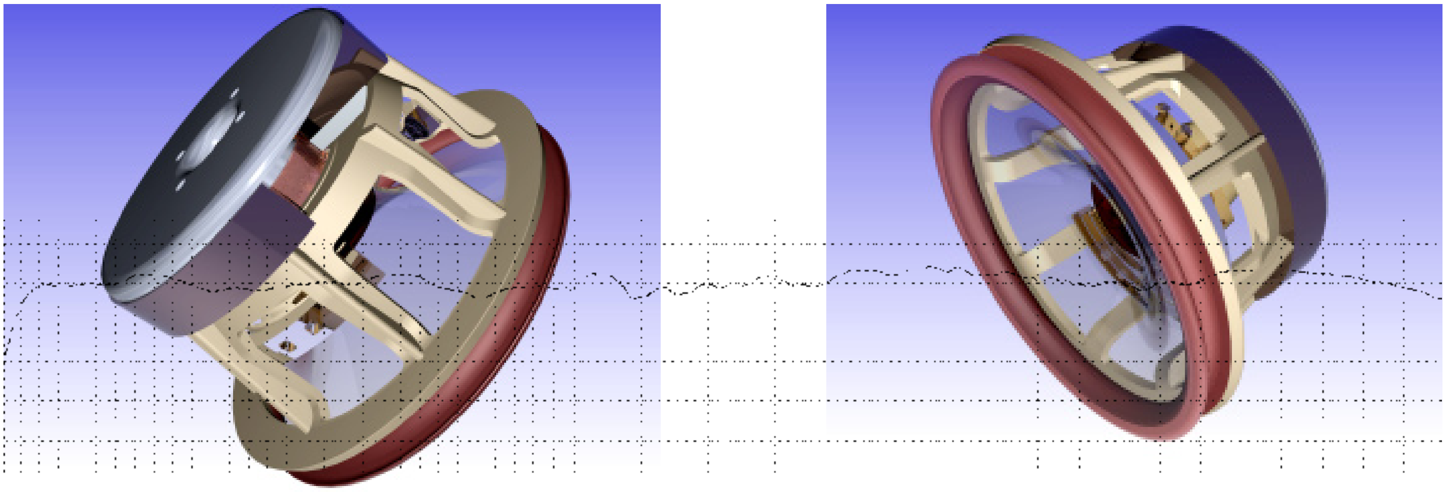

11/10/94 Revision A 06/07/95

PATENT INFORMATION - REAR MOUNTED SURROUND (RMS) LOW FREQUENCY DRIVER LFM811

INVENTORS:

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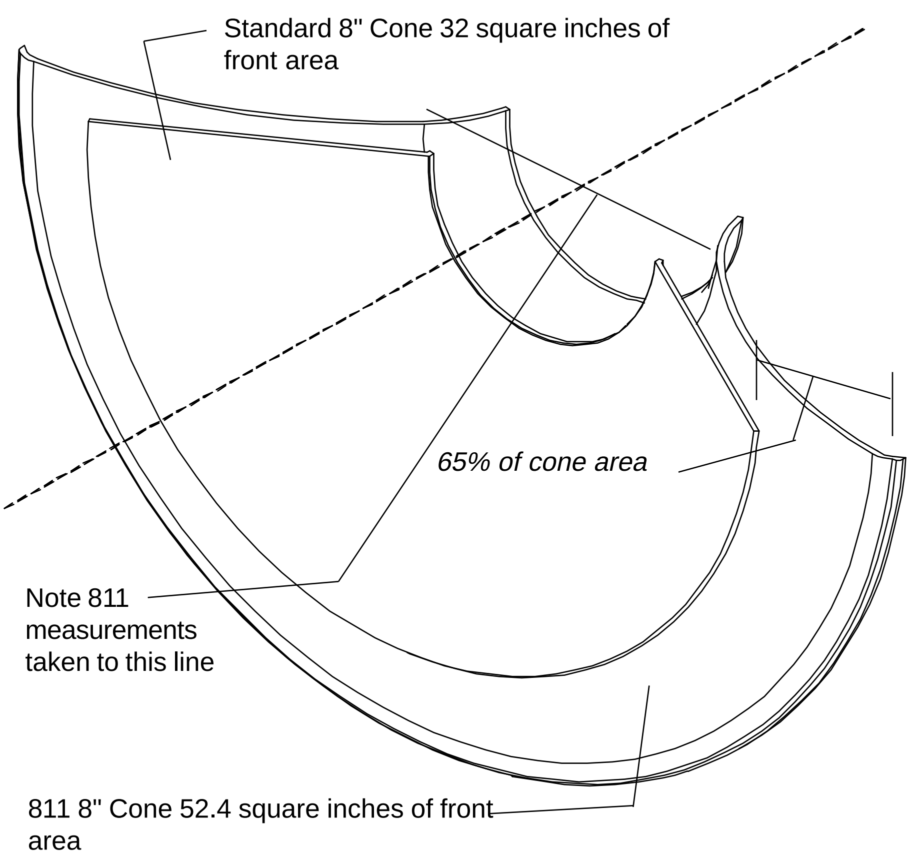


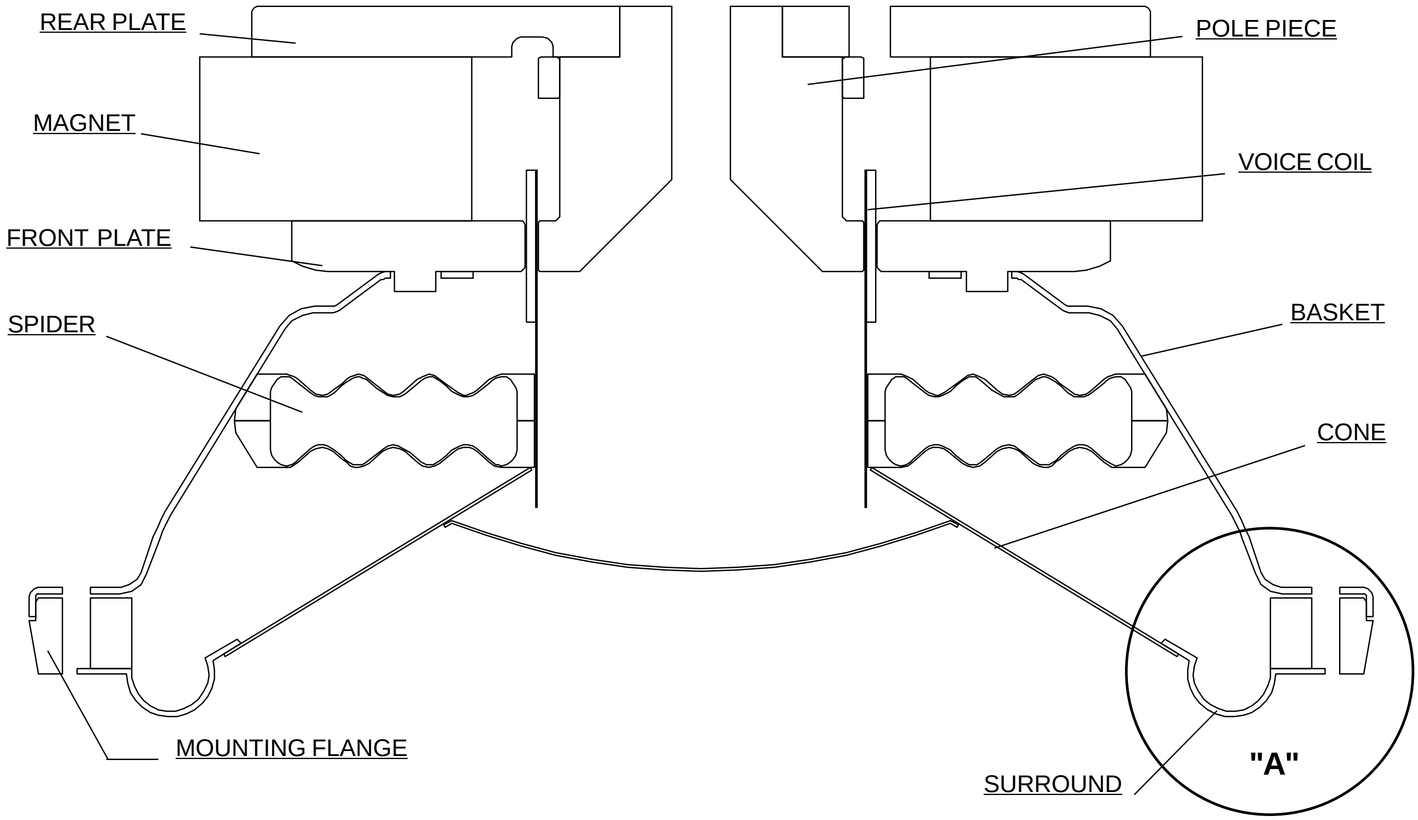
CONCEPT:

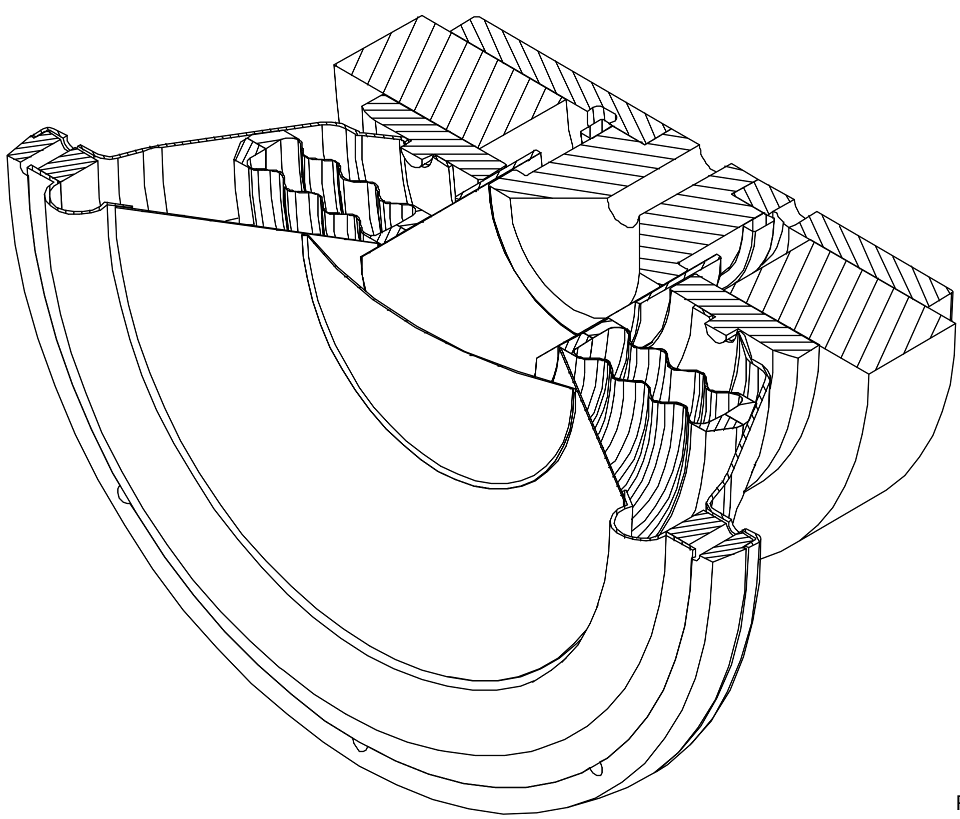
All conventional low frequency drivers (Woofers) waste approximately 65% of their front radiating area by allowing space for a "Front Mounted Surround" and "Driver Mounting Flange". *(see below and pages 2 "A" and 3 "A")*

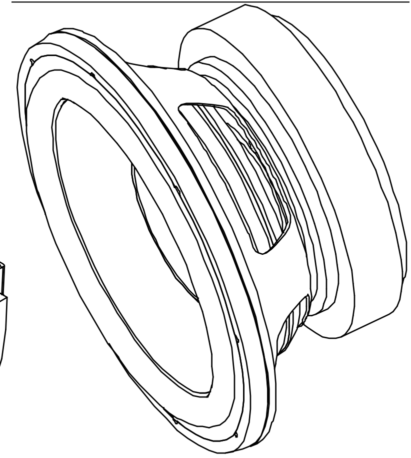
The "Rear Mounted Surround" eliminates this by attaching the "Surround" to the back side of the cone and rotating the "Roll Shape" 90 degrees radially inward . The driver can than be mounted using "Toe Clamps" (see page 3 "B") in areas on the front of the speaker or rear mounting hardware from the inside of the cabinet. This design will fit in any cabinet that is currently using an industry standard 8" ,10" ,12" or 16" diameter driver.

We estimate that this design will

STANDARD 8 INCH TEST DRIVER

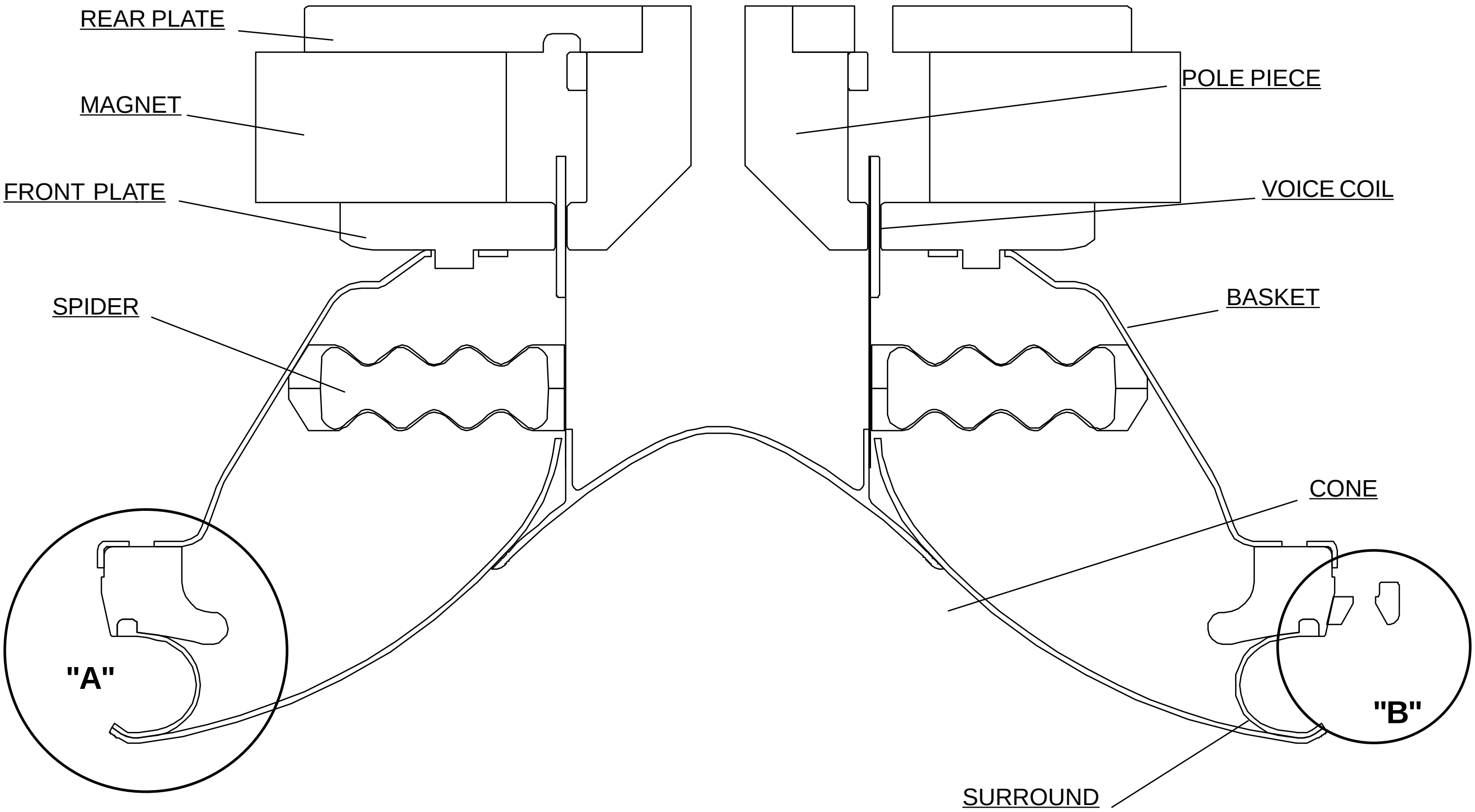


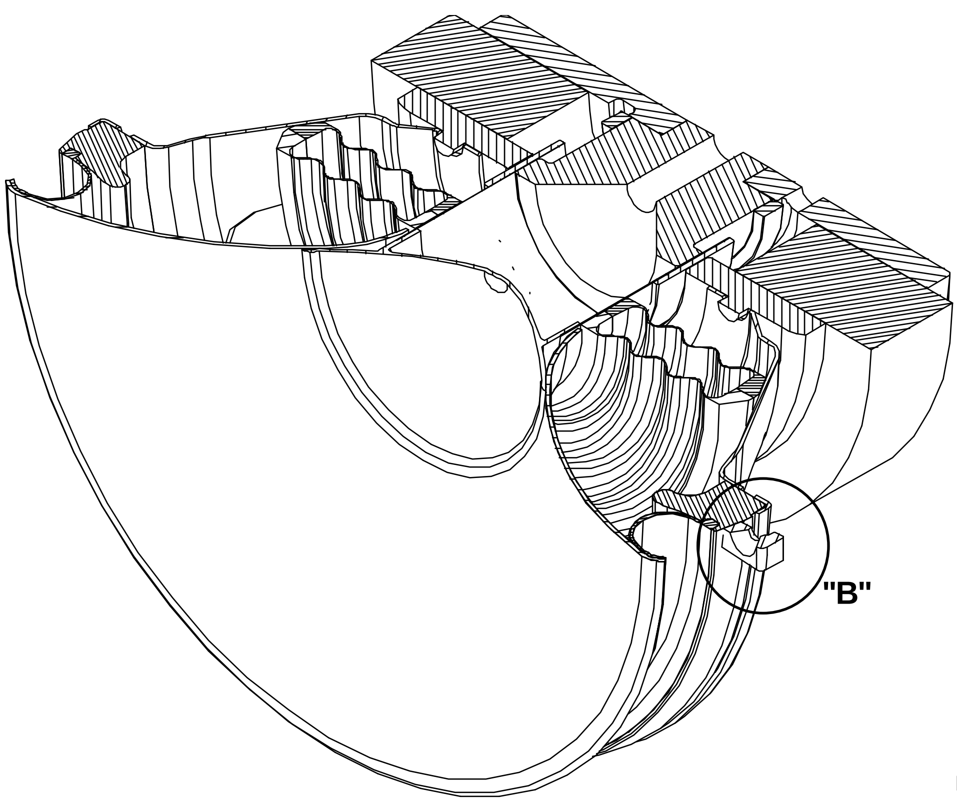


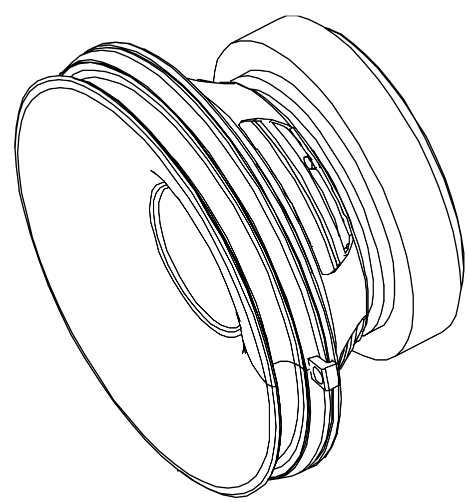


increase efficiency, extend the usable bottom end another octave and decrease distortion in the 25hz -39hz range. This has been documented on pages 4 thru 9.

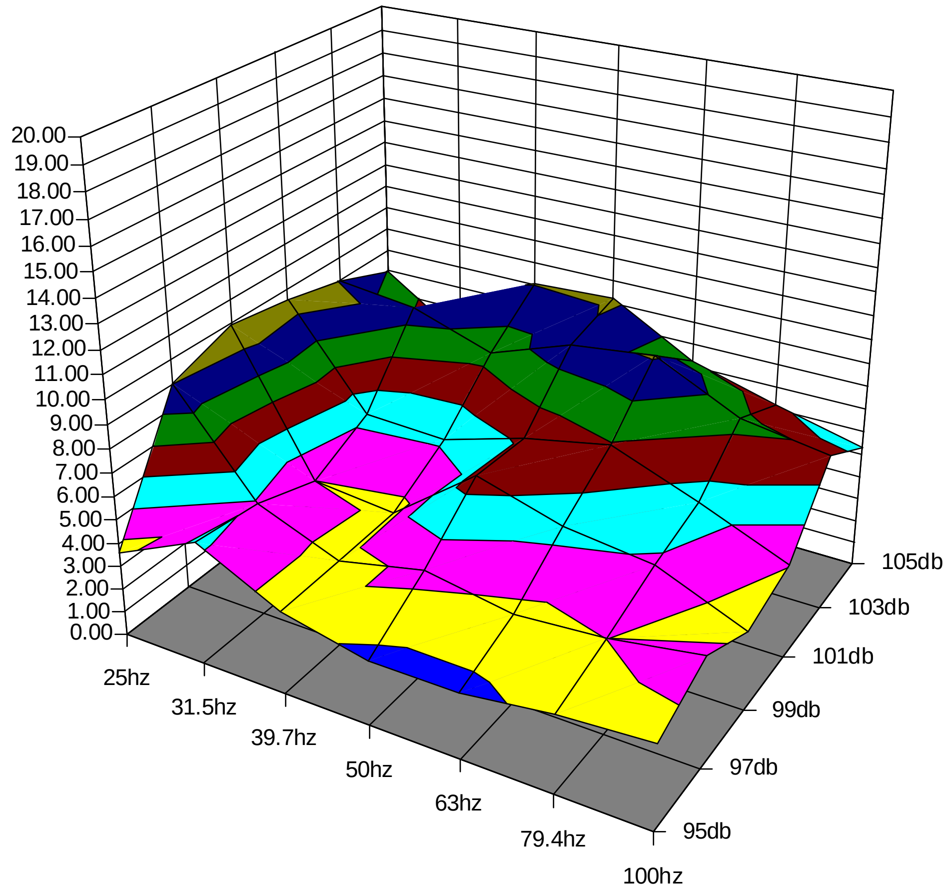
STANDARD 8 INCH TEST DRIVER WITH 811 RMS RETROFIT







The surround is made of Ciba-Geigy RP6401 REN:C:O-THANE Polyurethane Elastomer.



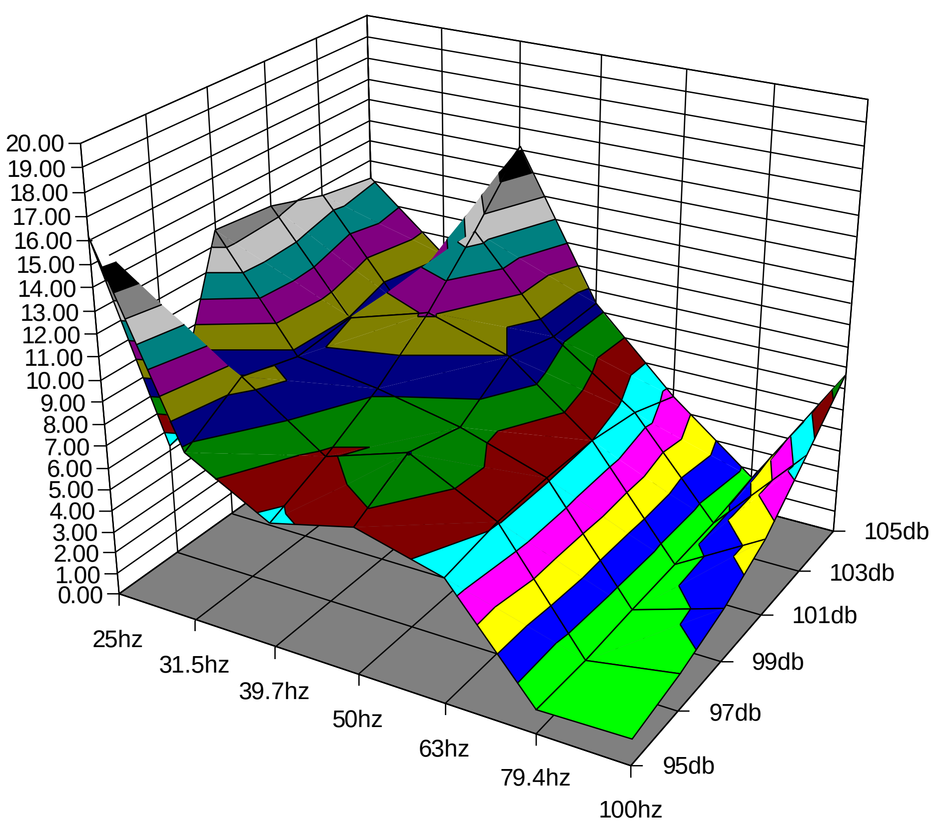
Distortion plot for Modified 8" driver with 811 retrofit

HARMONIC DISTORTION:

HDS measurements were taken with a TEF 20 analyzer using Sound Lab SLX software. These tests were taken from 25hz to 100hz (by 1/3rd octaves) with a range beginning at 95db and ending at 105db . (2nd, 3rd ,5th and 7th order are reflected in the test graphs shown at left.)

All measurements were made using a BK Omni directional 4007 microphone positioned 1 meter on driver center and referenced to the same level.

Both drivers were using the same suspension (spider) systems with 70oz ceramic magnet motors.

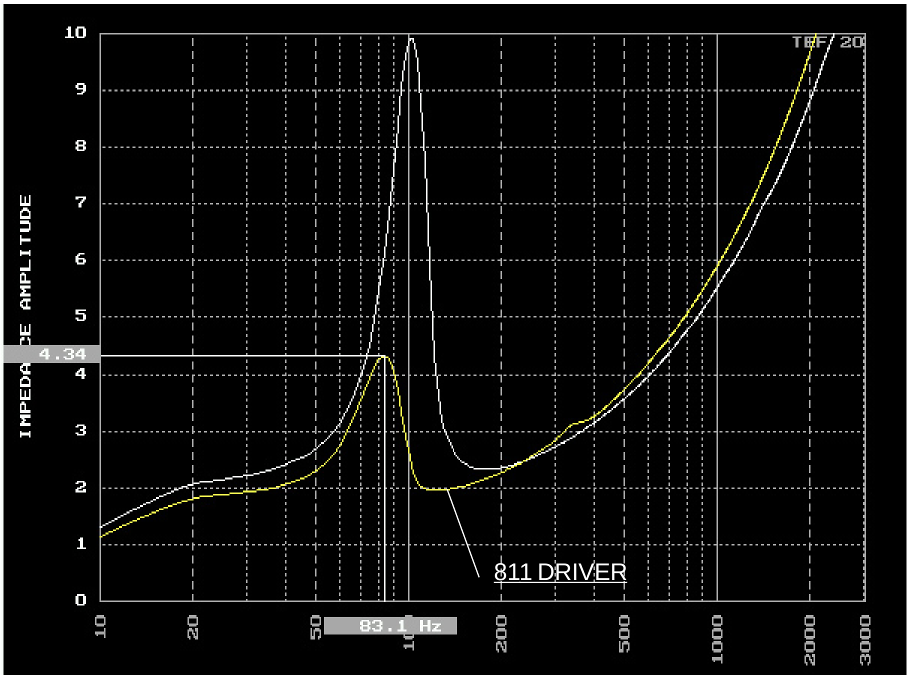


Distortion plot for Standard 8" driver

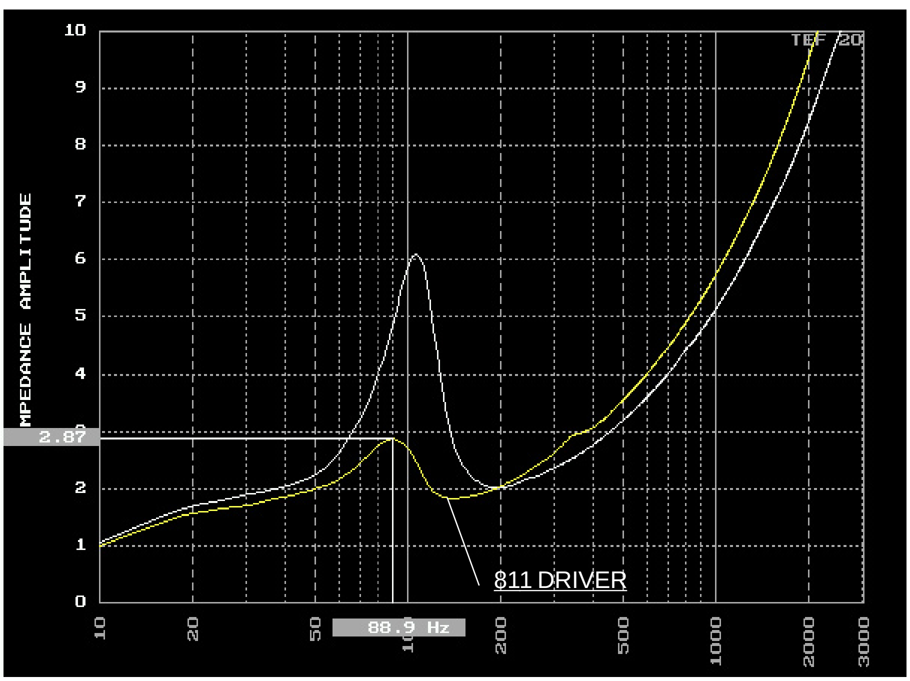
IMPEDANCE / RESONANCE

Graphs 5a and 5b represent the results of the driver resonance tests in "Free Air" and in an "Enclosure". These tests are the best we have ever seen on a system of this type and again reinforce the fact that the "Rear Mounted Surround" is a well balanced suspension system in keeping with the original design intent .

Graph 5a is "Free Air" resonance and the bottom graph (5b) is in an "Enclosure".



5A Impedance /Resonance in free air



5B Impedance /Resonance in an enclosure

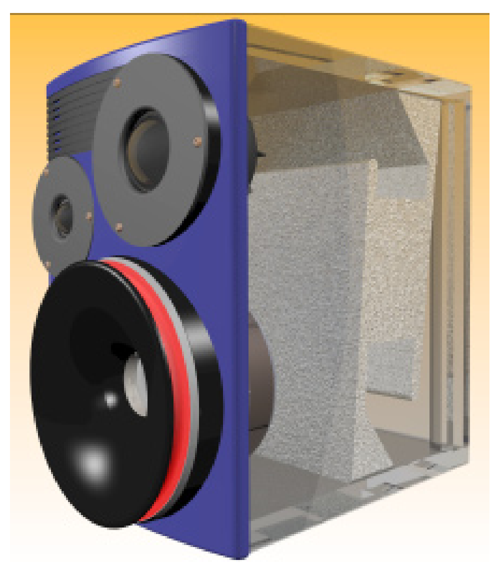
FREQUENCY RESPONSE

Graphs 6a and 6b represent frequency response with and without a crossover in the same enclosure.

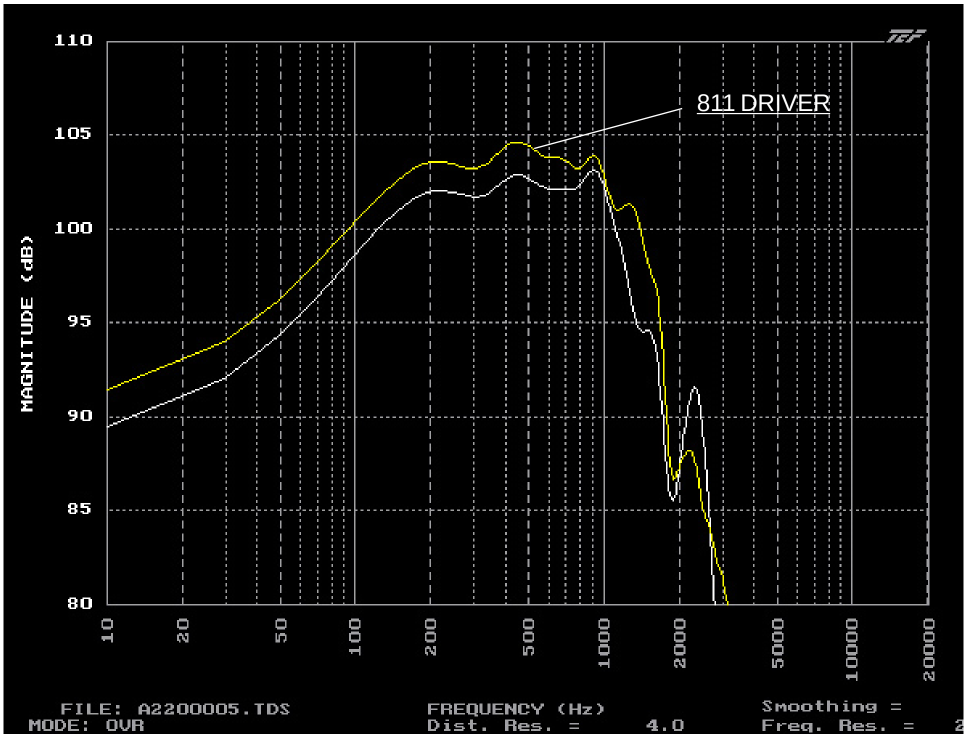
It is clearly evident that the 811 driver produces an average of 2db more output in the tested range with the same input level. (see 6a)

The peaks at 1000hz, 2300hz, 3300hz and 6600hz (which are typical on low frequency drivers) are totally gone with the 811 driver which will make cross over design much easier. (see 6b)

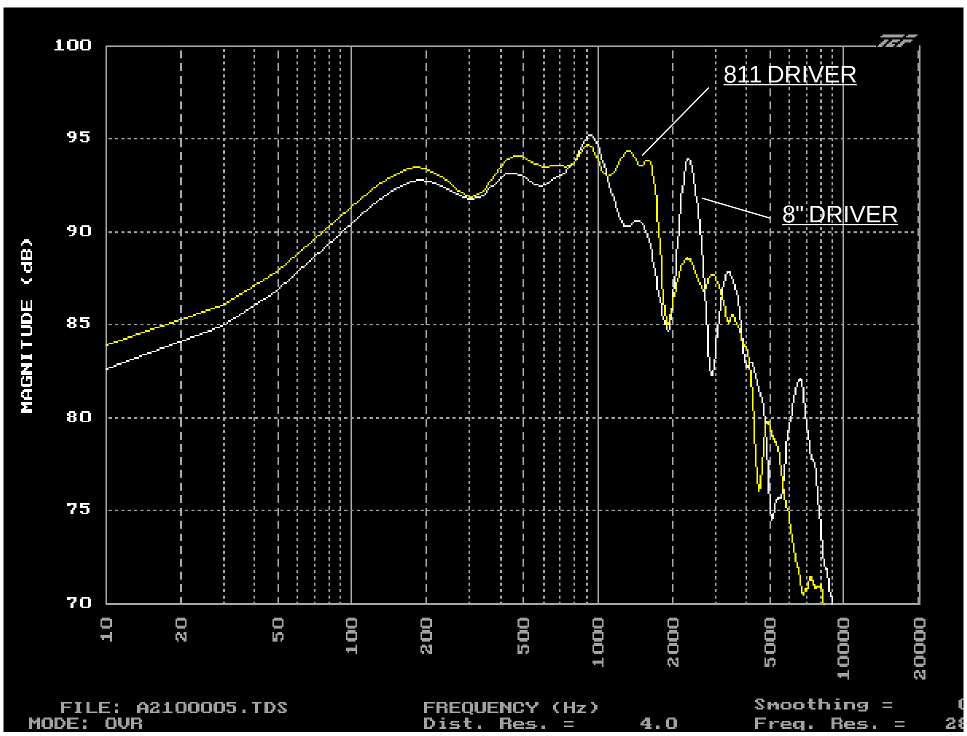
Graph 6b also shows a marked improvement in extending useful frequency response beyond 1000hz to 1700hz. This provides for easy construction of 2 way systems or reduced load on the mid-range driver in 3 way systems.



Audigo SGI Near Field with 811 retrofit driver



6A Frequency response thru a electronic crossover



6B Frequency response without crossover

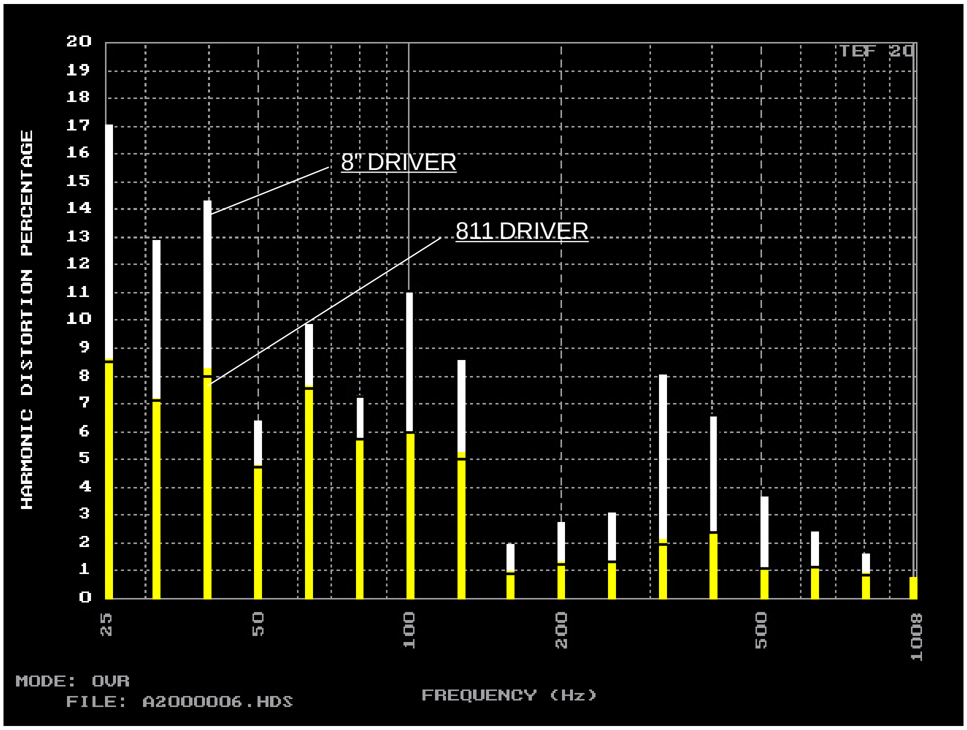
SUMMARY

The information enclosed in this report clearly shows a marked improvement in the areas of driver output , lower distortion and extended usable range. The key element to our patent claim is as noted:

What makes this design unique is the positioning of the flexible suspension component (1) which is disposed reward of the diaphragm (2) and is turned inward toward the center (3) of the assembly so that it does not extend beyond the diameter of said diaphragm's piston area. This allows the use of a diaphragm of the same diameter as the mounting flange (4) of the loudspeaker, resulting in an increase in acoustical output , reduced distortion and an extended usable range when the 811 driver is used for a replacement for conventional driver in an existing loudspeaker enclosure or enclosure design. (refer to diagram 7b)

CONCERNS FROM PRIOR ART

We call your attention to patent 2,490,466 12/06/1949 Loudspeaker Diaphragm Support Comprising Plural Compliant Members Harry F Olson Radio Corporation of



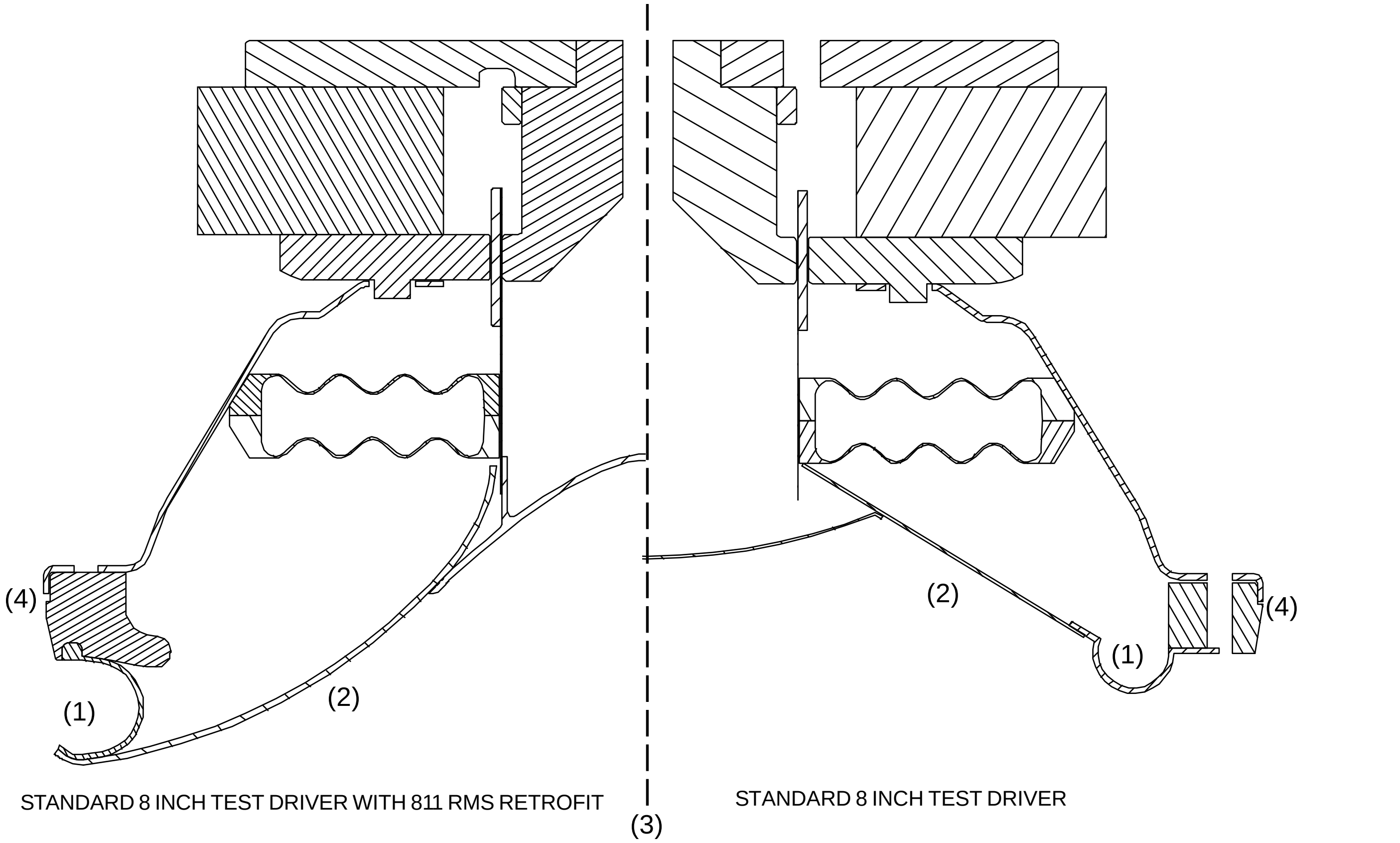
7A 2nd ,3rd,5th and 7th Order Harmonic Distortion Clearly showing 1/2 the distortion at 100db 1 meter this position

America.

On page 2 column 3 paragraph one Mr. Olson makes the following claim:

" THIS MAKES POSSIBLE THE USE OF A LARGER DIAPHRAGM WITH A GIVEN SIZE OF HOUSING FRAME AND DESIRED AMOUNT OF COMPLIANCE IN THE FLEXIBLE SUPPORT."

Figure 2 of this patent shows what appears to be an inward suspension ,however the drawing is not sectioned to show this.



7B Comparison of Standard 8" driver with 811 retrofit to Standard driver without retrofit

Patented Dec. 6, 1949 2,490,466

UNITED STATES PATENT OFFICE

2,490,466

LOUDSPEAKER DIAPHRAGM SUPPORT COMPRISING PLURAL COMPLIANT MEMBERS

Harry F. Olson, Princeton, and John Preston, Hopewell, N. J., assignors to Radio Corporation of America, a corporation of Delaware

Application July 19, 1944, Serial No. 545,672

11 Claims. (Cl. 181—31)

1

This invention relates to sound producing devices, and more particularly to loudspeaker diaphragm supports and housings, for use in radio receivers, phonographs, announce systems, and the like.

An object of the invention is to increase the power handling capacity of a small speaker, making it comparable to one substantially larger in size in its output of undistorted acoustic energy and fidelity of reproduction of desired low as well as high frequency sound waves.

Another and more specific object of the invention is to provide an improved diaphragm suspension structure in a loudspeaker characterized by a reduction in the effect of the suspension impedance, thus lowering the natural resonant frequency of the speaker of a given size, without increasing the mass reactance of the moving parts.

A further object of the invention is to provide an improved compliant suspension in a limited space for a piston-type loudspeaker diaphragm of small mass reactance whereby the diaphragm is free to vibrate at large amplitude over a substantially extended portion of the lower audio frequency range without amplitude distortion.

A still further object of the invention is to improve the low frequency response of loudspeakers mounted in small housings as in small radio receivers.

In accordance with the invention, an acoustical system has been devised that extends the low frequency range of small speaker-housing combinations, such as table model radio receivers, as much as one octave. The quality of musical reproduction has been substantially improved. The intelligibility and quality of speech has been increased as a result of elimination of cabinet resonance. The non-linear distortion has been reduced to as much as one-tenth in certain portions of the range. The invention comprises essentially a completely enclosed housing for the rear surface of a cone type loudspeaker having a novel base suspension of substantially lowered stiffness, the arrangement being simple and inexpensive.

Still further in accordance with the invention, there is provided an improved dual flexible support for the base of a frusto-conical or piston type of diaphragm adapted to move as a whole at low audio frequencies and characterized by the fact that greatly increased axial flexibility is obtained with no greater than normal diametrical space requirements. The increased flexibility and efficiency is obtained in certain forms of the invention by arranging in tandem compliant radial sections located in planes, respectively, substantially normal to the axis of the diaphragm. These, as well as other features of the invention, will become apparent from the following description with reference to the drawings, in which:

2

Figure 1 is a side elevation view, in section, of a dynamic type loudspeaker including a diaphragm suspension embodying the invention,

Figures 2, 3 and 4 are fragmentary side elevation views, in section, of modified forms of the invention,

Figure 5 to 10, inclusive, are characteristic curves of performance of various forms of loudspeakers, mostly embodying the invention,

Figures 11 to 16, inclusive, are characteristic curves illustrating principles underlying the invention,

Figures 17, 19, 21, 23 and 25, inclusive, illustrate various sizes and shapes of speaker housings, in plan view, together with corresponding characteristic curves (Figs. 18, 20, 22, 24, 26) illustrating principles underlying the invention,

Figure 27 shows a schematic side elevation view of a standard type speaker diaphragm and flexible base support,

Figure 28 shows characteristic curves of the speaker illustrated in Figure 27, and

Figure 29 shows a characteristic performance curve A of a speaker and cabinet constructed in accordance with the invention, as in Fig. 25, in comparison with a characteristic curve B of a speaker and housing not including the present invention, as in Fig. 23, these curves being similar, respectively, to the curves in Figs. 26 and 24.

Heretofore the usual type of flexible suspension for the base of a frusto-conical acoustic diaphragm has consisted in an annularly corrugated fibrous support rim attached to the base of the diaphragm, or molded integrally therewith, as in Hawley 2,006,830. The purpose of such a suspension has been to provide lateral stiffness to sidewise movement of the diaphragm while allowing freedom of movement in an axial direction, the direction in which the diaphragm is normally driven. The difficulty, particularly with small size speakers, is that there has been too great stiffness in the axial direction, with the result that the range of low frequency response has been limited. Attempts have been made to increase flexibility by increasing the radial dimension of the suspension, but this has resulted in unduly large diaphragm housings in the diametrical direction, or has resulted in decreasing the size of a speaker diaphragm for a given size housing. Since the low frequency resonance, below which response falls off rapidly, of a speaker is a function of the mass reactance of the moving structure and the stiffness impedance or compliance, it is essential that the stiffness of the flexible support be reduced to a minimum in order to lower the resonant frequency, and hence materially extend the low frequency end of the audible range of reproduction. Increasing the mass in order to lower the range is objectionable because it reduces the effectiveness for the reproduction of higher audio frequencies.

In accordance with the invention, the desired results have been accomplished by providing flexible support means comprising a plurality of compliant sections connected in series relation and disposed in parallel planes in superposed or overlapping relation, thereby getting at least as good compliance effect as with a single flexible support of much larger radial extent. This makes possible the use of a larger diaphragm with a given size of housing frame and desired amount of compliance in the flexible support. Alternatively, it makes possible the reduction in overall size of a speaker housing frame in the diametrical dimension for a given size diaphragm.

The sound power output of a mass-controlled dynamically-driven diaphragm operating below the frequency of ultimate resistance is independent of the frequency. In this range the velocity of the cone is inversely proportional to the frequency. Below the fundamental resonance frequency of the cone and suspension the system is stiffness-controlled and the velocity is proportional to the frequency. Since the radiation resistance is proportional to the square of the frequency, the response falls off very rapidly below the fundamental resonance frequency of the loudspeaker. Suspension systems in use today are non-linear. Since the loudspeaker is stiffness-controlled below the fundamental resonance frequency, the use of a non-linear suspension results in harmonic production. One solution of the problem of improving the low frequency response and reducing the non-linear distortion is to decrease the stiffness of the suspension system. When the stiffness of the suspension is reduced by increasing the size, difficulty is experienced in the mid-frequency range. This type of suspension breaks into various modes of vibration in the mid-range which produces a non-uniform response characteristic.

Referring to Fig. 1, an electro-dynamic speaker is shown as comprising a diaphragm **1** having a stiffened central portion, preferably frustroconical and a fibrous seamless felted construction. It is provided at its small end with a voice coil form **3**, cemented thereto and carrying a voice coil **5**. The base of the diaphragm terminates in a compliant peripheral fibrous ring member or support rim **7**, preferably circumferentially corrugated, and extending radially outward from the base. The outer peripheral edge of ring member **7** is flexibly supported by a fibrous, compliant ring member **9**, members **7** and **9** being joined or cemented together at their outer edges, member **9** extending radially inward from this joint in spaced overlapping relation with respect to rim **7**. The members **7** and **9** also function as an acoustic seal for the baffle in which the speaker is mounted. The member **9** is curved in cross-section as shown at point **9**, resembling a relatively large corrugation, and is also circumferentially corrugated as shown at point **10** to further increase the flexibility. The effect of the corrugations is to give the auxiliary member **9** a high degree of compliance in the axial direction of diaphragm movement. This auxiliary member is supported and attached at its inner edge to a rigid metallic diaphragm support housing **11** by means of an intermediate fibrous ring **13**, which is cemented to the housing and to the member **9**. The member **9** is preferably made by the felting process.

The flexible suspension system for the diaphragm base is protected circumferentially as well as axially by means of a stack of annular fibre members **15**, attached to a flange portion **17** of the diaphragm housing and extending forwardly of the plane of the diaphragm base. This additional compliant member **9** greatly reduces the stiffness of the diaphragm base suspension for axial or longitudinal movement of the diaphragm, and because of its re-entrant disposition does not increase the overall diametrical size of the speaker. This auxiliary compliant member is so designed as not to substantially decrease the lateral stiffness of the suspension system. The small end of the diaphragm is flexibly supported by an outwardly extending corrugated disk **8**, as disclosed in Patent 1,893,049 to Bodette. There is adequate room for an extended support for the small end of the diaphragm, resulting in adequate flexibility, but the limiting factor in suspensions has been in the base support for the diaphragm. The speaker shown is basically a standard type known as the RL—76—2, modified in accordance with the invention, by the addition of the auxiliary compliant member **9**.

Referring to Fig. 2, a triple-folded suspension is shown without the usual compliant corrugations. In this arrangement, the base of the diaphragm was extended radially into a flexible fibrous flange **21**, the periphery of which had cemented to it a fibrous coupling ring **23** extending circumferentially around the outer edge of the member **21**. A second fibrous flexible annular member **25** was cemented to the lower edge of coupling element **23**; and a third compliant fibrous member **27** was coupled at its inner edge, by means of an annular fibrous element **29** (as in the case of element **23**) to the corresponding peripheral edge of element **25**. The fundamental resonance frequency of this construction was found to be as low as 25 cycles, as compared with a resonance frequency between 110 to 150 cycles for the conventional molded paper base suspension, and 60 or 70 cycles for a diaphragm of similar nature supported by leather or imitation leather. This low resonance is somewhat lower than necessary for most purposes, but it illustrates the improvements in low frequency response made possible by the present invention. The elements **23** and **29**, by reason of their shape, are relatively stiff and serve as light-weight spacing elements coupling the compliant members **21**, **25** and **27**.

Referring to Figure 3, a more practical embodiment of the triple suspension of Figure 2 is shown. In this arrangement, the integral annular flange **21** on the base of the diaphragm is corrugated circumferentially as usual and is provided at its outer portion with a downwardly extending edge **23'**, similar in function to coupling element **23** in Fig. 2, for the purpose of attachment to a second compliant member **25'** and for spacing the two members as shown. A third suspension member **27'** is provided at its inner circumferential edge with an upwardly extending spacing portion **29'** for attachment to the inner edge of compliant member **25'** and for spacing the second and third compliant members. The outer edge of the third compliant member **27'** is supported on the flange **17** of the diaphragm housing, as by means of a fibrous ring **13** as in Fig. 1. The suspension structure **27'** is flexible for the force exerted by the driving mechanism and functions effectively as a third compliant member in series with the peripheral member **21** and ring member **25'**.

Referring to Fig. 4, the arrangement is somewhat similar to Figs. 1 and 3, except that the

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LOUDSPEAKER DIAPHRAGM SUPPORT COMPRISING
PLURAL COMPLIANT MEMBERS
Filed July 19, 1944 3 Sheets-Sheet 1

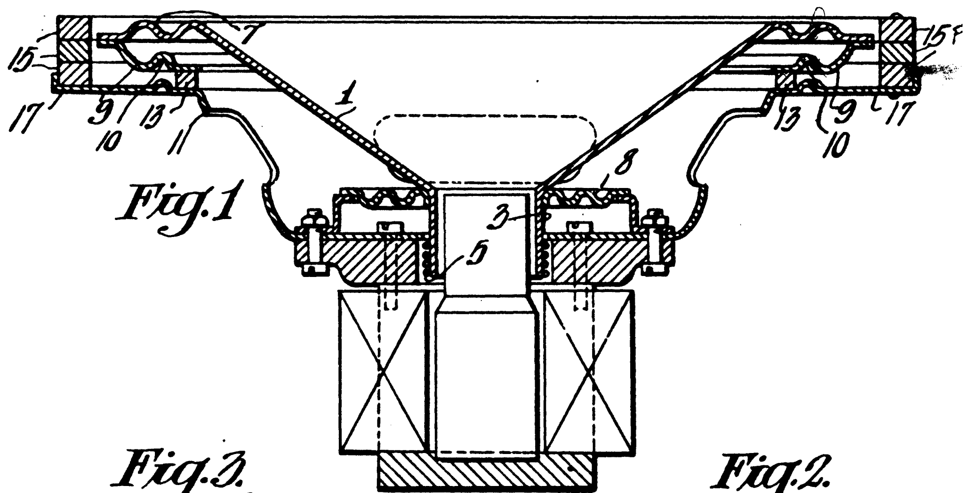
Fig. 1

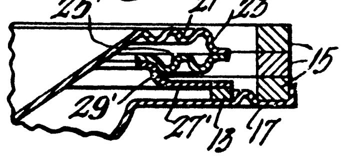
Fig. 3

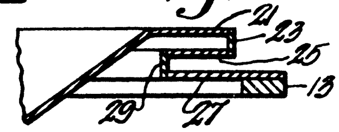
Fig. 2

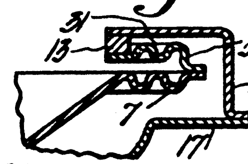
Fig. 4

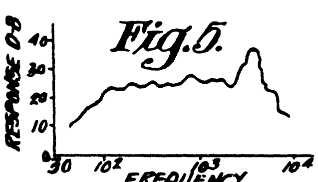

Fig. 5

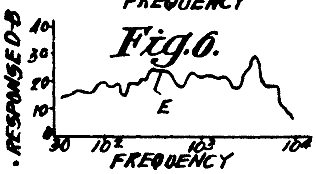

Fig. 6

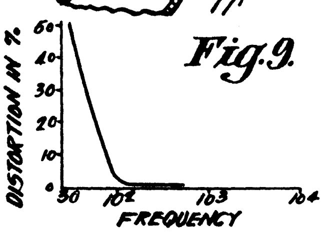

Fig. 9

Fig. 7

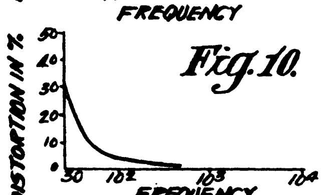

Fig. 10

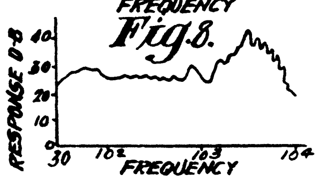

Fig. 8

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