Sept. 15, 1942. R. E. BOWLEY 2,295,527

ELECTRODYNAMIC AND ELECTROACOUSTICAL APPARATUS

Filed Oct. 17, 1940

Fig-1-

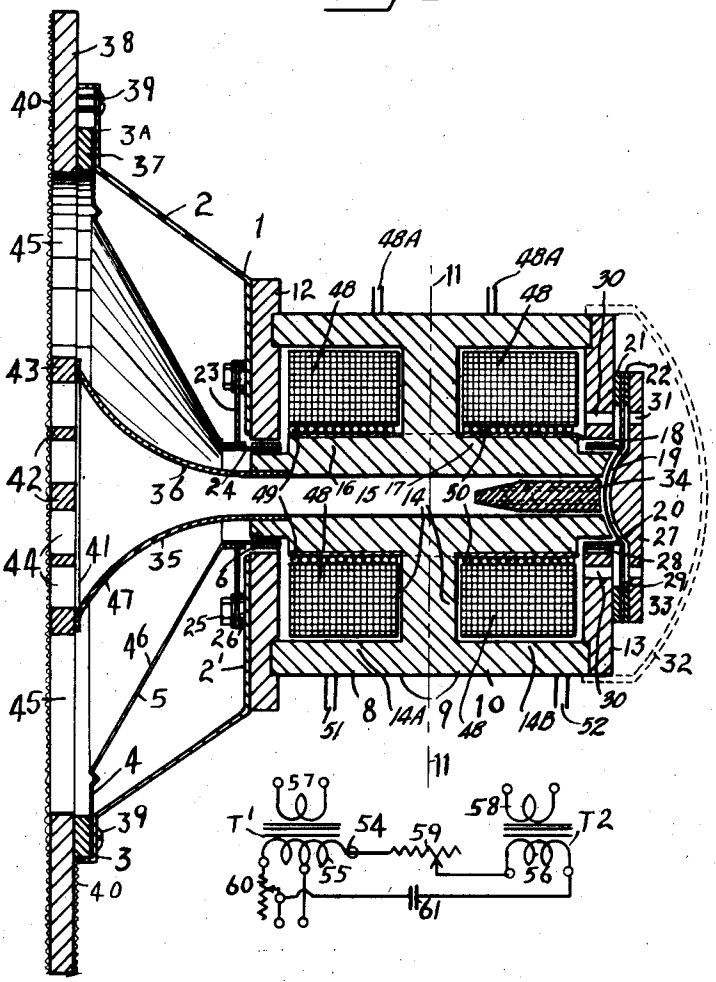


Fig-2-

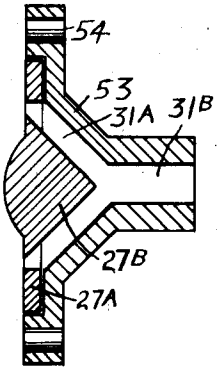


Fig-3-

INVENTOR

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Patented Sept. 15, 1942 2,295,527

UNITED STATES PATENT OFFICE

2,295,527

ELECTRODYNAMIC AND ELECTROACOUSTICAL APPARATUS

Raymond E. Bowley, San Anselmo, Calif., by decree of distribution to Eve Mary Bowley

Application October 17, 1940, Serial No. 361,593

2 Claims. (Cl. 179—116)

This application for U. S. Letters Patent is a modification and continuation in part of Patent No. 2,189,161 issued February 6, 1940, and copending application for Letters Patent in U. S. Serial No. 317,266 filed February 5, 1940, allowed May 29, 1941, not issued. This invention is also a modification of the apparatus described and claimed in Reissue Patent No. 20,395 issued June 8, 1937; carrying forward the basic idea and the method and apparatus therein disclosed in other species of the invention.

The present invention relates to an electro-acoustical system; to loud speakers; to microphones; and to similar electro-acoustical devices. More particularly it relates to such devices having electro-dynamic means for actuating the diaphragm thereof, wherein the diaphragm carries a signal current coil mounted thereon and projected flexibly movable in a magnetic air-gap.

The invention relates more particularly to an electro-acoustical device comprising two sound reproducing diaphragms each carrying a signal current coil in a magnetic air-gap, wherein one diaphragm is larger than the other and is of the direct acting type, and the smaller diaphragm is of the relatively solid small type in acoustic relationship with a tubular resonant air column or with the air column of a horn passing through the inner pole portion of the electro-dynamic actuating unit and also through the center of the direct acting type diaphragm, whereby both diaphragms will project sound waves in substantially the same general direction and in substantially concentric relationship, the sound waves passing through an orificed baffle in acoustical coupled relationship with the direct acting type diaphragm.

The present invention also relates to an improved electro-acoustic system comprising electro-dynamic means for actuating the diaphragm or diaphragms thereof, at least one direct acting type diaphragm, orificed baffle means acoustically coupled with the diaphragm, and a dividing-compensating-coupling circuit network in cooperative combination, employing acoustical conduction resonance action to the rear of the orificed baffle.

An object of the present invention is to provide a method and apparatus of the character described adapted for faithfully responding over a wide band of audio frequencies substantially in accordance with a desirable characteristic curve according to a broad band width having a sharp cut-off and at the same time preserving a sufficiently level response over a wide band width.

Another feature of the present invention provides an attachment for use in combination with the two diaphragm loud speaker, for attaching the loud speaker to a conventional horn, for example, to a theatre horn or an auditorium horn, for replacing the single diaphragm loud speaker units of the prior art, or for replacing the two loud speakers of the prior art sound systems with a two diaphragm single loud speaker adapted for more faithful reproduction of sound over a wider band of audio frequencies, for effectively improving the articulation, the intelligibility and the illusion of reality desired by theatre managers and sound engineers. This feature of the invention is also adapted for use in radio-audio, and in radio-audio-television receiving systems by employing tubular acoustical conduction within the apparatus cabinet behind the baffle acoustically associated with the direct acting type diaphragm, in a modification of the apparatus described and claimed in one or the other of my reissue U. S. patent, Re. 20,395 hereinbefore identified. A cooperative orificed baffle modification of the apparatus described in this reissue patent is shown and described herein with reference to the accompanying drawing.

The coupling-dividing, or compensating coils, transformers and circuit networks herein shown and described are modifications of the apparatus described in either my U. S. Patent No. 2,189,161 issued Feb. 6, 1940; or in my copending application for Letters Patent in the U. S. Serial No. 317,266 filed Feb. 5, 1940.

Other features of my invention too numerous to relate in detail will be disclosed in the description with reference to the accompanying drawing taken together or separately. For the sake of explaining the principles of the invention, I will now describe illustrative embodiments thereof. The drawing is for illustrative purposes only and is not drawn to scale. The details of mechanical construction being left to the skill of experienced workmen employing the apparatus herein described and claimed.

In the drawing:

Fig. 1 represents a modification of electro-acoustical and electro-dynamic apparatus embodying the invention.

Fig. 2 represents an attachment for connecting the device shown in Fig. 1 with an external horn, or with a tubular resonant air-column load.

Fig. 3 represents a coupling and dividing net-

work for connecting the signal current coils of the device shown in Fig. 1 to a circuit network.

Referring to the drawing:

In Figures 1 to 3: electro-acoustical devices of the electro-dynamic type may be electro-magnetically energized, or they may be of the permanent magnet type, according to the particular conditions encountered.

For example, in a radio-audio receiving system operating from a power supply line, the electro-magnetic field supply by means of a field coil may be satisfactorily employed, but in auto-radio-audio systems and farm battery radio-audio systems, and in address-auditorium and theatre sound systems where the loud speaker is often located at a distance from the audio frequency amplifier and from the power source, permanent magnet electro-dynamic loud speakers are preferably used.

The modifications illustrated in the accompanying drawing show the electro-magnetically energized system, but it is understood that in order to get maximum usefulness from this invention either method of energizing the magnet of the electro-dynamic actuating means may be employed within the scope of the claims.

Permanent magnet devices are also employed with electro-dynamic microphones. Therefore when the devices of the present invention are used as microphones or in systems where the electro-magnetic field supply is not readily available, the devices of this invention may be of the permanent magnet electro-dynamic type.

The form of the magnet illustrated readily adapts the magnet for either a permanent magnet or an electro-magnet. When used as an electro-magnet an H form as shown may be used, or any other suitable form. When used as a permanent magnet an H form may be used or any other form may be used. When separated the magnet may be U shaped, or round, or any other practical shape.

The diaphragms may be arranged whereby one diaphragm responds more effectively at one end of the audio range of frequencies, while the other diaphragm deals more effectively with the other end of the audio band of frequencies. Or any desirable relative response arrangement may be employed for obtaining desired results.

Parallel magnetic circuits are employed for more flexibility in obtaining compensation and tone control than may be had from a series magnetic circuit arrangement, where any compensation applied to one magnetic pole and air-gap, or to the associated signal current coil in the said air-gap will also tend to modify currents passing in the series magnetic circuit through the other pole end and magnetic air-gap and through the second signal current coil therein. In the parallel magnetic circuit system of this invention improved electro-acoustical and electro-dynamic features are provided.

Cooperative orificed baffle means is another feature of the invention in the acoustical compensation portion thereof for cooperating with the direct acting type diaphragm of the invention.

Sound waves continue to spread in free air, with only a very small loss due to the absorption of the sound by the air itself. When however, the waves reach any solid body, they are in general partly transmitted, partly reflected, and partly absorbed. Many solids as is well known transmit or conduct sound very well indeed. The transmission or conduction may be partly due to a resonant diaphragm action, if the solid is in the form of a panel, as an orificed baffle, by sound-board resonance action when the orificed baffle is cooperatively acoustically coupled with a loud speaker as herein shown in the accompanying drawing and described in the specification, which is in accordance with my U. S. Reissue Patent 20,395 hereinbefore identified.

When a direct acting type diaphragm produces the lower tones, the slow air oscillations corresponding to these tone ranges on either side of the diaphragm have, as is known, the tendency to equalize around the rim or periphery of the diaphragm.

In order to obviate this, a baffle is usually arranged to extend from adjacent the periphery of the diaphragm. The orificed baffle of the present invention not only prevents the direct equalization of the air vibrations corresponding to the lower tones, but intensifies them by resonance.

Baffle, or sound-board resonance added to resultant tones tends to effect the lower tones more than the higher tones. The lower tone ranges are usually not brought out with proper effective proportionate relationship with other higher tones by the diaphragm alone.

The acoustical coupling between the peripherial portion of the loud speaker and the associated baffle are very important features determining the quality of tones emanating from apparatus of the class herein described. The tubular resonant air column conduction action of the present invention in cooperation with the orificed baffle of the device tends to bring out a wider band of audio frequencies having improved resultant tones.

In Fig. 1, electro-dynamic electro-acoustical device 1 may be a loud speaker 1, a microphone 1, or both a loud speaker and a microphone in a single unit 1, wherein one diaphragm may be connected for use as a microphone and the other diaphragm connected for use as a loud speaker.

Element 2 is a mounting for the unit having an annular peripherial supporting portion 3 or 3A for the direct acting type diaphragm 5. The flanged periphery 4 of the substantially conical diaphragm 5 is supported by the mounting portion 3—3A of the mounting 2 and the ring shaped or annular baffle portion 37 of mounting 2. Mounting portions 3 and 3A show two different arrangements. Arrangement 3A is a modification of the apparatus described and claimed in Re. Patent No. 20,395.

Mounting portion 3 is a modification showing one of the soundboard and loud speaker arrangements in combination with a ring shaped auxiliary baffle member 37, described and claimed in my U. S. Reissue Patent No. 20,467.

Auxiliary baffle member 37 interposed between the flanged periphery 4 of diaphragm 5 and the rear surface of orificed baffle 38 spaces the periphery 4 of diaphragm 5 rearwardly from baffle 38. Auxiliary baffle member 37 may be composed of any suitable material adapted for cooperatively and freely conducting sympathetic vibrations between the mounting portion 3—3A and the flanged periphery 4 of diaphragm 5 and the rear surface of the orificed baffle 38 whereby sound vibrations are caused to be modified or modulated by means of cooperative acoustical conduction resonance action between the said associated elements 3—3A, 4 and 37 in combination with sound board resonance action of the orificed baffle 38.

Screws or bolts 39 secure device 1 on the rear side of the baffle 38. Baffle 38 forms a baffle

"support" for the electro-acoustical electro-dynamic device 1. Fabric 40, which may be for ornamental purposes, or for acoustically damping the resonant action of baffle 38, or which may be both useful and ornamental, is applied to the front surface of baffle 38 and across the orificed portion thereof.

A suitable gasket 41 of cardboard, fibreboard, rubber, felt, or other suitable material is applied between the front end of the horn 35 and the annular portion 43 of baffle 38, the baffle portion 43 provides the orificed portion 44 in baffle 38 substantially concentric with diaphragm 5 and a larger orificed portion 45 providing free passage for sound waves between the front surface 46 of diaphragm 5 and the outer surface 47 of the horn 35 to the atmosphere, or from the atmosphere to the fluid area between the inner surface 46 of diaphragm 5 and the outer surface 47 of horn 35.

Grill elements 42 may be provided across the orificed portion 44 of baffle 38 for ornamental purposes, for protective purposes, or for providing damping compensation for the resonant air column 36 within horn 35.

Baffle "support" 38 may be composed of metal, wood, cardboard, fibreboard, ply-board, or other suitable material. The baffle 38 may be an element of device 1 forming a support for device 1, or baffle 38 may be mounted in a cabinet, or baffle 38 may be mounted on a radio-audio receiver chassis, or in any other suitable arrangement within the spirit of the invention, subject to my U. S. Reissue Patent 20,395 hereinbefore identified.

Mounting 2 of device 1 may be U shaped, or the mounting 2 may be stamped out of any suitable sheet material, which is lighter, cheaper, and simpler for construction purposes than prior art solid or rigid cast mountings.

Direct acting type diaphragm 5 carries a signal current coil 6 projected in the magnetic air-gap 7 of the electro-dynamic actuating unit 9.

Electro-dynamic actuating unit 9 has parallel actuating units 8 and 10, providing parallel magnetic circuits divided at the cross-sectional line 11 shown in Fig. 1. Magnet portion 8 has an outer apertured pole plate 12 forming a support 12 for attaching the unit 9 to the mounting portion 2' of the mounting 2.

The other magnet portion 10 has an apertured outer pole plate 13 at the rear of device 1. Numeral 14 indicates a common magnet portion having an aperture 15 therein. Magnet portion 8 includes an inner pole piece 16. Magnet portion 10 includes an inner pole piece 17. Inner pole portions or pieces 16 and 17 are hollow and open at both ends. The outer end of pole piece 16 projects into aperture 7 in outer pole plate 12 forming the annular air-gap 7. The outer end of inner pole piece 17 projects into aperture 18 in the outer pole plate 13 forming the annular air-gap 18.

A relatively solid small type diaphragm 19 having a dome shape and a peripherial supporting portion and carrying a signal current coil 20 projected in the magnetic air-gap 18, is mounted between rings of suitable material 21—22, such as cardboard, fibre, leather etc., and attached to the outer side of the pole plate 13, the diaphragm 19 being in acoustic relationship with the air column 15 within the inner pole portions 16—17 and common magnet portion 14.

The inner ends of pole pieces 16 and 17 are butted against the common portion 14 of the magnet 9 on opposite sides of aperture 15 so that a single tubular air column 15 is formed thereby open at both ends.

The magnet portions 14—14A and 14—14B may be cast of suitable material in one piece or block, or the magnet portions 14—14A and 14—14B may be separately stamped out of suitable sheet metal in U shape. The two separate portions may then be placed back to back as shown by numerals 8 and 10 and fastened securely together forming a single unit 9. Various means are suitable for fastening portions 8 and 10 together when this construction is employed, such as welding, riveting, bolting, screwing, etc. The inner pole portions 16 and 17 may be a single element 16—17 inserted through aperture 15 in common magnet portion 14 and securely fastened to portion 14 with the outer ends thereof projecting into apertures 7 and 18 in outer pole plates 12 and 13 respectively forming the magnetic air-gaps 7 and 18 therein, in which case air column 15 is separated from aperture 15 in the common magnet portion 14 through which the inner pole portion will project, as shown by the dashed lines in Fig. 1 across portion 14. The drawing shows the magnet portions 14—14A and 14B cast in block. The particular details of mechanical construction will vary according to the particular conditions encountered depending obviously greatly upon the particular use to which the device will be put, and are therefor left to the skill of the experienced workmen employing this method and apparatus within the spirit of the invention and the scope of the claims, various modifications being possible, according as to whether the device is employed as a loud speaker, or as a microphone, or as both a loud speaker and as a microphone wherein one diaphragm is constructed and arranged for a microphone and the other diaphragm for a loud speaker.

A flexible member 23 is attached to the cylindrical sleeve 24 carrying the signal current coil 6 on diaphragm 5, and is also attached to mounting portion 2' by screws 25. Washers 26 space flexible member 23 from mounting portion 2' for locating the signal current coil 6 in the proper position in magnetic air-gap 7 flexibly movable for best effective desired results.

The peripheral supporting portion of diaphragm 19 may be flat or corrugated according to the amount of flexibility desired. A member 27 secures the periphery of diaphragm 19 associated with rings 21 and 22 to the pole plate 13 so that a small resonance space or chamber 28 is formed between diaphragm 19 and pole plate 13; another small resonance space or chamber 29 being formed between the other surface of diaphragm 19 and the member 27.

Diaphragm 19 is attached to pole plate 13 so as to vibrate in accordance with electro-acoustical vibrations or currents associated therewith. The chambers 28 and 29 tend to provide compensation for controlling the mechanical motion of the diaphragm 19 utilizing the mass, elasticity and viscosity of the air to efficiently damp the mechanical motion of the diaphragm 19.

An aperture or apertures 30 through pole plate 13 provides air pressure or resonance release for modifying the damping effect of chamber 28 upon diaphragm 19. An aperture or apertures 31 provides air pressure or resonance release from chamber 29 for modifying the damping effect of chamber 29 on diaphragm 19. The dimensions of chambers 28 and 29, and of the apertures 30 and 31 may be proportioned so as to obtain the best acoustical damping effect and compensation

for maximum efficiency in accordance with a desirable characteristic curve according to a wide audio band width having a sharp cut-off and at the same time preserving a sufficiently level response over a wide band width.

A casing 32 may be employed in combination with device 1 and diaphragm 19 as part of actuating unit 9, providing an additional resonance chamber 33 forming an acoustical load on diaphragm 19 through the aperture or apertures 31 in member 27.

The insert 34 located in the tubular air column 15 within the inner pole portion 17 is secured concentrically therein in spaced relation to the walls of the air column 15 by means of suitable fins or guides, providing a load on the adjacent surface of diaphragm 19. The insert 34 is of such shape as to provide an air passage through the chamber 15 increasing in cross-section gradually from adjacent diaphragm 19. The insert may be solid as shown, or the insert 34 may be perforated by one or more tubular chambers, 75, as indicated by the dashed lines therethrough longitudinally therewith, the insert 34 may be in other forms, and when the device 1, or the portion 10 of device 1 is employed as a microphone the insert may be omitted.

A horn 35 having a resonant air column 36 therein may be attached to the forward end of inner pole portion 16 as shown. The forward end of pole portion 16 and walls of tubular air column 15 therein are recessed for having the horn 35 secured thereto so as to form an extension of the air column 15 through the open portion of direct acting type diaphragm 5 to a region in front of diaphragm 5 substantially concentric with the periphery thereof and substantially concentric with the orificed portion 45 of the baffle 38.

Diaphragm 5 is in the form substantially of a truncated cone having a flanged periphery 4, carrying a signal current coil 6 and having an open portion adjacent the signal current coil 6 through which horn 35 is projected.

When device 1 is employed as a two diaphragm loud speaker sound waves emanating from the diaphragm 19 will pass through air column 15 to air column 36 within horn 35 and through horn 35 to the region directly in front of diaphragm 5, in substantially the same general direction as sound waves propagated from the front surface of diaphragm 5 through orifice 45 in baffle 38 to the outer atmosphere and substantially concentric therewith.

Plural field coil windings 48 are applied to pole portions 16 and 17 for energizing the actuating unit 9. A stationary electro-dynamic compensating coil or biasing coil 49 is applied to pole portion 16 and connected in series with signal current coil 6 carried by diaphragm 5. Another stationary electro-dynamic compensating or biasing coil 50 is applied to pole portion 17 and connected in series with the signal current coil 20 carried by diaphragm 19.

The compensating or biasing coils 49 and 50 are features of the present invention carrying forward the basic idea disclosed in my U. S. Patent No. 2,189,161 issued Feb. 6, 1940.

In the present invention the coils 49 and 50 or a coil 49 or a coil 50 provides compensation tending to bring the two diaphragms into proper resonance for the most efficient operation in accordance with a desirable characteristic curve according to a wide audio band width having a sharp cut-off and at the same time preserving a sufficiently level response over a wide band width.

The compensating or biasing coils may be employed with either permanent magnet electro-dynamic devices or with electromagnetic electro-dynamic devices employing two or more diaphragms in a network system. Only a few turns are necessary for biasing coils 49 and 50. The coils 49 and 50 may be connected or arranged in various ways for providing compensation within the spirit of the invention and the scope of the claims. My Patent No. 2,189,161 covers the use of a stationary electro-dynamic coil in other single diaphragm arrangements.

Circuit leads 51 and 52 may be connected to any suitable audio frequency circuit system, in either the input portion of the circuit or the output portion of the circuit within the spirit of the invention without departing from the scope of the claims.

Circuit lead 51 is connected with coils 6 and 49; circuit lead 52 is connected with coils 20 and 50. Leads 48A are the field coil leads for field coil 48 applied to the actuating unit 9.

In Fig. 2, another modification of member 27 is shown, indicated by numeral 27A in combination with an attachment 53, for connecting the portion 10 of device 1 and diaphragm 19 with an external horn or tubular resonant air column load, such as a horn of the type employed in auditoriums, theatres and other places of entertainment, formed to project sound waves to the atmosphere at an angle of substantially 180° to the intake throat portion thereof.

The attachment 53 makes the device 1 suitable for a wider range of usefulness in the entertainment field. For example, a bass horn may be attached to device 1 by means of attachment 53 for bringing out the lower tones. The opposite surface of diaphragm 19 being operatively connected with the horn 35 arranged for higher frequencies, while the direct acting type diaphragm 5 may be arranged to function over the intermediate band of audio frequencies or any suitable portion of the audio frequency band, as between 50 cycles and 7,500 cycles, or between 300 cycles and 10,000 cycles, or diaphragm 5 may be arranged to bring out the lower frequencies and diaphragm 19 arranged to bring out the higher frequencies.

Instead of device 53 connecting device 1 with an external horn, the device 1 may be connected with a tubular air column within an apparatus cabinet and device 1 located in an apparatus cabinet, such as in combination with a radio-audio receiver, or with a common radio receiver and amplifier for picture and sound, in a modification of the apparatus described and claimed in my Reissue Patent Number 20,395 hereinbefore identified. The present invention carries forward the basic idea of the invention therein disclosed.

The portion 27B of element 27A is modified so that the aperture or apertures 31A provide passage means from diaphragm 19 to the throat 31B of the attachment 53 having impedance sufficient for providing a load on the adjacent surface of diaphragm 19. Apertures 54 are provided in device 53 for the passage of screws or bolts for attaching device 53 to actuating unit 9, or to portion 13 thereof.

In Fig. 3, a coupling-compensating-dividing network system is shown, indicated by numeral 54, which is a modification of the inductance-impedance combinations and circuit networks described and claimed in my U. S. Patent No. 2,189,161, and in my copending application for

U. S. Letters Patent Serial No. 317,266 hereinbefore identified, carrying forward the basic idea therein disclosed, providing a dividing network system **54** employing two transformers and inductance-impedance elements, in an audio frequency circuit system employing two diaphragms each diaphragm carrying a signal current coil connected to the network **54** by means of circuit leads **51** and **52**, shown in Fig. 1.

Transformer T' is described and claimed in U. S. Patent No. 2,189,161, having a winding divided at an intermediate tapping point **55** and an impedance comprising a transformer winding, in transformer T2, a resistance unit **59** and a condenser **61** and a resistance **60** connected in parallel with the outside tapping points of the transformer winding **55**.

Resistance units **59** and **60** are for individually adjusting or regulating the volume or tone associated with each coupled diaphragm, as **5** and **19** shown in Fig. 1. Resistance units **59** and **60** may be variable, or they may be of the type having a sliding contact adapted for being permanently secured in position when the proper setting is determined, or they may be fixed resistance units of the value found to effect the best cooperative results. Condenser **61** provides a capacitive impedance adapted for modifying the tones of current frequencies passing through transformer T2 and circuit **52** to diaphragm **19** in combination with winding **56** and resistance **59** forming an impedance in series with the transformer winding connected to point **54** of the dividing network system. Transformer windings **57** and **58** provide coupling network circuits for connecting the dividing network **54** with circuit leads **51** and **52** of device **1** shown in Fig. 1.

The device **1** in Fig. 1 is not shown connected to the coupling-dividing-compensating network **54** of Fig. 3 because I desire to bring out that this application is a continuation in part of my copending application Serial No. 317,266, and that the several coupling networks described and claimed therein provide improved coupling arrangements and circuit networks for connecting circuit leads **51** and **52** of the device **1** with the dividing circuit network leads and windings **57** and **58**, of the network system **54**, or of any other suitable network in an audio frequency circuit system.

We meet with resonance in the diaphragm of a microphone or of a loud speaker, in the human voice, in drums, disk recorders, and other places. Sounding bodies usually have several natural resonances, strings vibrate as a whole and also in parts, and the same is true of air columns, diaphragms and baffles or sound-boards. These various resonances are set up concidently and are responsible for the components or overtones elicited from the device or instrument. Without resonance there is no tone quality. A sound reproducing device designed to avoid resonance will eliminate the necessary components or overtones necessary for bringing out depth, timbre and brilliant tone quality.

In the case of the stringed instruments, including the piano, instruments of the violin family, plucked string instruments etc., the vibrations of the strings are communicated to the body or sounding board and the tone quality is determined by the resonance of the sounding board and the air-column of the resonance chamber of the instrument acting to blend overtones with the fundamental tones produced by the instrument.

This is the basic principle and the basic idea upon which my methods and apparatus are based.

"Cabinet cavity resonance" is another and different kind of resonance, (see "resonance" defined in Webster's International Dictionary.)

My methods and apparatus employ "resonant diaphragm and acoustical conduction resonance" action. My methods and apparatus avoid "cavity resonance" in the apparatus cabinet, that causes reverberation distortion.

It is inherent in apparatus of the character described that some vibrations will be impressed upon the baffle **38** by the elements of sound reproducing device **1** or **71**. Auxiliary ring-shaped baffle member **37** tends to make these vibrations "sympathetic." "Sympathetic vibrations" have the same period of vibration as the body they cause to vibrate, causing an increase in intensity and amplitude of said vibrations, by resonant diaphragm, or conduction resonance.

Numerous ideas have been carried out in this invention, with recognition on my part that one or more novel elements, arrangements or combinations can be employed separately, or the various elements, arrangements, or combinations may be employed collectively. I want it understood that I do not limit my invention. I realize that other modifications are possible and it is my intention to cover all other modifications which can be made without departing from the spirit of the invention and the scope of the claims. Features of my invention shown and described herein and not claimed, are claimed in one or another of my U. S. patents or patent applications hereinbefore identified, and listed below. Re. 20,395 issued June 8, 1937; 2,189,161 issued Feb. 6, 1940; or application, Serial No. 317,266 filed Feb. 5, 1940.

I claim:

1. In combination in an electro-dynamic electro-acoustical device forming a loud speaker, two diaphragms each carrying a signal current coil mounted on a cylindrical sleeve attached thereto, one diaphragm having a relatively stiff curved central portion and a flanged periphery permitting the stiff central portion of the diaphragm to move relatively to the fixed outer periphery thereof, the other diaphragm having the form substantially of a truncated cone having an unobstructed open center portion coinciding with the sleeve and coil carried thereby, and having a flanged periphery, and two electro-dynamic field magnet units including a pair of inner pole portions one in front of the other, a pair of outer pole plates each having a circular opening therein concentric with the inner pole portions, the outer end of each inner pole portion projecting into the circular opening in one outer pole plate, the arrangement forming two magnetic air-gaps one in front of the other, and apertured magnet yoke portions in adjacent relationship supporting the butt ends of the inner pole portions and connecting the two field magnet units in adjacent concentric systems, the inner magnet poles being hollow and open at both ends forming a single open ended air column extending through the apertured yoke portions of the magnet system, the two air-gaps and the two diaphragms being located adjacent opposite ends of the inner magnet poles, separate mountings for the two diaphragms attached to the magnet system supporting the peripheries thereof in a fixed position, a flexible member associated with the conical diaphragm and its

mounting flexibly suspending the sleeve and coil movable in one magnetic air-gap, the signal current coil carried by the smaller diaphragm being flexibly suspended movable in the other air-gap wherein the contour of the smaller diaphragm and the adjacent portions of the magnet poles coincide, the arrangement forming a chamber having small volume between the smaller diaphragm and the magnet poles, and an orificed baffle member applied to the opposite side of the smaller diaphragm, the orificed portion of the baffle forming passage for sound waves from one side of the baffle member to the fluid area on the opposite side of the baffle member in acoustical relationship with the smaller diaphragm, and a horn attachment applied to the device on the outer side of the orificed baffle member having communication through the orificed portion of the baffle with the smaller diaphragm, the arrangement forming a chamber having small volume between the adjacent surface of the baffle member and the smaller diaphragm, the mass, elasticity and viscosity of the air in the said two small chambers tending to cooperate in efficiently modifying the mechanical movement of the smaller diaphragm.

2. An electro-dynamic electro-acoustical device forming a loud speaker including a combination of elements substantially in accordance with claim 1, wherein an orificed baffle member is applied in the smaller diaphram having a surface contour adjacent the smaller diaphragm substantially coinciding with the contour of the smaller diaphragm arranged and forming a chamber having small volume between the said adjacent surfaces of the smaller diaphragm and baffle member, and a horn attachment applied to the outer side of the orificed baffle member, the horn attachment interior having communication with the outer side of the baffle member forming at least one passage chamber having relatively small volume between the baffle member and the interior wall surface of the horn attachment having communication with the intake throat portion of the horn attachment and also having communication with the first said chamber and the smaller diaphragm through the orificed portion of the baffle member.

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