Feb. 8, 1938. G. VEAL 2,107,920

APPARATUS FOR REPRODUCING SOUND

Filed Nov. 16, 1935

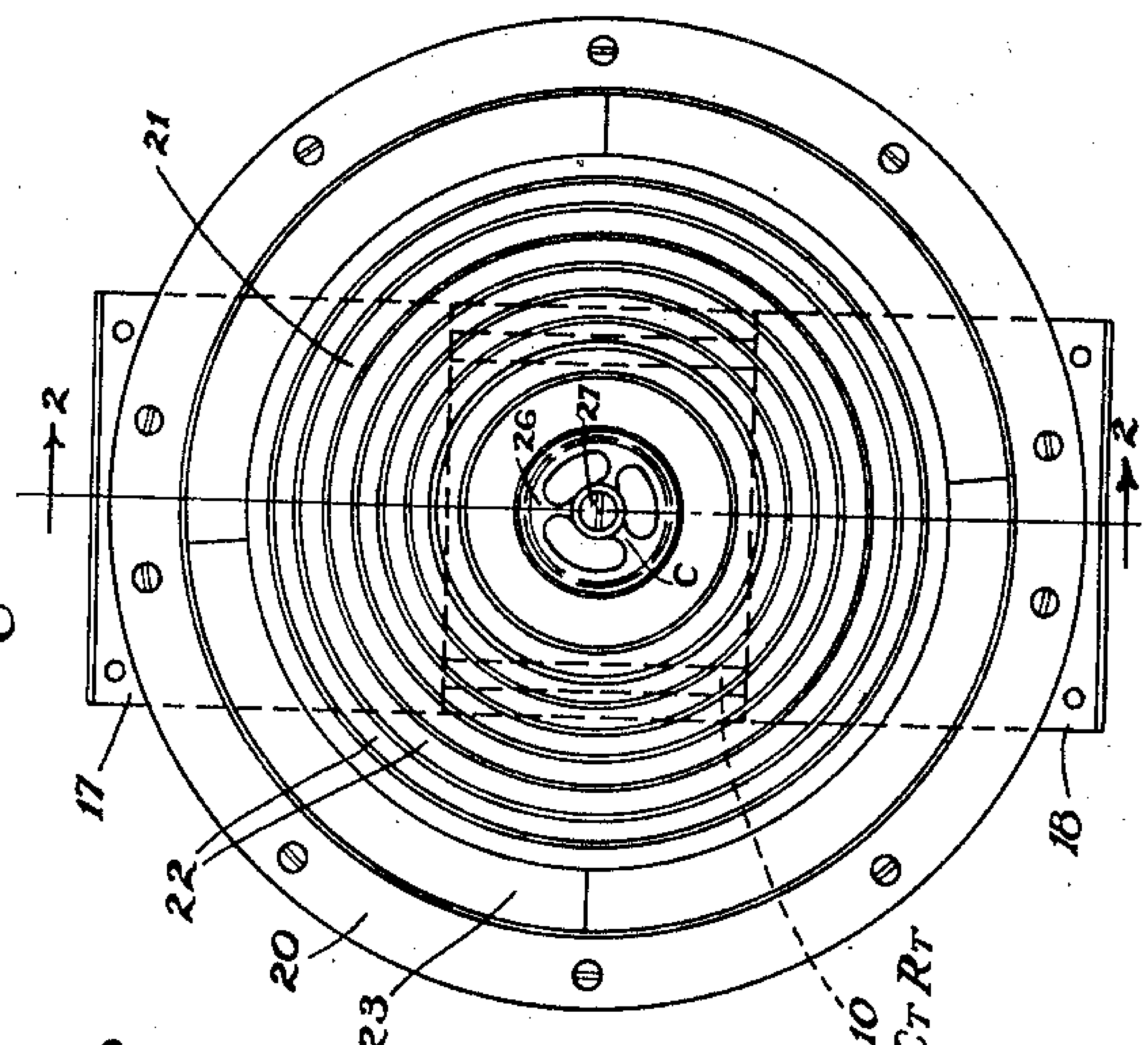

Fig 1

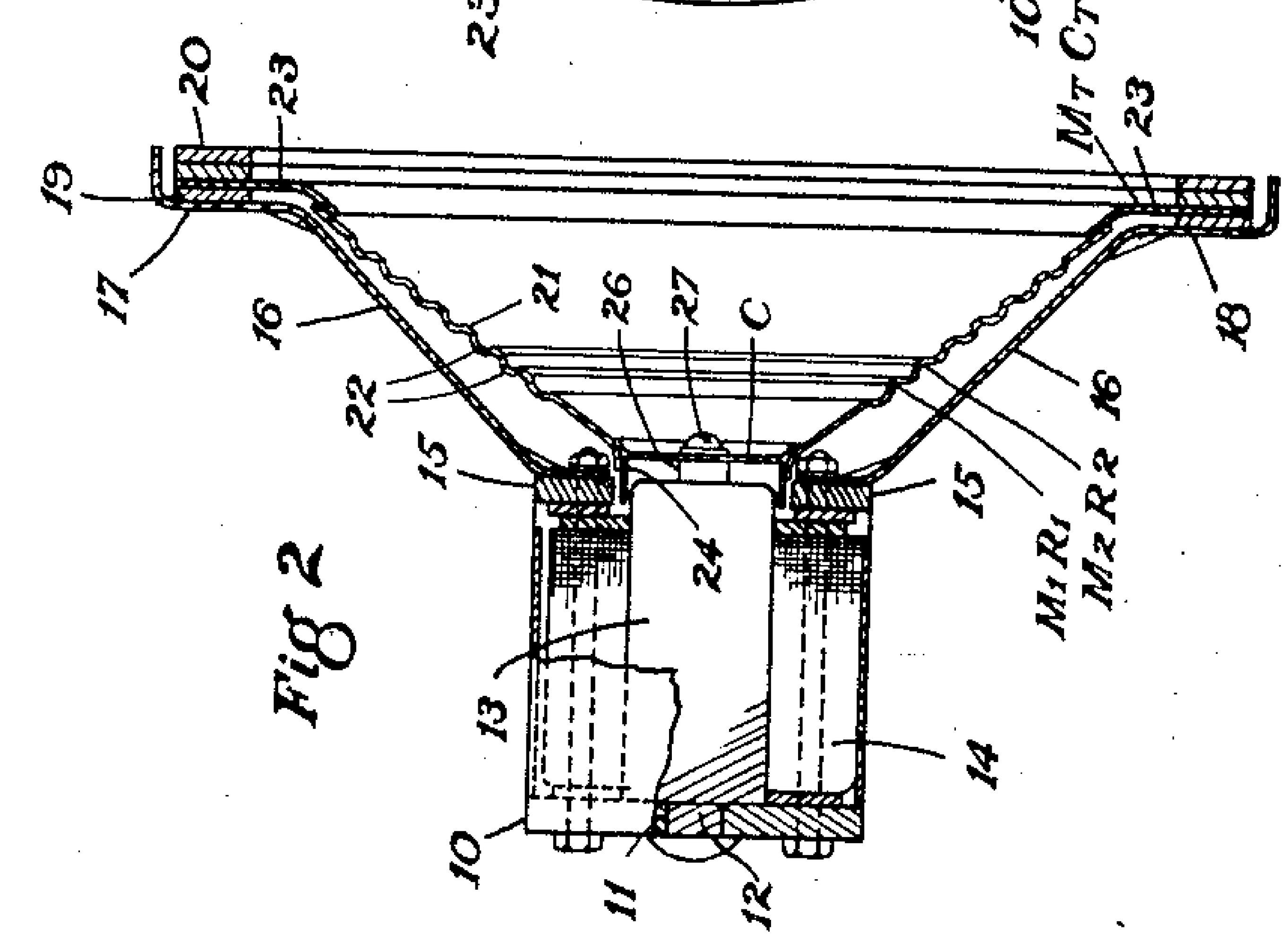

Fig 2

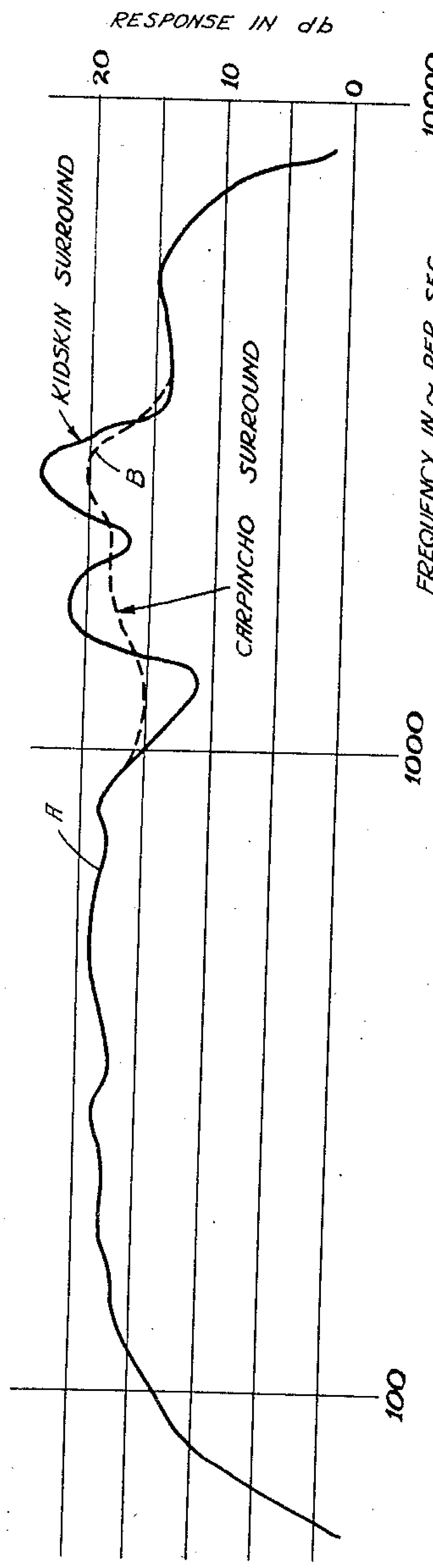

Fig 4

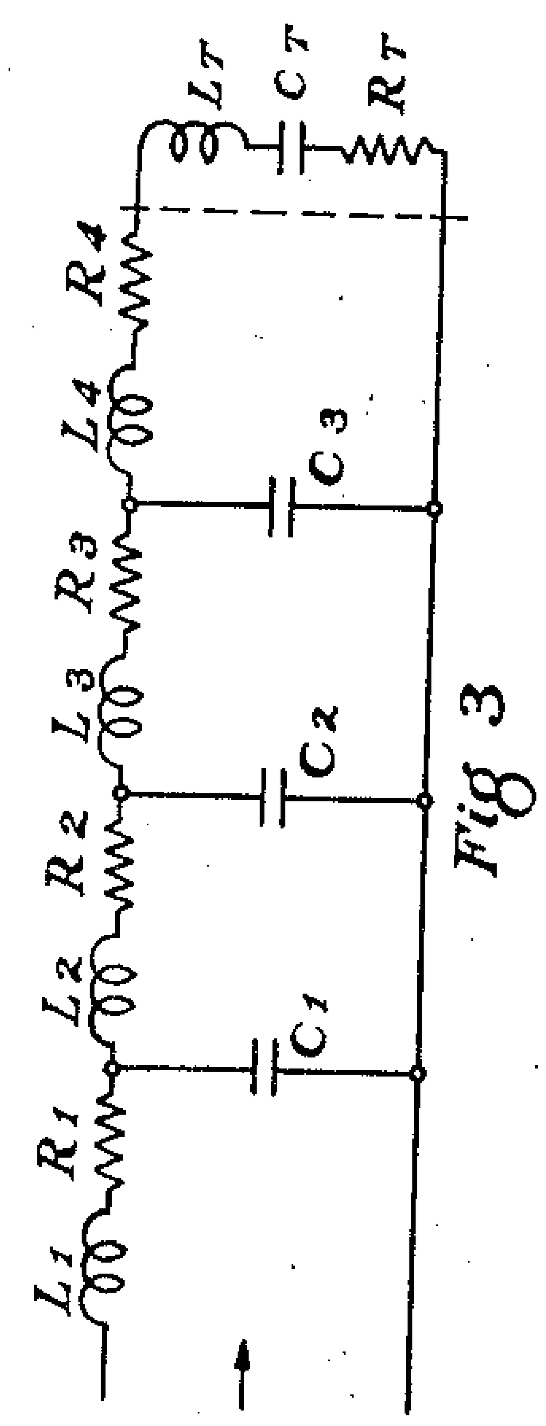

Fig 3

INVENTOR
GENTRY VEAL

BY *D. Clyde Jones*
ATTORNEY

Patented Feb. 8, 1938

2,107,920

UNITED STATES PATENT OFFICE

2,107,920

APPARATUS FOR REPRODUCING SOUND

Gentry Veal, Rochester, N. Y., assignor to The Stromberg-Carlson Telephone Manufacturing Company, Rochester, N. Y., a corporation of New York

Application November 16, 1935, Serial No. 50,203

5 Claims. (Cl. 181—31)

This invention relates to sound reproducing devices and more particularly to sound reproducing devices of the open radiator type.

It is known that any sound reproducing device of the open radiator type, such as a loud speaker employing a cone as the radiating element, does not uniformly reproduce all frequencies of sound to an equal degree with the result that certain reproduced sounds are distorted or exaggerated, a condition expressed visually by pronounced peaks in the response curve of the loud speaker.

In accordance with the present invention, a loud speaker is provided in which the undesired resonance peaks in the response curve of the loud speaker are controlled as to amplitude or substantially eliminated, with the result that more accurate sound reproduction is effected.

The various features and advantages of the invention will appear from the detailed description and claims when taken with the drawing in which Fig. 1 is a front view looking into the diaphragm of a cone type loud speaker of the present invention; Fig. 2 is a partial section taken through this loud speaker substantially on the line 2—2 of Fig. 1; Fig. 3 is an electrical network useful in describing the operation of the loud speaker and Fig. 4 is a chart showing in full lines the response curve of a commercial loud speaker and showing in dotted lines the response curve of the present invention.

Referring especially to Figs. 1 and 2, **10** designates a U-shaped magnet which is apertured at **11** to receive the reduced end **12** of a cylindrical core or central pole piece **13**. An energizing coil **14** formed of many turns of wire and adapted to be energized from a direct current source, surrounds the core **13**. On the free ends of the U-shaped magnet **10**, there is fastened a yoke or pole piece **15** having an opening therein slightly larger in diameter than that of the core **13**, the free end of the core **13** projecting into this opening to provide an annular space or air gap. A bracket **16** fastened to the yoke has its free ends **17** and **18** flaring outwardly to support an annular frame comprising two rings **19** and **20**, which constitute the edge support of a diaphragm **21** having the shape of a truncated cone. This diaphragm is formed of light but relatively stiff paper material and is provided with a series of annular corrugations **22** to give stiffness to the diaphragm. The edge of the diaphragm has attached thereto a surrounding flexible suspension **23**, the free edge of which suspension is clamped between the mentioned rings **19** and **20**.

It has been discovered that if the flexible surrounding suspension **23** is made from split carpincho leather with the grain thereof removed and having a thickness of from twenty thousandths to thirty thousandths of an inch, the suspension will have the proper mass, compliance or pliability, and mechanical resistance as to greatly improve the reproduction of the loud speaker so that the response curve (Fig. 4) representing the reproduction of this loud speaker is substantially free from so-called resonance peaks.

The truncated portion of the cone has fastened thereto coaxially therewith, a cylindrical movable coil **24**, comprising a support of pasteboard or other similar light rigid material on which there is wound many turns of fine wire. This coil and its support are adapted to move in the annular air gap between the core and the side of the opening in the yoke. Since it is essential that the coil and its support move in the mentioned air gap only in a direction parallel to the principal axis of the core, there is fastened to the truncated end of the diaphragm a spider **26** of rigid material which is mutilated as shown in Fig. 1 to permit portions thereof to move in a direction parallel to the axis of the core and yet insure that there will be substantially no movement of the voice coil supported thereby, out of parallelism with this axis. The spider is fastened by means of one or more screws **27** to the free end of the core after the coil has been properly centered in the mentioned air gap.

The invention will best be understood from the following description of the operation of the loud speaker. The energizing coil is steadily energized throughout the operation of the loud speaker from a source of direct current (not shown) while current at audio frequencies corresponding to the sound to be reproduced, is introduced into the movable coil **24** whereby the reaction between the field of the energizing coil and the field of the movable coil drives the diaphragm in a manner which will reproduce sound. At low frequencies, for example, below one thousand cycles per second, the cone diaphragm when driven axially by any force vibrates as a rigid plunger, the spider or center suspension and the edge surrounding suspension **23** yielding elastically to permit such motion. At higher frequencies however, the internal stresses set up in the cone diaphragm become sufficient to deform it and motion is transmitted through the material of the cone in flexual waves. At the same time there is energy dissipation both in internal friction between the fibers of the cone material and in the sound radiated therefrom. In prior loud speakers, a substantial amount of energy reaches the outer or free edge of the cone area where a portion of it may be dissipated in the surrounding suspension and the remainder reflected from this suspension back into the material of the cone. The reflected waves travel back toward the center of the cone, the displacement of any particular area of the cone at a given instant being that due to the sum of the waves passing through that area at that instant. At certain critical frequencies dependent upon the velocity of propagation of vibration through the material and upon the dimensions of the cone diaphragm, there occurs a stationary interference pattern between the direct and the reflected waves and an accompanying condition of resonance somewhat similar to the acoustic resonance which takes place in pipes. At these frequencies a given portion of the cone area may attain large velocities and the sound output of the loud speaker may either rise above or fall below its average level dependent upon the form of the interference pattern and the relative phases and velocities of the several portions of the cone area. It is this phenomenon which is chiefly responsible for the irregularities or distortions observed in the response of a cone type loud speaker as represented by the full line curve A of Fig. 4.

In accordance with the present invention, the surrounding suspension **23** is made of such material that the reflected waves are substantially eliminated since any waves reaching the free edge of the cone are substantially absorbed by the suspension material, thereby eliminating the peaks in the response curve A as represented by the broken line portion B thereof.

Perhaps this phenomenon will be better appreciated if the action of the loud speaker cone diaphragm is treated as somewhat analogous to that of an electrical transmission line. In the corrugated cone diaphragm of Figs. 1 and 2 the masses of the various portions of the cone area may be denoted by $M1$, $M2$, etc., the resistance of these portions including internal friction and acoustic radiation by $R1$, $R2$, etc. and the compliance or flexibility of the corrugations by $C1$, $C2$, etc. The suspension likewise has mass, resistance and compliance denoted by Mt, Rt, Ct respectively. In the equivalent electrical network shown in Fig. 4, the inductances $L1$, $L2$ etc. correspond to the masses $M1$, $M2$ etc. while the resistances and capacitances of the electric circuit $R1$, $R2$, etc. and $C1$, $C2$ correspond to the similarly designated resistances and compliances of the cone diaphragm system.

In the case of an electrical transmission line to which the electrical network of Fig. 3 is equivalent, it is well known that for the condition of no reflection at the receiving end, the line must be terminated in its iterative impedance represented by Lt, Ct and Rt, this impedance being a function of the distributed electrical constants of the line. In case the line is terminated in an impedance other than the iterative impedance, the amount of reflection is dependent upon the ratio of the terminating impedance to the iterative impedance. In a like manner, if the elements of the mechanical impedance of the cone diaphragm surround **23**, namely Mt, Ct, and Rt are equal to the mechanical iterative impedance of the cone structure no reflection will take place at the free edge of the cone and the irregularities or resonance peaks in the response of the loud speaker will be substantially eliminated.

In the past, kid skin, sheep skin, cloth of various kinds both plain and treated, imitation leather and rubber impregnated paper have been among the materials used for diaphragm surrounds or suspensions. It is necessary to choose a material sufficiently elastic to permit the wide excursions of the cone which are associated with its rigid plunger mode of vibration at the low frequencies but, unfortunately few materials have this property in combination with those which would make it a satisfactory terminating impedance over the frequency range wherein the cone vibrates flexurally. Some materials have too large a mass component and some have insufficient compliance, but the most common defect is insufficient mechanical resistance. Mechanical resistance may be due to internal friction among the fibres of the material alone or in combination with viscous air damping within the material. This latter type of damping may be due to air being forced in and out of minute interstices of the material when waves of mechanical vibration are transmitted through the edge suspension.

What I claim is:

1. In a sound reproducing device, a support, a cone-shaped diaphragm having a free edge, and a surrounding suspension joining the free edge of said diaphragm to said support, said suspension having the softness and pliability of carpincho leather with its grain surface removed.

2. In a sound reproducing device, a support, a cone-shaped diaphragm having a free edge, and a surrounding suspension joining the free edge of said diaphragm to said support, said suspension having the characteristics of carpincho leather with its grain surface removed.

3. In a sound reproducing device, a support, a cone-shaped diaphragm having a free edge, and a surrounding suspension joining the free edge of said diaphragm to said support, said suspension having the characteristics of carpincho leather of a thickness between twenty thousandths and thirty thousandths of an inch and with its grain surface removed.

4. In a sound reproducing device, a support, a cone-shaped diaphragm having a free edge, and a surrounding suspension joining the free edge of said diaphragm to said support, said suspension having the softness, pliability and mechanical resistance of carpincho leather with its grain surface removed and having a thickness of twenty thousandths to thirty thousandths of an inch.

5. In a sound reproducing device, a support, a conical shaped diaphragm having a free edge and possessing the characteristic of mechanical iterative impedance, and a surrounding suspension joining the free end of said diaphragm to said support, said suspension having the characteristic of softness and pliability and mechanical impedance approximately equal to the mechanical iterative impedance of said diaphragm.

GENTRY VEAL.