Aug. 4, 1936. A. A. THOMAS 2,049,784

TELEPHONE INSTRUMENT

Filed July 10, 1925 3 Sheets-Sheet 1

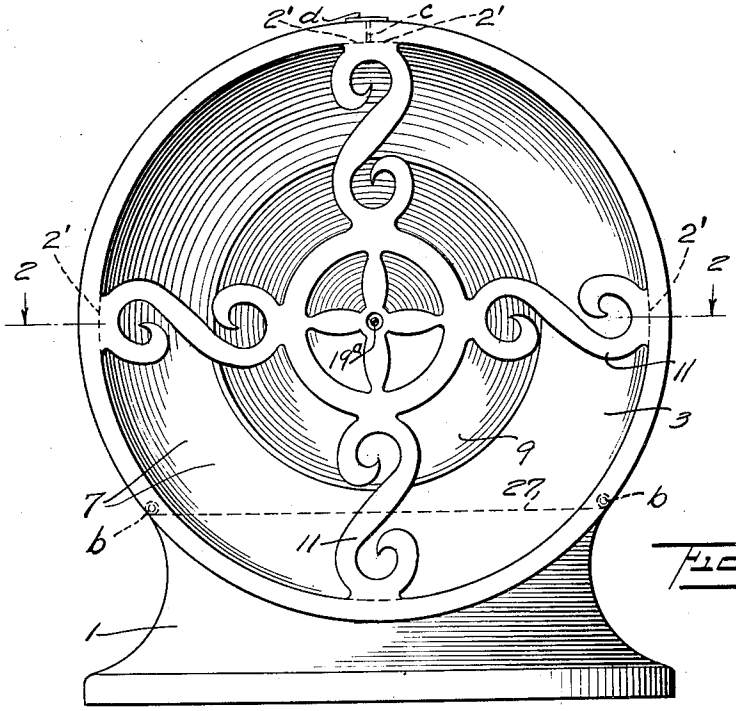


FIG. 1.

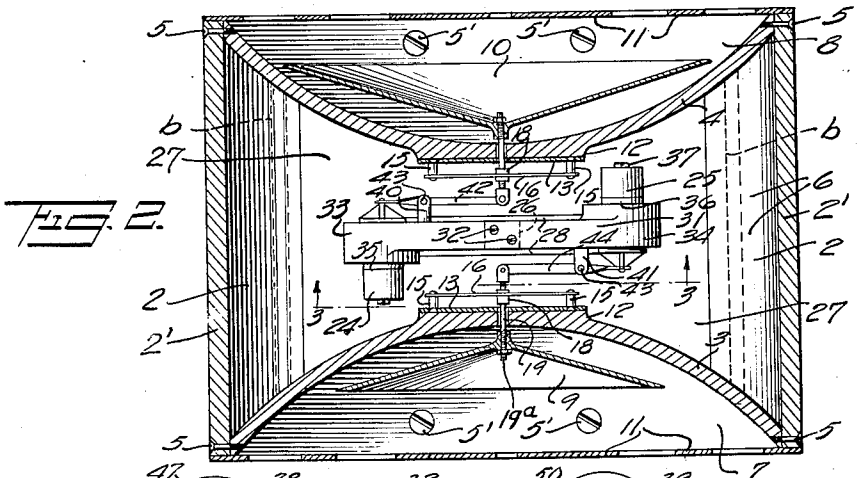


FIG. 2.

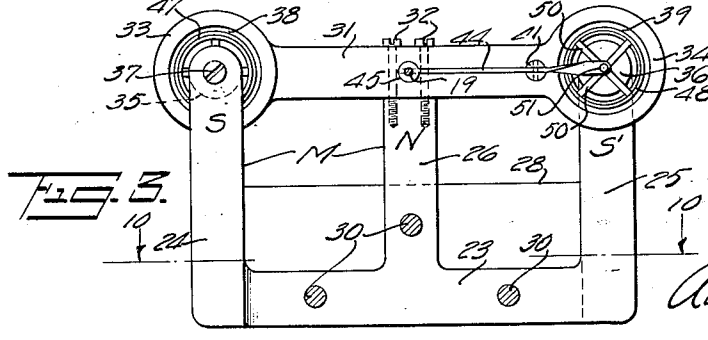


FIG. 3.

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Filed July 10, 1925 3 Sheets-Sheet 2

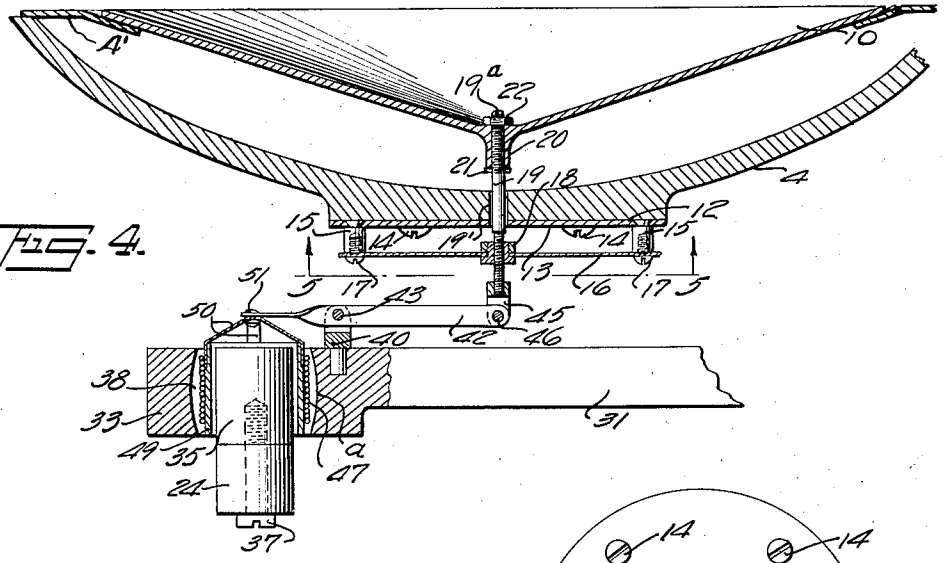


FIG. 4.

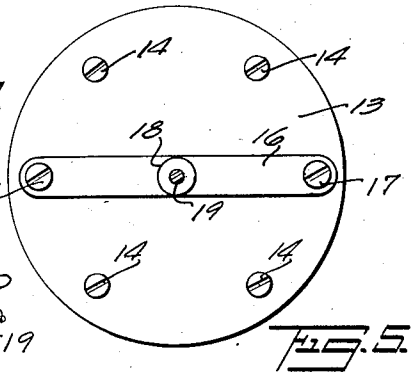


FIG. 5.

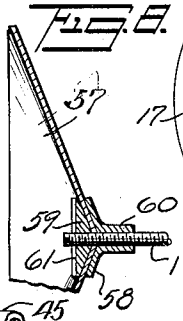


FIG. 8.

FIG. 7.

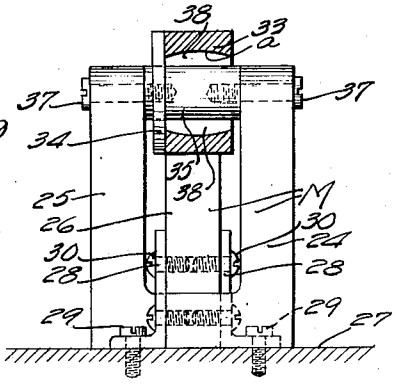


FIG. 6.

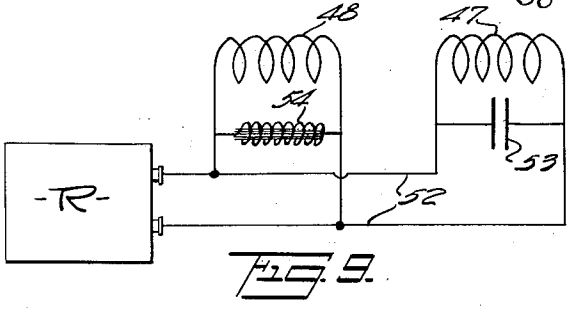


FIG. 9.

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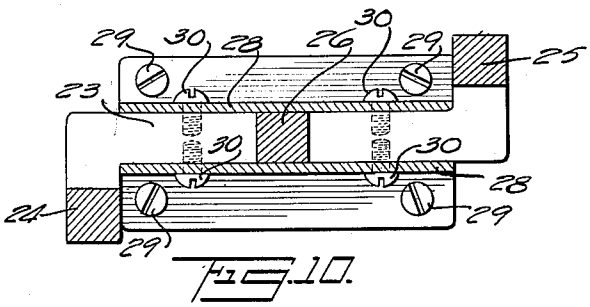


FIG. 10.

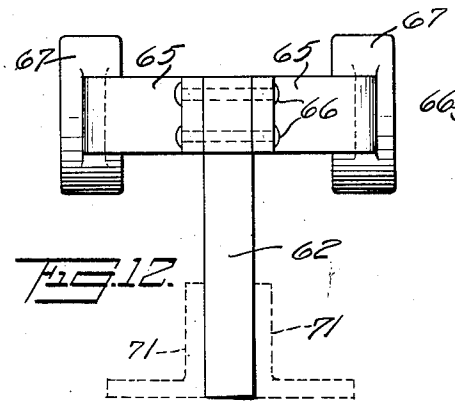


FIG. 12.

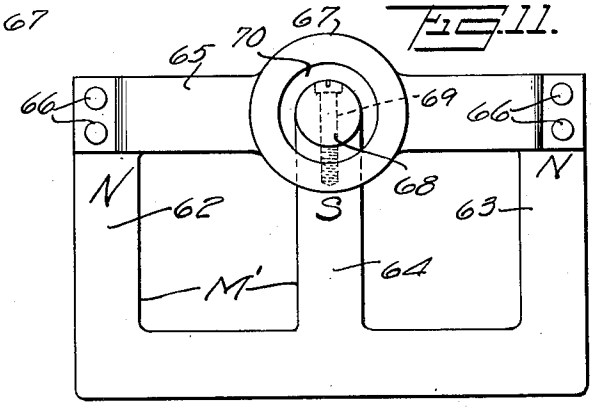


FIG. 11.

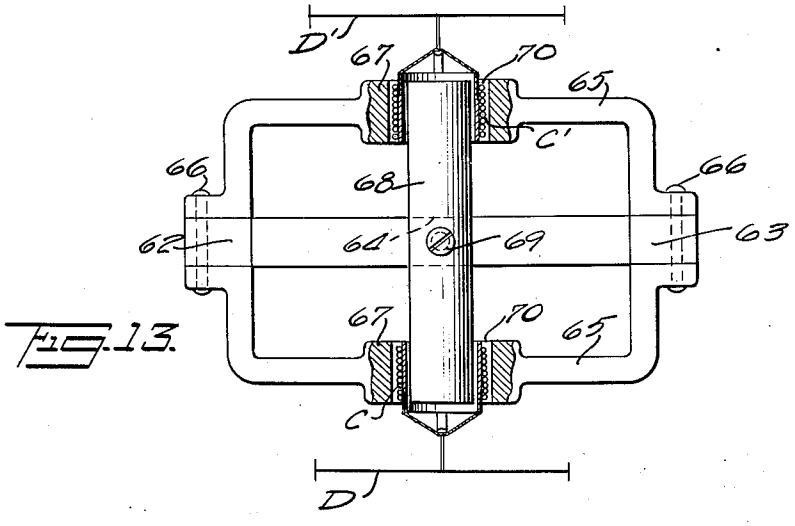


FIG. 13.

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Patented Aug. 4, 1936 2,049,784

UNITED STATES PATENT OFFICE

2,049,784

TELEPHONE INSTRUMENT

Adolph A. Thomas, New York, N. Y., assignor to Radio Corporation of America, New York, N. Y., a corporation of Delaware

Application July 10, 1925, Serial No. 42,626

27 Claims. (Cl. 179—115.5)

My invention relates to telephone instruments, and its object is to provide a receiver of the so-called loudspeaking type embodying various features of novelty for improving the acoustic reproduction. The loudspeaker of my invention is particularly useful for radio reception, but it is broadly applicable in any connection where electrical energy is utilized in the reproduction of sound.

It is a generally recognized fact that a telephone receiver with only one diaphragm cannot give out high and low notes with an equal degree of fidelity, because the acoustic capacity of a single diaphragm cannot possibly extend over the entire musical scale. Thus, a diaphragm having a high natural frequency cannot properly respond to low notes, and a diaphragm that responds best to low notes does not operate satisfactorily on high notes. Then, too, a diaphragm that is held rigidly bound at its circumferential edge will always accentuate frequencies which are at or near the natural frequency of the diaphragm, thereby distorting the reproduction. Also, in prior loudspeakers, all sounds issue out of the same horn or (as in the cone-type speakers) from the same diaphragm, so that, where orchestral or band music is reproduced, the fine notes of the violin and flute come from the same spot as the deep tones of the bass instruments. This is unnatural, for in the actual rendition of such music, the players are so arranged that the high notes and the bass notes reach the hearers from different parts of the room.

In order to overcome the foregoing and other defects and objections in prior loudspeakers, I have provided an instrument employing a plurality of diaphragms (two are usually sufficient) having different acoustic capacities or characteristics so as to encompass the entire musical scale. One diaphragm has a high natural frequency, and the other a low natural frequency, the two together reproducing high notes and low notes with practically equal resonance and naturalness. These diaphragms, although controlled by the same telephone circuit, are mechanically disconnected and therefore free to operate independently of each other, so that each produces its own vibrations without being hampered by the movements of the other. For this purpose, I have devised a novel construction of electromagnetic mechanism in which a single magnet (preferably of the permanent type) provides two separate cylindrical air gaps. In each airgap operates a coil connected in a circuit of variable currents, and each coil is connected with a diaphragm. In the embodiment which I prefer at the present time, the two coils are connected in parallel in the telephone circuit. Across one of the coils is connected a self-induction device (such as a choke coil), and across the other coil is shunted a condenser. The operating coil with the self-induction device accentuates the high notes and operates the diaphragm having a high natural frequency. The other operating coil, with the condenser connected across, emphasizes the low notes and actuates the diaphragm which has a low fundamental frequency. In this construction, the two diaphragms (or more than two, if desired) cover the entire range of tones in speech and music, and thereby give a reproduction of minimum distortion at all frequencies occurring in practice.

The size and area of the diaphragms are sufficiently large to give a loudspeaking reproduction without the need of horns or other mechanical amplifiers, although such may be added if desired. The diaphragms are preferably cone-shaped and are constructed of any suitable material which gives the diaphragm the proper degree of rigidity. The mounting of the diaphragms, as will later appear, is such that they may be left free at the circumference, so that they vibrate bodily with the same amplitude over their entire area. The practical advantages of this construction will become clear as the description proceeds.

Another feature in my new loudspeaker consists in so mounting the diaphragms that their vibrations are projected in different directions into the free air. This adds to the naturalness of the reproduction, especially in band and orchestral music, for the high notes projected by one diaphragm and the low notes of the other diaphragm seemingly come from different parts of the room. A preferred method of producing this effect is to provide the outer casing of the instrument with a pair of open chambers oppositely arranged, and in each chamber is mounted a diaphragm. As the diaphragms vibrate, the high and low notes are projected in opposite directions, and this avoids the "choky" effect so apparent in those loudspeakers where all tones, high and low, issue out of a single opening or from the same diaphragm. The chambers associated with the diaphragms are preferably bowl-shaped and amplify the sound produced by the diaphragms.

The foregoing and other objects and advan-

tages of my invention will be clearly understood from a detailed description of the accompanying drawings, which illustrate a preferred embodiment and also modifications in certain details. In these drawings—

Fig. 1 represents an elevational view of a loudspeaker constructed in accordance with my invention;

Fig. 2 shows a plan view in cross-section on line 2—2 of Fig. 1;

Fig. 3 is a detached view, in elevation, of the electromagnetic system which operates the diaphragms;

Fig. 4 is a fragmentary view in section similar to Fig. 2, but enlarged to illustrate more clearly the mounting of the diaphragms and their operative connections with the telephone coils;

Fig. 5 shows a face view of the disk and spring arm on which each diaphragm is adjustably supported;

Fig. 6 is an end view of the magnetic structure illustrated in Fig. 3, certain parts being shown in section for clearness;

Fig. 7 is a cross-sectional fragmentary view of a double cone-shaped diaphragm;

Fig. 8 is a fragmentary cross-sectional view of a modified construction for adjustably mounting a cone-shaped diaphragm on a rod;

Fig. 9 is a diagrammatic illustration of a preferred form of circuit connections for the telephone coils which control the diaphragms;

Fig. 10 is a cross-section on line 10—10 of Fig. 3;

Fig. 11 shows a modified construction of magnetic frame in which two annular airgaps are arranged centrally in axial alignment;

Fig. 12 is an edge view of Fig. 11; and

Fig. 13 is a plan view of Fig. 11, certain parts being shown in section for clearness.

Referring to Figs. 1 and 2, there is an outer casing or frame comprising a base 1, a cylindrical wall or housing 2 which is open at both ends, and a pair of concave disks 3 and 4 securely connected to the housing by any suitable means, as by screw 5 or otherwise. These disks, which act as sound boards or panels, are rigidly held in position by being fastened either to the housing 2, as by screws 5, or to the upright extension of base 1, as by screws 5'. The housing 2 and the disks 3 and 4 form a closed chamber 6, practically dust-proof, containing the electromagnetic mechanism of the instrument. To permit ready assembling and adjusting of the parts in this chamber, the housing 2 may be provided with a removable section or it may consist of one or more sections hinged on base 1. In Figs. 1 and 2, the housing 2 comprises a pair of sections 2' hinged or otherwise movably connected at *b* to opposite sides of the base. The top edges of these separable sections meet at *c*, where they may be locked together by a suitable latch *d*, or any similar device adapted to be readily opened. When the housing 2 is made of the separable sections 2', the screws 5 are not necessary, since the concave disks 3 and 4 are secured to the base 1 independently of the sections 2', as by the screws 5' or otherwise. When I refer to the members 3 and 4 as disks, I do not mean that they must be circular, for they obviously may be of any other practical design.

The concave or bowl-shaped disks 3 and 4, which may be formed of wood, metal or a suitable composition, constitute bowl-shaped chambers 7 and 8, in which are mounted the acoustic diaphragms 9 and 10, respectively. These diaphragms are preferably cone-shaped, as illustrated, and may be constructed of any material that is sufficiently rigid and light in weight—such as, stiff paper (preferably moisture-proof), fiber, stiffened cloth, bakelite canvas, aluminum, or any other metallic or non-metallic substance that is found practical for this purpose. The diaphragm chambers 7 and 8 may be provided with decorative covers 11 of grille work sufficiently open to permit the ready passage of sound. The concave disks 3 and 4 also act to reflect such sound waves as may strike their surface, so that all sound produced by the diaphragms is projected into the free air. It is thus clear that the bowl-shaped chambers 7 and 8 amplify or reenforce the sound produced by the operation of the cone-shaped diaphragms.

As seen in Fig. 2, the diaphragms 9 and 10 are of different size. The small diaphragm 9 has a high natural period of vibration, and I may therefore conveniently call this the high diaphragm. The large diaphragm 10, which has a relatively low fundamental frequency, will be referred to as the low diaphragm. The size, weight and material of the diaphragms are so chosen as to secure the best acoustic results with each diaphragm in any particular design and size of instrument under construction, as any expert in this art can determine. When I refer to the diaphragms as cone-shaped, I do not mean that the diaphragms must be in the exact mathematical shape of a cone, but I use the term in its broad practical sense of a diaphragm constructed to give loudspeaking response. While such diaphragms are usually bulged in the shape of a cone, that is merely a mechanical convenience to impart the necessary rigidity or tautness to the sheet material of which the diaphragm is made.

The back of each bowl-shaped disk 3 and 4 has a flat surface 12 on which is rigidly secured a plate 13 by means of screws 14 or otherwise. Each plate 13 is provided with a pair of hollow screw studs or posts 15 on which is supported a vibratory strip 16 held in place by screws 17. The strip or arm 16 is made of spring steel or other suitable resilient metal. At the center of each spring strip 16 is fixed a screw-threaded bushing 18, which may consist of two parts screwed together, as shown in Fig. 4, for readily fastening the same to the spring strip. Through the bushing 18 passes a screw-threaded rod 19, which extends through an opening 19' in the center of each disk 3 and 4. The opening 19' constitutes a guide for the axially movable rod 19, as will be clear from Figs. 4 and 7. On the outer end of one of the rods 19 is mounted the diaphragm 9, and on the other rod is similarly mounted the diaphragm 10, as shown in Fig. 2. In the present instance, merely by way of example, each diaphragm is provided at the center with a rearwardly extending hub 20 (see Fig. 4), which is screw-threaded to receive the outer screw-threaded end of rod 19. A fixed pin or lug 21 on rod 19 limits the inward movement of the diaphragm on the rod, and a nut 22 holds the diaphragm rigidly in place. Any other practical means may be employed for mounting the diaphragms on their respective rods 19.

It will be seen from the foregoing that the diaphragms 9 and 10 are supported at the center entirely by the vibratory spring strips 16, which are of the required strength and resiliency, as may easily be ascertained by experiment. The members 16 thus constitute resilient vibratory supports for the diaphragms, which thereby are

left free at their circumferential edges and vibrate bodily with practically uniform amplitude over their entire area. Such uniform bodily vibration cannot take place where the diaphragm is held clamped around the edge, as in prior constructions, for such a diaphragm necessarily vibrates with maximum displacement at the center, from which the vibrations spread in decreasing amplitude toward the circumference. In a circular diaphragm, these transverse or radial vibrations produce so-called nodal circles, and along these nodal circles there is no vibration of the diaphragm. The essential result of this enforced manner of vibration of an edge-bound diaphragm is distortion of the acoustic reproduction. This and other defects and objections inherent in edge-bound diaphragms are obviated where the diaphragms, as in the construction above described, is free at the circumference and vibrates with substantially the same amplitude over its entire surface, thereby giving a more natural reproduction. When I say that the diaphragms 9 and 10 are free at the edge, I mean that they are not held rigid along the circumference in a fixed support, and I do not exclude the possibility of providing a thin flexible membrane between the edge of the diaphragm and the adjacent disk 3 and 4. This is shown at 4' in Fig. 4. Such a thin membrane might be used to close off the space back of each diaphragm from the outer air, or to act as a yielding support for the circumferential edge of the cone without interfering with its free floating movements. Of course, it will be understood that, so far as other features of my invention are concerned, the diaphragms 9 and 10 may be supported for vibratory movement in any other practical way. Also, while these diaphragms are primarily intended for use without horns, they may in certain instances be made sufficiently small to require the addition of amplifying horns, as when the instrument is to be embodied in a large radio cabinet where the horns are concealed from view. Ordinarily, however, the bowl-shaped sound-amplifying chamber 7 or 8 associated with each diaphragm makes the use of a horn unnecessary.

I will now describe the electromagnetic mechanism for operating the diaphragms. A magnet indicated as a whole by M is rigidly mounted in the chamber 6 formed by the outer casing or ring member. This magnet, in the preferred construction shown, comprises a base section 23, a pair of upright end legs 24 and 25, and a middle leg 26. These parts are preferably formed out of a single piece of magnet steel, if the magnet M is to be a permanent magnet. Or, the frame 23—24—25 may be composed of steel laminae capable of retaining magnetization for a long time. In the broader aspect of my invention, magnet M may be constructed as an electromagnet, in which case the frame would be of soft iron. The middle leg 26 extends in the same plane as the base section 23, but the end legs 24 and 25 lie in planes on either side of the base section, as best shown in Fig. 10. The purpose of this lateral displacement of the legs 24 and 25 will presently become apparent. If the middle limb 26 is magnetized as the north pole N, the end legs 24 and 25 are the south poles S and S'. Obviously, the polar legs 24 and 25 may be north poles, and the middle leg 26 a south pole.

The magnet M is secured to the flat bottom 27 (or any other part) of chamber 6 by any suitable means. In Figs. 6 and 10, I have shown a pair of brackets 28 in the form of L-shaped plates, which are fastened to the base of the instrument by screws 29, and between these plates is clamped the magnet frame by bolts 30 or other means.

On the central leg 26 of magnet M is mounted a transverse polar arm 31, fixed in place by any suitable means, such as screw bolts 32. The magnetic arm 31, which may be solid or laminated, terminates in annular heads or enlargements 33 and 34, which are preferably wider than the body of the arm (see Fig. 4) to provide an airgap of sufficient depth, as will presently be explained. Into the circular opening of polar head 33 extends centrally a cylindrical pole piece 35 projecting laterally from the end of polar leg 24. In like manner, a cylindrical pole piece 36 at the end of polar leg 25 projects centrally into the opening of polar head 34. The pole pieces 35 and 36 extend laterally from their respective polar legs in opposite directions so as to lie fully within the cylindrical openings of the polar rings 33 and 34. If the pole pieces 35 and 36 are made separate from the body of the magnet frame, they are secured to the legs 24 and 25 by screws 37 or in any other practical way. If the magnet frame is made of cast iron or steel, the pole pieces may be integral with the body of the frame. The polar ring 33 and pole piece 35 form an annular airgap 38, and the polar ring 34 and pole piece 36 form a similar airgap 39.

The polar extension 31 carries a pair of slotted lugs 40 and 41 projecting laterally from the opposite sides of the arm. On lug 40 is pivoted an arm or lever 42 by means of a pin 43 (see Fig. 4). A similar arm or lever 44 is pivoted on lug 41. The inner end of arm 42 is pivotally connected with the inner end of the rod 19 which carries the diaphragm 10. This connection may be of any practical form. In the present instance, there is a slotted nut 45 screwed on the inner end of rod 19 and carrying a pin 46 which passes through the arm 42. The inner end of the operating arm 44 is similarly connected with the rod 19 of diaphragm 9. The outer end of arm 42 carries a coil 47, and the outer end of arm 44 supports a coil 48. Coil 47 is operatively held in the annular airgap 38, and coil 48 is supported for movement in the airgap 39. A simple mounting for each coil is illustrated in Fig. 4. The coil is wound on a cylindrical shell 49 of light non-magnetic material (such as stiff paper, aluminum, etc.), and this shell is provided with radial extensions 50, which may simply be strips formed integral with the shell. The extensions 50 meet or cross each other at the central point 51, which represents a pin or stud for fastening the shell 49 to the outer end of the arms 42 (or 44). In this way, the coils 47 and 48 are rigidly connected to the arms 42 and 44, and are held in proper position within the annular airgaps 38 and 39, respectively.

Attention is called to the fact that the pivot point 43 of the operating arms or levers 42 and 44 is considerably nearer the coil-supporting end than the other end to which the diaphragms are connected. This means that the vibrations of the coils are transmitted to the respective diaphragms through the arms 42 and 44 in amplified ratio, depending on the ratio of length 43—46 to length 43—51. In the particular example illustrated, this increased tranmission ratio is nearly 2:1, but it may obviously be varied as desired, depending upon the requirements of any instrument under construction.

The coils 47 and 48 are adapted to be connected in a suitable circuit of variable currents, such as a telephone receiving circuit. In the diagram of Fig. 9, the two coils are connected in parallel in the circuit 52 of a radio receiving set R, which may be of any approved type. Across the coil 47, which controls the low diaphragm 10, is connected a condenser 53 of proper capacity. The coil 48, which operates the high diaphragm 9, is shunted by a choke coil 54 of predetermined self-induction. If desired, the condenser 53 and choke coil 54 may be adjustable, so that their correct electrical values may be readily ascertained in each instance. In other words, the acoustic effect of either diaphragm is controllable independently of the other diaphragm, so that the combined sound output of the two diaphragms may be regulated for the best acoustic result. By virtue of the foregoing circuit connections, all current variations in circuit 52 pass through both coils. However, the coil 47 receives variations of low frequency more readily than those of high frequency, since the latter are absorbed (as it were) by the condenser. Contrariwise, current variations of high-frequency more easily traverse the windings of coil 48, and low-frequency currents tend to pass through the choke coil 54. In other words, coil 47 operates with best efficiency on low notes, and coil 48 on high notes. This means that diaphragm 9 and its controlling coil 48 cooperate to accentuate the tones in the higher register of the musical scale, while coil 47 and its diaphragm 10 cooperate to emphasize the tones in the lower register. In this way, each note reproduced, from the lowest tone to the highest, is given its proper value. That is to say, the instrument is equally sensitive to high and low notes, and responds uniformly at all frequencies. When I say that the diaphragm 9 reproduces the high tones and the diaphragm 10 reproduces the low tones, I do not mean that the first diaphragm stands absolutely still on low notes and that the other diaphragm is unaffected by high notes, for all frequencies pass through coils 47 and 48, but not in the same proportion or degree, as previously explained. What I do mean is that one diaphragm and coil predominate on high frequencies, and the other diaphragm and coil predominate on low frequencies.

It goes without saying that the windings of coils 47 and 48, the capacity of condenser 53 and the self-inductance of choke coil 54 are so chosen as to obtain the most satisfactory operation of diaphragms 9 and 10. This lies within the skill of the electrical man familiar with the art of telephone receivers and acoustic reproduction.

It will not be necessary to go into the theory on which the coils 47 and 48 operate when traversed by variable currents. I need only say that the flux of the magnet passes across each annular airgap from the polar rings 33 and 34 to the cylindrical pole pieces 35 and 36 (or vice versa). When current flows through the coils, the tendency of each coil is to cut the magnetic lines of force across the airgap by moving in a direction along its own axis. The direction and amplitude of movement of the coils at any moment depend upon the direction and intensity of current flowing through them, and these vibratory movements are transmitted to the diaphragms 9 and 10 through the connections previously described.

The annular airgaps 38 and 39 are preferably shaped wider at the center than at the ends for the purpose of making the density of the magnetic flux more uniform across the entire depth of the airgap. This form of airgap is best obtained by curving the circumferential wall of the opening in each polar ring outwardly, as shown at *a* in Figs. 4 and 6. In an airgap with a uniform width (and therefore having uniform reluctance across its area), the magnetic lines of force have a tendency to crowd across the central portions of the spaced pole-pieces between which the airgap is formed. As a result, the density of the magnetic flux across such an airgap is lower near the outer edges of the pole-pieces than at the center. A vibratory magnetic member operating in an airgap having such a non-uniform flux distribution is not acted upon with equal force in different sections of the airgap. For instance, in loudspeakers of the so-called electrodynamic type as heretofore constructed, where a coil operates in an annular airgap and is carried by an acoustic diaphragm, loud notes are not reproduced with the proper intensity and are therefore not given their correct acoustic value. This is due largely to the fact, as I believe, that on strong vibrations the coil operates near the ends of the airgap where the magnetic field is weaker than at the middle. This objection is overcome by so constructing the walls of the airgap that the magnetic reluctance is slightly greater at the center than at the ends, whereby a substantially uniform flux density is obtained. It is obvious that the same result may be obtained by so shaping the cylindrical pole-pieces 35 and 36 as to widen the airgaps at the center.

The normal position of the coils 47 and 48 in their respective airgaps is adjustable by simply turning the rod 19, which moves the inner end of arm 42 (or 44) either toward the magnet or away from it, depending on which way the rod is turned. The pivotal adjustment of arm 42 or 44 by the rotatable rod 19 may be accomplished by making either the part 18 or 45 a collar in which the rod turns and making the other part a nut in screw-threaded connection with the rod. For example, if part 18 is a collar in which the rod 19 turns without axial movement, it is evident that turning the rod will move the nut 45 axially of the rod. Consequently, the arm 42 is rocked about its pivot to adjust the normal position of coil 47. Or, if element 18 is a nut and element 45 a collar in which the rod 19 turns but which can not move axially of the rod, rotation of the latter causes it to move axially in nut 18 and collar 45 follows the axial (but not the rotary) movement of the rod. To permit easy adjusting of the rod 19 from outside the casing and without disturbing any part of the mechanism, the outer end of each rod 19 is slotted, as indicated at 19*a*, for the insertion of an instrument like a screwdriver. It will be understood that the normal position of coils 47 and 48 to some extent affects the operation of the diaphragms, particularly as to volume.

In Fig. 7, the rod 19 carries a diaphragm of double-cone shape, comprising two conical disks 54' and 55 placed edge to edge. The circumferential edges are fastened together in any practical way, as by screws or rivets 56, by gluing, or otherwise. The diaphragm 54'—55, like the diaphragms 9 and 10, is free to vibrate bodily with uniform amplitude over its entire area. The tendency of the diverging walls of diaphragm 54'—55 is to diffuse or scatter the sound waves more than the recessed diaphragms 9 and 10. What has been said about the materials of dia-

phragms 9 and 10 applies to diaphragm 54'—55, except that this double-cone construction permits the use of even lighter materials.

In Fig. 8, the diaphragm 57 is adjustably mounted on rod 19 by being clamped between a small plate 58 and a nut 59. The plate 58 projects from one end of a screw-threaded bushing 60 and is interiorly cone-shaped to receive the similarly shaped wall of the diaphragm. The inner face of nut 59 is likewise cone-shaped, so that the diaphragm is firmly held at the center with uniform pressure over the entire contact area. The outer face of nut 59 may have a slot 61 to permit easy manipulation thereof by a suitable instrument.

In Figs. 11, 12 and 13 there is illustrated a modified construction of field magnet for providing a pair of centrally arranged annular airgaps. The magnet M', preferably a permanent steel magnet, has two outer limbs 62 and 63, and a central limb 64. The two outer limbs constitute one pole (marked N in Fig. 11), and the limb 64 is the other pole, here assumed to be the south pole. The polar limbs 62 and 63 are connected by a pair of arms or bars 65 of soft iron or other material of high magnetic permeability. Bolts 66 or other fastening devices hold the arms 65 firmly to the ends of the polar limbs 62 and 63. Each arm 65 is formed at the center into a ring 67, the two rings being in axial alignment. The rings 67 constitute annular pole pieces. To the central limb 64 is secured a cylindrical pole piece 68, which may be in the form of a single bar held in place by a screw 69, as shown, or which may consist of two oppositely extending sections. The ends of pole piece 68 project centrally into the polar rings 67 to provide the annular airgaps 70, in which operate coils C and C' connected to diaphragms D and D'. These diaphragms and their connections with coils C and C' are indicated in Fig. 13 for the sake of simplicity in a diagrammatic way. These diaphragms may be like diaphragms 9 and 10, or like the diaphragm 54—55, or of any other practical construction. Also, the operative connections between coils C—C' and diaphragm D—D' may be like the connections shown in Fig. 4, or may comprise any other suitable means. The annular airgaps 70 may be shaped like the annular airgap in Figs. 4 and 6. The magnetic frame M' is secured to a base or other fixed support in any practical way. In Fig. 12, the dotted lines 71 represent any suitable securing means for the magnet. It will be observed that the polar arms 65 are spaced from the central limb 64 a considerable distance in order to prevent magnetic leakage across the intervening space, as such leakage would weaken the flux density across the annular airgaps.

One of the main practical advantages of the magnetic structure shown in Figs. 11–13 is a more balanced flux distribution across the annular airgaps than is possible to obtain in the magnet structure of Fig. 2. This advantage is due to the fact that in Figs. 11–13 each polar ring 67 is arranged between the polar limbs 62 and 63. Therefore, the magnetic flux enters (or leaves) the annular pole pieces 67 through two iron paths arranged symmetrically with respect to the polar limbs 62 and 63. This construction, besides increasing the uniformity of flux distribution, tends to decrease magnetic leakage.

It is hardly necessary to mention that the parts shown in the various views are not drawn to relative proportions that are mathematically exact. The drawings have been made as simple and clear as possible, and on that account the parts are spread out more than would be necessary in actual construction. The relative sizes and dimensions of the parts depend upon the particular size and design of instrument under construction, and are readily determined by the skilled experimenter. While the instrument of my invention is primarily intended for use as a telephone receiver, it will be understood that certain features may be employed in the construction of transmitters.

Although I have herein shown and described certain specific constructions, I want it understood that I have done so merely by way of example and not for the purpose of restriction or limitation. In the broader aspect of my invention, the various features of novelty may be mechanically embodied in other constructions than herein set forth. Also, it is evident that certain features of my invention may be employed without certain other features.

What I claim as my invention is:

1. A loudspeaker of the cone type comprising a cabinet having a concave circular wall constructed to form an open sound-reflecting chamber, a cone-shaped diaphragm mounted in said chamber adjacent to said wall, said diaphragm being so arranged as to diverge outwardly toward the open end of said chamber, the space in said chamber back of said diaphragm being open to the outer air, so that sound waves generated back of the diaphragm are reflected by said concave wall out of the cabinet, and electromagnetic means for operating said diaphragm independently of said wall.

2. In a telephone instrument, a magnet having an annular airgap, a coil in said airgap, a pivoted arm to which said coil is connected, a resilient vibratory support, a rod adjustably secured to said support, a diaphragm mounted on the outer end of said rod, and means for connecting said arm to the inner end of said rod, said rod being rotatable from the outside of the instrument to rock said arm and thereby adjust the normal position of said coil in the annular airgap.

3. A loudspeaker comprising, the combination of an outer casing, a loudspeaking diaphragm, electromagnetic mechanism within said casing for operating said diaphragm, said mechanism including a movable coil supported for vibration at all audible frequencies within a certain range and operatively connected to said diaphragm, and means operable from outside the casing for adjusting the normal position of said coil in said airgap without affecting its range of response.

4. In a loudspeaker, a resilient vibratory member, an edge-free diaphragm supported at the center by said member, electromagnetic actuating mechanism including a vibratory element, and an amplifying connection between said element and said member for vibrating said diaphragm, said resilient member also serving to hold said element in predetermined normal position.

5. A hornless loudspeaker having an outer casing provided with two oppositely arranged recessed walls which form open chambers in substantially axial alignment, a loudspeaking diaphragm operatively supported in each chamber, said diaphragms being free at the circumference so as to vibrate over their entire surface with substantially uniform amplitude, and electromagnetic mechanism mounted in said casing between said walls for simultaneously operating said diaphragms.

6. A hornless loudspeaker having an outer casing provided with two oppositely arranged re-

cessed walls which form open chambers, a pair of rods resiliently supported in said casing independently of each other and each projecting through an opening into one of said chambers, a loudspeaking diaphragm secured to the outer end of each rod, said diaphragms being free at the circumference so as to vibrate over their entire surface with substantially uniform amplitude, electromagnetic mechanism mounted in said casing between said walls for simultaneously operating said rods independently of each other, and means comprised in said mechanism whereby one of said diaphragms operates best on high frequencies and the other diaphragm operates best on low frequencies.

7. In a telephone receiver, a pair of independent arms pivoted intermediate their ends, a coil carried by one end of each arm, a single magnetic frame provided with two annular airgaps, said coils being operatively held in said airgaps by said arms and being movable independently of each other, a pair of independently supported diaphragms connected to the other ends of said arms, the pivot point of said arms being closer to the driving ends whereby a multiplying connection between each coil and one of said diaphragms results.

8. In a telephone instrument, a diaphragm, an adjustable rod passing through said diaphragm, a vibratory coil, and a connection between said rod and said coil, said connection being such that rotary adjustment of said rod controls the normal position of said coil.

9. In a telephone instrument, a magnet having an annular airgap, a coil supported for vibration in said airgap, a diaphragm, a multiplying connection between said coil and said diaphragm, and means for adjusting said connection to vary the normal position of said coil in the airgap.

10. In a telephone instrument, a vibratory spring strip, a rod adjustably supported by said strip, a diaphragm adjustably mounted at its center on one end of said rod, said diaphragm being unsupported at its circumference, a vibratory member controlled by current variations in a circuit, and a connection between said spring strip and said member for operating said diaphragm in amplified transmission ratio.

11. A hornless loudspeaker having a plurality of cone-shaped diaphragms of different natural frequencies, and electro-magnetic mechanism for simultaneously operating said diaphragms, said mechanism including a plurality of vibratory coils connected each to one of said diaphragms.

12. In a loudspeaker of the cone type, a cone-shaped diaphragm, a rod passing centrally through said diaphragm and terminating in a projecting end by which the rod is turnable in either direction, electromagnetic mechanism for operating said diaphragm, and means whereby rotary adjustment of said rod controls the electromagnetic action of said mechanism.

13. In a loudspeaker of the cone type, electromagnetic actuating mechanism including a vibratory member, a rod connected to said member and axially vibrated thereby, a cone-shaped diaphragm connected to said rod, and means whereby said rod is turnable to adjust the normal position of said member.

14. A hornless loudspeaker having an outer casing provided with two recessed walls oppositely arranged to form open chambers in substantially axial alignment, a loudspeaking diaphragm operatively supported in each chamber, and electromagnetic mechanism mounted in said casing between said walls for simultaneously operating said diaphragms.

15. In an electromagnetic loudspeaker, an edge-free acoustic diaphragm comprising a pair of cones connected at the periphery and diverging at their apices to form a hollow chamber, a sleeve at the apex of each cone, at least one of said sleeves being screwthreaded, a screwthreaded rod on which said sleeves are mounted, whereby said diaphragm is adjustably supported on said rod for vibratory movement, and electromagnetic means connected to said rod for vibrating the same in an axial direction.

16. A loudspeaker having a coil movable in a magnetic field and adapted to vibrate in response to current impulses over a wide range of audible frequencies, a diaphragm operated by said coil, and manually operable means for adjusting the normal position of said coil in the magnetic field without affecting its range of response.

17. A loudspeaker comprising a casing, electromagnetic operating mechanism mounted in said casing, said mechanism including a coil movable in a magnetic field and adapted to vibrate in response to current impulses over a wide range of audible frequencies, a diaphragm in said casing operatively connected to said coil, and means operable from outside the casing for adjusting the normal position of said coil in the magnetic field, the operation of said adjusting means having substantially no effect on the frequency response of the coil.

18. In a telephone instrument, a magnet having an annular airgap, a coil arranged in said airgap for vibratory movement, a diaphragm, means for connecting said coil to said diaphragm, and means for adjusting said connecting means to regulate the normal position of said coil in the airgap.

19. A loudspeaker comprising a cone diaphragm, a coil movable in a magnetic airgap, and a driving connection between said coil and diaphragm, said connection including two members pivotally connected in substantially right-angled relation, one of said members being connected to said coil and the other member being connected to said diaphragm.

20. In a loudspeaker, the combination of a cone diaphragm, electromagnetic means for operating said diaphragm, said means including a coil movable in a magnetic airgap and connected to said diaphragm, said coil being responsive to audible frequencies within a certain range, and rotary screw means for adjusting the position of said coil without affecting its frequency response.

21. In a loudspeaker, the combination of a cone diaphragm, electromagnetic means for operating said diaphragm, said means including a coil movable in a magnetic airgap and connected to said diaphragm, said coil being responsive to all audible frequencies within practical limits, and means for adjusting the position of said coil from the front of the diaphragm, said adjusting means having substantially no effect on the frequency response of said coil.

22. In a telephone instrument, the combination of an outer casing, a diaphragm, electromagnetic mechanism within said casing for operating said diaphragm, said mechanism including a coil movable in a magnetic airgap and connected to said diaphragm, said coil being responsive to audible frequencies within a certain range, and means operable from outside the casing for adjusting the normal position of said coil in said

airgap, said adjusting means having no effect on the frequency response of said coil.

23. A loudspeaker comprising an outer casing, a pair of loud-speaking diaphragms supported at opposite ends of said casing, a sound-reflecting member mounted back of each diaphragm to throw the sound out of the casing at each end thereof, said members being separated to form a chamber acoustically insulated from said diaphrams, and electromagnetic mechanism in said chamber for simultaneously operating said diaphragms.

24. A loudspeaker comprising an outer casing, a pair of loud-speaking diaphragms supported at opposite ends of said casing, said diaphragms having different natural frequencies to accentuate the upper and lower registers respectively, a sound-reflecting member mounted back of each diaphragm to throw the sound out of the casing at each end thereof, said members being separated to form a chamber acoustically insulated from said diaphragms, and electromagnetic mechanism in said chamber for simultaneously operating said diaphragms.

25. A loudspeaker comprising an outer casing, a pair of loud-speaking diaphragms supported at opposite ends of said casing, said diaphragms having different natural frequencies to accentuate the upper and lower registers respectively, a sound-reflecting member mounted back of each diaphragm to throw the sound out of the casing at each end thereof, said members being separated to form a chamber acoustically insulated from said diaphragms, and electromagnetic mechanism in said chamber for simultaneously operating said diaphragms, said mechanism including a vibratory coil connected to each diaphragm.

26. The combination of a cabinet, a loudspeaker device having a diaphragm, said loudspeaker device being mounted in said cabinet, a casing mounted rearwardly of said diaphragm and substantially enclosing the rear of said diaphragm whereby sound waves from the rear of said diaphragm are prevented from circulating in said cabinet, and means for closing off the space back of the diaphragm from the front of the diaphragm.

27. The combination of a radio cabinet, a loud speaker device having a vibratile diaphragm, means supporting said loud speaker device within said cabinet with its diaphragm adjacent an opening in the cabinet, a casing arranged rearwardly of said diaphragm to substantially enclose the rear of said diaphragm whereby sound waves from said diaphragm are kept out of said cabinet, and means at the peripheral edge of said diaphragm for closing off the space back of the diaphragm from the front of the diaphragm.

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