiated from the rear surface of said radiator, through the bottom of said cabinet at a point acoustically remote from said front surface.

16. In combination, a baffle having an opening therein, a loud speaker including a radiating diaphragm with its margin mounted in a frame engaging the margin of said baffle at said opening whereby sound is transmitted to the atmosphere substantially unmodified from one surface of said diaphragm through said baffle opening, actuating means for said diaphragm, and means including a conduit treated internally with sound absorbing material and leading from the other surface of said diaphragm to free air at a point remote from said first-mentioned surface of said diaphragm, said conduit having a relatively small cross-sectional area as compared with the area of said baffle.

17. In combination, a baffle having an opening therein, a loud speaker including an exposed radiating diaphragm having one of its surfaces adjacent said opening for transmitting substan-

5 tially unmodified sound therethrough to the atmosphere, actuating means for said loud speaker, a housing enclosing one surface only of said diaphragm, and a folded sound absorbing conduit
10 of substantial length communicating with the interior of said housing and extending therefrom to free air.

18. In a sound reproducing system a baffle having an opening therein, a loud speaker including
10 a diaphragm having one surface mounted adjacent the opening in said baffle and arranged to radiate unresonated sound to the atmosphere from said surface only through said opening, and
15 means including a folded conduit having its inner surface treated with sound absorbing material and leading from the other surface of said

diaphragm to free air at a point acoustically remote from said first-mentioned surface.

19. In combination, a baffle having an opening therein, a loud speaker including an exposed radiating diaphragm having one of its surfaces
5 adjacent said opening transmitting unresonated sound therethrough to the atmosphere, actuating means for said loud speaker, a housing enclosing one surface only of said diaphragm and a
10 folded sound absorbing conduit of substantial length leading from the interior of said housing to an opening discharging into substantial free air, the general plane of the margin of said discharge opening extending in a direction substantially at right angles to the principal plane
15 of said baffle.

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