Feb. 11, 1936. M. L. DULL 2,030,574

ELECTRICAL REPRODUCER

Filed Aug. 22, 1932 2 Sheets-Sheet 1

FIG. 1.

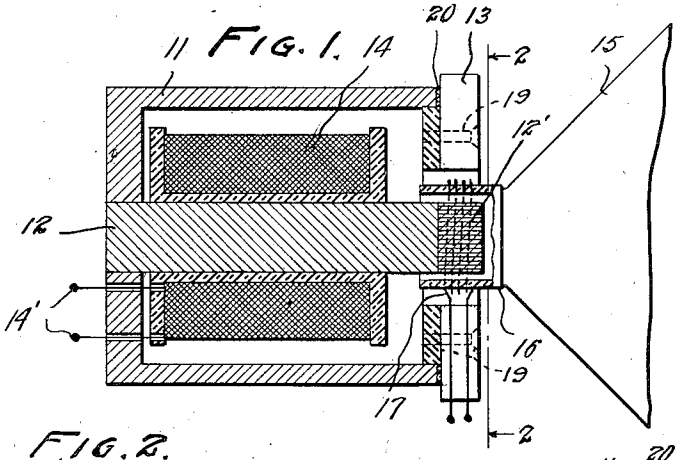


FIG. 2.

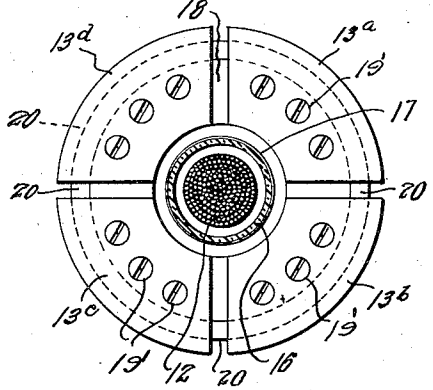


FIG. 3.

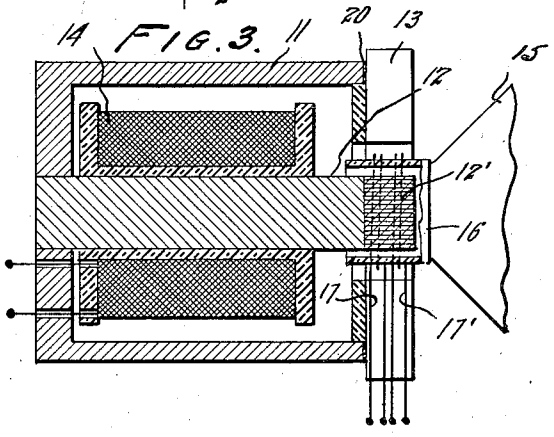
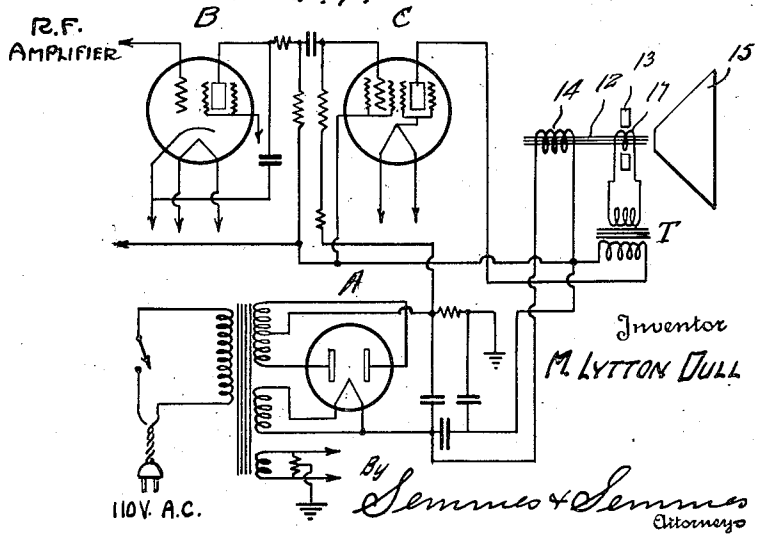


FIG. 4.



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Feb. 11, 1936. M. L. DULL 2,030,574

ELECTRICAL REPRODUCER

Filed Aug. 22, 1932 2 Sheets-Sheet 2

FIG 5

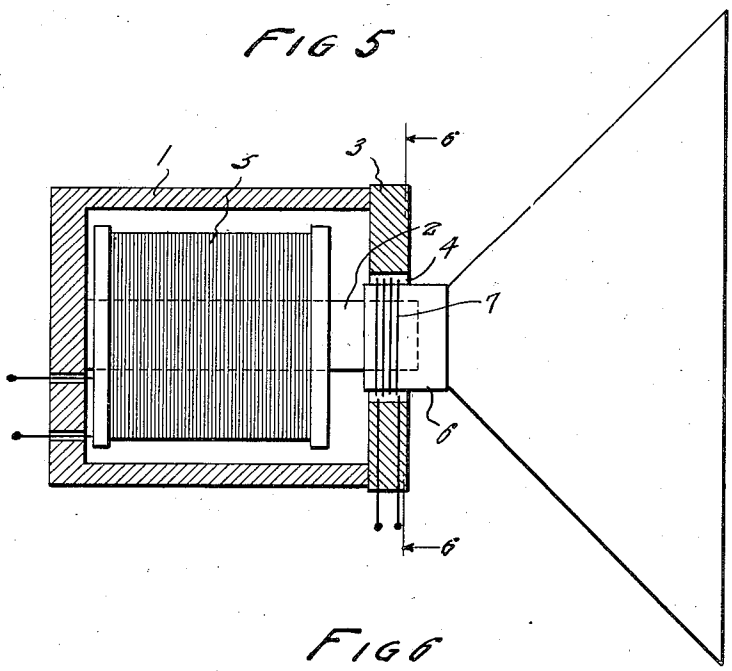
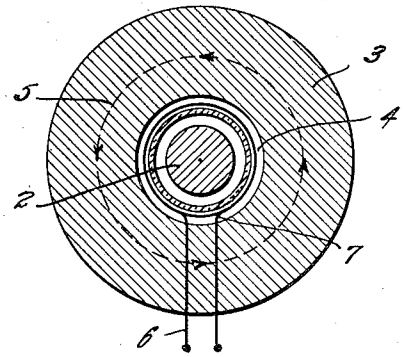


FIG 6



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UNITED STATES PATENT OFFICE

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ELECTRICAL REPRODUCER

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Application August 22, 1932, Serial No. 629,965

7 Claims. (Cl. 179—115.5)

This invention relates to improvements in electrical reproducers and more particularly to electro-dynamic speakers.

The typical electro-dynamic speaker, as is known, comprises essentially a diaphragm actuated by a coil which is movable in the magnetic field. Such speakers are constructed with an iron core attached to a metal case, which latter carries an annular pole piece spaced from the core to form a gap. About the core is placed a field coil which is connected in a suitable circuit, such that it is energized by the unidirectional pulsating current. When the voice or telephone coil mounted within the gap is energized by an alternating current, such coil is displaced longitudinally of the core and actuates the diaphragm.

Such reproducers although generally satisfactory do present inherent disadvantages. It is known and recognized that a considerable quantity of the input energy to such speakers is not effectively utilized, but is dissipated in the form of heat. It is likewise recognized that the typical dynamic speaker is peculiarly susceptible to second harmonic distortion.

A major object of the present invention is to provide a dynamic speaker in which these disadvantages are minimized.

Another object is to provide an electro-dynamic speaker of novel construction and improved operation.

A further object is to provide a loud speaker in which harmonic distortion is materially reduced and a more faithful reproduction of sound insured.

With these and other equally important objects in view the invention resides in the concept of specially constructing a loud speaker unit so as to minimize or eliminate losses inherent in speakers of present day design.

In order to enable a more ready comprehension of the invention, physical embodiments of it are shown in the accompanying drawings, in which:

Fig. 1 is a longitudinal section of a speaker embodying the features of the invention.

Fig. 2 is a cross-section taken on line 2—2 of Fig. 1.

Fig. 3 is a longitudinal section of a modified form of the device.

Fig. 4 is a schematic diagram illustrating the association of the speaker with a typical receiving set.

Fig. 5 is a view of the typical form of loud speaker.

Fig. 6 is a cross section of the device taken on line 6—6 of Fig. 5.

As intimated hereinbefore the typical loud speaker in use at the present time presents the major disadvantages of relatively high losses and undesired harmonic distortion. The reasons for these, together with the method of largely obviating such disadvantages, will be comprehended from a consideration of the nature and operation of such speakers.

The typical loud speaker, as shown conventionally in Fig. 5, comprises a cup shaped metal member 1 having a central or pole piece 2 attached to the member and concentrically mounted within it. At one end a continuous annular ring of metal 3 is attached to the case. This has a central aperture 4 which forms an air gap with the core or pole piece 2. A field coil 5 is wound upon the central pole piece and is housed within the casing formed by the members 1 and 3. In the known manner the field coil is connected to a rectifier and transformer, which latter is connected to an alternating current supply.

The cone of the speaker is formed with a cylindrical section 6 upon which is mounted the telephone or voice coil 7. This voice coil is positioned within the air gap and is so wound that the plane of winding is the same as that of the annular pole piece.

From an inspection of Fig. 6 it will be seen that the member 2 constitutes a core for the telephone coil 7. It will likewise be appreciated that the annular plate 3 essentially is a single turn closed coil of very large cross sectional area. In other words, the core 2, coil 7 and plate 3 essentially and functionally constitute a simple open core alternating current transformer. In this structure the alternating current coil 7 constitutes the primary, as it receives energy from an external source. The plate (closed coil) 3 similarly functions as the secondary in the transformer action or effect.

In such circumstances, therefore, when energy is fed to coil 7 there is induced in the plate 3 approximately equal quantities of energy, but in a different current-voltage relationship, depending upon the ratio of turns between coil 7 and closed coil 3. Inasmuch as the plate 3 is a single annulus it may be considered as a completely shorted secondary and, as such, introduces tremendous losses. Hence, much of the potentially effective input energy in the coil 7 is dissipated in losses which appear in the operation of the reproducer as straight heat losses and as effecting a large percentage of the second harmonic distortions. It will be seen, therefore, that in the present day type of electro-dynamic reproducer cer-

tain electrical phenomena are unintentionally operative and as a result materially detract from the effectiveness of the unit. As will be pointed out more fully hereinafter, these disadvantages are simply and effectively eliminated in the present improvement.

As noted above, the prior type of constructions in electro-dynamic speakers accentuated the undesired second harmonic distortion. This will be seen from a consideration of the inherent transformer effect alluded to above. The coil 7, of course, differs from the primary coil of an alternating current transformer in that it is more or less free to move axially of the core. In view of the losses introduced as a result of this conventional mode of assembly the coil 7 will naturally tend to take the path of least resistance, and in operation actually moves or displaces in preference to forcing energy into the shorted secondary 3. Now in an alternating sign wave there are two energy peaks for each cycle, namely the positive and negative, and hence it is apparent that the coil 7 will move two times for every fundamental cycle in the actuating currents fed to it. With the prior assembly, as noted above, the coil 7 will tend to move, in response to alternations in its input, rather than energize the secondary 3. As a result of this additional movement the second harmonic distortion is considerably accentuated.

There is also an additional reason why the prior type of loud speaker did not operate at maximum efficiency. In these speakers the core 2 consisted of a solid piece of iron. This, as noted above, functions as a transformer core. The magnitude of eddy current stresses set up within this solid piece of metal, when it is surrounded by an alternating field having a high frequency, of the order of ten thousand cycles per second, will immediately be apparent. This magnetic stress appears as heat and is dissipated. Such dissipated heat represents a proportional quantum of electrical energy which is wasted and results in a correspondingly low order of efficiency of reproduction.

Now I have found that by simple modifications of structure the undesired transformer effects described above may be practically eliminated so as to provide a speaker of improved operation. The rationale of the modification of structure employed will be appreciated from the preceding description given.

According to the present invention, and as shown in Fig. 1, an improved type of speaker may be readily manufactured in which losses are considerably minimized and second harmonic distortion largely eliminated. Such a speaker may comprise a cylindrical casing 11 within which is concentrically mounted metal core 12. To the casing 11 is attached a pole piece 13. The core, as shown, comprises a solid piece of iron extending from the end of case 11 up to the plate. The section 12' of the core which is within the air gap is of special laminated structure and is integrally joined to the solid core 12. As in the conventional type of loud speaker, a field core 14 is provided, the leads 14' of which are adapted to be connected to a suitable circuit so that the field coil may be supplied with a unidirectional current. The pole piece 13 is spaced from the end 12' of the core so as to provide the usual air gap. The reproducer is provided with a diaphragm, such as a truncated cone 15. This is formed with the cylindrical extension 16 which fits within the air gap and upon which is mounted the telephone or voice coil 17. It will be understood that the cylindrical extension 16 is spaced from the core and is held in such spaced position by any suitable means, such as spider arms and so forth.

As will be seen from Fig. 2, the annular pole piece 13 and the core 12' are of special construction. The core 12' is laminated, that is to say is made up of a large number of respectively insulated sections of wire of high permeability. Such wires, for example, may comprise suitable material such as silicon steel and permaloy, and so forth. The core section 12' may be joined to the core 12 by any suitable fusion joint.

The pole piece 13, instead of being made up of one piece as has been the custom in the past, is laminated, that is to say is made of a plurality of segments respectively insulated from each other. Such a pole piece, for example, may comprise the quadrantle segments 13*a*, 13*b*, 13*c*, and 13*d*. It will have been appreciated during the discussion of the prior art that the purpose of this segmental structure is to eliminate the undesired effects of the shorted secondary. Hence, while the pole piece has been shown as comprising a specific number of segments, it will be understood that the invention is by no means limited to any number or size of segments, but comprehends any and all structures in which the ring is made discontinuous so as to obviate the undesired effects of the shorted condition described.

In the preferred embodiment, as shown in Fig. 2, the segments 13 are respectively segregated and insulated by the insulating strips 18. While this insulation has been shown in rather exaggerated size in the drawings, it will be appreciated by those skilled in the art that rather thin members may be employed, for, as noted above, the major purpose is to establish a plane of electrical discontinuity. In actual practice loud speakers have been made in which the insulating strips 18 are approximately one-thousandth of an inch thick. It will be understood that this insulation may be of any desired material, such as well known types of dielectric plastics known in the art. In some circumstances however the discontinuity may be obtained by segmenting the plate and leaving an air gap between the adjacent sections.

The plate segments 13 may be mounted upon the casing 11 by means of the insulating mounting plate and screws 19'. As shown in Fig. 1, it is preferable to interpose a thin strip of insulation between the plate 13 and the casing 11, as shown at 20 in Fig. 1. This strip 20 may be quite thin, of the order of one-thousandth of an inch thick or more. The structure of the plate, including the insulations 18 and 20, are given merely as illustrative of any means by which the device may be assembled so that the plate will comprise a discontinuous ring which is insulated from the other parts of the reproducer; in other words of any structure whereby the undesired effects of the shorted transformer secondary are obviated.

It will be appreciated from the foregoing description that the improvements of the present invention are of general application in electro-dynamic sound reproducers. Such improvements may be incorporated in speakers of the type described by copending application Serial No. 608,504, shown in Fig. 3. This speaker includes the essential elements of the speaker shown in Fig. 1 but, as described fully in the copending ap-

plication referred to, is provided with a second coil 17' so associated with the coil 17 and with a connected circuit that the reproducer may always be operated by the maximum output energy of the receiving set or other associated apparatus, whatever the position of the volume control. When the improvements of the present invention are incorporated in the electrical reproducing system of the application above referred to, strikingly improved results are secured.

Reproducers constructed in accordance with the present invention, such for example as those shown in Figs. 1 and 3, may be utilized in any suitable receiving circuit, a conventionalized form of one of which is diagrammatically shown in Fig. 4. Thus the field coil 14 may be energized with rectified alternating current from the power pack A. The received signals impressed on the antenna circuit are passed through any desired number of radio frequency amplification stages, shown diagrammatically at B, and any suitable number of audio frequency amplification stages designated generally at C. The signal currents from this or any other other associated equipment are fed to the telephone coil 17 through the transformer T in the well known manner. When a speaker of the improved type shown in Fig. 3 is employed it will be understood, as described in my copending application, that an improved volume control unit is interposed between the secondary of transformer T and the voice coils 17 and 17'.

It will be appreciated that the improvements described herein insure an electrical reproduction of improved results. Due to the novel construction described, the losses due to the solid core and solid front plate are largely eliminated. The described disadvantages of the prior art structures have been determined to arise from a prior common design of speakers. The present invention, therefore, is considered to ramify more broadly than a mere structural change and is considered to reside broadly in the concept of a fundamental change in the characteristics and operation of such reproducers. Obviously other specific mechanical expedients may be utilized to secure the improved operation herein described, as such functional equivalents are considered comprehended within the spirit of the present disclosure.

Similarly other additional changes may be made in the reproducer of the present invention to improve certain phases of its operation or to adapt it to predetermined conditions, such for example as providing for the longitudinal adjustment of the pole piece, the utilization of neutralizing coils, etc. Hence, while preferred embodiments of the invention have been described, it is to be understood that these are given as merely illustrative of the broad principles involved and as typical but not exclusive methods of securing the stated improved results.

I claim:

1. In a loud speaker, a magnetic circuit comprising a central core, a metallic casing attached to and surrounding the core, a plate comprising a plurality of respectively insulated segments attached to the casing and spaced from the core to form an air gap therewith and a voice coil mounted for movement within the air gap.

2. An electro-dynamic speaker comprising a metallic casing, a central pole piece attached to the casing, a plate attached to the casing and spaced from the core to form an air gap therewith, the plate being segmented and the segments being respectively insulated as to insure a discontinuity of electric path therethrough.

3. An electro-dynamic speaker comprising a metallic casing, a central pole piece attached to the casing, a plate attached to the casing and spaced from the core to form an air gap therewith, the plate being formed with a plurality of segments, insulation material between the segments as to preclude a continuous electrical path therethrough and means to insulate the segmented plate from the casing.

4. That method of increasing the sensitivity of electro-dynamic reproducers provided with an annular plate serving as a magnetic pole for the reproducer which comprises establishing in the said plate a plane of discontinuity, and insulating such plate.

5. An electro-dynamic speaker comprising a metallic casing, a solid central core mounted with the casing and having a laminated section at one end, a plate comprising a plurality of segments with insulation positioned between the segments, said plate being attached to the casing and spaced from the laminated core section to form an air gap therewith.

6. An electro-dynamic speaker comprising a cup shaped metallic casing, a central solid core attached to the casing and formed at one end with a laminated section, a plate comprised of a plurality of respectively insulated segments attached to the casing but insulated therefrom, the plate being formed with a central aperture into which the said laminated core section extends.

7. That method of increasing the sensitivity of electro-dynamic reproducers provided with an annular plate serving as a magnetic pole for the reproducer which comprises establishing in the said plate an open circuit to the currents induced therein through the medium of a transformer effect, by an alternating flux produced by the currents in the voice-coil assembly which operates in a gap formed between an opening in the plate and a magnetic pole-piece located centrally therein, and insulating the plate from the rest of the mechanical structure so that the discontinuity so established is maintained.

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