# AN IMPROVED LOUDSPEAKER SYSTEM FOR THEATERS*

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***Summary.***—*This paper gives a description of a new 2-way loudspeaker for theaters. New permanent magnet low-frequency and high-frequency units having replaceable diaphragms are described. These units are combined in a horn system having the following advantages: A higher efficiency, extended frequency range, permanent magnet units providing higher air gap flux densities, elimination of backstage radiation from the diaphragms, belter transient response, and an improved over-all presence.*

The use of the present 2-way multicellular horn systems over the period of the last 10 years has permitted the theater to give the public a sound quality representative of the sound recording technique available during the same period. However, during this 10-year period, experience has been gained indicating that still better recording technique is possible when better loudspeakers are available for monitoring purposes.

Accordingly, new loudspeakers are now being designed for this purpose, and it is the hope that they will bring the quality of sound even nearer to the ideal objective of sound engineers. We are sure that all of us will agree on this objective; we want improvement in both high- and low-frequency units, and we want the use of these units in a loudspeaker system having greater efficiency, higher power capacity per unit, better transient performance, an extension of the frequency range, a higher definition in quality, and a better over-all presence.

But it is necessary to have a new motion picture loudspeaker system (Fig. 1) in order to gain these improvements. Before such a new horn system could be developed, other things had to come. We had to have new methods of manufacturing diaphragms, we needed better voice coil construction, and magnets had to be developed that would be considerably superior to anything we have had in the past—and

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these magnets came along as one of the developments in the war industry.

In the past, poor presence has been one of the principal deficiencies, which can be attributed to several causes. As an example, dips in the 250-500-cycle region tend to give the effect of individual low- and high-frequency sources. Resonances in the low-frequency units and horns have accentuated narrow bands. Backstage resonance, caused in part by radiation from the rear of the speaker system, has caused detrimental hangover and masking of the auditorium sound with an attendant loss of presence. Long air column low-frequency horns become involved in phasing trouble and loss of presence is encountered owing to the fact that the apparent source of sound tends to recede back in the horn progressively with an increase of frequency. Folding of the horn tends to limit the frequency range in proportion to the sharpness and number of the turns. Rigidity is necessary so that the walls of the horn will not vibrate and dissipate

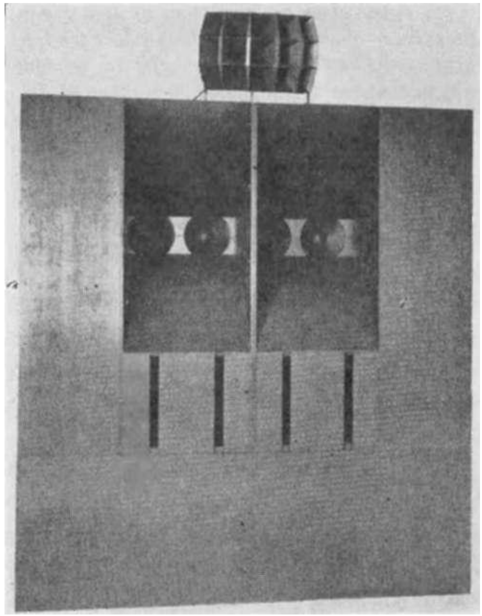

**FIG. 1. Front view of *A-2* loudspeaker.**



sound power by absorption and also give uncontrolled directional effects.

With this long list of difficulties in mind to begin with, new low- and high-frequency units were designed. These units have improved impedance characteristics, longer life diaphragms which dissipate more power safely, permanent magnet units with diaphragms that can be changed easily, and new magnetic circuits combining long life at high efficiencies.

### 288 HIGH-FREQUENCY UNIT

One of the basic improvements in the loudspeaker system has resulted from the design of a new high-frequency unit. The larger metallic diaphragm units available in the past have used the annular type of compliance. This type of compliance, while adequate at high frequencies, did not provide the necessary amplitude at lower frequencies. As a result, both the power and frequency characteristics in the region from 250-500 cycles have been found inadequate owing to the inability to handle the necessarily large excursion properly.

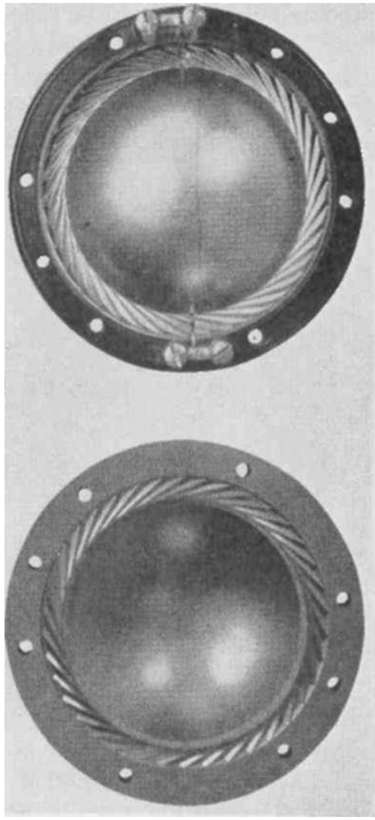

**FIG. 2. Front and rear views of *288* replaceable diaphragm assembly.**

Back in 1925, E. C. Wente[1] of Western Electric recognized the necessity for a tangential compliance in loudspeaker units and microphones in order that the distortion be held to a minimum at low frequencies. Diaphragms used in the Western Electric ***555*** receiver had such a compliance.

Recently, **J.** B. Lansing has developed a hydraulic method of drawing metal diaphragms which simplifies the process considerably over the previous methods. As a result, it is now possible to draw larger diaphragms and provide a tangential compliance in these larger sizes. This method provides an *amplitude approximately* ***3*** times as great as the annular type and the increased length of compliance insures that the diaphragm (Fig. 2) can operate at the required amplitude without undue strain.

The voice coil is wound with rectangular aluminum ribbon which has been treated with a temperature resistant varnish so that it will safely dissipate higher power without damage. The use of edgewise wound ribbon provides more volume of conductor in the magnetic circuit which, in turn, increases the efficiency. Beryllium copper leads are spot-welded to the voice coil wires. This provides a heavy duty lead (Fig. 2) which will not fatigue under use.

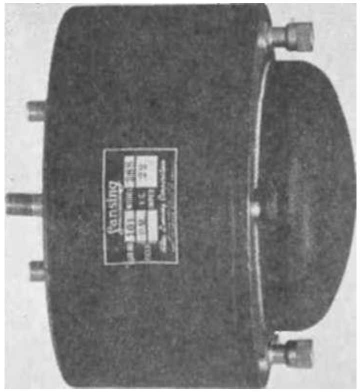

FIG. 3. Side view of *288* high-frequency-loudspeaker.

The entire voice coil and diaphragm assembly is mounted in a cast bakelite ring. The voice coil leads are clamped and soldered under flat terminals and a screw is provided for fastening each connecting lead to its binding post. By removing the leads to the binding post and 6 screws which anchor the bakelite ring to the top plate of the field assembly, the diaphragm and voice coil may be removed for replacement purposes. Two dowel pins are provided for alignment. The use of this method of mounting the diaphragm assembly permits its removal even though the magnet is charged. As a result, field replacement of the assembly is a simple operation and does not require that the entire unit be returned to the factory nor does it require any special tools.

The entire unit (Fig. 3) weighs 21 lb which is considerably lighter than previous units of comparable efficiency and power capacity.

The impedance of the unit when mounted in a properly matched horn is approximately 24 ohms over a wide frequency range.

Excitation of this new high-frequency unit is obtained from a



newly developed Alnico No. ***5*** permanent magnet material. The flux density is greater than has been used in the best separately excited units supplied.

The magnet itself is of the center core type. The soft magnetic material forming the path between the pole pieces is amply designed so that the flux is conducted through the outside walls and up to the air gap with little loss. The external leakage loss is extremely low in

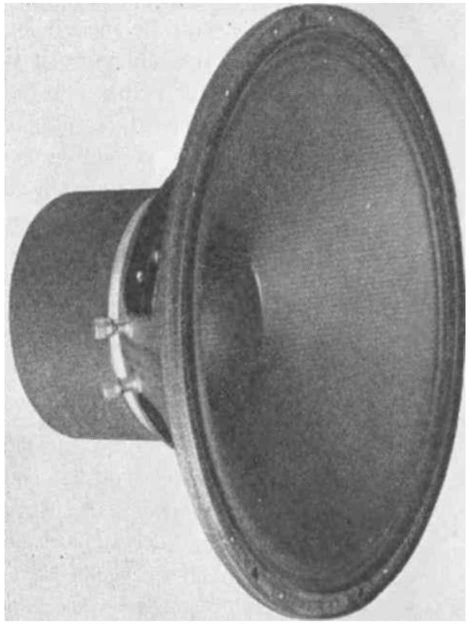

**FIG. 4.** View of *515* low-frequency loudspeaker.

this design and as a result does not attract metal objects in the immediate vicinity. The efficiency of the ***288*** high-frequency unit when mounted in a suitable multicellular horn is such that a sound level of 98 db (ref. $10^{-16}$ w per sq c) is produced at 5 ft distance for an electrical input of 0.1 w at 1000 cycles.

#### 515 LOW-FREQUENCY UNIT

The ***515*** low-frequency unit is mounted in a 15-in. die-cast frame which assures permanent alignment of the cone and voice coil assembly as shown in Fig. 4. It uses a seamless moulded cone having an effective area of 123 sq in. and is moisture resistant. An edgewise wound copper ribbon coil (see Fig. 5) is attached to the cone and a dome is inserted in the center of the cone to provide the maximum active vibrating area. The use of edgewise wound copper ribbon improves the space factor over that of round wire and since more conductor material can be placed in the air gap, the efficiency is raised and the operating temperature decreased. Since the 3-in. voice coil diameter is considerably larger than the 2- and 2 1/2-in. diameter coils formerly used, it has a correspondingly increased ability to handle higher power without undue temperature rise, and, as a result, the efficiency is little affected with changes in power.

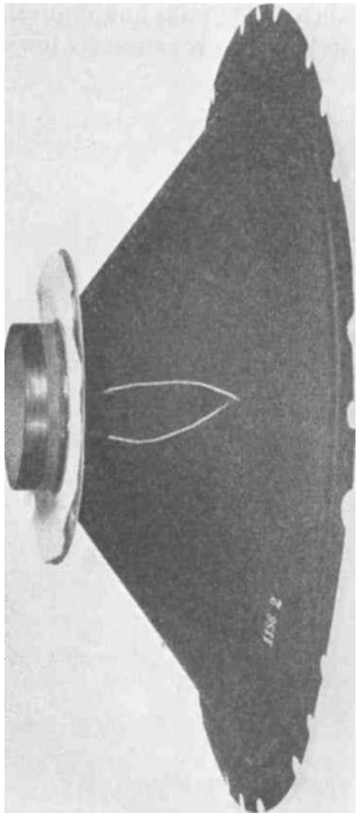

**FIG.** 5. **Replacement cone and voice coil assembly for** *515* **low-frequency loudspeaker.**

A clamping ring fastens the outer rim of the cone to the frame. The inner spider assembly is held down by means of *screws so that it is* a simple operation to remove the entire voice coil and cone assembly for replacement purposes.

An Alnico No. ***5*** permanent magnet is provided for the field excitation. The total energy available with tins magnet is greater than that previously supplied in energized units now being used.

The resonance of the cone and voice coil assembly is 40 cycles in free air. The impedance of the unit is approximately 20 ohms as normally used. The unit will safely handle an input signal of 25 w. The unit is 15 3/16 in. outside diameter, 8 in. deep and weighs 33 lb.



### DIVIDING NETWORK

The ***N-500-C*** dividing network used (see Fig. 6) is a parallel-type constant resistance network. It consists essentially of a low- and high-pass filter designed to operate from a connnon source at their input ends. The insertion loss of the network is less than ½ db. The crossover point is at 500 cycles and at this point the power is divided between the high- and low-frequency legs such that each branch is down 3 db. The attenuation slope is approximately 12 db per octave on either side of the crossover frequency.

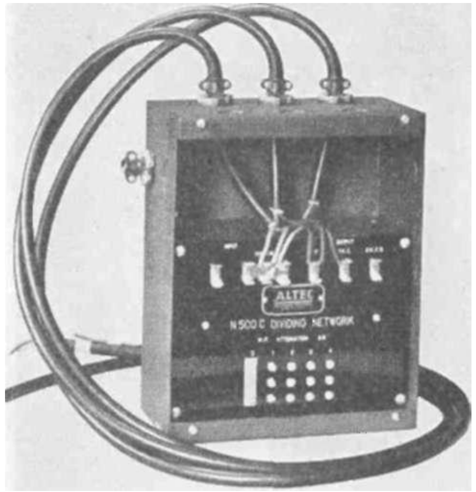


**FIG. 6.** *N-500-C* **dividing network.**

Provision is made for 5 steps (1 db each) of attenuation in the high-frequency output. This is accomplished by changing the shorting strip held under 3 screws.

The input impedance of the dividing network is 12 ohms.

### COMPLETE SYSTEMS

The new improved low-frequency horn (see Fig. 7) which is used for medium size theaters has two ***515*** low-frequency units mounted beside each other in a straight exponential horn. The area of the throat of the horn has been made approximately equal to the area of the 2 diaphragms, giving a loading factor of unity. This increased loading over that formerly used provides better damping of the units and increases the excursion of the diaphragm.

These new units are enclosed from the rear (see Fig. 8) so that radiation from the back side is dissipated in the enclosure. However, at frequencies below 100 cycles this dissipation is not complete and ports are provided in the front of the speaker, below the mouth of the horn. These ports provide an acoustic impedance which raises the output

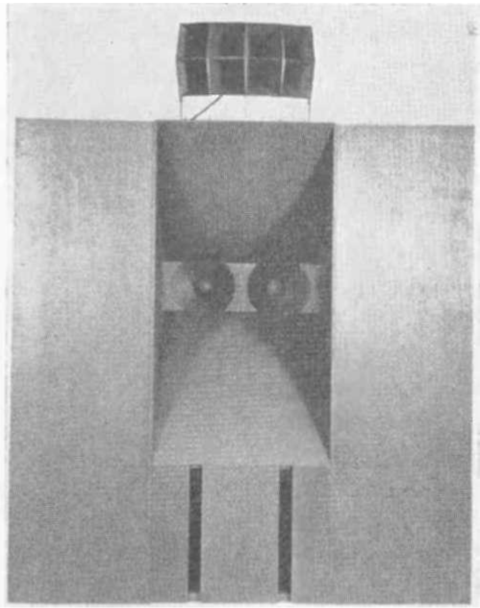

**FIG. 7. Front view of *A-4* loudspeaker system.**

several decibels around 50 cycles. Wings are provided for additional low-frequency loading.

One ***288*** high-frequency unit is used on the proper horn which depends upon the shape of the room.

Early experience with the first 2-way loudspeakers indicated that the relative phasing of the 2 units was important.[2] For correct phasing the 2 horns must have equal path lengths. The design of previous loudspeaker systems has not permitted this optimum phasing condition to be obtained. Measurements recently made out of doors in free space indicate that wide variations in response can be ob-



tained at the crossover frequency when the horns are shifted so that the mouths of the horns are not in the same vertical plane. This new horn system has a path length such that the tip of the high-frequency multicellular horn mouth is exactly in line with the mouth of the new low-frequency horn for correct phasing, and under these conditions there is no variation in the response at the crossover.

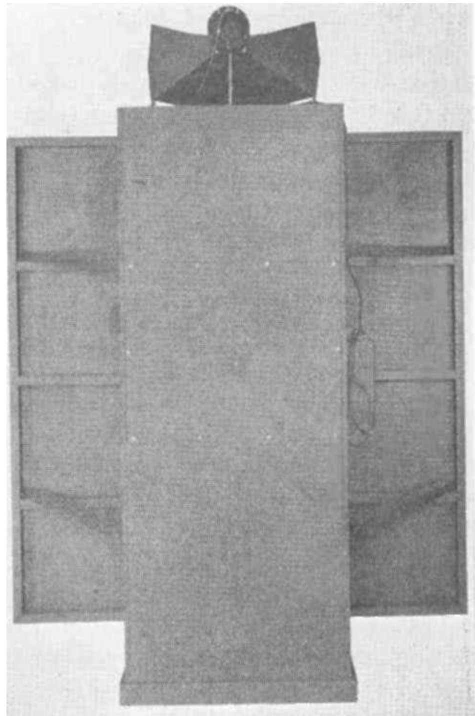

**FIG. 8. Rear view of *A-4* loudspeaker system.**

The ***A-4*** medium size horn system (see Fig. 7) has a rated capacity of 40 w. Destructive tests indicate that this rating provides a safety factor of greater than four over that necessary to damage the unit.

The ***A-2*** large size horn system (see Fig. 1) is composed of 2 low-frequency horns placed side by side and two ***288*** high-frequency units mounted on a double throat. The dividing network is mounted on the side of the baffle. The installation time is materially decreased, since the only wires needed are those from the output of the amplifier.

Sufficient damping of the vibrating elements of the units are provided in the magnetic circuit so that it is not necessary to provide additional damping from the driving amplifiers. In the past it has been customary to adjust the amplifier output impedance to a value of approximately one-half to one-third of the average loudspeaker impedance. Improved performance can be obtained with the new loudspeaker when the amplifier and loudspeaker impedances are approximately equal.

Anticipating that these new systems may be called upon to provide the sound channel in television work, it was necessary to restrict the stray magnetic field in order to prevent magnetic distortion of the television image caused by the proximity of the cathode-ray tube. Additional benefits from these features of the design are increased efficiencies owing to lower magnetic losses, and the fact that it is possible for these new permanent magnet units to be handled without endangering wrist watches or other devices which may be susceptible to damage from magnetization.

The efficiency of this new horn system is approximately the same as Dr. Fletcher's system[3] and is from 2-8 db higher than commercial loudspeaker systems now in use in theaters.

An ***A-2*** Altec Lansing horn system is now installed and is being used at the Pantages Theatre in Hollywood where field tests are being conducted. The Academy Research Council Standards Committee has recently had a meeting at the theater and has listened to the Academy test reel and current studio release product.

The electrical characteristic tentatively selected by this group is identical to the published metallic diaphragm characteristic[4] which has been adopted by the Committee for the range above 300 cycles.

Since the new horn systems have a smoother low-frequency response, experience to date indicates that a bass boost as much as 2 db at 50 cycles may be used with present product without interfering with dialogue quality. The straight low-frequency horn provides an unattenuated output up to and beyond the 500-cycle crossover point. This increased output in the region from 300-500 cycles over that of older horn systems adds materially to the presence and loudness of the over-all system. Recording and rerecording staffs in the studios indicate from their listening tests that over a period of time it should be possible to fully utilize the increased performance of the new loudspeaker system so that a smoother and more extended frequency and volume range can be reproduced.



It is our feeling that the early presentation of these loudspeaker systems will be a distinct aid to the sound equipment manufacturers in preparing their designs of future theater sound systems in order that the industry may not be limited to the quality standards established by older loudspeaker systems.

Similarly, the higher quality standards which can be reached through the use of these loudspeaker systems influence studio recording and monitoring practices. Because of the long interval which necessarily intervenes between the recording of a motion picture and its presentation to the public, considerable time must necessarily elapse before the full influence of the advancements in recording and reproducing can be presented to theater patrons.

The advantages of the new Altec Lansing loudspeaker systems are summarized as follows:

(*1*) **Higher efficiency,**
(*2*) **Wider frequeucy range with a better transient response,**
**(3) New permanent magnets,**
**(4) Diaphragms that are easily replaceable,**
**(5) No backstage resonance,**
**(6) A higher safety factor at increased power,**
**(7) An improved over-all presence with a much better definition of sound quality.**

### REFERENCES


1 WENTE, E. C, AND THURAS, A. L.: "A High Efficiency Receiver for Horn-Type Loudspeaker of Large Power Capacity," *Bell Sysl. Tech. J.,* VII, 1 (Jan,, 1928), p.140.

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4 RESEARCH COUNCIL, ACADEMY OF MOTION PICTURE ARTS AND SCIENCES. "Revised Standard Electrical Characteristics for Two-Way Reproducing Systems in Theaters," *Tech. Bull.* (Oct. 10,1938).