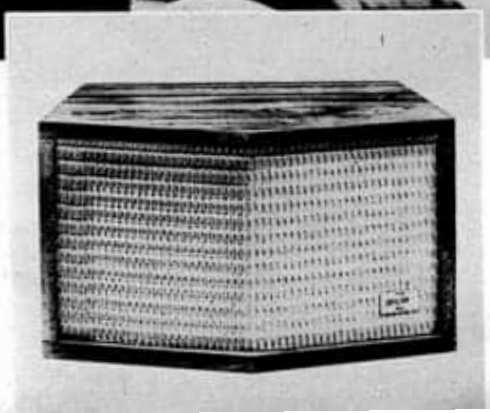
Chapter 9
The Speaker System

Above, J. B. Lansing "Ranger Paragon" stereo reproducer weighs 850 lbs., uses two 15-inch woofers, two midrange, two tweeters, two networks.



JansZen electrostatic speaker has frequency response of 700-30,000 cps, 8-ohm impedance, uses two radiators with power supply in the cabinet.

WHEN the electrons in an electric current cause the molecules in air to vibrate and produce sound, the device that produces this transformation is called the loudspeaker. These are the terminal facilities of the hi-fi system, the end of the line. If the sound isn't right when it leaves the speaker diaphragm, nothing can be done to save it. The hi-fi system has done its job, for better or for worse.

The vast majority of loudspeakers are of the dynamic type, and any such speaker must have two essential elements. One of these is the *driving motor*, which is basically an electric vibrator whose movements coincide with the variations in audio current producing them. This motor is attached to the *acoustic radiator*, the element which actually radiates the sound.

In many speakers the acoustic radiator is the *cone*, made of special paper. Add to this a supporting framework and suspensions for the cone, and you have the basic speaker, the kind most commonly found in ordinary home instruments and auto radios.

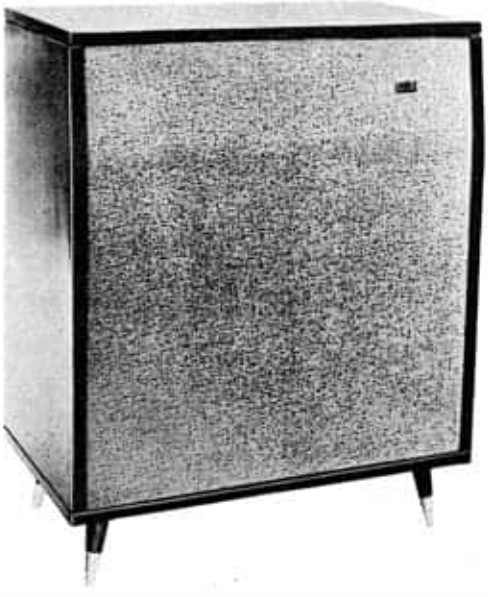
Even the most inexpensive hi-fi speaker, however, has refinements beyond this point. Because the high frequencies are produced only in the area near the apex of the cone, there is often some sort of decoupler which permits the apex to vibrate independently of the overall motion of the cone.

The simplest way of building in decoupling is to mold an annular ridge into the cone, which forms a springy joint between the two sections of the cone. Another method is to build the cone in two sections, with a viscous cement joining the two. In any case, the stiffness of the paper usually changes at this point, with the cone being softer in the outer area than in the center. Finally, a small dome of convex metal or plastic is usually attached over the apex. This not only serves to provide dust protection for the motor, but also tends to disperse the higher frequencies, which otherwise travel in rather narrow beams.

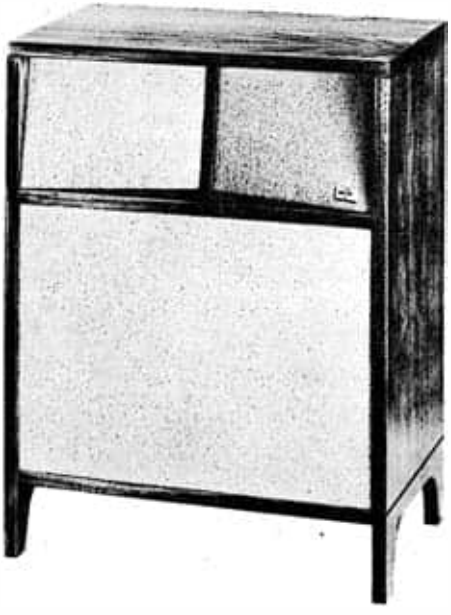
A speaker of this sort comprises the basic extended-range hi-fi unit, and it is reasonably good for a start. But it has long been known that no single speaker is capable of reproducing the entire audible spectrum, any more than a tuba can be made to sound like a piccolo. Only two or more speakers, each specifically designed to reproduce a part of the spectrum, can do the full job.

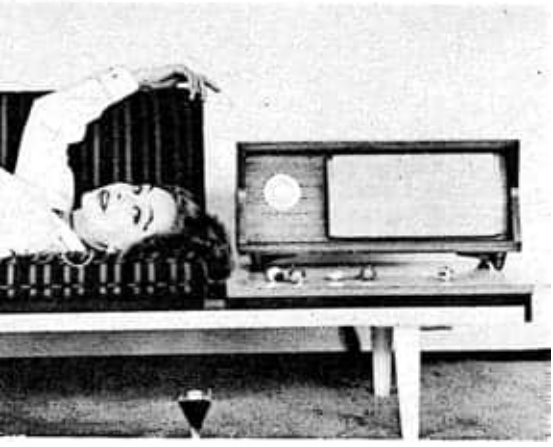
The first two-way systems were designed for motion-picture theaters, where

JansZen 200 system comprises 12-inch woofer and 4-radiator electrostatic tweeter, power supply. Range: 30-30,000 cps; 16-ohm impedance; 2.5 cu. ft.

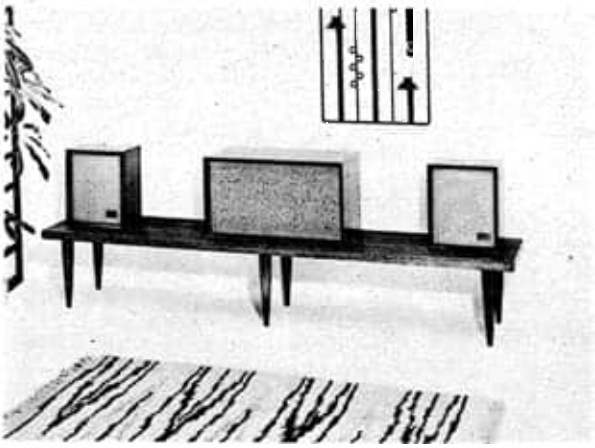


Z-300 JansZen system has 8-ohm impedance, a 2-radiator electrostatic tweeter, 11-inch woofer. Power handling capacity is up to 100 watts peak.

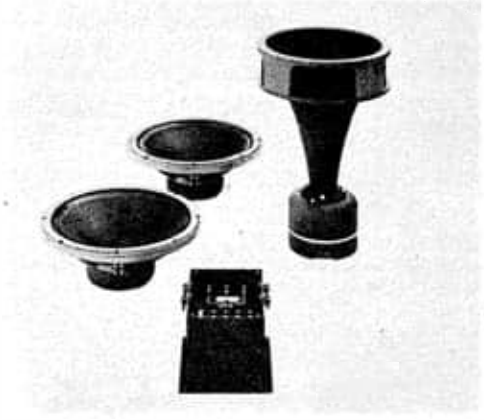




Bel-Aire by J. B. Lansing has 8-inch woofer and 2,500-cycle crossover tweeter, plus network. Two units give stereo system. Single cabinet: $166.

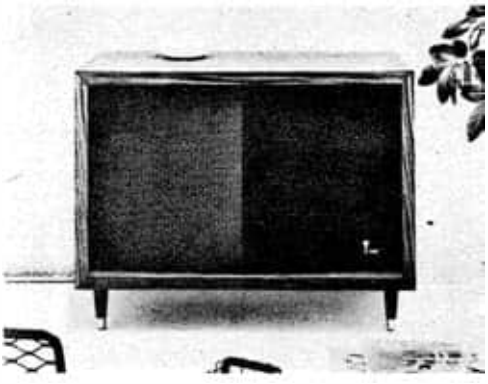


Electro-Voice stereo system comprises one full-range system and two (above 300 cps) add-on-units. Complete price, with mixer, is $223.50.



James B. Lansing kit units shown are (clockwise from bottom) dividing network, two 15-inch woofers, exponential horn with midrange-high driver.

Rear-loaded horn by J. B. Lansing has 15-inch extended range speaker, h-f tweeter and network. Can also be adapted for 12-inch speaker.

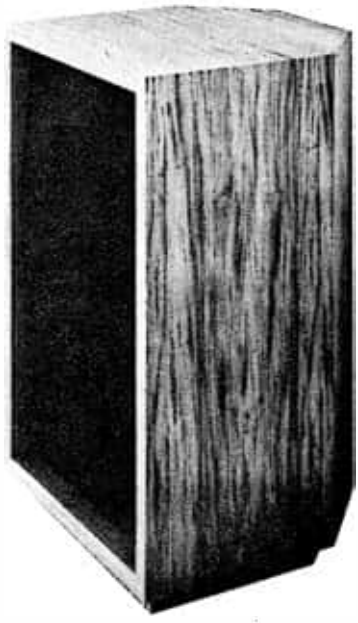


the low-frequency speaker is called a *woofer*, and the treble speaker a *tweeter*. But with present hi-fi speaker systems often cutting the spectrum three or four ways, these names no longer have such definite meaning. But those who are fond of nicknames seem to go along with calling the midrange unit a *squawker*, and the very-high-frequency unit a *super-tweeter*.

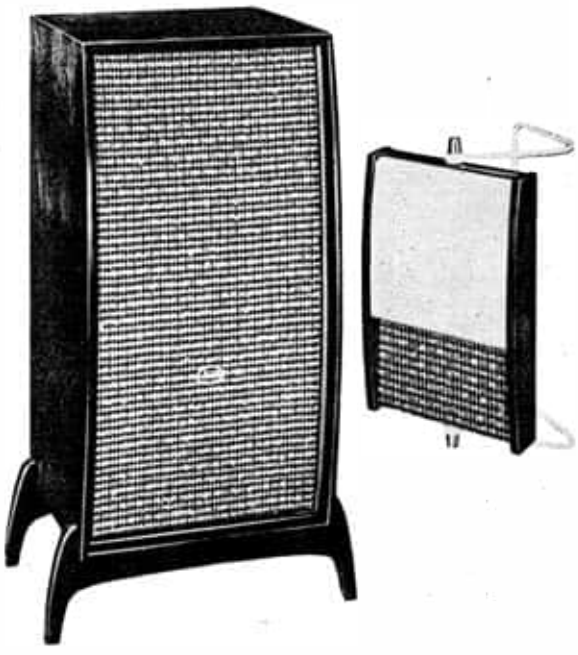
These several speakers may be entirely independent of one another, or they may be constructed coaxially. If you use the add-on method of building up your speaker system, you will probably have the several elements spaced out on a common mounting panel. The coaxial types are usually of integrated construction which doesn't lend itself to the add-on system.

There is widespread confusion concerning the many coaxial speaker types, with many audiophiles thinking they have a better unit than they actually possess. This is such an important subject that we should spend some time in discussing just what the facts are.

The simplest coaxial speaker is just a small jump above the ordinary extended-



Lansing Model 34 has exponential folded horn with an effective 6-foot length, accepts either one full-range speaker or a 2-unit, 2-way system.



Jensen "Galaxy" stereo system has one bass center unit and two add-on satellites. One woofer gives below-350 cps response, has two voice coils.

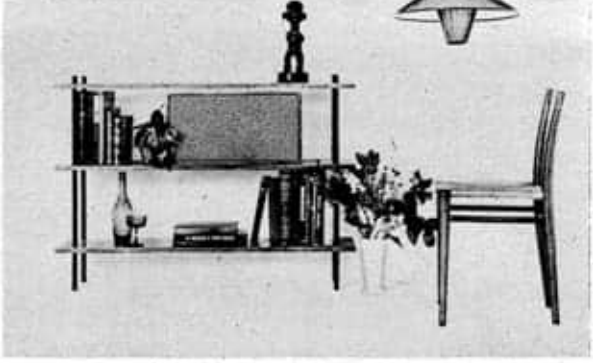
range type. The difference is that it has two cones instead of one, the conventional full-sized cone acting as the woofer, while a smaller, stiffer cone inside it acts as the tweeter. But note carefully that while this speaker has two acoustic radiators, they are both driven by one and the same motor. This is not a true two-way coaxial speaker, although many people owning this type think that it is.

A speaker of this type is sometimes said to have a "mechanical crossover," which is the key expression to look for in the sales literature. It means that while the voice coil in the driving motor may vibrate at all frequencies, each cone will vibrate only in the range for which it was designed. This separation is determined solely by the physical size and shape of the two cones.

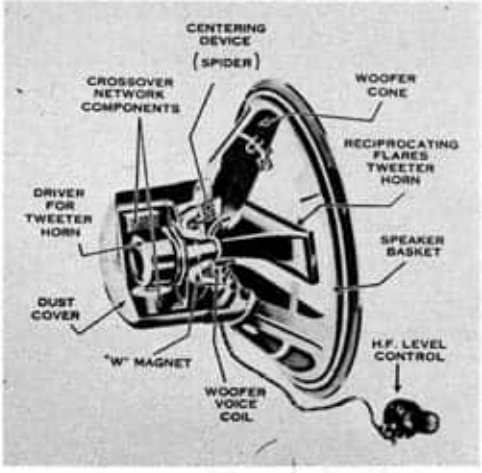
A true two-way speaker operates quite differently. In the first place, the splitting of the spectrum into two bands is done *electrically*, by a filter device known as a *crossover* network. Then each group of signals is fed to its own separate and complete driving motor. Only then, when two

Two-way speaker by Jensen has 16-ohm impedance, 36-14,000 cps frequency response, costs $79.50. Unit is available as cabinet kit only, $29.75.

University "Debonaire" system with two add-on "Stereoflex I" units for stereo reproduction. A 12-inch dual voice coil woofer is used here.



Several types of two-way speaker systems are made by University. Above is the Model S-80 for limited space installation; 8-ohm impedance.

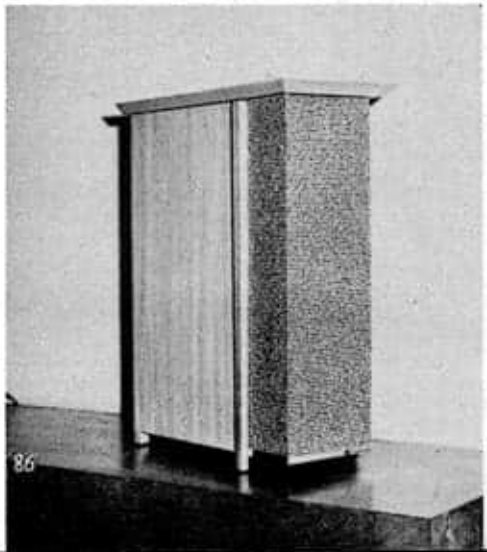


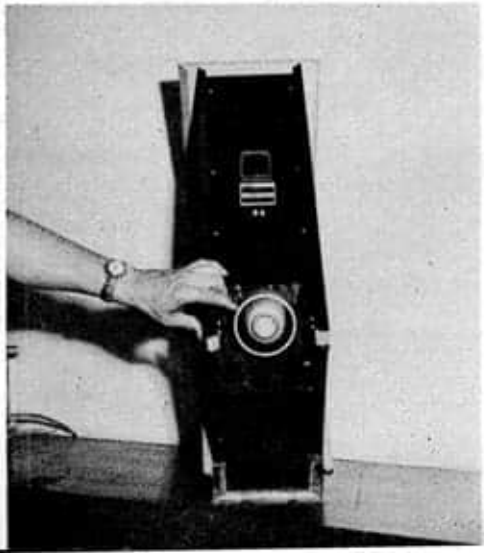
Cutaway drawing of University dual range coaxial 12-inch speaker. Tweeter with driver is mounted through center axis; built-in network, control.

Dual voice coil 12-inch University woofer can be adjusted for 700, 2,500 or 5,000 cps high-end cutoff to suit requirement of the tweeter.

University makes the "Stereoflex II," comprising a 150-cycle horn and driver, tweeter, and balance control. Unit can be used as second channel of stereo system in which main channel utilizes a wide range speaker, or two units may be combined with single woofer. Response: 150 cps to inaudability.

Photos by Fred Honig





completely separate speaker systems are mounted coaxially, can the speaker system be truly called two-way.

The next speaker type is really a composite of the two types just discussed. It has three acoustic radiators with but two driving motors. In this case the large main cone acts as the woofer, a smaller parasitic cone attached to it is the squawker, and an independently driven small element is the tweeter.

This unit, with three radiators and two drivers, was for quite some time sold as a "triaxial," and is still incorrectly thought of as that by many poorly-informed audiophiles. There is only one truly triaxial speaker, and it happens to be one of the best ever made. This is the Jensen Triaxial, which at this writing is the only one having coaxial mounting of three complete loudspeakers, with three separate driving motors and three separate acoustic radiators.

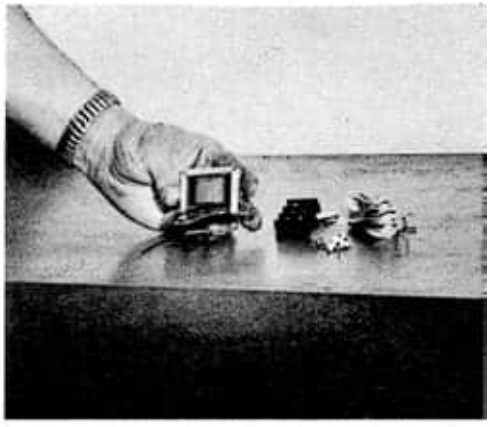
Until now, we have assumed the acoustic radiator in every case to be a cone, but this needn't always be the case. Tweeters of the cone type send out high-frequency waves in rather sharp beams, with the result that the reproduction at any distance off the center line of the speaker is rather deficient in highs. This condition may be partially rectified by using two or more tweeters arranged around in an arc, but it is usually better to use a *horn* at these frequencies.

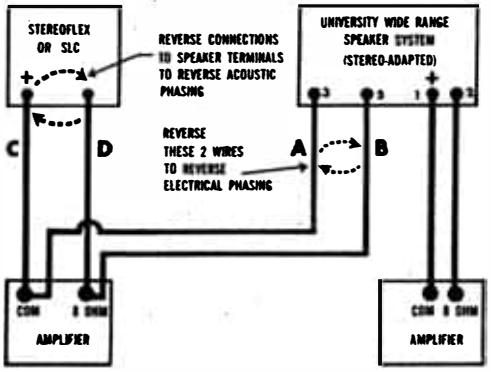
The driving motor in the horn is essentially the same as in other types of speakers, but the acoustic radiator is a small diaphragm instead of a cone. The diaphragm is in turn surrounded by a sound chamber, which opens out onto a small opening at the throat of the horn. This arrangement gives broader high frequency coverage, and greater efficiency.

With advantages like these, it would seem that the horn should be used for all frequencies. It's a great idea which has been used successfully, but there's a hidden joker. While any loudspeaker must be big and husky to do justice to the low frequencies, this is several times more true in the case of the horn, which is a very effective high-pass filter. While its high-frequency response is practically limitless, it cuts off rather sharply below a certain point which is determined by its geometry. And to handle all of the bass properly, the horn must be huge. Just to get down to 30 cps, for example, it must have a mouth diameter of over eleven feet, and its length would have to be even greater that that. So while some people have built horns in their attics, with the mouth of the horn covering the entire grillwork ceiling, or in an attached garage, with the mouth of the horn covering a whole wall, this is a little too esoteric for most of us, who must be content with the mundane cone-type woofer.

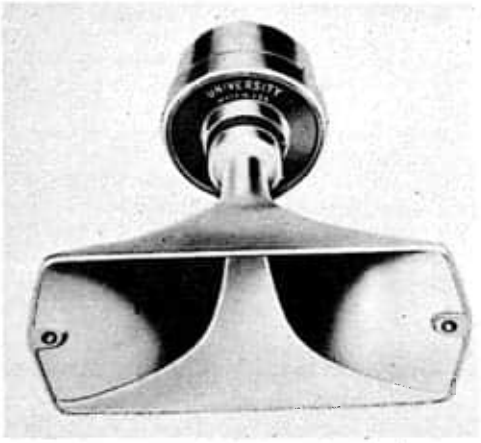
However the sound is produced, the vibrating element will set up two groups of opposing sound waves simultaneously, one from its front surface and another from the rear. If these two waves combine, they can either add together and sound boomy, or try to cancel each other out, with a resulting sound which is weak and thin. As a third alternative, they can combine

Using the University "Stereoflex" unit with a full range system containing a dual voice coil woofer gives complete stereo reproduction. Diagram, below, right, shows how connections are made. Below, left, are components of stereo conversion kit which attach to terminals of the woofer; hardware included.



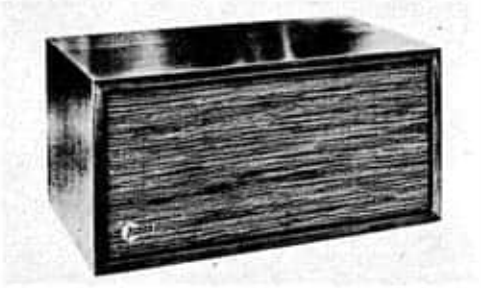


CONNECTION FOR STEREOFLEX OR SLC AND WIDE RANGE SYSTEM HAVING DUAL VOICE COIL WOOFER

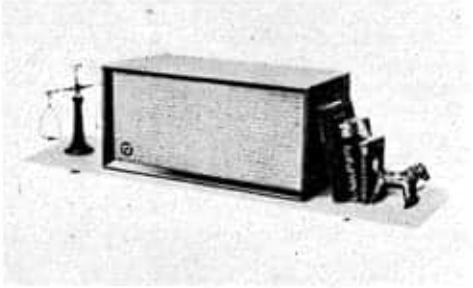


University 4401 tweeter has compression loaded driver, reciprocating-flare horn. Frequency response is 2,000-15,000 cps; 25-50 watt power.

Balance control by University regulates speakers of different efficiencies, balances sound to room acoustics. For midrange speakers and tweeters.



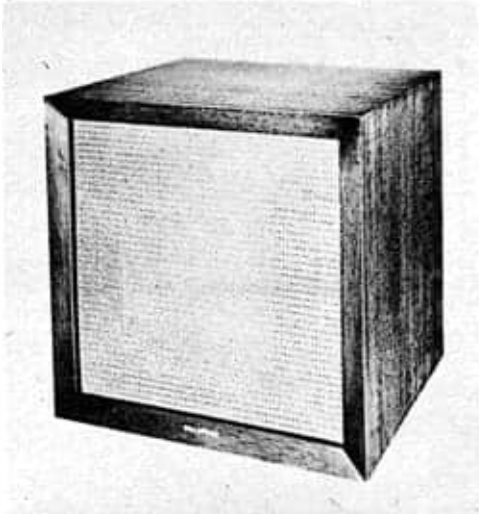
Wharfedale full range two-way system has 12- and 5-inch speaker, 1,000 cps network; impedance is 15 ohms; includes treble control. From $159.

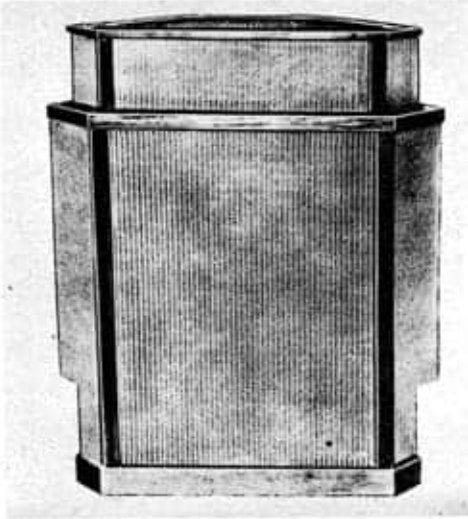


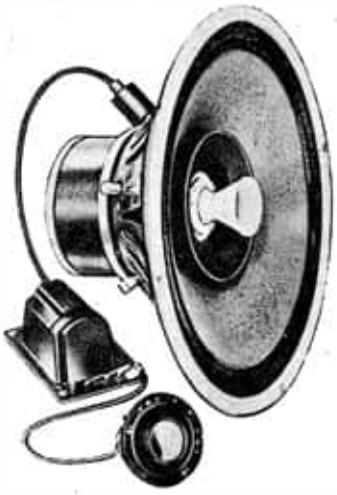
R-J enclosure with Wharfedale speaker has 8-inch full range reproducer, fits into bookcase. Also available in floor models with 15-inchers.

Bradford enclosure with British Bakers 12-inch speaker has totally enclosed baffle, can be used with any speaker from 8 to 15 inches in size.

Briggs sand-filled 3-speaker corner system with imported Wharfedale speakers has bass chamber of plywood frame and panels, filled with sand.

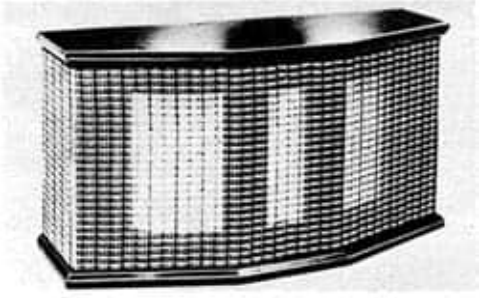




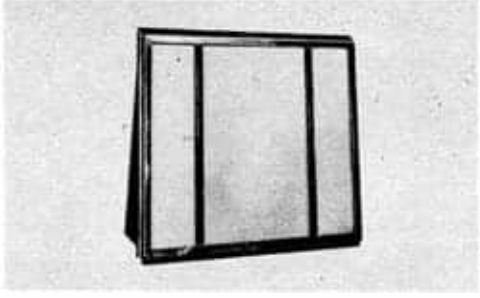


Lafayette 3-way coaxial is built by Goodmans of England, comes in 12- and 15-inch size with 45- and 50-watt capacity. Response: 30-20,000.

Floor model RJ enclosure for 12-inch speakers extends the bass range to 50 cps without resonant peaks. Enclosure is slightly larger than speaker.



Electrostatic tweeter by Lafayette Radio has a 3-element high-frequency tweeter unit, can be used as part of stereo or monaural system.



Wharfedale sand-filled baffle designed by Briggs, has frequency bass response down to 30-35 cps, 15 ohms impedance, does not need a wall behind it.

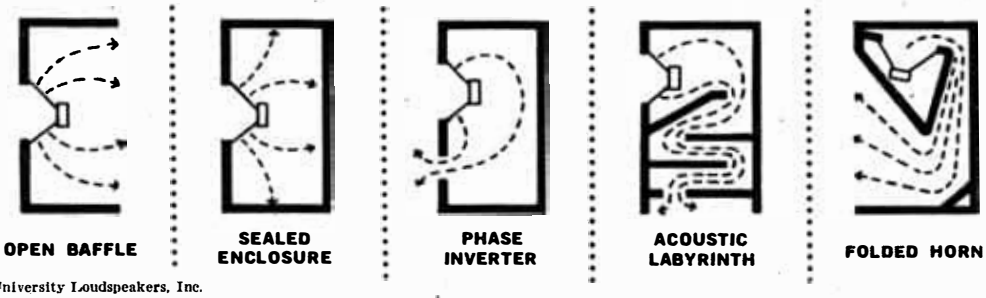
additively to compensate for an inherent deficiency.

Whether or not these waves combine at all will be determined by the loudspeaker *enclosure.* If they do, the enclosure has the further important function of determining that they do so under properly controlled conditions. Of all the wide variety of enclosures designed to do this job, each will fall into one of only three categories:

1. The *direct radiator,* in which the back wave is never permitted to join the forward wave.
2. The *resonator,* in which the back wave joins the forward wave under controlled conditions.
3. The *horn,* which is a direct radiator with the addition of a flared opening at the front, presenting a partially enclosed volume of air for the diaphragm or cone to push against.

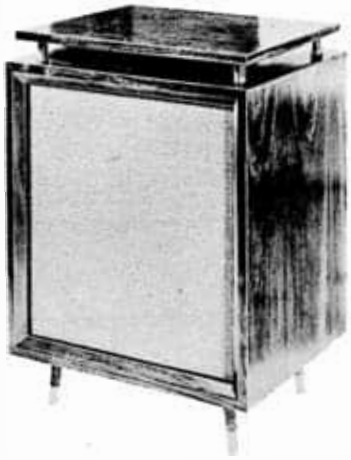
The direct radiator mounting is often called a *baffle,* and in its simplest form is nothing more than a plane surface with a hole in it, through which the speaker is mounted. The back wave cannot join the forward wave until it travels out to the end of the baffle and then into the area of the cone. To prevent the back wave from ever catching up with the forward wave, the baffle would have to be infinitely large, or an *infinite baffle.*

A reasonable approximation of this is the wall of a room, where the front of the speaker generates sound in the listening room, while the back wave escapes into the room adjacent. Now if we continue to reduce the size of this infinite baffle even further, soon the room has shrunk to closet size. This is a fairly popular arrangement, in fact, having the speaker mounted in the closet door.



University Loudspeakers, Inc.

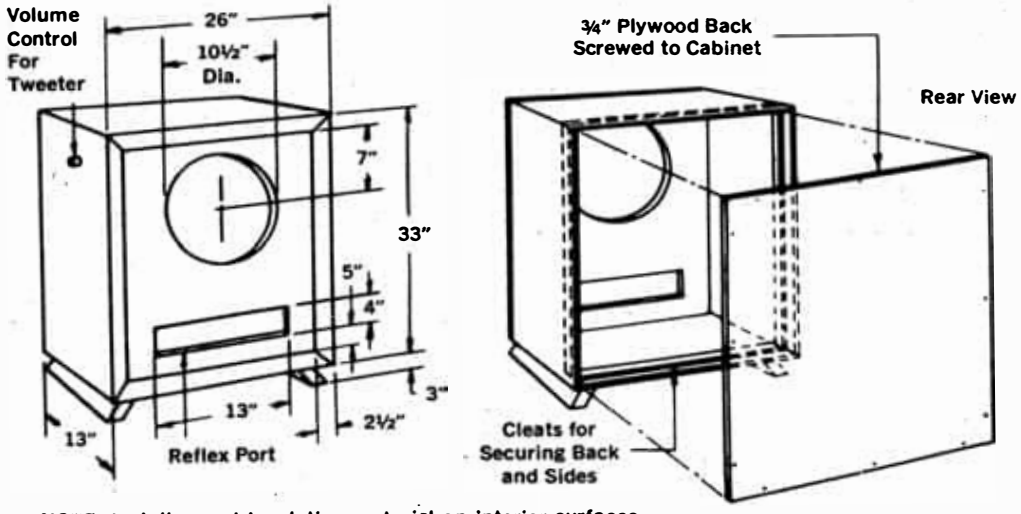
Above are sound-path diagrams of some of the most popular types of speaker enclosures.



Kingdom Products, Ltd., make the "Compass," an omni-directional enclosure, with the speaker mounted to face the top baffle board, as shown.

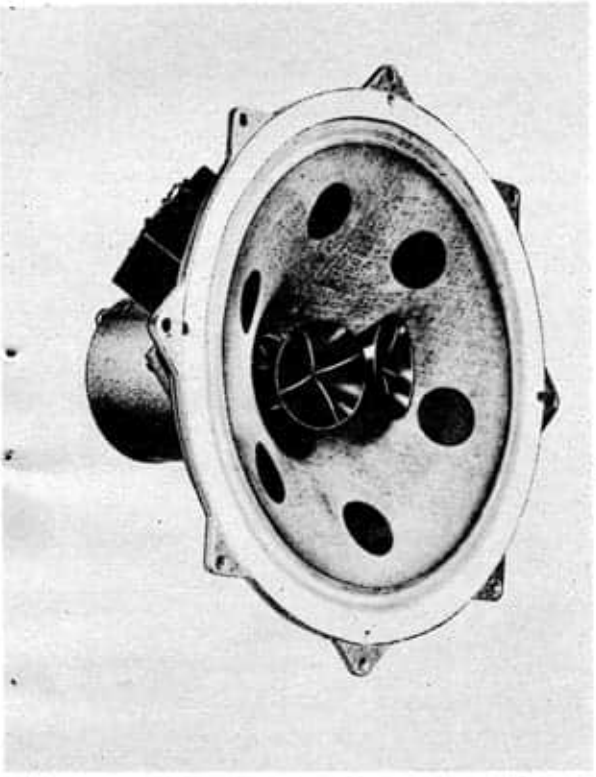
Wide-range system by Kingdom is the "Audette," with 30-18,000 cps response, 20-watt peak power, 8-ohm impedance. Contains 8-inch Lorenz woofer.

CONSTRUCTION OF A BASS REFLEX ENCLOSURE



NOTE: Install sound insulation material on interior surfaces. Cover back completely and approximately 50% of remaining surfaces

University Loudspeakers, Inc.



Stentorian 15-inch Duplex weighs 16 lbs., has low-frequency flux density gauss of 14,000; h-f gauss is 17,000; Alnico V magnet. Price: $159.

Klipsch patented corner horn enclosure uses a bass exponential horn for the reproduction of the lowest note of a pipe organ without any distortion.

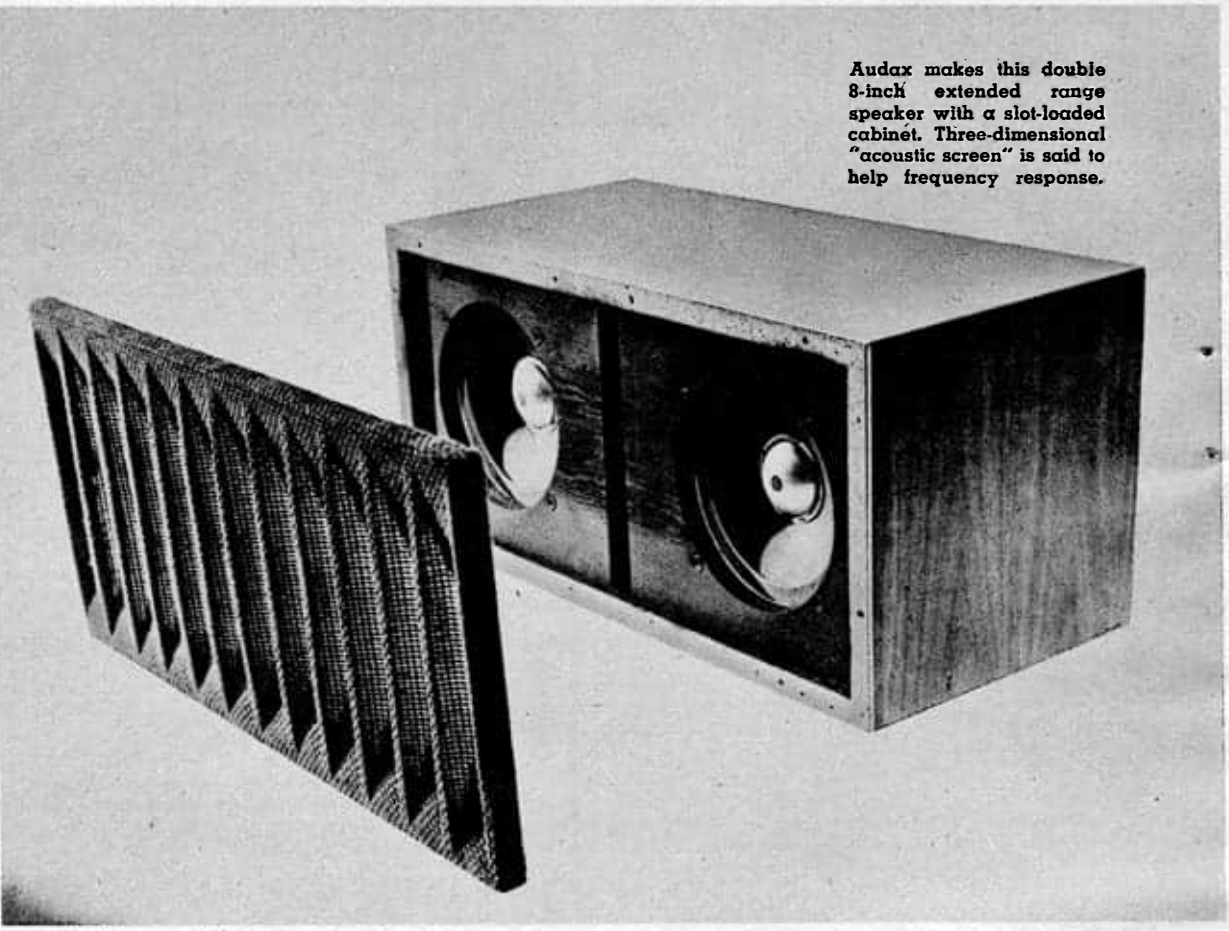
Continuing to decrease the size, we finally get down to a small box, completely enclosed. This is often the form of the bookshelf enclosures. These boxes seem to have astounding bass for their size, until we examine them more closely. Then we find that the bass response has a very big peak in it, with almost complete cut-off below that peak.

So take your time and listen carefully before buying any small enclosure. It is still axiomatic in speaker design that to get big sound you must have a big system. If your budget won't stand that, then you must be very careful to avoid ending up with gimmicked sound which will soon wear out its welcome.

The basic idea in all of the resonator types is phase inversion. This, incidentally, is not the same as that discussed for paraphase push-pull in the preceding chapter. Whereas in the push-pull amplifier we need a single wave to be converted to two waves of opposite polarity, in the resonator loudspeaker enclosure we want just the opposite. The back wave, which is normally exactly opposite in polarity from the front wave, is shifted in such a manner that when it joins the forward wave it adds to and reinforces it. Since adequate bass is always the big problem in speaker systems, especially the smaller types, the treble end of the spectrum is normally absorbed by padding within the enclosure, so that only the bass part of the back wave emerges from the front, to provide in effect a bass boost.

One example of the resonant phase inverter is the acoustic labyrinth, which has a serpentine pathway for the back wave, much like the mystic maze in an amusement park. The labyrinth performs quite well, but its structural intricacy, and consequent high cost, have limited its popularity.

The most popular enclosure by far is still the bass reflex, another member of the resonator family. This was developed by Jensen back in the days when hi-fi was the interest of only a handful of hardy



Audax makes this double 8-inch extended range speaker with a slot-loaded cabinet. Three-dimensional "acoustic screen" is said to help frequency response.

pioneers. It has since withstood the onslaughts of dozens of trick variations, each claiming to be the ultimate in hi-fi reproduction. But most speaker design engineers, as well as your own listening tests, will tell you that the bass reflex is still the best thing yet in small enclosures.

In construction it is nothing more than a padded box with two holes in it, one for the speaker and another for a vent or port, to emit the back wave. Whether buying or building a bass reflex enclosure, however, it is important to have a cabinet specifically designed for the speaker with which it is to be used. The size and shape of the box, the size and location of the port, and the resonant frequency of the loudspeaker, all must be properly integrated for optimum performance. This is not a difficult problem, but it does mean that you should follow the recommendations of the manufacturer of your speaker when considering what to do about enclosures. He will gladly advise you on what to buy or how to build a bass reflex which will get the most out of your speaker.

The true horn, as we've noted, employs a small diaphragm driver which sets air into motion in the narrow neck of a straight flaring trumpet. But as we have also seen, the huge size required for adequate bass response makes it prohibitive for most home hi-fi applications.

The cone-type radiator may also be used with a horn, in which case the enclosure is really a directional baffle. Ideally, the flare of the baffle should follow a mathematical formula, which brings us right back to the same space problem encountered with the true horn. This is circumvented in the so-called horn used in some hi-fi systems by twisting the pathway for the air into a *folded horn.*

The great size required for the mouth

The Speaker System

opening of the horn is taken care of after a fashion by placing the folded horn in the corner of the room. The walls, floor and ceiling thus act somewhat as extensions of the sides of the horn, with the listener in effect seated right inside it.

Since most of the highs would be lost in traversing the intricate bends of the enclosure, the folded horn is usually a bass unit only, and requires one or more additional speakers for the middle and upper ranges. An exception to this may be found in the back-loaded folded horn, where the cone radiates a forward wave directly, while the back wave escapes through the folded path of the horn. This is not a true horn, obviously, but is more properly classified with the resonators.

The Stereo Story

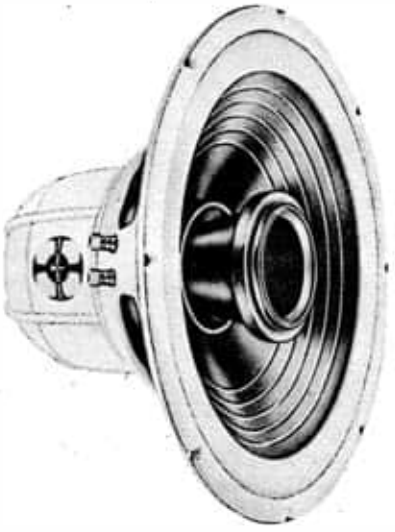
The biggest problem in stereo is the loudspeaker system, for audiophiles and manufacturers alike. Ideally you should have two top grade speakers, preferably of the same make and model. And right here is where the problems begin:

1. Expense
2. Decor

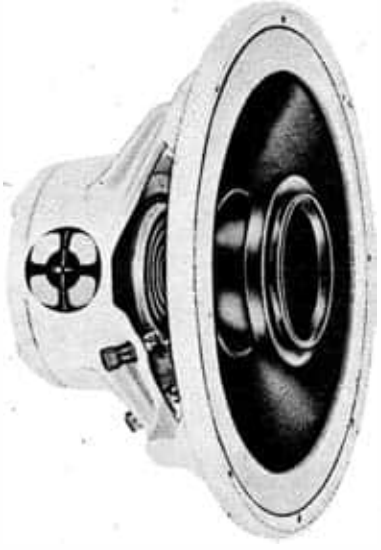
The loudspeaker represents one of the largest expenditures in the entire hi-fi system. Doubling that expenditure can put a crimp in anybody's budget. Then the placement of these speakers is fairly critical, and no respecter of interior decoration.

Designers have attacked both problems simultaneously by bringing into play the popular theory that the ears perceive no directivity effect below 300 cps. Therefore, it is said, a single low-frequency speaker in the middle plus a pair of small tweeters at either side will do the job. The only way to determine if this arrangement will suffice for you is to listen to the many such systems available.

Stereo speakers, and in fact any multiple loudspeaker setup, must be so connected that all radiators are simultaneously pushing air in the same direction. If they do not, there will be some partial cancellation, especially noticeable by a thinness of bass quality. The phase switch in stereo controls will take care of this, although reversing the wire leads to one speaker only will also usually take care of the problem. •



Tri-cone 15-inch by Audax covers range from 20-20,000 cps, uses coaxially mounted tweeter. Impedance: 8 ohms; 24 cps resonant frequency.



Audax A-120X has 40 cps resonant frequency, is priced at $59.95. Impedance is 8 ohms, power handling capacity, 20 watt. Flux: 12,500 gauss.