What Is the Best Loud Speaker, and Why?

By H. WINFIELD SECOR

A good horn-type loud speaker is desirable for use with most cone speakers. The horn-type speaker shown in the accompanying cut is one recommended by the author, because of its large, well-designed horn, which has a thick non-metallic wall.
Photo courtesy The Reichmann Company

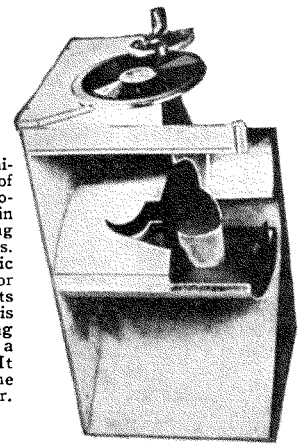
THE task of designing and building a satisfactory loud speaker for use in radio receiving sets, has hidden within it a vast amount of science and laboratory research. This is not realized by the average person; he may, perhaps, buy a loud-speaker unit and fit it to a talking-machine or other horn, and ask proudly, "What's the matter with that?"

It has taken most of us quite a long time to become educated to the fact that the average loud speaker, whether of the cone or the horn type, left much to be desired. We thought that we were hearing good music from even the first loud speakers, in many instances; but since the cone speakers came to the front so strongly, during the past year, we have begun to realize that the real backbone, of a great portion of the musical renditions by orchestras and bands, is represented by the bass and baritone notes, which are the tones in the lower part of the musical scale. All who have a true musical ear, and who are used to listening to quartettes and other vocal and instrumental groups, are aware of the importance of the bass and baritone.

DOUBLE-SPEAKER EQUIPMENT

At least one of the well-known American radio manufacturers (the Zenith Company of Chicago) has for several years supplied in every one of its cabinet sets, two loud speakers; one to take care of the higher audio frequencies, and the other to care for the lower and intermediate vocal frequencies. At the present time this idea has been gaining favor with the radio public very rapidly; and during the past few months, several radio set builders have announced that their cabinets are being fitted with the very happy combination of a cone speaker and a horn speaker. The merit of this lies in the fact that the cone gives us a very fine reproduction of the extremely valuable bass and baritone notes, while the horn helps tremendously, on all vocal selections especially, by doing its part to bring out the higher intermediate and treble notes.

If we refer to the graphic chart (Fig. 1) we find the whole story of this loud-speaker problem pretty well exemplified by the horizontal graph lines which indicate clearly the range of the various human voices, such as soprano, alto, bass and baritone; and also we learn the position of the lowest, medium and highest instrumental notes —those of the bass viol, violin and piccolo. From these graphs, it is clear why the average cone or horn speaker, with the range of frequencies shown, does not cover all of the audio frequencies that are so necessary in faithful musical and vocal reproduction.



This is a semi-sectional view of the new orthophonic horn used in one of the leading talking machines. This orthophonic horn is curved or folded so that its great length is capable of being contained in a small space. It makes a very fine radio loud speaker.
Photo courtesy Victor Talking Machine Co.

A great deal of the science required in the design of a satisfactory loud speaker, whether of the horn or cone type, is made evident by means of the accompanying graphic diagram. If we want to listen to an exact reproduction of a musical selection being rendered by an orchestra, we actually need a horn 35-feet long, as the wavelength of the lowest note given out by the bass viol is 35 feet in air. As the dotted outlines of various sizes of horns indicate, the smaller horns are able to give us an imitation of a bass note only by vibrating at one of its harmonics.

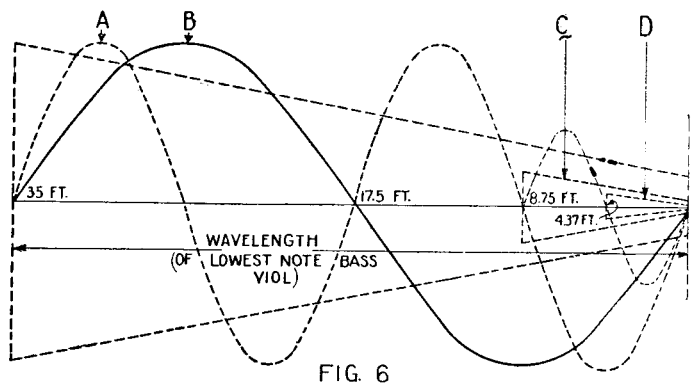
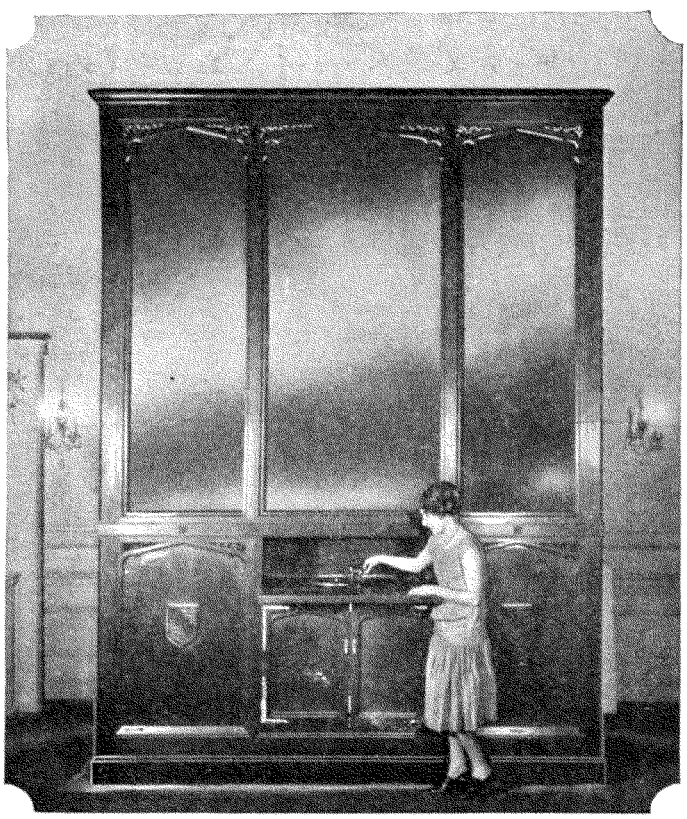


FIG. 6

REMARKABLE NEW HORN

The new orthophonic horn, whose design has been worked out by the engineers of the Western Electric Company and the A. T. and T. Company, and which is now supplied on a well-known line of talking machines, is a most remarkable product of the scientist's laboratory. The range of notes to which the orthophonic horn, in the 72-inch size, will respond or resonate, is shown graphically and clearly in Fig. 1. Therefore, it would seem to indicate to us that the solution of the loud-speaker problem may eventually resolve itself into the utilization of a horn of this type fitted with a good loud-speaker unit. In a $1000 model talking machine, fitted with the orthophonic horn and connected to a superheterodyne radio set, for instance, its owner has a most wonderful sound-reproducer; and those who have heard this instrument have stated repeatedly that it gives the finest reproduction of the human voice or musical instruments that they have ever heard.

In this case, it is well to remember that the orthophonic horn does most of the work; it is not necessary to fit it with an elaborate loud-speaker unit, though a good unit should be used. In the case of the talking machine referred to, the makers have designed what they call an "orthophonic-speaker" unit which has a special duralumin diaphragm, with a special suspension, which gives a very fine quality of reproduction in itself. The point, however, which the writer wishes to emphasize is



The picture at the left shows a talking machine, containing a large 20-foot orthophonic horn, installed in a hotel. This horn gives tremendous volume and very faithful reproduction of bass, baritone, and treble notes from an ordinary phonograph record. Radio music and voice can be reproduced through this horn when desired.
Photo courtesy Victor Talking Machine Co.

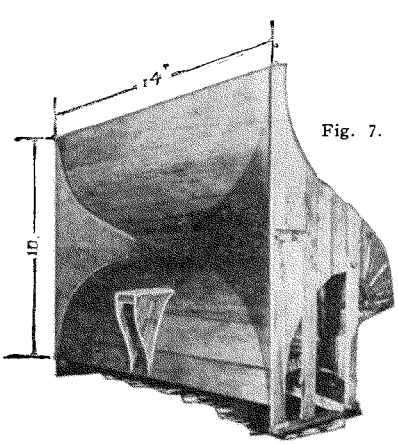


Fig. 7.

The picture at the right shows dimensions and appearance of an experimental 40-foot orthophonic horn.
Photo courtesy Victor Talking Machine Co.

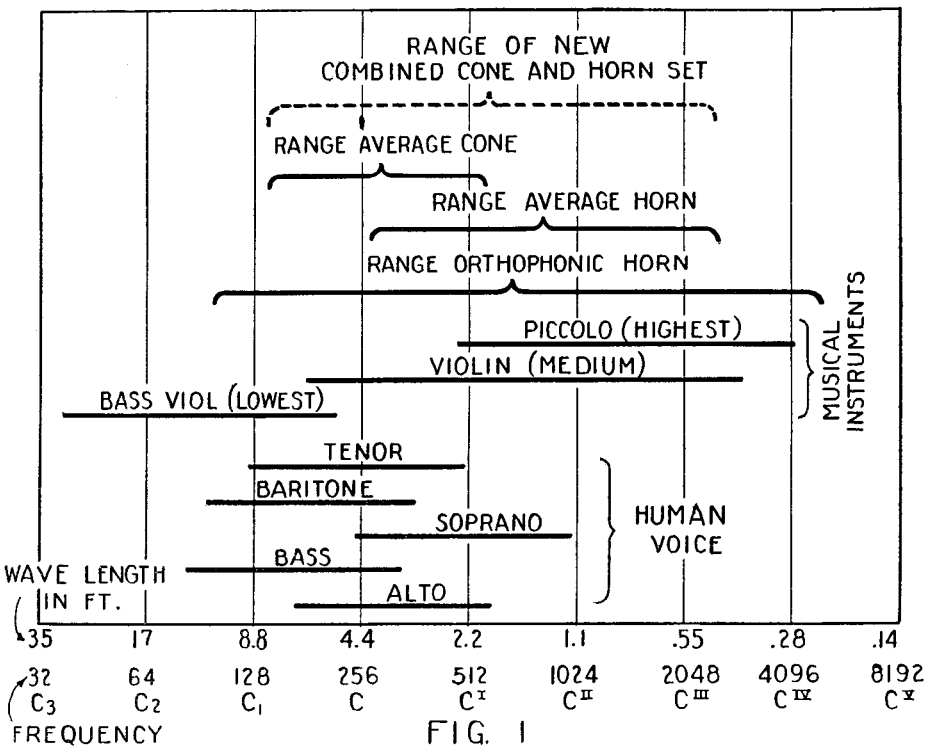


FIG. 1

This diagram, prepared with the aid of data given in a recent scientific paper by S. T. Williams, chief engineer of the Victor Talking Machine Company, makes it very clear why the average horn or cone speaker is not entirely satisfactory. The orthophonic horn in the 72-inch size, however has a range from 100 to 5,000 vibrations per second, covering practically all musical notes. To approximate this, anyone can improve his radio quality a great deal by using a horn together with a cone speaker, connected in series or parallel, as trial may dictate.

that this orthophonic-loud-speaker unit is practically as helpless as any other speaker unit, if it is fitted to an ordinary horn. Many of the writer's friends, after reading about some of the features of the orthophonic horn (particularly the fact that in the larger talking machines there is incorporated a six-foot length of horn cleverly folded up, or concentrated in the cabinet of the machine), have asked the question, whether they could not obtain similar results by using a straight six-foot horn? The answer is, yes, if the horn is properly designed, so that it increases in size in a certain mathematical ratio.

In any event, as Prof. Dayton C. Miller pointed out quite a few years ago to the writer, the long horn, anywhere from 4½ to 7 feet in length, will far surpass anything that a small horn can do. It is interesting to note in passing that Prof. Miller at that time about ten years ago, mentioned that he had obtained very wonderful results with a 7-foot horn made of concrete 4 inches thick, as well as with wooden horns of the same length. The orthophonic horn is 6 feet or 72 inches in length, and larger sizes of this orthophonic type of horn have been experimented with, up to 40 feet in length. The 20-foot horn of this folded type, curved to the mathematicians' taste, as dictated by the inventors, has become a standard unit, for use in large hotel dining rooms and other locations, where an ordinary phonograph record and electrical pick-up arm are used to send forth sonorous tones of tremendous volume and power.

It would seem to a present-day observer, after carefully reviewing all that has been done by the various loud-speaker manufacturers in the past few years, that the old-fashioned horn (having an average axial length of about 1½ feet) can never be made to do any more than it does at present, as shown in the graph (Fig. 1). This means that, unless the small horn is supplemented by a cone, to take care of the lower notes, such as the bass and baritone, radio broadcast listeners simply cannot hear a vocal or instrumental selection reproduced in their home just as it is sung or played in the studio or concert hall.

The next step in the development of our future loud speakers would seem to be toward something on the order of the orthophonic horn; or else direct adoption of this device, fitting the horn with a good loud-speaker unit. Another alternative appears in the development of a new type of cone, the advance models of which have recently been put on the market. Fig. 2 shows a new model receiving set, fitted with both cone and horn speakers.

Figs. 3 and 4 illustrate and explain one of the latest developments in cone speakers, which the writer has been testing for some time. This cone and one or two others represent the newest advance in cone-speaker design: *i.e.,* they are constructed with two vibrating members or sections, one of which reproduces the bass and low intermediate notes, such as baritone, while the high-pitched part of the cone reproduces the high intermediate and treble notes, such as tenor and soprano. The writer feels free to express an opinion to which many of his colleagues agree, that the average single-cone speaker is liable to lower the register of the tenor and soprano voices, as well as that of the high-pitched musical instruments. In fact, this usually occurs unless special care is taken to adjust the unit very carefully and also see to it that the cone is operated with a suitable set and in the proper manner. Cones are best connected to the output of a radio receiver by means of a choke-coil and condenser, in order to eliminate the "B" battery current from the speaker.

The most obvious remedy for the high-note deficiency in the musical reproduction of the average cone is to use two speakers, as previously mentioned: while the ultimate solution, hard to carry out just now, as orthophonic horns are not being sold separately from the talking machine, is to adopt the orthophonic horn in connection with a good speaker unit. There is now on the market a high-priced power cone, used in the Panatrope talking machine, which has a vocal frequency range from the bass notes up to highest soprano; but the price is beyond the reach of many people. This cone works differently from all others, and is thus able to reach up the scale.

Referring to Fig. 4, the action of the new cone having two vibrating sections for the low and the high notes, is clearly shown. As will be seen, the annular section (outer ring) of the diaphragm, repro-

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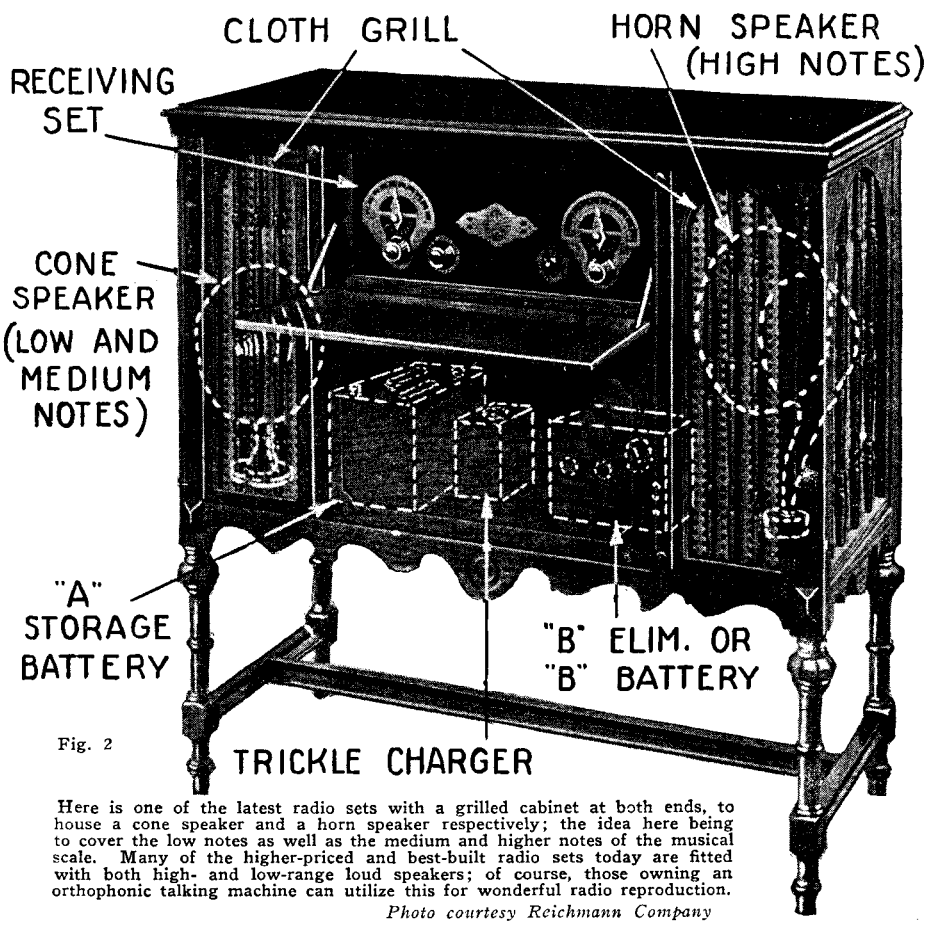

Fig. 2

Here is one of the latest radio sets with a grilled cabinet at both ends, to house a cone speaker and a horn speaker respectively; the idea here being to cover the low notes as well as the medium and higher notes of the musical scale. Many of the higher-priced and best-built radio sets today are fitted with both high- and low-range loud speakers; of course, those owning an orthophonic talking machine can utilize this for wonderful radio reproduction.

Photo courtesy Reichmann Company

Radio News for March, 1927
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(*Continued from page* 1107)

duces the bass and low baritone notes, while the conical (pointed center) portion reproduces the upper baritone and soprano notes. The writer was certainly very much surprised when he first tried this cone and especially when he heard the voice reproduction. Almost any cone speaker will sound fine, as long as a violin or bass viol is playing; but an uncanny effect is produced when the announcer starts to talk.

As I have mentioned before, it is of course frequently the case that the cone is being operated with a poorly-designed set, or perhaps it is not getting enough power, or else it needs the introduction of a choke coil and condenser into the circuit feeding the cone from the last stage jack. The diagram for this connection of the cone speaker has been published so many times that it needs no repetition here, and

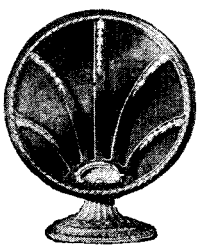

Fig. 3

There are dozens of cone speakers on the market, each of which seems to have some little advantage or merit of its own; but the one here shown, and recommended by the author from among several which he has tested, not only possesses the unusual faculty of bringing out and emphasizing the bass and baritone notes, but it is so designed that the smaller section of the cone emphasizes the high notes. *Photo courtesy Reichmann Company*

the experts in the radio stores will tell you all about it. Figs. 8 and 9 illustrate two output transformers or filters which the writer has found to improve the quality of reproduction a great deal.

The first picture shows a very fine model of horn speaker which the writer has been using in his experiments for over a year in connection with various cones. One of the good points about this speaker is the fact that the horn is non-metallic. It is made of molded bakelite, about ¼-inch thick, and has a considerable axial length, sufficient to give a fairly good reproduction of the baritone and bass notes of the musical scale. As Prof. Miller and others pointed out long ago, the horn itself must not vibrate; only the air column within it. This speaker has also a controlled mica diaphragm; the design of the talking unit being such that a push-pull action on the diaphragm is obtained. This speaker is the best the writer has ever tried out for use

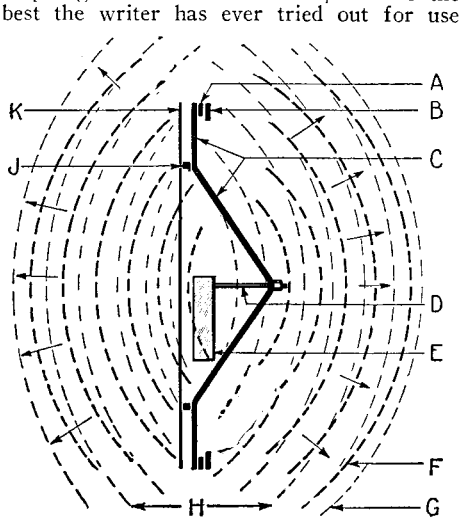

FIG. 4

Diagram above shows how both bass and treble sound waves are created and brought out by the large and the small vibrating sections of the dual-type cone speaker pictured above.

on small dry-cell sets, using three or four tubes of the UX-199 type; as it gives surprising volume with a very slight amount of current variation.

Of course there are plenty of good horn speakers on the market, and also many fine cone speakers. You should go to your radio dealer and hear a number of speakers before you decide to buy one; and when you do so, you should pay particular attention to a horn speaker, to see that it reproduces the bass notes fairly well. On the other hand, when buying a cone speaker, note particularly how it reproduces the higher musical notes, such as upper baritone and tenor voices.

Another graphic chart is shown (Fig. 6) which will help to make clear just why it is quite impossible, for a speaker with a short horn or of small diameter, if of the common cone type, to reproduce bass and baritone notes with any degree of fidelity. Looking at this graph in Fig. 6, we see a wavelength of 35 feet represented graphically, this corresponding to the lowest note from the bass viol, as shown by the frequency chart (Fig. 1). Theoretically and also practically, if you care to reproduce this lowest bass viol note with full intensity, you will require a horn 35 feet or more in length. The Victor people, in their experiments with the orthophonic horn, have actually built a folded horn of this type, with an axial length of 40 feet, a photograph of which is reproduced in Fig. 7.

EXPONENTIAL SUPER-HORNS

Some of the questions that arise in the average person's mind, when he thinks of a 40-foot horn being used to sound this low bass note, are: How about the higher notes up in the tenor and soprano ranges? How does such a horn manage to resonate

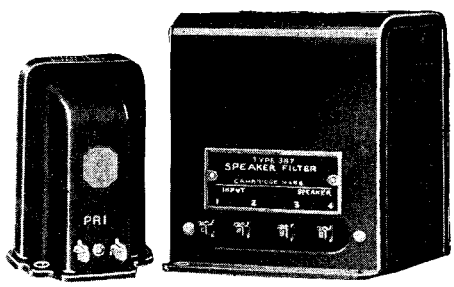

Fig. 8 Fig. 9

Above are shown junior and senior models of loud-speaker filters. These filters keep the battery current out of the loud-speaker circuit, and prevent blasting and "hard" music. *Photos courtesy General Radio Co.*

such a high-frequency, short-wave note? It might seem off-hand, perhaps, that such a horn could not handle a high soprano note, such as high C; but strange to relate, when the horn is mathematically worked out as to its curves and progressive "exponential" increase in size (such as we find in the case of the orthophonic horn), all of the notes are resonated or sounded equally well. It is hard to realize that one horn six or even fifteen feet long can reproduce all these different frequencies with equal efficiency and quality; but as the old saying goes, "the proof of the pudding is in the eating." If you have never heard a talking machine fitted with an orthophonic horn, you owe yourself a great musical treat; and the first time you have an opportunity, you should certainly visit some local phonograph dealer and have one demonstrated. Only then will you be able to realize what you have been missing with the ordinary phonograph.

Incidentally, it is interesting to note from a scientific point of view that when the orthophonic horn, six feet or more in length, is used with an ordinary needle soundbox to pick up the voice from the new electrically recorded disks, a greater volume than was ever heard from an ordinary phonograph of the old type is at once realized. This means a great deal in the future development of radio loud speakers; for we at once see that, if we ever reach the point where orthophonic horns or their equivalent become available to the radio manufacturer, he will have only to add a small loud-speaker unit of good design, such as the orthophonic unit or its equivalent. Then the music will roll forth in sonorous volume and with a quality that has never been realized until the present day, except by those who have sat in the presence of a symphony orchestra.

THE OCTAVES IMITATE THE FUNDAMENTAL

The question has often been asked the writer, how can a small horn ever possibly reproduce a bass note, or even make an attempt at it? Fig. 6 will help to show how this is possible. Practically all musical sounds are rich in harmonics: *i.e.*, they are built up of a number of different frequencies, which are multiples of the one pronounced or predominant frequency, which is called the fundamental. It is this fundamental frequency, or tone, which we hear most strongly, in the case illustrated in Fig. 6; but, as we look at this diagram, we see that the second harmonic is of a different frequency (it is exactly an octave above the fundamental). This is where the small horn gets its chance to give forth a sound (or, specifically speaking, a partial sound) taking on the nature of the true fundamental-tone frequency. Suppose the bass viol sends forth a note with a wavelength of 35 feet and that you have only an 8¾-foot horn to reproduce it; this horn will have to resonate this note on the fourth harmonic (second octave) which has a wavelength of 8.75 feet in air, as Fig. 6 shows. Suppose again you have only a short horn with an axial length of 4.37 feet; if the bass viol's lowest note, about 35-foot wavelength, is sounded, this little horn, 4⅓ feet in length, will attempt to give you a sound something like the fundamental, by resonating at the partial frequency or eighth harmonic (third octave).

It is a case, as one can see, of "the tail wagging the dog." If you want to realize all the beauty of the great bass and baritone notes, which form the real background of practically all musical renditions, whether vocal or instrumental, you will have to do it in some other way than by using simply a single reproducing instrument, fitted with a small horn a foot or two in length.

From the above considerations, it is obvious why some of the principal cone-speaker makers have developed and are marketing large cones three to four feet in diameter. In the laboratories of one of these cone manufacturers, cones as large as ten feet in diameter have been successfully used; they give the tones of the voice very faithfully, not to mention the most wonderful musical reproductions. These huge cones, remarkable as it may seem, are effectively actuated by a small electro-magnetic unit, such as that employed in the small table cones with which we are all familiar. (An explanation of the "exponential" horn will be found in RADIO NEWS for April, 1926, page 1422—"The Passing of 'Canned Music,'" by Major J. S. Hatcher; and one of the nature of sound-wave propagation and its effects on the ear in RADIO NEWS for June, 1926, page 1662, "Audio-Frequency-Amplifier Transformers," by Sylvan Harris).