The Authoritative Magazine About High Fidelity

AUDIO®

MARCH 1971

60¢

BEHIND THE SCENES

BUYERS GUIDE TO LOUDSPEAKERS

HORN AND ELECTROSTATIC LOUDSPEAKERS

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POWER and purpose are implicit in its every distinctive line...

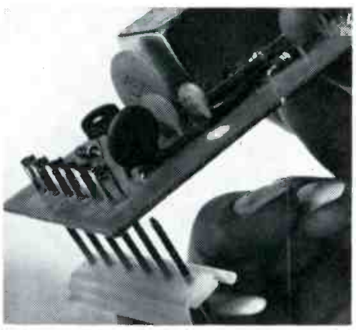
Never before has there been a receiver like the 387. Power and purpose are implicit in its every distinctive line . . . from its bold new high-visibility dial face to the sweep of its comprehensive control panel. And just wait until you experience the 387's effortless performance! A new kind of receiver power is yours to command — instantaneous, undistorted, unmatched for flexibility and responsiveness.

Inside, the 387 justifies its advanced exterior. Here are tomorrow's electronics . . . Integrated Circuits, Field Effect Transistors, solderless connections, and electronic safeguard systems to keep the 387's 270 Watts of power totally usable under all conditions.

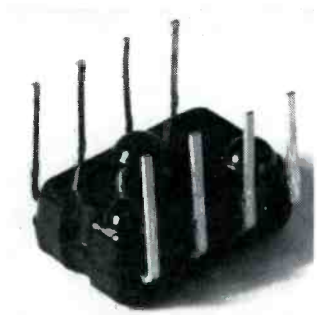
Decades of manufacturing experience and engineering skill have gone into the 387. But to really appreciate how its designers have totally rejected the ordinary, you must see it and hear it.

SCOTT 387 AM/FM STEREO RECEIVER

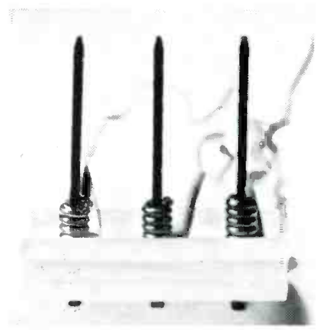
Computer-activated "Perfectune" light: Perfectune computer decides when you're tuned for the best reception and lowest distortion, then snaps on the Perfectune light.



New **Modutron Circuit Board Exchange Policy:** Takes over after your warranty expires; insures quick, inexpensive replacement of any plug-in printed circuit board for as long as you own your Scott unit.



Ultra-reliable **Integrated Circuits:** Seven IC's are included in the 387 . . . totalling 91 transistors, 28 diodes, and 109 resistors.



New **solderless connection techniques:** Tension-wrapped terminal connections plus plug-in circuit modules result in the kind of reliability associated with aerospace applications.

387 SPECIFICATIONS

AMPLIFIER SECTION: Total power (±1 dB) 270 Watts @ 4 Ohms; IHF music power, 220 Watts @ 4 Ohms; 140 Watts @ 8 Ohms; Continuous output, with one channel driven, 100/100 Watts @ 4 Ohms; 63/63 Watts @ 8 Ohms; Continuous output, with both channels driven, 85/85 Watts @ 4 Ohms; 55/55 Watts @ 8 Ohms; Harmonic distortion, 0.5% at rated output; IHF power bandwidth, 10 Hz — 38 kHz; Hum and noise, phone, —70 dB. TUNER SECTION: (FM); Usable sensitivity (IHF), 1.9 uV; Stereo separation, 40 dB; Capture ratio, 2.5 dB; Signal/Noise ratio, 65 dB; Cross modulation rejection, 80 dB; Selectivity, 42 dB. TUNER SECTION: (AM); Sensitivity (IHF), 4 uV @ 600 kHz; Selectivity (IHF), 32 dB.

Price: Less than $450.

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The Panasonic Ultra Hi-Fidelity Turntable.

For about $390.
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*The Panasonic Ultra Hi-Fidelity Turntable, Model SP-10 with wow less than 0.03% RMS. Flutter less than 0.02% RMS. Rumble less than −60dB. Speeds 33⅓ and 45 rpm. Fine Speed Control ± 2.0%. Build-up Time ½ rotation at 33⅓ rpm. Multi-pole DC Brushless Motor. Drive System Direct Drive. Electronic Control. Turntable 12" Aluminum Diecast. Turntable about $350. Base about $40.

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MODEL 770 STEREOPHONES

the ultimate in listening pleasure . . . now *guaranteed* for life

Superior craftsmanship and highest standards of quality control. These ingredients, built into every **SHARPE** model 770 Stereophone are now backed by a lifetime guarantee . . . for a lifetime of listening pleasure. **SCINTREX** will repair or replace any **SHARPE** model 770 Stereophone which develops a malfunction due to defective workmanship or materials, or from normal wear and usage . . . during the life of the original owner.

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FEATURE ARTICLES

EQUIPMENT REVIEWS

RECORD/TAPE REVIEWS

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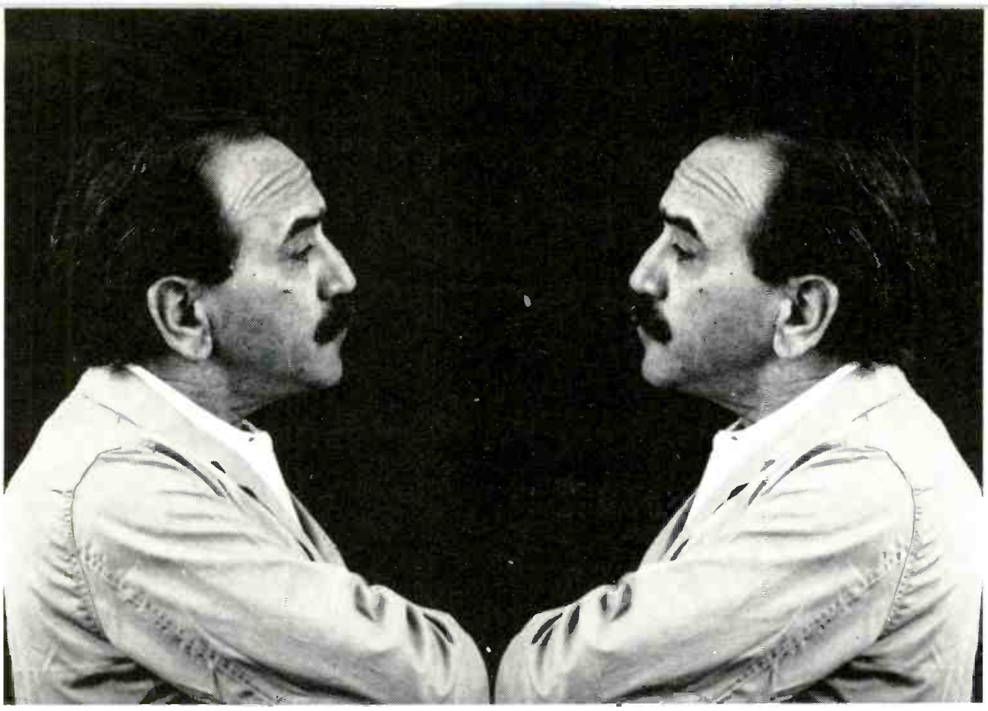

At our Swindon works, for every man who assembles we have one who tests.

Garrard of England is the world's largest producer of component automatic turntables.

And our SL95B is generally conceded to be the most advanced automatic you can buy, at any price.

Yet we confess to some startlingly old-fashioned ideas.

Instead of rewarding the speedy, for example, we encourage the persnickety.

In final assembly, each man who installs a part tests that finished assembly. The unit doesn't leave his station until he's satisfied it's right.

For a faulty unit to be passed down the line, a man must make the same mistake twice. An occurence we find exceedingly rare.

If something *isn't* up to standard, he adjusts it on the spot—or sets it aside to be made right.

Hardly the sort of thing production records are made of.

A modest record

But as Brian Mortimer, Director of Quality Assurance, has said, "We absolutely refuse to let units per hour become an obsession. It is simply a useful statistic.

"Each final assembly line for our 95B consists of nineteen men and women.

"In top form, they turn out twenty units an hour. A rather modest record in these days of mechanized production lines.

"But if we were to speed it up, we'd pay for it in quality. And, in my book, that's a bad bargain."

Of roots and heritage

We admit, however, to enjoying a special circumstance. Garrard recently marked its fiftieth year, all of them in the town of Swindon, England.

In a time of people without roots and products without a heritage, many Garrard employees are second and third generation.

Brian Mortimer's father, E. W., hand-built the first Garrard.

And in all, 256 of our employees have been with us over 25 years.

A happy circumstance, indeed.

To buy or not to buy

In an age of compromise, we indulge still another old-fashioned notion.

Of the 202 parts in a Garrard automatic turntable, we make all but a piddling few.

We do it for just one reason. We can be more finicky that way.

For instance, in the manufacture of our Synchro-Lab motor we adhere to incredibly fine tolerances.

Bearings must meet a standard of plus or minus one ten-thousandth of an inch. Motor pulleys, likewise.

To limit friction (and rumble) to the irreducible minimum we super finish each rotor shaft to one *micro-inch*.

And the finished rotor assembly is automatically balanced to within .0008 in.-oz. of the absolute.

Not parity, but superiority

Thirty-odd years ago, H. V. Slade (then Garrard of England's uncompromising Managing Director) set policy which endures to this day.

"We will sell a Garrard in the U.S. only when it is more advanced than any machine available there."

Spurred by this commitment, Garrard engineers have produced every major advance in automatic turntables.

Today's SL95B remains the world's premiere automatic turntable.

Its revolutionary two-stage synchronous motor produces *unvarying* speed, and does it with an ultra-light turntable.

Its new counterweight adjustment screw lets you balance the tone arm to a hundredth of a gram.

And its patented anti-skating control is permanently accurate.

The six Garrard component models range from the 40B at $44.50 to the SL95B (shown) at $129.50.

Your dealer can help you select the right one for your system.

Garrard®
British Industries Co.

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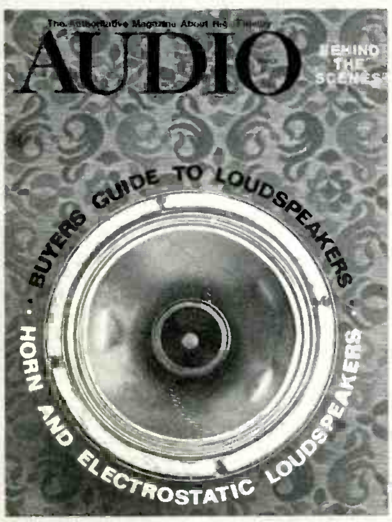
Coming In April

What Matters in Amplifiers—Specifications and how to read them.

How to Build a Delay Line—Duane Cooper describes a method of making delay lines suitable for simulated four-channel stereo.

Equipment Reviews Include:
Pioneer TX-900 AM/FM tuner
KLH Model 41 Dolbyized tape recorder

PLUS
Record and Tape Reviews and all the regular features



About the Cover: Here we have a picture of a most interesting loudspeaker, Model 1851. Designed in 1949, or thereabouts, by Hugh Brittain of the British GE company, it was one of the first full-range speakers to use a metal cone and voice coil. The center "bung" was replaced later by a HF pressure unit to increase the frequency range above 11 kHz. The surround was very flexible and free air resonance was about 20 Hz. An enclosure known as the *Polyphonic* used two of these 1851's in a unique push-pull arrangement.

Audioclinic

JOSEPH GIOVANELLI

Refrigerator Interference

Q. I recently bought a small refrigerator which produces so much interference that I cannot listen to my music system. The refrigerator starts every ten minutes and runs for two minutes. When it starts, I hear a noise. This noise isn't too bad, however. When the refrigerator stops, the noise is as loud as a circus whip.

I am living in an old house on the third floor without a ground wire. All outlets on the second and third floors are on the same circuit.

Do you have a solution to this problem? —John Hadzevich, Toronto, Canada.

A. Unless you can get at the contacts of the thermostat of your refrigerator there is probably not much you can do to solve this problem.

As you know, the operation of a refrigerator is controlled by contacts which are operated by a thermostat. Gas pressure acting on a diaphragm causes the switch to complete or disconnect a circuit, depending on the temperature of the box. Perhaps the gas pressure in your particular thermostat is not sufficient to cause the contacts to open quickly. If this is the case, your thermostat contacts will soon be permanently welded closed. I realize that your refrigerator is new, but you still might have a thermostat problem.

Assuming that the thermostat is in good condition, you may be able to shunt the contacts with a series combination of a resistor and capacitor. The capacitor will probably have to have a value of 0.05 μF. The resistor would have to have a value of no less than 100 ohms. The voltage rating of the capacitor should be 600 volts. The resistor can be a half-watt unit. You will have to experiment with the value of this capacitor until you arrive at a capacitance value which suppresses the noise. Apparently when your contacts open, they arc. The purpose of this network is to absorb a portion of this arc voltage.

You might try grounding your refrigerator to your outlet box. This sometimes helps to a degree.

Because so many circuits are fed from one line, it might be that the stopping of the refrigerator results in a dramatic rise in power line voltage. The suddenness with which this rise takes place could cause the transient clicks you are hearing.

Perhaps you should tell the dealer from whom you bought the refrigerator about the trouble that you are having, or you might write directly to the manufacturer of the unit.

I have not had a great deal of success in solving problems of this sort. It might be that another reader will have some observations which will be helpful. I will welcome the chance to hear from such a person and will print the material if it proves relevant.

Amplifier "Pops"

Q. When my amplifier is turned off, with or without an input source feeding it, my speakers produce a loud "pop." Is the "pop" considered normal with solid state equipment? If not, what is a solution? John Hanley, Woodside, N.Y.

A. From time to time I run into an amplifier which exhibits a "pop" when it is turned off. This has to do with the sudden interruption of the a.c. I think that this transient enters the amplifier as a pulse and becomes audible. I do not believe this is a matter of whether the amplifier is solid state or not. I have seen both tube and solid state gear exhibit this "pop."

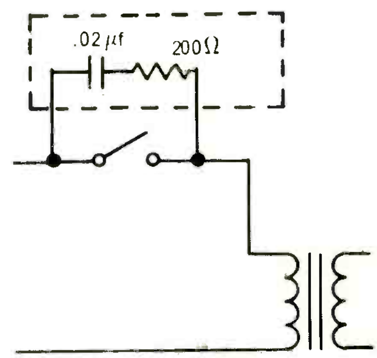


Fig. 1—Click filter circuit. The resistor may have to be increased to 100 ohms.

You might try bypassing the switch with a series combination of a 0.02-mF capacitor and a 200-ohm resistor. When the switch opens, this combination will act as a slight buffer to reduce the sharpness of the transient, and, we hope, will eliminate the "pop" for the most part. (See Fig. 1.)

Letter on Thumping

From time to time I receive items which might prove interesting to my readers. The following is a case in point:

Quite a few issues ago, a reader asked you a question about a heavy thump when switching on powerful transistor amplifiers.

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I have found a method of appreciably reducing it. I have been using this system now for a number of weeks without noticing any audible drop in power output. Here it is, for the benefit of other sufferers like myself:

Buy a so-called "tube saver" (300-watt type is adequate) and plug it between the power line and the linecord of the power amplifier. The tube saver consists of a temperature-dependent resistor with a negative temperature coefficient (carbon, etc.). When it is used, there is an appreciable drop in line voltage at the amplifier. The voltage builds up gradually (few seconds) to a value about two volts lower than without the resistor. This gradual rise of the applied line voltage allows the electrolytic blocking and filter capacitors to charge slowly. The desired effect of a less violent "thump" is thus achieved at a cost of only about $2.50.

I hope that other solid state amplifier users will find this suggestion helpful. Alex Azelickis, Morton Grove, Illinois.

Treble Cleanness and Volume

Q. On the amplifiers to which I have listened there seems to be a "kick-in" point on the volume control, where the treble becomes clearer and not so subdued. It does not matter what other components were used. It happens all the time. I usually have the volume past the "kick-in" point to truly allow me to enjoy the music.

Why do amplifiers do this? Sgt. Dennis Z. Muller, APO, San Francisco, California.

A. In most amplifiers the treble does not increase with respect to overall sound as the volume is raised. However, subjectively, the human ear perceives more treble and more bass, too, with respect to the middle frequencies, as the volume of sound is increased. Above a certain point the ear does not observe a further buildup of treble. This situation is a phenomenon of human hearing. It is not a problem associated with amplifiers. Therefore, if you wish to hear more treble, but not at so high a volume, advance the treble control to suit your needs. I notice that many of us tend to leave the tone controls on "flat." However, they were designed into the equipment to be used for just such situations as yours.

If you have a problem or question on audio, write to Mr. Joseph Giovanelli at AUDIO, 134 North Thirteenth Street, Philadelphia, Pa. 19107. All letters are answered. Please enclose a stamped self-addressed envelope.

When was the last time you saw a round piano?

Or a round violin or guitar?

You haven't. Because these instruments have acoustical sounding boards with irregular shapes. They produce sound with a bending motion. Natural sound.

And that's why our Yamaha Natural Sound Speaker isn't round. It's irregular in shape like the sounding board of a grand piano.

So when sound comes out, it comes out with a bending motion. The way it was originally produced.

With Yamaha, you don't have to get bent out of shape to get the most natural sound. It comes to you naturally. Write for complete technical information. The Yamaha Natural Sound Speaker.

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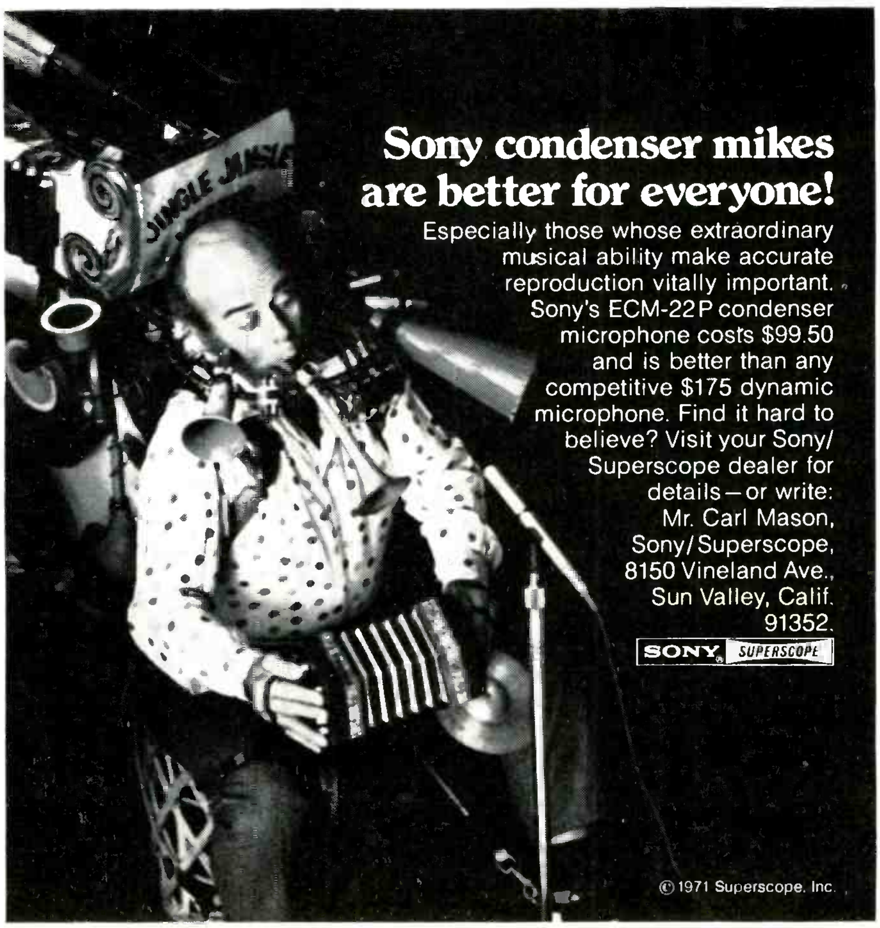

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What's New in Audio

Sony AM/FM stereo receiver/cassette recorder

Sony AM/FM stereo receiver cassette recorder

The Models CF-620, CF-610, and CF-500 each contain a high performance cassette recorder, AM/FM stereo radio, control center, and a pair of extended-range speaker systems. Features include a tape select switch for equalizing bias to standard tape or to chromium dioxide tape, straight-line volume and tone controls, FET circuitry in the tuner, magnetic phono, auxiliary, and microphone inputs, telescopic FM antenna, automatic recording level control, tape counter, and monitor jack. The speakers and control center latch together to form a single attache case-sized package. Prices: CF-620, with walnut cabinetry, $299.95; CF-610, with high impact plastic cabinetry, $289.95, and CF-500, with fewer features, $219.95.

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Booklets and Catalogs

Sony Corp. of America has issued the second volume of "Sony Videocorder," a broad compilation of case histories in video tape recording. The 52-page booklet presents 23 recent applications of VTR equipment.

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Howard H. Sams & Co., Inc. has released a new edition of Norman H. Crowhurst's "ABC's of Tape Recording," which offers practical, up-to-date information choosing and using tape recorders, judging recording quality, and recorder maintenance.

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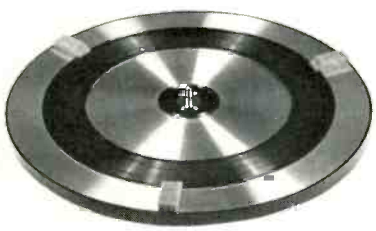
S & C turntable pads

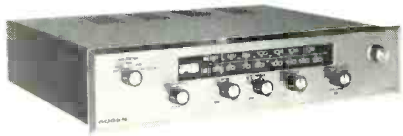


This set of three specially formulated pads is placed on the turntable to assure constant vertical tracking angle. Each record placed on the turntable compresses the pads the thickness of the record, placing the top record at the optimum height for a 15 degree vertical tracking angle. Other advantages include isolation from turntable noise and use of cueing control on stacked records. Price: $2.00.

Check No. 101 on Reader Service Card

Bogen RM300 P.A. receiver

This 30-watt receiver is designed to provide high fidelity FM and AM reception for background music systems. Inputs from external sound sources include record player, tape deck, microphone, and intercommunication paging phones. An auxiliary input will accept either a tape recorder with built-in preamp or the sound section of a TV receiver. Price: $374.90.



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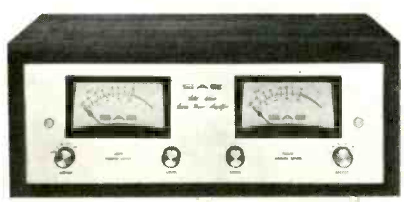
SAE Mark Three power amplifier

This basic power amplifier has impressive specifications: Power output is 120 watts rms per channel @ 8 ohms from 20 Hz to 20kHz; rms harmonic distortion is guaranteed less than 0.1% at 120 watts rms; IM distortion is guaranteed less than 0.1% at 120 watts sine wave power; response is $\pm$ 0.1 dB from 20 Hz to 20 kHz, and the S/N level is said to be better than 100 dB below 120 watts rms. Price: $700.



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Scott 433 tuner prototype

Four methods of FM station selection are incorporated into this tuner prototype: programmed cards, automatic station scanning, automatic stereo station scanning, and manual channel selection. Features include digital frequency readout, scanning steps based on a quartz crystal base, phase-locked loop, multipath and signal strength meters, channel scan speed control, and a four-channel multiplex output jack on the rear panel.

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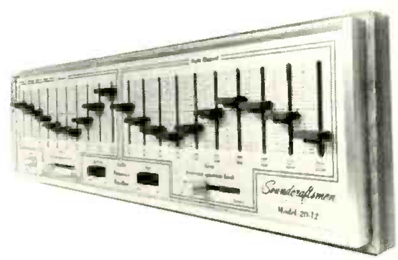
Soundcraftsmen 20-12 equalizer

This audio frequency equalizer is used to equalize the sound pressure level across the audible spectrum, taking into account qualities of the listening room, records, broadcast stations, tapes, etc.



It provides 10 controls for each of two channels, with each control spanning a single octave and having a 24 dB range. A separate frequency spectrum level control provides up to 24 dB boost or 18 dB cut in each channel. A special equalization test record is supplied with each unit, along with charts to mark settings. Price: $299.50.

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The either-or stereo from JVC

Model 4344 is the latest pacesetter from JVC. With more features, more versatility than any other compact in its field. You can enjoy either its superb FM stereo/AM receiver. Or your favorite albums on its 4-speed changer. Or 4-track cassettes on its built-in player. Or you can record your own stereo cassettes direct from the radio, or use its microphones (included) to record from any outside source. And you get all these great components in a beautiful wooden cabinet that can sit on a book-shelf.

But don't let its size fool you — JVC's 4344 is a real heavyweight. With 45 watts music power, 2-way speaker switching and matching air suspension speakers, illuminated function indicators, handsome blackout dial, separate bass and treble controls, FM-AFC switch. Even two VU meters to simplify recording, and more.

See the Model 4344 at your nearest JVC dealer today. Or write us direct for his address and color brochure.

JVC Catching On Fast

JVC America, Inc., 50-35, 56th Road, Maspeth, New York, N.Y. 11378

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Tape Guide

HERMAN BURSTEIN

Monitor Level Drop

Q. When I record monophonic FM on both tracks of my tape machine at the same time, or when I take a mono source and split it so as to send the same signal to Channel A and Channel B, upon balancing the input by meters with the monitor switch in the source position and then switching to tape monitor, I find the overall level dropped considerably and Channel A 2-3 dB below Channel B. When I use the output control to obtain the same listening level in the tape monitor and source monitor position, a comparison indicates an obvious deficiency of bass in the tape monitor position. I have made the above checks with several different brands and types of tape, and all gave comparable results. Please advise how to solve the problem. —John D. Moss, Hartselle, Alabama.

A. A difference of 2-3 dB in level between channels is not "considerable" but just about on the edge of significance so far as the human ear is concerned. This difference could be due to a difference in calibration of the meters, to a difference in amplification by electronic stages, to a difference in efficiency of the two sections of the record head, to a difference in output of the two sections of the playback head, and perhaps to other factors. One would have to make a careful check, with suitable test equipment (signal generator and VTVM) to discover where the difference originates and what to do about it. What to do about it depends in part upon the adjustment facilities available inside your tape machine. Some machines contain fairly elaborate internal controls in order to permit balancing channels in recording and playback.

The above answer also applies to your problems of a drop in level when switching to tape monitor (tape playback). Some machines contain internal controls for balancing input and output levels.

In the absence of suitable internal controls to achieve balance between channels and between input and output, you have to rely upon your external controls (for recording and playback) to achieve such balance.

The bass deficiency when listening to tape playback may be due to faulty playback equalization. Playback equalization can be checked with a test tape and a VTVM connected to the output of your tape machine. Proper equalization will result in flat playback response.

Red vs. Black Oxide

Q. I have often wondered why all prerecorded tape is of the red oxide variety. This dirties up equipment much faster than black oxide tape. I assume that the reason why black oxide tape dirties up equipment less is that the oxide is much harder. If the oxide is harder, then the commercial studios probably stay away from it because it wears out heads and parts faster. Any comments you have on the subject will be appreciated.—M. Glen Blair, Idaho Falls, Idaho.

A. I am not familiar enough with the physical properties of black oxide tape to comment on it as a cause of wear of heads and other tape machine parts. If you are correct that it causes more wear than red oxide, this would be a good reason for staying away from it, because high quality tape heads are very expensive items.

Furthermore, my understanding is that the two oxides have quite different magnetic properties, involving frequency response, bias requirements, noise, signal level, drive requirements, etc.; and that it has generally been found that red oxide is superior for most audio use.

Whistling Recorder

Q. I am writing to you about the problem of recording from FM stereo. I get a barely audible whistle at 7½ ips, but at 3¾ ips the whistle is very audible. Since my tape machine makes very listenable tapes at 3¾ ips, I of course wish to use this speed. I know from repairing several friends' machines that machines with 100 kHz bias have little or no troubles with "birdies." However, my recorder uses 80 kHz bias. I assume that the extra treble boost at 3¾ ips compared with treble boost at 7½ ips boosts the 19 or 38 kHz present in the tuner output and therefore accentuates the whistle at the lower speed. (This whistle results from mixing of the recorder's bias frequency and the tuner's 19 or 38 kHz output—HB.) *I am satisfied that the tuner is OK as I have tried two other tuners with the same result. Can you advise me regarding a filter to be used ahead of the high-level inputs of my tape recorder?*—Clarence Geidenberger, Jr., Newark, Ohio.

A. You might contact your local audio store or some of the audio mail order houses to inquire what they have in the way of a multiplex filter. If you wish to construct your own filter, you can try a simple circuit consisting of a capacitor and inductor in series, tuned to 19 kHz, and placed across the input jack of your tape recorder. (Of course, one such filter for each input.) This is the method used in some tape machines. Tandberg, for example, in its Model 64 uses a 2200 pfd capacitor in series with what is apparently a 34 mhy inductor. You can perhaps obtain a TV width coil tunable in the range of 10 to 20 mhy. If so, and assuming you adjust the coil to about 15 mhy, you would use a capacitor of about 5,400 pfd. If you use an inductor of about 10 mhy, the capacitor would be about 7,000 pfd. In short, the product of inductance in mhy times capacitance in pfd would be about 70,000 if you are tuning to 19 kHz.

Large-Reel Adaptor

Q. I have a Revox tape deck and have some questions regarding the use of 10½" reels on this machine. I have noticed that many of the 10½" plastic reels used on this machine are warped, sometimes severely so. Is this a common problem, and if so would you recommend the use of these reels? I would prefer to use the large-hub metal reels, but many people have told me that no satisfactory adaptor exists which would permit the use of these reels on my Revox. Apparently many of these adaptors simply do not perform well, and numerous problems are encountered when they are used. Is this really the case? If not, which adaptors do function properly, and where can these be obtained? What would you recommend as the best overall method of using 10½" reels on this machine?—Stephen L. Siegel, Chicago, Illinois.

A. I think that your question on how to handle the problem you describe should really be addressed to the manufacturer of your tape machine. I agree that use of a metal reel is preferable, but do not have the background of experience which would indicate the proper adaptor to use with the Revox (if there is such an adaptor). Why not write to Revox?

Equalization

Q. My question concerns equalization when playing records through the amp in my tape recorder. The only equalization in my recorder amp is for the two speeds 3¾ and 7½ ips. I play records

(Continued on page 28)

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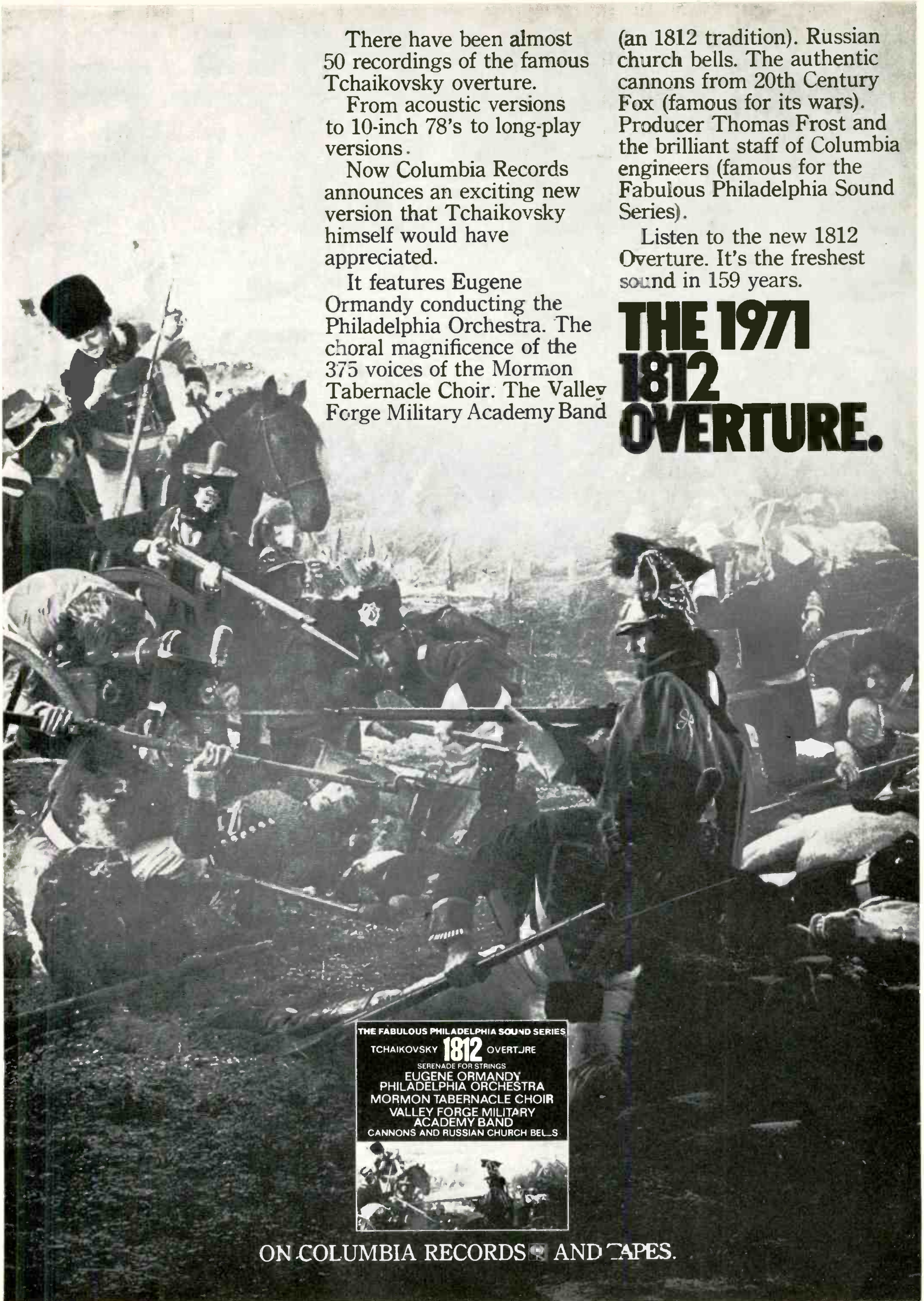

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BEHIND THE SCENES

BERT WHYTE

EVEN THE most casual observer of the audio scene is aware of the intense activity in the field. The various aspects of four-channel stereo, developments in the cassette format, Dolby noise reduction . . . all these are healthy indices of the dynamic growth and rapidly expanding technology of audio. Having delivered this nice fat platitude, one is bound to say that there are people who view some of these developments with something less than enthusiasm. For example, there are some hard-nosed audio retailers who feel that all the hoopla about four-channel stereo is premature and unwarranted and can only have an adverse effect on their two-channel stereo business. Okay . . . that's understandable . . . no one wants to get stuck with obsolete inventory. I personally don't think this is going to be a major problem. With cool-headed buying and the application of imaginative merchandising, these dealers can cope with the advent of four-channel stereo, just as we dealt with the transition from monophonic sound to stereo. I can tell you this fellas, you had better review your situation and adjust your attitude, for there is every indication that four-channel stereo could be a viable market entity as early as the fall of this year. The massive RCA advertising campaign for Quad Eight stereo will have terrific impact and it would be unwise not to be prepared for the overall boost this will give to four-channel stereo. You would be surprised at how many record companies, *besides RCA*, are busily preparing Quad Eight cartridges! Which brings up another point. . . .

I have seen the release lists for the Quad Eight cartridges from a number of record companies, and I have talked to their engineers. There is little doubt that the type of four-channel stereo sound that will predominate will be of the total surround ping-ping/pong-pong variety, with equal amplitude on all four channels. While this should apply mainly to pop music, unfortunately there seems to be some talk that classical music will be similarly processed. It would appear that there will be relatively few of the classical works recorded with ambient information on the rear channels. Of course, it must be admitted that there are very few classical recordings which have been recorded in the four-channel stereo mode. And as I have pointed out a number of times, there are some fairly divergent views on how to record classical four-channel stereo. So I am afraid we will be subjected to some pretty "hoky," phony four-channel stereo classical recordings, in much the way the same thing happened in the early days of two-channel stereo. It is a relatively easy thing to "mix down" an 8- or 16-channel pop recording to the equal amplitude four-channel stereo format. As I have noted in these pages previously, in the strictest sense, neither two- nor four-channel stereo pop recordings are stereo in the classic definition. They are really a number of monophonic tracks with reverberation added for "liveness" and oriented left/right, or as is the case with four channel, pan-potted as well.


Eargle

It is quite another matter to take a two- or three-channel stereo classical recording and convert it to four-channel stereo, especially if what is wanted is equal-amplitude, "total surround" sound. Some ghastly things have been proposed, such as taking the middle channel and splitting it to left and right rear! Since with the usual recording set-up in a concert hall the center channel of a three-channel stereo recording is mainly woodwinds, with perhaps some strings . . . that is what you would be hearing behind you! Bizarre is hardly the word. The big problem for anyone trying this kind of manipulation with a classical stereo recording is that he is dealing with a *true* stereo recording. Thus the orchestra totally interacts with the acoustic environment of the hall, producing both direct sound and multiple reflections, which are picked up by the microphones as functions of "time of arrival" and differences in intensity and phase. In a properly made three-channel recording for example, while we get directional information which tells us that the first violins are on the left and cellos on the right, there is a certain amount of overlap in the polar patterns of the microphones (they are deliberately positioned to take advantage of the overlap) so there is no gross isolation between the channels. The ideal of course, is to obtain a panoramic "wall of sound," with sufficient directional cues for localization of a discrete instrument or groups of instruments. This lack of pronounced isolation would make very difficult the pop-oriented mixdown of a classical stereo recording.

As most everyone knows, the human eye can be fooled with a variety of optical trickery. So too can the ear be fooled, with psychoacoustic factors prominent in this respect. Now in any four-channel stereo recording, the principal information is on the front left and right channels, and it is a very large proportion . . . probably on the order of 90 percent or even more. Now suppose we could take a two-channel preferably a three-channel classical stereo recording and somehow process it so that we could get a four-channel recording with ambient information on the rear channels, which would sound to our ears as if the recording was made in the four-channel stereo mode originally! Well friends, such a process exists! John Eargle, Chief Engineer of Mercury Records presented a paper and gave a demonstration at the last AES Convention in New York of his system of processing two- and three-channel classical stereo recordings into four-channel stereo recordings. As you might expect, it is a fairly complicated process, and next month I will report on it in detail. It is important to remember that in his process Mr. Eargle is concerned only with the creation of reverberant information to simulate the ambiance of the concert hall. The resultant processed tape is in the four channels in-line format, and is played through four amplifiers and loudspeakers. In other words, it is treated like a true four-channel stereo classical recording. As is pretty well known, I'm an audio purist. I can assure you that Mr. Eargle is equally uncompromising in his audio endeavours. So when I heard about this process and who had worked it out I was a bit shocked . . . and reluctantly . . . skeptical. As far as I was concerned,

(Continued on page 12)

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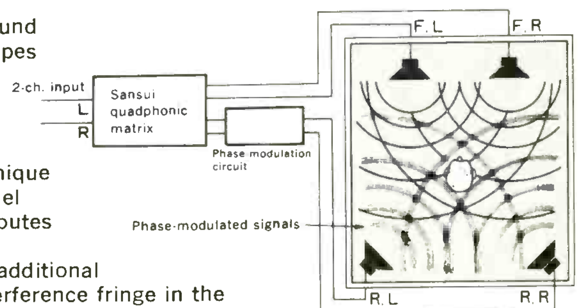
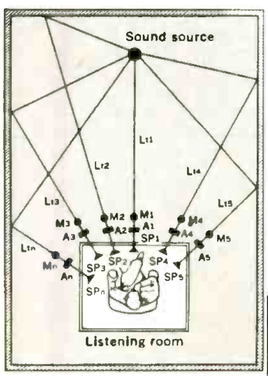


After having discovered that the ambient components of the original total sound field are already contained in hidden form, in conventional stereo records, tapes and broadcasts, Sansui engineers developed a method for sensing and recovering them. These subtle shifts and modulations, if re-introduced, breathtakingly recreate the total of the original sound as it existed in the recording or broadcast studio.

The heart of the Sansui Quadphonic Synthesizer* is a combination of a unique reproducing matrix and a phase modulator. The matrix analyzes the 2-channel information to obtain separate direct and indirect components, then redistributes these signals into a sound field consisting of four distinct sources.

This type of phase modulation of the indirect components, applied to the additional speakers, adds another important element. It sets up a complex phase interference fringe in the listening room that duplicates the multiple indirect-wave effects of the original field. The result is parallel to what would be obtaind by using an infinite number of microphones in the studio (M1 through Mn in the accompanying illustration) and reproducing them through a corresponding number of channels and speakers.



The startling, multidimensional effect goes beyond the four discrete sources used in conventional 4-channel stereo, actually enhancing the sense of spatial distribution and dramatically expanding the dynamic range. Also, the effect is evident anywhere in the listening room, not just in a limited area at the center. And that is exactly the effect obtained with live music! This phenomenon is one of the true tests of the Quadphonic system.

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SPECIFICATIONS: FREQUENCY RESPONSE: 60—15,000 Hz ± 3 db @ 1⅞ ips. WOW AND FLUTTER: 0.25% RMS. SIGNAL TO NOISE RATIO: Greater than 46 db. FIXED PRE-AMP OUTPUT: 1.0 V. per channel. CONTROLLED PRE-AMP: 0-5 volts per channel. PRE-AMP INPUT: 50mV to 2 volts. MICROPHONE INPUT: .1mV to 3mV, low impedance.

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Behind the Scenes

(Continued from page 10)

any deviation from honest-to-God four-channel stereo recording was anathema. Mr. Eargle kindly supplied me with one of his processed tapes . . . and the results were astonishing. The system not only works, but works so well that the ear immediately accepts what it hears as indistinguishable from a true four-channel recording. The hard part is that you know you're being tricked, but the ears refuse to acknowledge this and insist you are hearing four-channel stereo. A truly remarkable technique that opens up all sorts of possibilities with the thousands of recordings in the classical catalogs. More next month.

Dolbyized Cassettes

You will recall that last month I reported on the first Dolbyized cassettes from Ampex and from Decca of London and that I had two cassettes from Vox, which I would talk about this month. Vox cassette 678030 has a group of songs with orchestral accompaniment, by Satie, Milhaud, Stravinsky, and Ravel. Vox cassette 678029 has two rare piano concertos, one by Moscheles and the other the 4th piano concerto of Anton Rubinstein. Musically they are both excellent, with Darius Milhaud himself conducting on his work. From the technical standpoint, these cassettes are somewhat different from the Ampex and Decca, in that they were recorded on C-90 tape. C-90 has a thinner base and a somewhat thinner oxide than the C-60 type, and this turns out to have certain advantages over C-60. A recent communique from Dolby points out that C-60 provides good output at medium frequencies, but marginal high-level output at high frequencies. By using the thinner oxide C-90 a 1 dB reduction in medium frequency output results, but this is little sacrifice for the great improvement (typically 7 dB at 10kHz) obtained in the maximum output at high frequencies. This enables full frequency response to be maintained even in the loudest of passages. Another advantage of the C-90 is that the tape has greater mechanical compliance, affording better head wrap and tape head contact, resulting in decreased dropouts, d.c. noise, and modulation noise. Listening to the cassette, it was apparent that there was a significant improvement in high frequency response, evident in a smoothness not noted in the C-60 cassettes. There was also noticeably better transient response and the pianos benefitted therefrom, sounding bright, crisp

(Continued on page 79)

DOLBY AND MULTITRACK IN LONDON

With the increasing sophistication of pop and rock recording, quality conscious London studios are finding the DOLBY SYSTEM essential in preventing the noise problems which are otherwise inherent in multi track recording. In London's rapidly expanding network of 16-track studios, 19 of the 20 recorders currently in use are fully equipped with Dolby noise reduction units.

Robin Cable at Trident Studios
23 Dolby A301 units,
including 16 on two 16-track recorders

Mike Claydon at I.B.C. Recording Studios
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30 Dolby A301 units,
including 24 on three 16-track recorders

top right:
One of the Dolby installations at Olympic Studios
London's first multi-track studio to use
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DOLBY SYSTEM

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Editor's Review

THE FIRST dynamic speaker was probably invented by Siemans in 1881 but electronic power amplifiers did not appear on the scene for many years—but believe it or not, loudspeakers were used in the early nineteen-hundreds at a number of sports stadiums and exhibitions. And with very high power outputs, too. How? By using compressed air. Originally proposed by Edison, the first "air-speaker" patent was taken out by one Horace Short who demonstrated his "loudhailer" from the top of Eiffel Tower, in Paris. Later, in 1904, Parsons (the inventor of the steam turbine) evolved a more sophisticated device called the *Auxetophone* which used a 30-ft. horn. The British HMV company used both the Parsons and Short patents in smaller, more domesticated models that enjoyed limited sales until about 1914. These instruments employed an air valve developed by Dennison of the Victor Talking Machine Company and volume was sufficient for quite large halls and theatres. Parsons joined forces with Short and they evolved a compressed air amplifier for cellos and double-basses which was so successful that Sir Henry Wood used them with the Queens Hall orchestra in 1906. (The Musicians Union was *not* impressed!)

A few years later, another air-system was being extensively used in sports stadiums and other places needing high power. This was Gaydon's *Stentorphone* which had a rotary compressor similar to the present-day Wankel engine. It generated 10 lbs. per square inch with peak outputs up to 50. Owners of a Bexhill, London, skating rink were so enamoured with their Stentorphone that they allowed non-skaters to come in and listen at a small charge. Naturally, with the advent of electronic amplifiers all these exotic devices disappeared, but, who knows? Perhaps there is an optimist somewhere who is busily working on a new air-speaker that will Bring True Hi-Fi to the home, etc., etc.

Quadraphonics

Two record companies, *Ovation* and *Enoch Light Project III*, have announced that they will market four-channel records, and there is more news from *Electro-Voice* about the *Feldman-Fixler* systems. This company reports that encoders are now available for broadcast stations. Orders have been received from WNEW New York, WKNR Detroit, WJIB Boston, KSAN San Francisco, and last but not least WMMR in Philadelphia.

* * *

Philadelphia was also in the news recently when the Girard Bank announced that they have commissioned Samual Barber to write a Choral Symphony which will be premiered by Eugene Ormandy and the Philadelphia Symphony Orchestra in September. As far as I know, this is the first time a bank has sponsored a musical work of this nature but many people will echo the sentiments of Girard's Chairman Stephen Gardner who said "Good citizenship calls for such involvement."

Humor in Advertising

This is really an example of humor-in-translation and the tortured English describes one of the small electrostatic speakers mentioned on page 30 ". . . the static high-tone speakers known so far features the flat diaphragm, therefore the reflection takes place in copious bundles. This new speaker has no baffle plates, by-pass lines, metal tubes or similar auxiliary means which would after all bring fading symptoms, knots, and irregular reflections in their wake due to their different running times." Sounds more like the L.I. Railroad. . . .

* * *

Two of the writers in this issue are somewhat critical of the Doppler distortion theory. The other side of the argument is in our August issue (The Mud Factor by Paul Klipsch). This is a subject of some importance and other opinions will be published in future issues. One of the contributors is a well-known Dutch expert, Henry Van Hessen whose article is very amusing. The Dutch have no sense of humor? Don't believe it. Another writer is David Griesinger who has been busy taking measurements for the past few months.

* * *

As many readers have noted, many RCA records issued during the past year have been exceptionally thin and some cynics have accused RCA of "cheeseparing" in an effort to make more profits. This is not the case at all and the whys and wherefores of the thin disc—called *Dynaflex*—was the subject of a paper presented by Warren Isom at the last AES convention. Briefly, the change was made to reduce warping and the incidence of blisters (the thinner disc cools more quickly and the use of less compound facilitates the escape of process gasses) as well as the reduction in surface noise due to the more uniform molding. So, we have now set the record straight. . . . *G. W. T.*

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The Why and How of Horn Loudspeakers

Victor Brociner*

Horn loudspeakers are used whenever high efficiency is required and when special control is desired over directional characteristics. In a well-designed horn speaker, distortion is lower than in a direct radiator, at least towards the low-frequency limit of its range. Bass horns are capable of producing high sound pressure levels with a small cone excursion; because of this, both non-linear and Doppler distortions are lower than in direct-radiator woofers. Direct-radiator speakers become more directional as the frequency increases. Horns can be designed to provide good directional patterns up to the highest frequencies.

The theory of horn speakers to be found in textbooks is highly mathematical, difficult to understand, and very abstract. It does not provide a good intuitive understanding of horn speaker operation. Popular books, on the other hand, tend to present ostensibly simple explanations that are really not much more comprehensive. What is mean by saying that a horn is an impedance transformer? How does a horn "load" a driver unit? When a speaker is loaded by a horn, doesn't the increased load reduce the diaphragm excursion? If so, why does the acoustic output increase? This article is an attempt to explain horn speaker operation in terms that provide both an intuitive and a quantitative understanding, without using advanced mathematics. It will be assumed that the reader has some acquaintance with electrical analog circuits for mechanical and acoustical systems, and with concepts such as radiation impedance, motional impedance, mechanical compliance, and the like. It is freely confessed that, in the course of the development, some shameless simplifications will be made. The following is certainly not represented to be a design manual.

Direct radiator speakers have low efficiency because there is a bad mismatch between the impedance of the mechanical power source and the air into which it radiates sound, except at resonance, where *electrical* mismatching reduces the output. Fig. 1 is an analog circuit for a direct-radiator speaker in its middle frequency range in which losses are neglected. In this circuit, the acoustic output is the power produced in the radiation resistance R_{MA} by the velocity v:

$$P_A = V^2 R_{MA} \qquad (1)$$

Over the flat section of the frequency response curve shown in Fig. 2, the motion of the cone per unit of applied force is determined almost entirely by the mass of the moving system:

$$V = \frac{F}{2\pi fm} \qquad (2)$$

where v = cone velocity in meters per second
F = force applied by the voice coil, in Newtons
f = frequency, in Hertz
m = mass of the moving system (coil and cone) in kilograms

Equation (2) shows that cone velocity is inversely proportional to frequency. Figure 2 depicts this variation. The dashed curve shows how v^2 varies with frequency. The radiation resistance, R_{MA}, is a function of the square of the frequency, as shown by the dot-dash line. Now, referring to equation (1), the acoustic power output is derived as follows:

$$V \propto \frac{1}{f}$$

$$V^2 \propto \frac{1}{f^2}$$

but $$R_{MA} \propto f^2$$

so $$\rho_A = V^2 R_{MA} \propto \frac{1}{f^2} \cdot f^2 = \text{constant} \qquad (3)$$

This is seen in the power-frequency response curve of Fig. 2. Suppose the voice coil mass plus cone and air load mass equals .03 kg. At 400 Hertz, where the frequency response is flat, the reactance of the mass is

$Xm = 2\pi fm = 6.28 \times 400 \times .03 = 75$ mechanical mks ohms

This is the effective impedance of the generator. The load,

$R_{MA} = 1.57\omega^2 a^4 \rho o/c$*

where $\omega = 2\pi f$
a = radius of piston in meters
o = air density in kg/m^3
c = velocity of sound in m/sec.

Simplifying: $R_{MA} = .0132\ d^4 f^2$
where d = piston diameter in meters (5)
for a 10-inch cone, d = .24 meter approximately
At f = 400 Hertz
$R_{MA} = .0132 \times (.25)^4 \times 400^2$
$= 8.25$ mechanical mks ohms

So a 75-ohm generator feeds an 8.25-ohm load. This indicates the degree of mismatch in a typical case of a direct radiator speaker.

Matching can be improved by reducing the generator impedance or increasing the load impedance. The reactive generator impedance can be cancelled out by resonating its mass with a compliance. This is what happens at the resonance frequency of a direct radiator. At and near this frequency, the impedance match is good, and the mechano-acoustic efficiency is high. However, the low mechanical impedance that occurs at resonance is reflected into the electrical circuit as a high impedance, as a result of which the speaker cannot absorb much electrical power from the amplifier, that is, if the speaker is well damped. If not, there is bump in the response curve at resonance. This is not the kind of efficiency we want.

The reactive generator impedance can also be reduced by reducing the mass, m. This is done in tweeters by using small, aluminum voice coils and very light cones. In wide-range speakers or woofers, there is a limitation to mass reduction because the cone must be sufficiently strong so as not to buckle or break up into modes. Another problem is that reducing the mass raises the frequency of resonance, below which the frequency response falls rapidly. It also reduces the Q of the moving system, since

$$Q = \frac{2\pi fm}{R_m} \qquad (6)$$

where R_m is the damping resistance. An over-damped speaker has a frequency response that falls off as the frequency de-

*Vice President Engineering, H. H. Scott, Inc.

*Leo L. Beranek - Acoustics 1954 P. 124 Table 5.1

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creases. All of these factors are undesirable consequences of excessive lowering of mass.

This leaves the factor R_{MA}—the radiation resistance. Since R_{MA} increases proportionally to the area of the speaker, it is a simple matter to make it larger. But increasing the size of the cone raises its mass: rather rapidly, in fact, because the thickness has to be increased as well to maintain adequate stiffness. This works to counteract the increased efficiency obtained by the larger cone. Also, as examination of the frequency response curve of Fig. 2 discloses, the point at which the high-frequency response falls off is lower the greater the cone diameter. For a theoretically perfect piston, the drop in response begins at f = 8600/d where d is the piston diameter in inches. Thus, a 10-inch piston begins to drop in response at 860 Hertz, a 15-inch diameter results in a 573-Hertz transition point, and so on ----- downwards.

Increasing Radiation Resistance

If we could somehow manage to persuade a cone to produce plane waves, the radiation resistance would be 407 mechanical mks ohms per square meter of radiating area. A 10-inch cone, with an area of .05 square meter, would then work into 407 × .05 or 24 ohms which is certainly more favorable than the 8.25 ohms calculated in the example given above. We know that sound that is not too high in frequency is propagated as a plane wave along an infinitely long pipe. We could presumably get better efficiency by coupling the speaker to such a pipe. However, we might not care to wait around until the sound emerged from the pipe! What about a very long, but not infinite, pipe? The load on the speaker would be favorable, but now, at the mouth of the pipe we face much the same situation as we had with the speaker radiating directly.

The only way around this problem is somehow to attain a larger area at the point of transfer of sound from the pipe to the surrounding air. Fig. 3 shows a way of doing this. The expanding passage employed is called a horn.

To determine exactly how a horn works even with simplifying assumptions, requires abstruse mathematical treatment. However, there is a simplified approach which, although anything but rigorous, can convey a rather good idea of what goes on in a horn. Let us consider the propagation of a plane sound wave through a small pipe that feeds a larger one as shown in Fig. 4. Assume that both pipes are infinite in length. The acoustic resistance of the small pipe is 407 S_1 mechanical mks ohms, S, being its cross-sectional area in square meters. The large pipe has an acoustic resistance of $407S_2$. The resistances are not matched at the junction, so some reflection takes place, and not all of the power is transmitted from one pipe to the other.

The ratio of power transmitted is

$$r_p = \frac{4r_s}{(1 + r_s)^2} \qquad (7)$$

where

$$r_s = \frac{S_2}{S_1}$$

It is interesting to note that S_2/S_1 can be appreciably larger than 1.0 without a great deal of power loss. For example, a 1.5 to 1.0 ratio results in 96% transmission of the incident power. This suggests that it might be feasible to transfer power without excessive losses to a larger area by means of successive small steps of expansion,* as in Fig. 5. Calculations on increasing numbers of steps of expansion for a given ratio of S_2 to S_1 reveals a definite trend that can be seen in the following:

*It is not correct to couple steps together like this because there is an impedance mismatch, but in this case the end justifies the means.

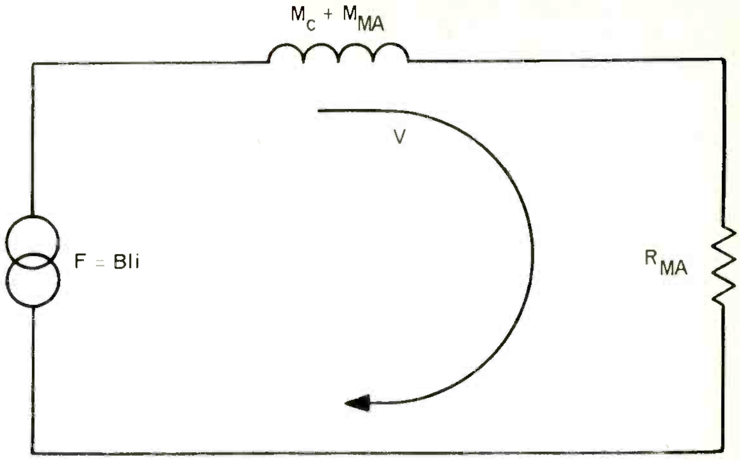

Fig. 1—Mechanical analog circuit of direct radiator loudspeaker with a constant current drive. Frictional losses are assumed as zero. F = force exerted by voice coil in Newtons; l = length of voice coil conductor in meters; i = current in voice coil in amperes; m_C = mass of voice coil and cone in kilograms; m_{MA} = equivalent mass of air load in kilograms, and R_{MA} = radiation resistance in mks mechanical ohms.

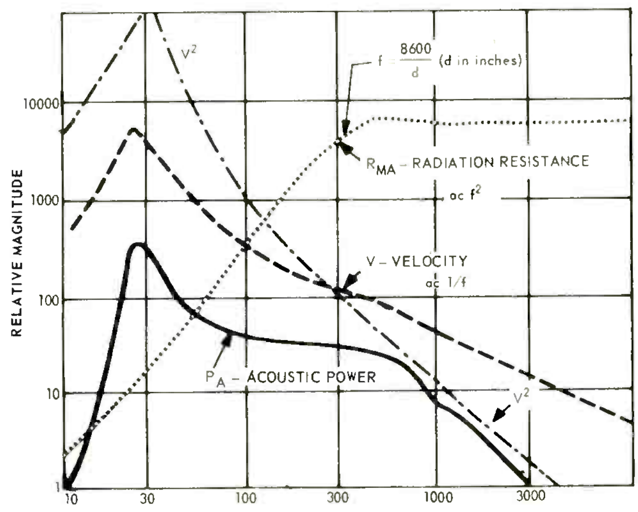

Fig. 2—Calculated performance of piston as direct radiator.

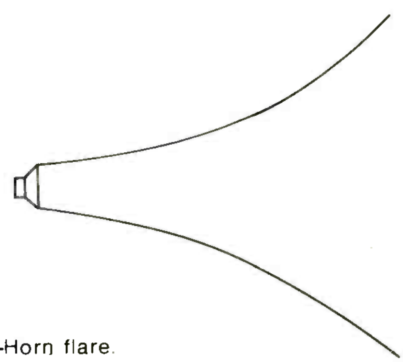

Fig. 3—Horn flare.

Ratio of areas per step	Number of Steps	r_p per step	Total r_p
2.00	1	.89	.89
1.41	2	.97	.94
1.26	3	.99	.97
1.19	4	.992	.98

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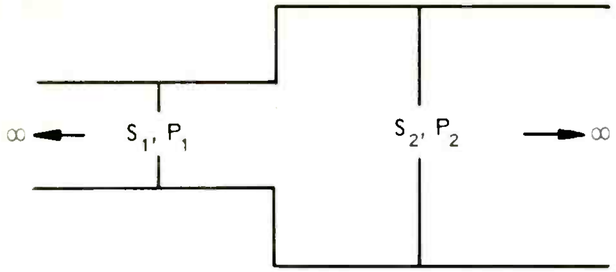

Fig. 4—Acoustic power transmission through stepped pipe. S_1, S_2 = cross-sectional areas; P_1, P_2 = power transmitted, and $r_P = P_2/P_1$.

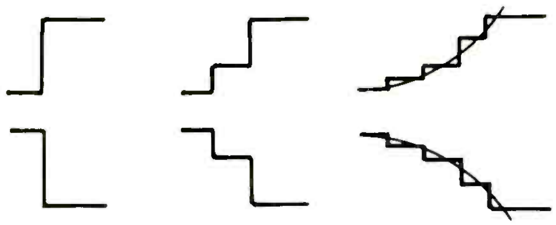

Fig. 5—Limit of successively larger numbers of steps of expansion of a pipe for identical initial and final diameters.

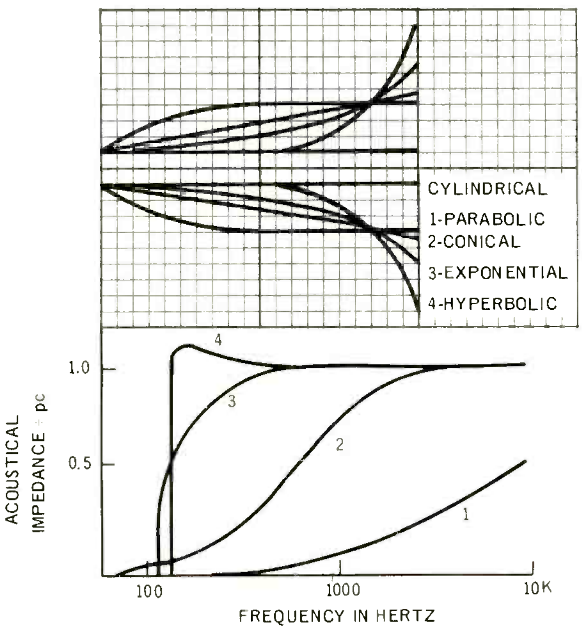

Fig. 6—Expansion rates of various types of horns. S = area at distance X from throat; S_T = throat area. Parabolic: $S = S_T(1 + X/X_0)$; Conical: $S = S_T(1 + X/X_0)^2$; Exponential: $S = S_T e^{mx}$; Bessel: $S = S_T(X + X_0)^m$; Catenoidal: $S = S_T(e^{mx} + e^{-mx})$; Hyperbolic: $S = S_T(\cos H\, X/X_0 + T \sin X/X_0)^2$. T is less than 1.

In all four cases, the ratio of output area to input area is 2.00 and it is evident that increasing the number of steps raises the efficiency of transmission. The trend appears to indicate that the limit of a continuous curve is 100% transmission. Now, if the far end of the pipe can be made large enough so that it produces plane waves, just as plane waves would be radiated by a large piston, the finite pipe behaves like an infinite pipe. There is no problem at the far end, power is transmitted 100% along the pipe (except for frictional losses) and the desired increased load is obtained on the diaphragm of the driving speaker. The device we have "invented" is a horn; the end near the speaker is called the *throat* and the far end the *mouth*.

Horns: Infinite and Finite

The shape of a horn is expressed by a mathematical formula indicating the ratio of the horn cross-sectional area at a given distance, x, from the horn throat, to the area of the horn mouth. The most widely used horn is is *exponential*:

$$\frac{S_2}{S_1} = e^{mx} \qquad (8)$$

where S_2 = mouth area
S_1 = throat area
m = flare constant
x = distance from throat

In this type of horn, each increment of distance results in a constant ratio of areas:

If $S_2 = S_1 e^{mx}$

then, for an increase of x in distance

$$S_2 = S_1 e^{m(x+\Delta x)} = S_1 (e^{mx} \cdot e^{m\Delta x})$$
$$= S_1 e^{mx} \cdot e^{m\Delta x}$$
$$S_2/S_1 = e^{m\Delta x} \quad \text{is a constant}$$

This is the type of horn we developed as a limit of the stepped pipe as the number of steps per unit distance increased indefinitely. Other useful horn shapes are Bessel, catenoidal, conical, hyperbolic, and parabolic. These are all shown in Fig. 6. The conical horn is the oldest form of artifical horn, seen in megaphones. The oldest natural form is approximately paraboloidal, consisting of a pair of cupped hands held before the mouth. Paraboloidal horns are used, in segments of different flare rates, to approximate horns of other expansion laws, in low-frequency horns. Many folded bass horns, which are usually made of wood, use a succession of short sections with a pair of parallel sides, the other pair expanding linearly. The area of such a horn section follows a parabolic law of expansion.

The hyperbolic and Bessel horns are families of horns, the exact curve depending on the values of certain parameters. The hyperbolic horn becomes exponential when T = 1, and catenoidal when T = 0. The Bessel horn becomes conical when m = 1.

Fig. 7, shows a comparison between the radiation resistance of a loudspeaker radiating directly into the air and the same unit working into an exponential horn. There is a large increase in radiation resistance at frequencies below the knee of the curve for the direct radiator, and none at all for high frequencies. The lack of improvement at the top end is not surprising when one realizes that a direct radiator produces virtually plane waves at high frequencies. These can be visualized as emerging as a beam from the speaker without being affected by the horn walls.

All of the curves go to very low values of radiation resistance as the frequency is decreased below a certain point. In an exponential horn, for example, the radiation resistance becomes zero when:

$$f_c = mc/4\pi \qquad (9)$$

where f_c = cut-off frequency
c = speed of sound
m = flaring constant.

The radiation resistance does not actually go down to zero, but retains a small finite value, not given by the usual horn formula because of the simplifying assumptions adopted in its derivation. At $\sqrt{2}\, f_c$, R_{MA} is $1/\sqrt{2}$ of its ultimate value. A horn driven by a piston whose velocity is independent of frequency has a sound pressure level that is down 3 dB at this frequency.

A convenient, if approximate concept, is that below the cut-off frequency the air in the horn does not propagate as a travelling wave but simply oscillates in the horn so that the

(Continued on page 22)

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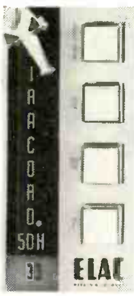
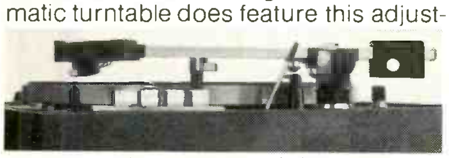
Lift this page and drop it... you'll see how gently the Miracord 50H treats your records.



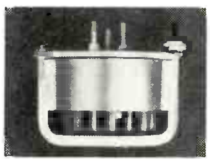
A gentle touch of the push-buttons brings forth a gentle reaction from the Miracord 50H. The dynamically balanced arm responds gently with its frictionless bearing system, faithfully and flawlessly tracking the intricate record grooves. Gentleness, however, is just one attribute of the 50H, a clue to its superior performance is found in its features.

Stylus overhang adjustment is essential for optimum tracking. Another automatic turntable does feature this adjust-



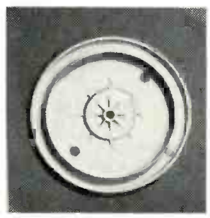
ment, but it's internal and difficult to set. The Miracord 50H offers external overhang adjustment with built-in gauge no shifting, no guesswork, no templates.

Other turntables offer a kind of synchronous motor. The 50H uses a *Papst hysteresis synchronous* motor with outer rotor for unvarying speed accu-



racy regardless of the voltage fluctuation or loads. The Papst motor is usually found in professional studios.

Consider cueing: in one leading automatic turntable, cueing does not operate in the automatic mode. In automatic, cueing is the ideal way to interrupt play for a moment when there is a stack of records on the spindle. The 50H provides silicone-damped cueing in both automatic and manual modes.



Another important feature is the 50H turntable. It is a heavy, one-piece, non-ferrous metal casting, lathe-turned to precise dimensions and then individually dynamically balanced. This contributes to the smooth, steady motion of the turntable, free of rumble, wow and flutter.

Nothing we can say short of experiencing it yourself can better describe the gentle way in which the Miracord responds and preserves the best in your records. Find out for yourself. Miracord 50H, $175 less cartridge and base. Miracord feathertouch automatic turntables start at less than $100. Benjamin Electronic Sound Corporation, Farmingdale, N.Y. 11735/a div. of ISC/available in Canada.

Miracord 50H

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NEW,
TRANSPARENT
AND BEAUTIFUL.

ADC's brand new 450A is a "high transparency" speaker system for the perfectionist who wants to own the best bookshelf system money can buy.

This two-way system avoids the use of complex crossover networks and the resultant phase distortion. By enabling the majority of the audio spectrum to be radiated by the high frequency unit, we achieve essentially a "single point source". The low frequency driver is then left to do the demanding but uncomplicated job of reproducing the low and basically non-directional portion of the audio spectrum.

The result is an extremely transparent true-to-life bookshelf speaker system you must hear to appreciate.

ADC 450A SPECIFICATIONS

Type . . . Full-sized bookshelf.
Cabinet . . . Oiled Walnut.
Dimensions . . . 25" H x 14" W x 12⅜" D.
Weight . . . 50 lbs. each.
Frequency Response . . . 25 Hz to 30 kHz ± 3 dB (measured in average listening room).
Speakers (2) . . . ¾" "point source" wide range tweeter and 12" high compliance woofer.
Nominal Impedance . . . 6 ohms (for optimum performance from transistorized amplifiers).
Power Required . . . 10 watts RMS minimum.
Price . . . $165 (suggested resale).

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AUDIO FOR
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Dear Editor,

Missing Issue

Dear Sir:

Just thought I'd drop a line to see if you were still in business, or if you had merely given it to me.

I had just finished reading the November issue, and I was beginning to worry. I already had the January issues of my other magazines (that's January, 1971, of course), but still there was no December issue of Audio. I know what kidders you fellows are, and I was seriously considering waiting until Christmas to see if you were having Santa come down my chimney to deliver it in person. But my chimney leads to the furnace, so that would not have done me much good, a charred Audio and a roasted Santa. Perhaps, if you *haven't* gone out of business, you could mail it to me. I have enclosed a mailing label. As you can see, it did not come off the cover in perfect condition, so I have reproduced it for you. Come to think of it, that may have had something to do with your magazine's demise; you may have been spending too much money for glue.

Mrs. Edward Keppner
Quincy, Ill.

Dear Mrs. Keppner:

Many thanks for your letter about the missing issue, which was passed to me—casting a grey shadow over the entire day. The December issue was sent to you but either the pack mules got sick and did not reach Quincy, Ill. or the magazine was put down the wrong chimney. Or it might have been destroyed by agents of those other magazines as part of a well-thought-out and highly calculated plot to keep Quincy, Ill. uninformed and knowing nothing of what is going on Behind the Scenes. . . .

However, another copy was sent to you on January 9th and you should have received the January issue too. If not, perhaps you would let me know? Before you write, please make certain you are still living on Eleventh St.

Finally, I am glad to say we are very much alive and that the chances of our survival for the rest of your subscription period appear excellent—*Ed.*

P.S. Have you ever thought about moving to Philadelphia?

Farnon Society

Dear Sir:

"Two Cigarettes in the Dark," an LP by Robert Farnon's orchestra, has been re-released in England as Eclipse ECS 2053, along with many other fine older London records which have been deleted since the 1950s. In the course of my three-year search for the original release (London LL 1052), which I finally did find a copy of, I discovered the Robert Farnon Appreciation Society in England, which is an active group of about 100 members all over the world. We trade information on recordings of *all* artists in the light orchestral, easy listening, and mood music fields.

I mention "Two Cigarettes in the Dark" because it would be a shame if other collectors are as desperate to find a copy as I was and aren't aware of the English re-release. Any readers who are interested in the Robert Farnon Appreciation Society may write to me.

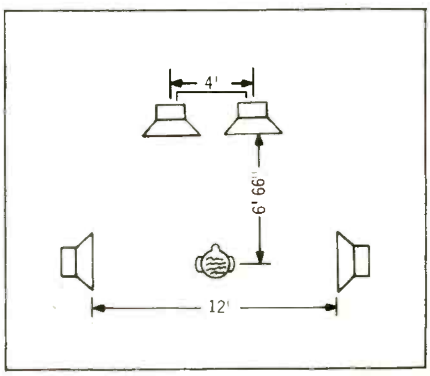
Steve Keller
1045 Oakland Road N.E.
Cedar Rapids, Iowa
52402

Three-Channel System

Dear Sir:

I am presently using a system, which may be too obvious since I haven't seen it suggested. Going Dynaco one better, I drive two speakers from the hot outputs of my amplifiers. So far, it doesn't appear to affect performance. This gives what I call three-channel, four-speaker stereo when used with two normally wired front speakers. I believe that four-channel stereo is probably very little better. Naturally, as with the Dynaco system, it would help if the records were made with the use of this output in mind. As a starting point for those wishing to experiment, I am enclosing my present speaker arrangement.

E. Strawn
Kokomo, Inc.



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It's not an easy decision to make. There's such a wealth of precision built into every Dual that even the testing laboratories can measure only small differences in performance among the Dual 1215 at $99.50, the 1209 at $129.50 and 1219 at $175.00.

This raises an interesting question for you to consider: What are the important differences to you among these three Duals?

Let's consider them in turn.

Even our lowest priced turntable, the 1215, boasts features any turntable should have (and few do).

Its low-mass counterbalanced tonearm accepts the most sensitive cartridge available today and tracks flawlessly as low as ¾ gram.

Tracking force and anti-skating settings are ingeniously synchronized, so one setting does for both. The cue control is silicone-damped, and eases the tonearm onto the record more gently than a surgeon's hand.

The hi-torque motor brings the heavy 3¾ pound platter to full speed in less than a half turn, and maintains that speed within 0.1% even if line voltage varies widely.

And it even has a control to let you match record pitch with less fortunate instruments such as out-of-tune pianos.

Even a professional doesn't need more.

But you may want more. In which case the 1209 offers some refinements that are both esthetically pleasing and add something to performance.

For example: its tonearm tracks at as low as a half gram. It's anti-skating system is calibrated separately for elliptical and conical styli. Its counterbalance features a 0.01 gram click-stop. And its motor is hi-torque and synchronous.

Now what could the 1219 add to this?

The only true gimbal suspension ever available on an automatic arm. Four identical suspension points, one ring pivoting inside another.

And the Mode Selector, which shifts the entire tonearm base — down for single play, up for multiple play — so that the stylus will track at precisely the correct angle (15°) whether playing one record or a stack. The tonearm is 8¾" long, and the 12 inch dynamically balanced platter weights 7 pounds.

So the question really isn't which Dual is good enough, but how much more than "good" your turntable has to be. If our literature doesn't help, perhaps a visit to your dealer will.

United Audio Products, Inc., 120 So. Columbus Ave., Mt. Vernon, New York 10553.

Now that you know you want a Dual, the next question is which one?

1219 — $175.00

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1209 — $129.50

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(Continued from page 18)

pressures in all planes at right angles to the horn axis are in phase. Under these conditions the air acts like a moving mass.

As a matter of fact, the air in the horn does not move exactly in phase with the driving pressure even in its working range; in other words, the acoustic impedance looking into the horn throat is not a pure resistance. The formula for the throat reactance is:

$$X_{MA} = \frac{\rho c^2 m}{S_T 4 \pi f} \qquad (10)$$

in which, be it noted, the frequency term is in the denominator. The reactance is positive, which leads one to conceive of it as a mass reactance, but it *decreases* as the frequency increases, as does a capacitance. Actually, the reactance is that of a negative capacitance. It acts to decrease the velocity for a given applied force, reducing acoustic output.

There is another limitation at low-frequencies as well, which is not shown by the curves of radiation resistance (Fig. 6) because these are based on horns of infinite length. It may be recalled that in developing the horn via the stepped pipe, it was stated that the mouth size had to be great enough for the assumption that it radiated plane waves.

Adequate "mouth loading" is generally considered to be provided when the circumference of the horn is equal to a wavelength, or $\pi d = \lambda$. This is somewhat easier to deal with in terms of frequency: $f = c/\lambda$ where c is the speed of sound. The resulting expression is:

$$d = \frac{c}{\pi f}$$

For d in inches, d = 4300/f. This is exactly one ocatve below the frequency at which the radiation resistance curve of a direct radiator has its knee. (See Fig. 2)

The formula provides some discouraging information. For example, a horn that performs well down to 43 Hertz has to be over 8 feet in diameter! Fortunately one can live with considerably less than perfect mouth loading. Also, the use of room walls and floor as reflectors increases the effective area. Bass horns designed to fit into the corner of a room work very well with equivalent mouth diameters not much greater than 2 feet.

If we now consider the frequency response of the simple horn speaker in the midfrequency range we find that we do not obtain a flat frequency response.

At 400 Hertz we found the mass reactance to be 75 mks mechanical ohms; by means of the horn the radiation resistance load was increased to 24 ohms, but this still leaves the mass largely in control of the veolcity (See Fig. 1). Meanwhile, the radiation resistance has become *independent* of the frequency (See Fig. 7). Since the velocity v still decreases with increasing frequency and R_{MA} remains constant, the formula $P_A = v^2 R_{MA}$ tells us that the response falls toward the high-frequency end. If R_{MA} is frequency-independent, v must be constant as well. This condition can be approached if R_{MA} is much greater than the mass reactance.

R_{MA} can be increased still more if the speaker is coupled to the horn by means of a stepped-down pipe as in Fig. 8. Now the speaker looks into a mechanical resistance

$$R_S = \frac{S_D^2}{S_T} \rho c \qquad (11)$$

where S_D = the diaphragm area
and S_T = the throat area
If $S_D/S_T = 4$; $R_S = 4 \times 24 \times 96$ mks mechanical ohms which approaches the condition we want of resistance-determined cone velocity. With true resistance control, the response is flat in the mid-frequency region. The variation with frequency of the response - determining parameters as well as the response curve itself, are shown in Fig. 9a, and the analog circuit in 9b.

As the frequency increases, the mass reactance begins to predominate in determining the velocity, which decreases. The power output drops at a rate of 6 dB per octave. Eventually, the compliance of the front air chamber C_F begins to act like a shunt across the radiation resistance R_{MA}, and response falls rapidly. If the low-pass filter formed by m_S and C is proportioned so that it is suitably mis-matched, the response in the region immediately below A can be elevated as shown by the dot-dash line with response falling above this point at a rate of 12 dB per octave. See Fig. 9c. At low frequencies the response falls because X_{MA}, as has been pointed out, is a negative capacitance, whose reactance increases, decreasing the diaphragm velocity. However, if the speaker resonance is placed near the horn cut-off frequency, the speaker compliance can be made to cancel out the negative compliance of the horn, removing this restriction and increasing the bass response. In high-compliance woofers, the required lower value of compliance can be obtained by enclosing the rear of the speaker in a very tight box.

Efficiency

We have found that adding a horn to speaker unit improves the impedance matching and increases the power output for a given driving force of the voice coil. What about the efficiency? Let us simplify the problem by considering the frequency range over which the cone motion is resistance-controlled, and neglect losses due to friction. The efficiency under these idealized conditions is called the initial efficiency.

The force exerted by the voice coil:

$$F = Bli \qquad (12)$$

where F is in Newtons
B = magnetic flux density in Webers/square meter.
l = length of voice coil conductor in meters

The cone velocity

$$V = F/R_{MA} \qquad (13)$$

where v is in meters/second
R_{MA} = radiation resistance in mks mechanical ohms.
Substituting from (12) to (13),

$$V = \frac{B \ell i}{R_{MA}}$$

Using the formula for acoustic power

$$P_A = V^2 R_{MA} = \frac{B^2 \ell^2 i}{R_{MA}} \text{ acoustic watts} \qquad (14)$$

The input power consists of the electrical power dissipated in the voice coil, plus that corresponding to the acoustic power.

$$P_E = i^2 R_c + \frac{B^2 \ell^2 i}{R_{MA}}$$

$$= i^2 \frac{R_c R_{MA} + B^2 \ell^2}{R_{MA}} \qquad (15)$$

Efficiency

$$\eta = \frac{P_A}{P_E} = \frac{B^2 \ell^2}{B^2 \ell^2 + R_c R_{MA}} \qquad (16)$$

For a 12-inch speaker with $B^2 l^2 = 64$ and $R_c = 6$ ohms, and $R_{MA} = 96$ ohms as in the horn previously analyzed:

$$\eta = \frac{64}{64 + 6 \times 96} = 10\%$$

This is not a startlingly high efficiency, but it is a great deal better than the typical 1% or lower efficiency of a typical high-compliance woofer.

How can efficiency be increased? Equation (16) tells us:

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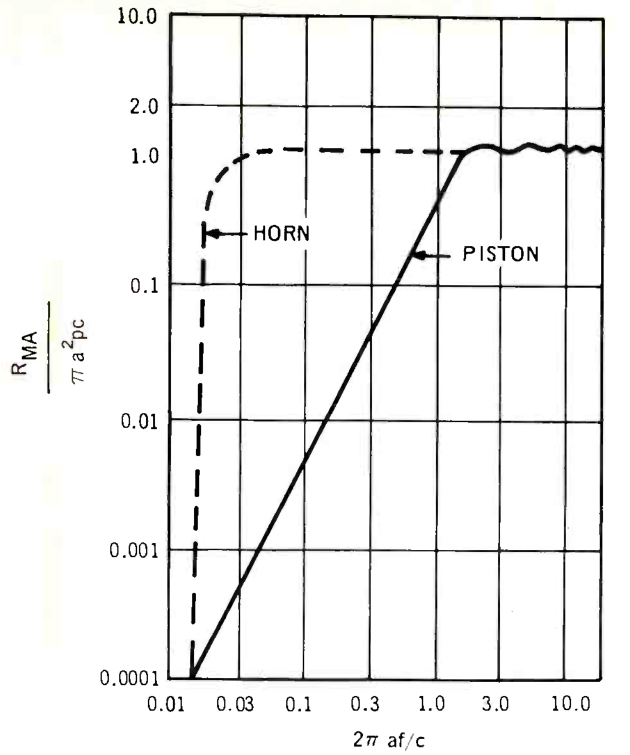

Fig. 7—Radiation resistance of exponential horn versus piston in infinite baffle.

Increase the flux density B, the length of voice coil conductor, reduce the voice coil resistance R_C, or reduce the radiation resistance R_{MA}. The first three items are somewhat interdependent. If l is increased, R_C is increased, opposing the increased efficiency, unless the wire diameter is increased. If this is done, the air gap must be made greater to accommodate the thicker voice coil, reducing B. Also, the moving mass increases, and its greater reactance opposes the condition of resistance control at a lower frequency, reducing the high-frequency response. It can be seen that a great deal of juggling must be done to obtain the desired performance.

Now for the last factor: R_{MA}. To increase efficiency, this must be decreased. But the whole point of horn loading was to *increase* R_{MA}. There seems to be a contradiction here. It is the result of the simplifying assumptions. For the direct radiator, we assumed mass control. For this condition, R_{MA} should be as great as possible. The horn efficiency equation was based on resistance control. Here, R_{MA} should be as small as possible. But if R_{MA} is made small compared to the mass reactance, the condition of resistance control no longer applies. One would expect an optimum point somewhere in between.

If an intermediate condition is assumed between mass control and resistance control, both elements must be taken into account in the expression for the velocity which now becomes

$$v = \frac{F}{\sqrt{R_{MA}^2 + X_M^2}} = \frac{B\ell i}{\sqrt{R_{MA}^2 + X_M^2}} \qquad (17)$$

and

$$P_A = v^2 R_{MA} = \frac{B^2 \ell^2 i^2 R_{MA}}{R_{MA}^2 + X_M^2} \qquad (18)$$

Now the input power is the sum of the output power and the power dissipated in the voice coil

$$P_E = i^2 R_c + \frac{B^2 \ell^2 i^2 R_{MA}}{R_{MA}^2 + X_M^2} \qquad (19)$$

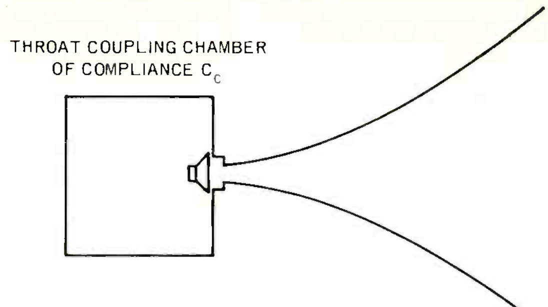

Fig. 8—Showing horn with chamber.

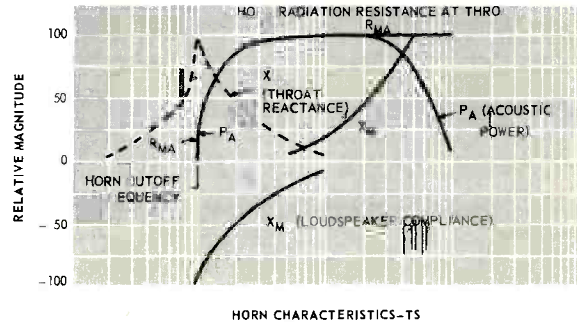

Fig. 9A—Horn characteristics.

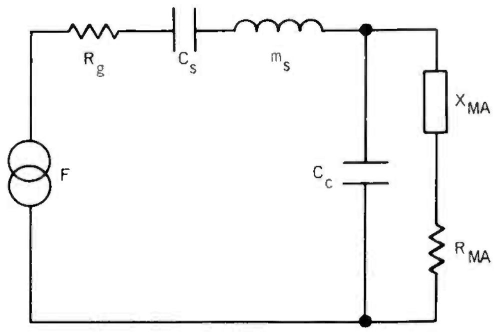

Fig. 9B—Horn loudspeaker analog.

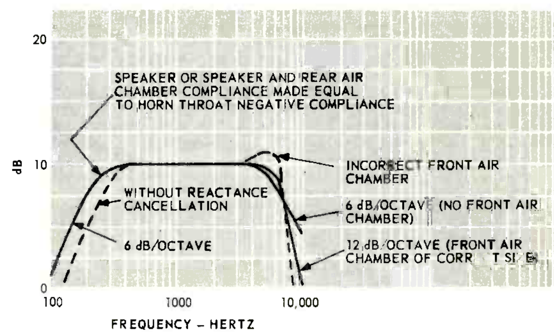

Fig. 9C—Frequency response of horn speaker.

and

$$\eta = \frac{P_A}{\rho_E} = \frac{B^2 \ell^2 R_{MA}}{R_c (X_M^2 + R_{MA}^2) + B^2 \ell^2 R_{MA}}$$

$$\eta = \frac{B^2 \ell^2}{B^2 \ell^2 + \dfrac{R_c (X_M^2 + R_{MA}^2)}{R_{MA}}} \qquad (20)$$

In this expression, η is maximum when

$$\frac{X_M^2 + R_{MA}^2}{R_{MA}}$$

is a minimum as R_{MA} varies.

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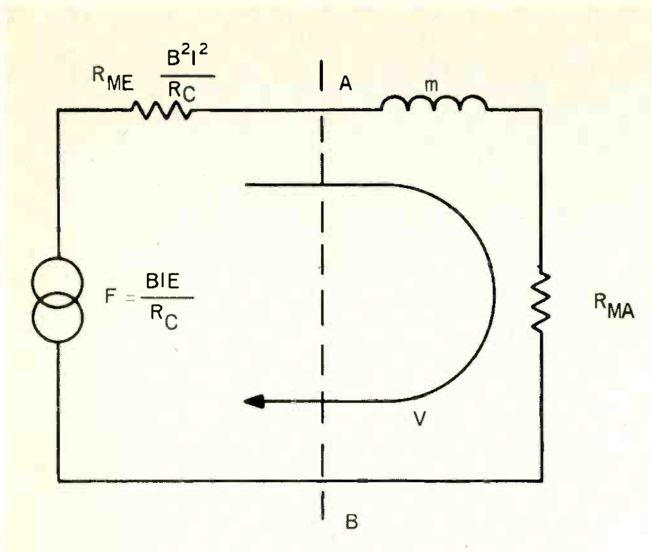

Fig. 10—Analog circuit of horn loudspeaker operated from constant-voltage source. The horn throat reactance is assumed to be cancelled out by the speaker compliance.

This occurs when $R_{MA} = X_M$. Then the maximum possible value of efficiency.

$$\eta_{MAX} = \frac{B^2 \ell^2}{B^2 \ell^2 + 2 R_c X_M}$$

where $X_M = 2\pi fm$ (21)

Since X_M varies with frequency we can select f to produce a maximum anywhere we please as long as $X_M = R_{MA}$ at some point on the flat part of the curve of R_{MA} vs. f.

Assume that this point is 50 Hz. Then for a .03 Kg moving system $X_M = 2\pi \times 50 \times .03 = 9.9$ mks mechanical ohms. If this is matched by making $R_{MA} = 9.9$ ohms also, then for the speaker previously considered as a direct radiator:

$$\eta = \frac{64}{64 + 2 \times 6 \times 9.9} = 41\%$$

For the same system at 500 Hz, $X_M = 2\pi \times 500 \times .03 = 99$ mks mechanical ohms. However, R_{MA} is fixed at 9.9 ohms. Now

$$\eta = \frac{64}{64 + \frac{6(99^2 + 9.9^2)}{9.9}} = 1.1\%$$

The high efficiency at 50 Hz has been obtained at the expense of a response that drops rapidly as frequency increases. This is an illustration of the concept of gain-bandwidth product. As the required bandwidth increases the efficiency goes down.

There is still another method of obtaining high efficiency that can be derived from equation (21). This is to reduce X_M by decreasing the moving mass. One way to accomplish this is to use a smaller cone. This is feasible because high values of R_{MA} can be obtained by means of the horn rather than through the use of a large radiating area.

Constant-Voltage Operation

In all the previous calculations it was assumed that the loudspeaker was operated from a constant-current source. This assumption brings about a considerable simplification in the formulas and provides a valid expression for efficiency. However, it does not provide a correct expression for the frequency response of the loudspeaker as actually used: From an essentially constant-voltage source. The reason is that the electric impedance varies with frequency. Because of this, the input power also varies with frequency.

The mechanical analog circuit of the loudspeaker must be modified from that of Fig. 1, when a constant-voltage amplifier is used. The revised circuit is shown in Fig. 10.

M is the mass of the moving system and R_{MA} the radiation resistance in mechanical units as before. The series resistance represents the effect of the voice coil resistance. Its value is derived as follows: Think of a loudspeaker whose voice coil motion is blocked by some means. If $v = 0$, there must be an open circuit in the loop shown in the figure. This corresponds to the manner in which we would measure the open-circuit voltage in an electric circuit. On the electrical side, there is no counter-e.m.f. generated since there is no motion of the voice coil. The only current-determining element in the circuit is R_C, the voice coil resistance. So $i = E/R_C$ where E is the amplifier output voltage. Substituting in the expression for

$$F = Bli \qquad F = \frac{BlE}{R_C}$$

Now consider what happens if the loudspeaker is operated into a vacuum and there is no friction. Nothing opposes the motion of the cone. This corresponds to a short-circuit across A-B. In the mechanical circuit $v = \frac{F}{R_{EM}} = \frac{BlE}{R_C R_{EM}}$

The velocity must be just enough to generate a counter-emf that equals the amplifier voltage. Then $Blu = E$ and substituting from the previous expression

$$B\ell V = \frac{B^2 \ell^2 E}{R_c R_{ME}} = E$$

The last two terms result in

$$R_{ME} = \frac{B^2 \ell^2}{R_c}$$

From Fig. 10, velocity

$$v = \frac{F}{R_c \sqrt{\left(R_{MA} + \frac{B^2 \ell^2}{R_c}\right)^2 + \omega^2 M^2}} \qquad (22)$$

Substituting $F = B\ell E/R_c$

$$v = \frac{B\ell E}{R_c \sqrt{\left(R_{MA} + \frac{B^2 \ell^2}{R_c}\right)^2 + \omega^2 M^2}}$$

We can now find a means of calculating the frequency response of the loudspeaker. The relative response is plotted as sound pressure vs. frequency. Since sound pressure is proportional to the square root of the power, it is convenient to think in terms of the ratio

$$\sqrt{P_A}/E$$

which corresponds to sound pressure per volt applied to the loudspeaker terminals. From the relation $P_A = V^2 R_{MA}$ we can write

$$\frac{\sqrt{P_A}}{ED} = \frac{v\sqrt{R_{MA}}}{E}$$

Substituting the equation (22)

$$\frac{\sqrt{P_A}}{E} = \frac{B\ell\sqrt{R_{MA}}}{R_c \sqrt{\left(R_{MA} + \frac{B^2 \ell^2}{R_c}\right)^2 + \omega^2 M^2}} \qquad (23)$$

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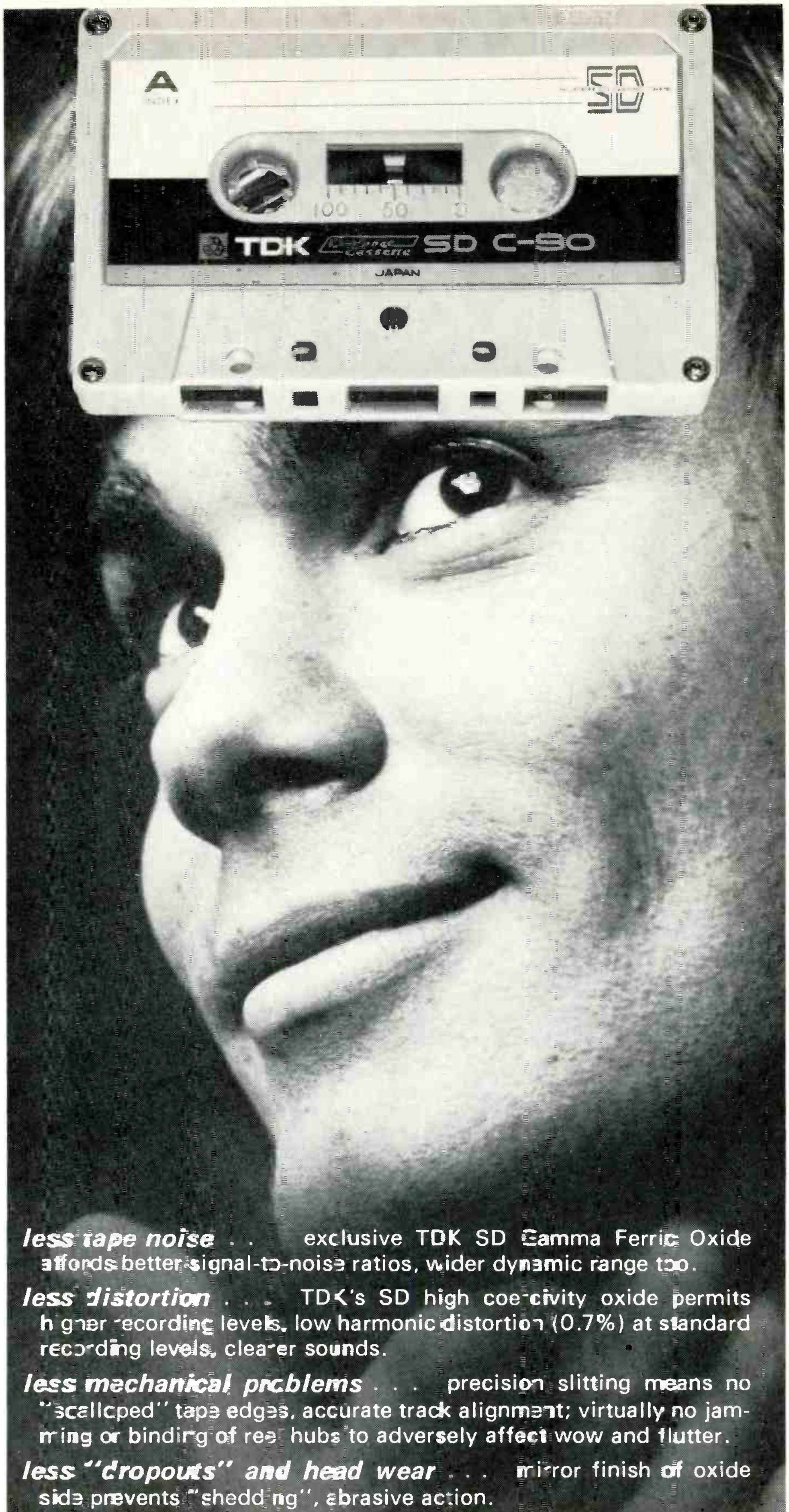

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Since ωm increases with frequency, the response begins to drop above the frequency where ωm becomes comparable in magnitude to

$$\left(R_{MA} + \frac{B^2 \ell^2}{R_c}\right)$$

Using the constants for the horn speaker whose efficiency was previously derived for 50 Hz and 500 Hz.

At 50 Hz.

$$\frac{\sqrt{P_A}}{E} = \frac{8\sqrt{9.9}}{6\sqrt{\left(9.9^2 + \frac{8^2}{6}\right)^2 + (6.28 \times 50 \times .03)^2}}$$

$$= 0.42$$

At 500 Hz.

$$\frac{\sqrt{P_A}}{E} = \frac{8\sqrt{9.9}}{6\sqrt{\left(9.9^2 + \frac{8^2}{6}\right)^2 + (6.28 \times 500 \times .03)^2}}$$

$$= 0.30$$

This is a drop in response of 2.5 dB. The previous calculation for constant current operation showed a drop of over 16 dB. Substantially better frequency response can be obtained with a constant-voltage source because the electric impedance of the speaker decreases at high frequencies and permits more current to flow.

Midrange and High-Frequency Horn Speakers

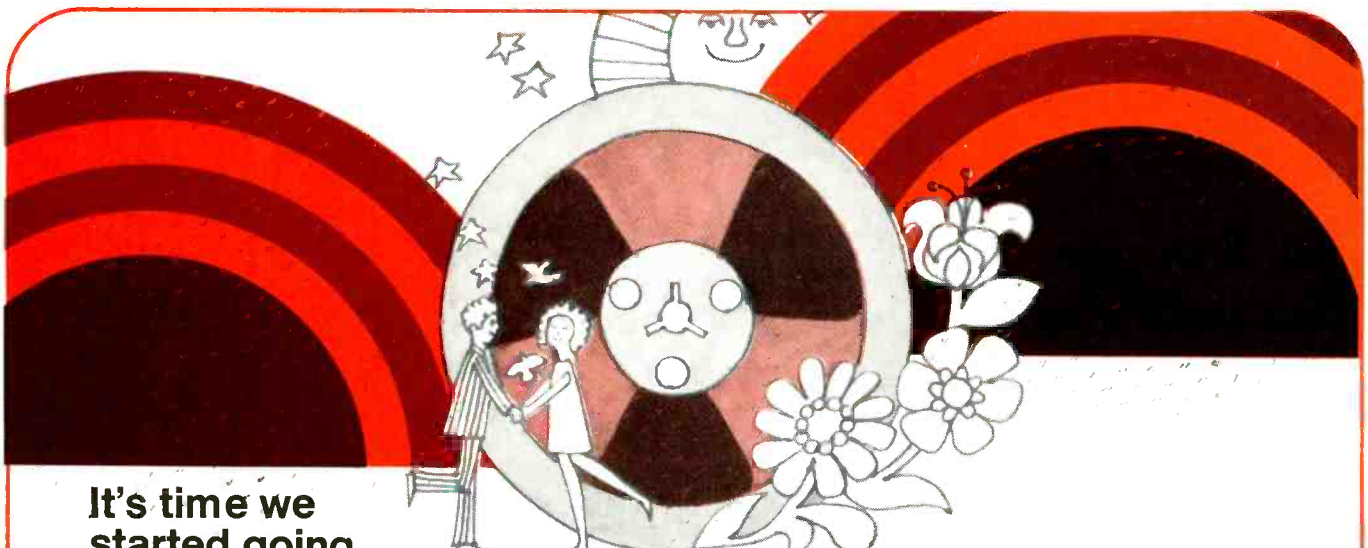
To this point we have considered only the case where a horn is added to a direct-radiator loudspeaker. Where both extreme low-frequency range and power capability are not needed, horn loudspeakers can be made more efficient by using small, light, rigid diaphragms. Small diaphragms reduce the value of R_{MA}, increasing the efficiency; the moving mass is also lowered, extending the high-frequency response. The smaller driver unit is capable of handling large amounts of power without excessive diaphragm excursion because of the greater load into which it works. The expression for the power output of a loudspeaker indicates that, for a given amount of acoustic power at a given frequency, the required rms velocity is inversely proportional to the square root of the mechanical radiation resistance imposed by the acoustic load. The required excursion is proportional to the velocity. A 10-inch come as a direct radiator, with an area of .05 m^2, works into 8.25 ohms at 50 Hertz. Horn-loaded to 96 ohms, its excursion for a given acoustic output would be

$$\sqrt{\frac{8.25}{96}}$$

or about 0.3 times as great as before. Alternatively, the cone size could be reduced and the radiation load maintained by decreasing the area of the horn throat, which would result in a longer horn.

The excursion varies inversely as the square of the frequency; consequently this requirement becomes rather unimportant except in the bass range. If a direct radiator requires a 3/8-inch peak excursion at 50 Hz, this would be decreased to perhaps 1/8-inch by horn loading. At 500 Hz the excursion would be only 0.0013". Since it is easy to obtain appreciably greater excursions than this in small-diaphragm drivers, mid-range speakers for horn loading can be made quite small. A 3-inch diameter diaphragm is typical in such an application. Diaphragms of this type are frequently dome-shaped and made of aluminum alloy or formed plastic. Consequently they are extremely light. Tweeters use even smaller diaphragms and lighter voice coils. Æ

(To be continued)



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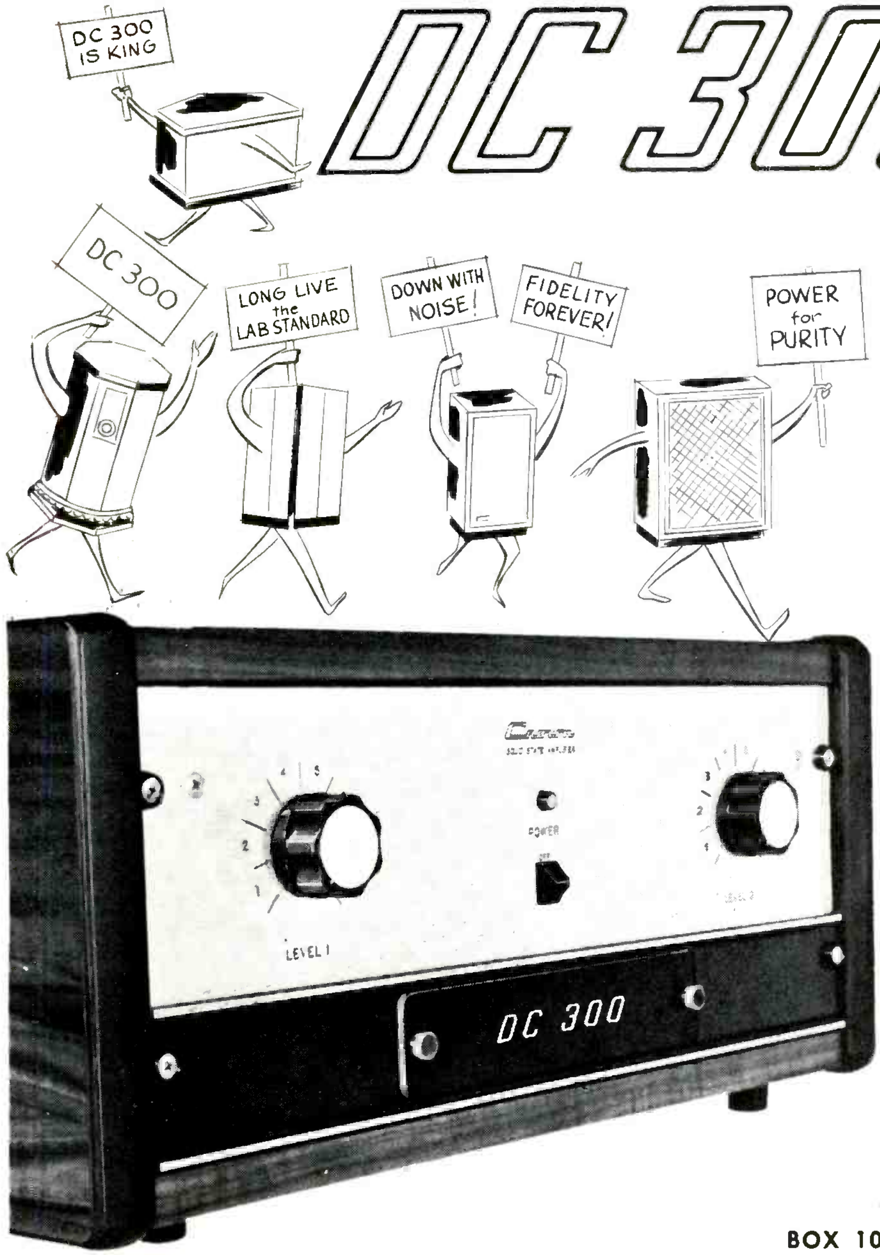
Why most hi-fi speaker manufacturers demonstrate with the Crown

DC 300



It's no secret to hi-fi show goers that Crown DC300's are at work in almost every independent speaker manufacturer's exhibit. And, if you could visit their factory design labs and test chambers, you would see DC300's in nearly every plant too. We don't have to tell you why. Speaker manufacturers are interested in hearing their speakers, not the amplifier. And the Crown DC300 is the only amp in the world which can deliver a signal so pure that distortion is practically unmeasurable, at any listening level. Plus adequate power to reproduce all of the critical transient signals without overload. Does that tell you something about how your system could sound with a DC300?

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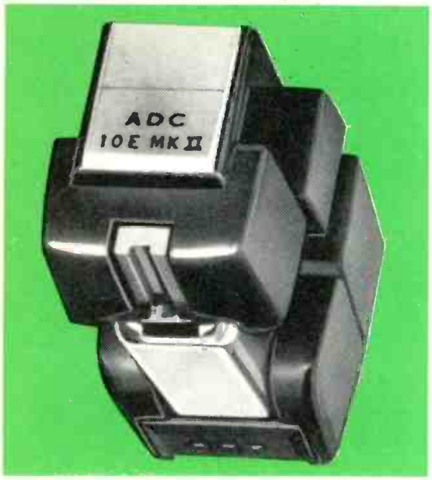

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Output: 4 mV at 5.5 cms/sec. recorded velocity.
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Channel Separation: 30 dB from 50 Hz to 12 kHz.
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Tape Guide

(Continued from page 8)

through my recorder amp by plugging the turntable outputs into the microphone jacks of the unit. How can I get phono equalization without buying a separate amp? Or wouldn't equalization make a great deal of difference?—Neil Passage, March AFB.

A. When played with a magnetic cartridge, a phonograph record requires a substantial amount of bass boost and a considerable amount of treble cut in playback in order to provide flat response. To give you an idea of how much equalization is needed—and therefore how important it is—the RIAA standard in this country requires bass boost, relative to 1,000 Hz, reaching about 17 dB at 50 Hz; and treble cut of about 14 dB at 10,000 Hz.

It would be possible to introduce such equalization into the microphone section of your recorder. But this would be a task for someone with the necessary technical competence; and it would mean giving up the use of microphone with your recorder, unless you went through the additional complexity of a switch to defeat the phono equalization. A simpler course would be to purchase one of the relatively inexpensive phono preamps that are available. Connect the output of your turntable to such a preamp, and connect the preamp to the high-level input of your tape machine.

Magnetization

Q. Ever since I got my first tape recorder in 1954, I have had a fear of a magnetized head ruining my tapes. It's gotten so that I'm almost afraid to play my good tapes for fear of erasing the high frequencies, adding to background noise, etc. I was once under the impression that a strong signal would magnetize the heads. I now wonder if the signal from the bias isn't so strong that some accidental over-recording wouldn't make any difference. When they say "high frequencies are affected," how high? Does the head become magnetized from just playing? Most important: Are the warnings appropriate to someone who plays his recorder maybe 20 hours a month and records maybe 3 hours, and uses the demagnetizer regularly, or are they meant for someone who lets the machine go for years without attention? I feel foolish wanting to demagnetize the heads every time I turn the recorder on. On the other hand, I worry that my "unscratchable" tapes will be ruined by "a worn needle," as it were.—Laird Brown, Dayton, Ohio.

A. The usual rule is to demagnetize the heads after every 8 hours of use. Don't worry about the bias signal. It is the audio signal—asymmetrical—which tends to magnetize the heads. The stronger the audio signal, the greater the tendency. Magnetized heads do have an increasing erasure effect as frequency rises. Abrupt changes of current through the heads tend to magnetize them. Some tapes machines have built-in provision for self-demagnetization of the heads.

Cupped Tape

From time to time readers have inquired what they might do about cupped tape. Following are some comments by another reader who has found a solution.

"I use 1 mil polyester tape exclusively. I once received an order of this tape which was cupped until it couldn't be recorded properly with a single-motor recorder of mine. I decided to experiment with two rolls of this cupped tape.

"I tension wound the two rolls in fast forward on a powerful 3-motor recorder by holding a gloved finger on the edge of the play-out reel to create extra tension. I did this with the thought that perhaps by leaving the tape in this tight-wound condition for a period of time, the uncupped side would be forced to stretch, and this stretching would eliminate the cups. The tape was left in the tight-wound condition for a year. To my surprise this worked better than I expected. When I examined the tape, I found that the cups had been completely eliminated. Yet to be determined is how long of a waiting period is really needed.

"This idea is presented with some warnings. It shouldn't be tried with underpowered single and 3-motor recorders, because motors and rotating parts could be damaged. It should be avoided if a recorder is driven with a synchronous single motor. Even with powerful 3-motor recorders, care should be used in not slowing the motors too much, as they operate at full voltage in the fast wind modes and could burn out."—M. Glen Blair, Idaho Falls, Idaho.

If you have a problem or question on tape recording, write to Mr. Herman Burstein at AUDIO, 134 North Thirteenth Street, Philadelphia, Pa. 19107. All letters are answered. Please enclose a stamped, self-addressed envelope.

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There's a record bias switch for both high-output, low-noise tape and standard tape alike. So you get the fullest dynamic range with any type of tape. It also ensures the TEAC A-1230's high-performance characteristics.

So much for new refinements. Remember those other advanced A-1230 features: three-motor solenoid operation, three heads; tape/source monitoring, mic and line mixing, independent record mode switches for ¼-track stereo/mono operation, independent stereo headphone monitor, tape tension and spring-loaded automatic shutoff arms.

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LOUDSPEAKER DESIGN

Hofmann's Iron Law -

a curiously useful way of looking at the low frequency performance of loudspeakers...

HENRY KLOSS*

THERE HAS always been a certain willingness to suspend both disbelief and rationality in the discussion of loudspeakers, and for the most part it doesn't really harm anything. People tend to wind up buying their speaker systems on fairly reasonable, pragmatic grounds, and aren't likely to be disturbed by the adman/salesman/theoretician who holds that it takes a round speaker to yield "round sound" or a speaker system the size and shape of a bass viol to reproduce the sound of one. We do, of course, see some nicely rounded and bass-viol-sized speakers in stores as a result, but the relatively few people who buy them probably have their reasons and can't be considered the worse for it.

Still, there are times when a loudspeaker designer has pangs and longs to sneak a bit more enlightment into the discussion—even if it makes clear, as the following may, that just about anyone might design a good-to-wonderful low-frequency loudspeaker system by following rules that are both few and simple.

So, then, a catharsis for a speaker designer. And an attempt at some new and hopefully useful ways of looking at the low-frequency performance of the kind of speaker system that has such wide acceptance as a high-performance device. That, of course, is the sealed-box, acoustic-suspension system now made (in various adjectival forms) by just about every speaker manufacturer. We won't argue the possibility of a better design somewhere in some better world, but simply proceed with the knowledge of the present design's sublime usefulness in this one.

*Advent, Inc.

One of the delightful things about the sealed-box, acoustic-suspension, single-degree-of-freedom speaker is that it's a quite simple system, with an attendant lack of eccentricity. The parameters that decide its behavior are *there* all the time, and you can vary them for different objectives—as we will be discussing—with known results. You don't wind up with egregious behavior in some performance area as a result of some apparently harmless change, and you don't then have to waste time looking for some "patch" that may itself have some strange effect.

Which means, of course, that low-frequency performance can't be determined by the sheer weight of money or the designer's ingenuity, since the rules stay the same whatever the designer's resources. But while this may disturb those designers who like to think they can buy their way out of a design limitation, or those who think that a particular kind of voice coil or cone material or construction has a certain mystique, it's very nice for all the rest of us. And it does leave the designer free to make some choices, hopefully enlightened, of what to emphasize and what not to emphasize, since total subjective effect or suitability isn't as nicely predictable as are curves and such.

So, while the behavior at low frequencies of a certain sort of speaker isn't the most metaphorically exciting subject for an article, it does give us a chance for a close look at some reasonably interesting things that can be stated both simply and rigorously. Nothing new, really, except perhaps a new window on reality.

What I propose to do is being with a speaker design of known excellence and discuss its basic and completely dependable interrelationships: What happens to performance from various physical changes, what physical changes are needed for a specific performance objective. The assumptions (forgetting about the vital question of your interest in all this) are:

- That we are talking about the sealed or effectively sealed speaker system. (Some latter-day ported systems are essentially sealed boxes that follow the rules we will be discussing.)
- That the speaker derives all damping from its voice coil moving in the field of its magnetic structure and is used with an amplifier of modern high-damping-factor (4 or above) design.
- That the amplifier is not tailored in frequency response to a particular speaker.
- That we aren't making any judgment on how much sound must be produced, but working within known and accepted parameters for average to demanding home use.
- That we aren't after the discovery or definition of one "ideal" loudspeaker, but discussing possibly useful variations within an area of known goodness (or, if you prefer, excellence).

The discussion which follows will be different from the usual presentations in an important way. We shall deal only with those parameters whose manipulations are at the discretion of a designer. By eschewing the inclusion in our statements of such quantities as the density of air, the velocity of sound, the value of 2π, and other constants that are constant for all speakers in this group, we are forbidden to make statements of equality in connecting physical parameters with performance characteristics.

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We can, and shall, make perfectly rigorous statements of proportionality which will permit us to *precisely* predict the performance of any new speaker as a function of the change in parameters of a prototype speaker.

If we are told, and we should certainly readily believe, that the weight of a pile of jelly beans is proportional to the number of jelly beans, we should be quite confident that if we multiply the number of jelly beans by 1.2, the total weight will increase by 1.2. Note that we did not have to know how much a jelly bean weighed. If our job is to manipulate the number of jelly beans and then keep track of total weight, we shouldn't concern outselves with those things (constants, i.e., weight of individual jelly beans) over which we have no control. If we are really dedicated to our job of getting at the essential truth, we can even readily accept the fact that these jelly beans are in a fixed size container whose weight does not appreciably disturb the relationship between number and weight of jelly beans over the range in which we are interested (see assumptions above). The whole presentation is directed toward an attempt to make a powerful final statement that connects together those several characteristics which directly affect the value of a loudspeaker to a user.

A good place to begin is the area of greatest comfort to any speaker designer: The frequency range from 800 Hz down to the point below 150 Hz where variations in low frequency curves may begin to be visibly and audibly significant. What is of such comfort about the 150-800 Hz range, as has been stated elsewhere many times, is that it's "flat" by nature [1]. Over that frequency range, the speaker's velocity and hence output is controlled by the mass of its moving system. Assuming good design as we are throughout, in this case of the cone, there is ideal piston operation. Cone velocity goes up as frequency goes down, doubling for each halving of frequency (a fact with which Mr. Klipsch apparently likes to frighten small children) to coincide nicely with the realities of decreasing radiation resistance. Output can be calculated precisely at any point in the range as the square of cone velocity times the square of the area times some constants. No trickery is needed to make it come true nor are any special cone materials (a wide variety of thoroughly conventional materials and compositions will do nicely).

But things change as the bass resonant frequency of the system is approached. In a proper closed-box system, output beings to drop at a point somewhere above resonance (we'll be more specific in a moment), drops more at resonance, and begins to roll off fairly sharply (12 dB/octave) somewhere below that as stiffness reactance *halves* the cone velocity for each lower octave. If benign nature seemed to rule in the 150-800 Hz range, the designer takes responsibility now for everything, including (a) the shape of the roll-off, resonance curve, (b) where it begins laterally on the frequency scale, and (c) where the curve *and* the resonably straight line between 150 and 800 Hz show up on the vertical scale of absolute power output.

He is responsible, all right, but the rules are the rules.

The shape of the frequency response curve of *every* speaker of the type we are discussing will inevitably correspond to one of the family of these familiar universal resonance curves. We can construct a graph with explicit labels for x and y axes which completely describes the speaker's performance quantitatively if we know three performance characteristics:

A. *Efficiency*, or the amount of output in the "flat" region for a given power input,

B. *Resonant frequency*, or the actual frequency at point labeled F_R on curve, and

C. *Which shape of curve.*

Now, there are four, and only four physical parameters that in turn set those three performance characteristics:

1. A = area of cone,
2. M = mass of moving system, (cone and voice coil largely),
3. Motor = "strength" of the magnet-voice coil motor [2], and
4. V = volume of air enclosed in sealed box.

Let us relate physical parameters to performance characteristics:

A. *Efficiency* $\hat{=} A^2/M^2 \times$ Motor;

B. *Resonant frequency*, which we shall call:

$$F_r \hat{=} \sqrt{\text{stiffness/mass}}$$

Stiffness here is assumed to be solely due to cone area pressing against a small enclosed volume of air and as such is approximately equal to A^2/V so that:

$$F_r \hat{=} \sqrt{A^2/VM}$$

C. *Shape of curve* is actually determined by the "Q" of system at resonant frequency. The relating of Q_{FR} to the physical parameters is a somewhat messy expression, involves all four of those parameters and does not readily permit a feel for the physical situation. We would like now to introduce a different term which relates to shape of curve that makes it much easier to figure out the new performance of a speaker when any one physical parameter is changed. Use of this new term will then lead us to a way to make a powerful and simple statement. We shall also relate this new term to Q_{FR} as we must be able to. They are both, after all, equally legitimate ways to describe the shape of curve.

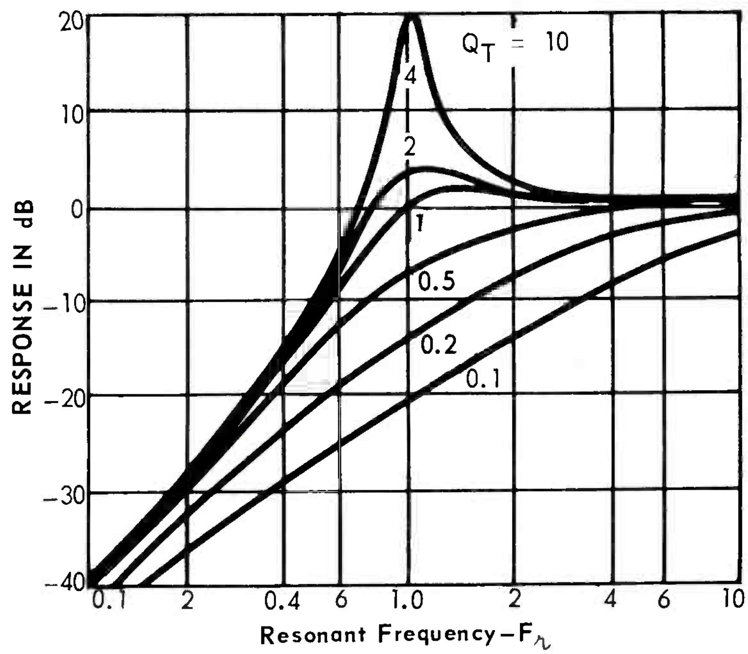

Fig. 1—Frequency response versus Q.

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Short Digression

Imagine a loudspeaker with no stiffness at all, that is a resonant frequency at 0 Hz.

Now, let us examine the output as we move down in frequency. We know there is a region of constant output and might expect this to continue to indefinitely low frequencies; we shall certainly never get to the 12 dB octave slope caused by stiffness reactance. Since this loudspeaker must have a motor (some volume of conductor in a magnetic field, here assumed to be fed from a low impedance), there must be some damping force, which, no matter how small, will at some low frequency equal the continually decreasing mass reactance and cause the output to decrease by 3 dB. We shall find it convenient to express the very important relationship between mass reactance (tendency for velocity to increase with lower frequency) and the resistive damping force (tendency for velocity to remain constant) as the frequency at which the two become equal. This we shall call the damping frequency. A stronger motor, i.e., more damping, will cause this frequency to be higher; a heavier moving system, more mass reactanct, will cause this frequency to be lower.

We can see that this quantity is in no way dependent on area of cone or volume of enclosure, but is just a way of describing the relative influence on the velocity of the cone at any frequency of the mass of the moving system and of strength of the motor, and one can readily see that damping frequency which we shall call FD approximately equals motor divided by mass.

To gain familiarity with damping frequency, FD, imagine a speaker with FD at 240 cps and resonant frequency, FR, at 60 cps. If we examine the shape of the frequency response curve going down in frequency from the flat region, we are told that already at 240 cps the damping force is significant compared to the mass reactance in determing cone velocity, and the output is thus below the flat region and shall be even lower by the time we move down to 60 cps. Now take a speaker with FD 15 cps and FR 60 cps. As we move down in frequency from the flat region, we see that when we get to the resonant frequency, the "damping force" is still not a strong contributor to determining cone velocity and, since mass reactance at this frequency (by definition) is cancelled by stiffness reactance, velocity, and hence response, is allowed to rise appreciably. One more example: A speaker with FD = 60 cps, FR = 60 cps. Remembering our definition of damping frequency, this speaker would have been down in response by 3 dB if there were no stiffness at all, i.e., resonant frequency = 0. Because resonant frequency is 60 cps, the mass reactance, which is equal to "damping force," is cancelled by stiffness reactance and the response is allowed to double, i.e., rise 3B to the level of the "flat" region. From this fact you can readily pick out the appropriate curve, namely QFR = 1. (See Fig. 1) In fact, the curve fitting the other two speakers examined can be readily found by making use of the relationship between QFR and FD that

QFR = FR/FD.

This is just a consequence of the way we have defined FD. Our first speaker is thus seen to have the curve corresponding to QFR = .25 and speaker number 2 has QFR = 4. One might complain that at the beginning we should have just *said* that FD = FR/QFR but that would have denied us the chance to get some physical "feel" for FD and to see why logically it is approximately equal to motor divided by mass.

So our digression has given us a way to express performance characteristic C in a slightly indirect way by specifying FD.

To then find shape of curve we note ratio of resonant frequency to damping frequency which gives us QFR to enable us to assign the proper curve. So for *C* we then write damping frequency approximately equals motor divided by mass.

This relating of physical parameters to performance characteristics makes it quite easy to readily identify all changes in performance when any one of the four physical parameters are varied. One can quickly go through the four examples: 1. Increase area: increase efficiency, increase FR. 2. Increase volume: decrease FR. 3. Increase mass: decrease FR, decrease efficiency, decrease damping frequency (QFR goes up). 4. Increase motor: increase efficiency, increase damping frequency (QFR goes down).

This is quite handy for a speaker designer but the interrelationship of a different set of characteristics has much broader importance. The loudspeaker buyer-listener is not, or should not be concerned with mass of system, area of cone, or strength of motor. None of these individually are separately discernible to a buyer-listener as being proper or improper. I believe we *can* identify three outstanding characteristics that truly determine the value of a speaker to *user* (remembering that we are here concerned solely with low frequency performance). This value, after all, at least here, is the most proper concern. Our intended service here is to show how these value characteristics are rigorously tied together in a very simple way.

The value characteristics are:

1. *Volume of enclosure.* The smaller the better. This strongly affects the utility of the speaker with respect to allowing optimum placement and even more strongly affects price.

2. *Efficiency.* The higher the better. Total loudness for given electrical power.

3. *Low frequency response performance,* which we have shown to be defined by:

   3a. *resonant frequency.* The lower the better.

   3b. *damping frequency.* The lower the better.

   (Assuming we are discussing a properly designed high performance speaker in which the motor, for sake of reasonable efficiency, has been increased beyond the point that frequency response alone would like, i.e., the speaker is overdamped.)

It turns out that these four quantities are closely interdependent. The exact statement of this interdependence turns out to be very pleasing for its simplicity, which is the reward that should be expected for the effort to acquire this new conceptual tool of damping frequency.

Let us again express each of these "user value characteristics" in terms of their dependence on physical parameters:

1. Volume $\simeq$ volume
2. Efficiency $\simeq A^2/M^2 \times$ Motor

3a. $F_r \simeq \sqrt{A^2/MV}$

3b. $F_d \simeq$ Motor/M

Now just a few lines of old math eighth grade algebra. From 3a, squaring each side we have:

$$F_r^2 \simeq A^2/MV$$
or
$$A^2 \simeq F_r^2 MV$$

Let us restate efficiency, substituting for A^2 as:

$$\text{Efficiency} \simeq F_r^2\ MV\ \text{Motor}/M^2 = F_r^2 V\ \text{Motor}/M$$

But we recognize:

Motor/M as F_d

So we finally get:

$$\text{Efficiency} \simeq F_r^2 F_d V$$

If one wants to consider only a given shape of curve, that is a given QFR, we can then express FD as some factor of FR and further simplify our law to:

$$\text{Efficiency} \simeq F_r^3 V$$

(Continued on page 56)

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To call it "an amplifier" would be like calling a Porsche "Basic transportation."

There is unusual satisfaction that comes from fulfilling a prosaic task in a far from prosaic manner.

Hence this amplifying system: the Sony TA-2000 professional preamplifier and the Sony TA-3200F power amplifier. Together, they perform all an amplifier's standard tasks in a satisfyingly impeccable manner; but their 67 levers, switches, meters, knobs and jacks allow you to perform some interesting functions that are anything but standard.

Dual-purpose meters.

The two VU meters on the preamplifier front panel, for example, are no more necessary than a tachometer on an automobile. But they do serve the dual purpose of simplifying record-level control when the TA-2000 is used as a dubbing center, and of allowing you to test your system's frequency response and channel separation (as well as those of your phono cartridge) and to adjust the azimuth of your tape heads.

A broadcast/recording monitor console in miniature.

The TA-2000 resembles professional sound consoles in more than its VU meters. In addition to the 20 jacks and seven input level controls provided on its rear panel for permanent connections to the rest of your hi-fi system, the TA-2000 boasts a professional patch board in miniature on its front.

Thus, you can feed the inputs from microphones, electric guitars, portable recorders or other signal sources into your system without moving the preamplifier or disturbing your normal system connections in the least. And a front-panel Line Out jack feeds signals for dubbing or other purposes into an external amp or tape recorder, with full control of tone and level from the front-panel controls and VU meters.

The tone correction and filtering facilities are also reminiscent of professional practice, allowing a total of 488 *precisely repeatable* response settings, including one in which all tone controls and filters are removed completely from the circuit.

The amplifier—no mere "black box"

A power amplifier can be considered simply as a "black box" with input and output connections, a power cord, and an on/off switch; and such an amplifier can perform as well (or poorly) as the next one. But in designing the TA-3200F Sony took pains to match the amplifier's facilities to the preamplifier's.

Thus to complement the TA-2000's two pairs of stereo outputs, the TA-3200F has two stereo pairs of inputs, selected by a switch on the front panel. Other front panel controls include independent input level controls for both channels, a speaker selector switch, and a power limiter (in case your present speaker should lack the power handling capacity of the next one you intend to buy).

Circuitry unusual, performance more so

The single-ended, push-pull output circuitry of the TA-3200F amplifier is supplied with both positive and negative voltages (not just positive and "ground") from dual balanced power supplies. This system allows the amplifier to be coupled directly to the speakers with no intervening coupling capacitors to cause phase shift or low-end roll-off (A switch on the rear panel does let you limit the bass response below 30Hz if you should want to, otherwise, it extends all the way down to 10Hz.)

The individual stages within the amplifier are also directly coupled with a transformerless complementary-symmetry driver stage, and Darlington type capacitorless coupling between the voltage amplifier stages.

As a result, in part, of this unique approach, the TA-3200F produces 200 watts of continuous (RMS) power at 8 ohms, across the entire frequency range from 20 to 20,000 Hz; IHF Dynamic Power is rated at 320 watts into 8 ohms (and fully 500 watts into a 4-ohm load).

But more important by far is the quality of the sound; intermodulation and harmonic distortion levels are held to a mere 0.1% at full rated output, and 0.03% at the more likely listening level of one-half watt. The signal-to-noise ratio is an incredible 110dB. And the full damping factor of 170 is maintained down to the lowest, most critical frequencies (another advantage of the capacitorless output circuit).

The companion TA-2000 preamplifier also boasts vanishingly low distortion and a wide signal-to-noise ratio, but this is less unusual in a preamplifier of the TA-2000's quality (and price). What *is* unusual is the performance of the phono and tape head preamplifier circuits; for though they have sufficient sensitivity (0.06mV) for the lowest-output cartridges (even without accessory transformers), these preamplifier circuits are virtually immune to overload—even with input signals 80 times greater than normal.

Their sole vice: they are hardly inexpensive

Of course, at a price of $329.50 for the TA-2000 preamplifier, and $349.50 for the TA-3200F power amp, this sytem cannot be considered other than a luxury, but then, it was intended to be. For there are those to whom fulfillment of prosaic tasks is unfilling. And among them are not only many of our customers, but also many of our engineers. Sony Corporation of America, 47-47 Van Dam St. Long Island City, New York 11101.

SONY

Check No. 33 on Reader Service Card

Porsche is a trademark of Dr.-Ing.h.c.F.Porsche KG

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Buyers Guide to Loudspeakers

The following are not all the speakers of the manufactuers listed; some were eliminated for lack of space, others because information was not supplied.

ADC 303AX

Advent

MANUFACTURER	Model	WOOFER Diameter, In.	WOOFER Resonance (In System), Hz	WOOFER Enclosure Type	MID-RANGE Diameter, In.	MID-RANGE Type	TWEETER Diameter, In.	TWEETER Type	Overall Freq. Response, Hz to kHz ± ? dB	Ampl. Pwr. for Avg. Room, W	Pwr. Handling Capacity (RMS Cont)	Crossover Frequency (ies), Hz	Impedance, Ohms	Enclosure Dimensions, W x D x H, In.	Wood Finish	Grille Material & Color	Weight, Lbs.	Price	SPECIAL FEATURES
ACOUSTIC RESEARCH	AR-3a	12	43	Acous.	1½	Dome	¾	Dome	*	25	**	575 5,000	4	25 x 11¾ x 14	Wal. Chry. teak, mah, birch, unf.	Cloth, Beige	53	250.00	*Complete frequency response and distortion data available from AR on request. **Depends on various factors; available on request.
	AR-5	10	55	Acous.	1½	Dome	¾	Dome	*	20	**	625 5,000	8	24 x 13½ x 11½	Wal. Chry. teak, mah, birch, unf.	Cloth, Beige	39	175.00	
	AR-2aX	10	55	Acous.	3½	Cone	¾	Dome	*	20	**	2,000 7,000	8	24 x 13½ x 11½	Wal. Chry. teak, mah, birch, unf.	Cloth, Beige	36½	128.00	
	AR-2X	10	56	Acous.	2½	Cone	–	–	*	20	**	1,200	8	24 x 11½ x 13½	Oil Wal. and 6 others	Burlap, Beige	33	102.00	
	AR-4X	8	65	Acous.	–	–	2½	Cone	*	15	**	1,200	8	19 x 10 x 9	Wal. unf.	Cloth, Beige	18½	57.00	
	AR-6	8	56	Acous.	–		1½	Cone	*	20	**	1,500	8	19½ x 12 x 7	Wal. unf.	Cloth, Beige	20	81.00	72.00 unf.
ADC	450A	12					½	Dome	30-20K ± 3	15	60		8		Wal.	Black		165.00	Two way sys. with 12" rubber surround woofer.
	303AX	10		Acous.			1½	Dome	37-20K ± 3	15	60		8	23¾ x 13 x 11¾	Wal.	Black	37	110.00	2-way spkr; 10" woofer; and wide dispersion super tweeter removable frame.
	210	8		Acous.				Dome	40-20K ± 3	15	50		8	20 x 11 x 10	Wal.	Black	30	75.00	2-way spkr; Hi comp 8" woofer and Hi accuracy wide disp. tweeter.
	404	6		Acous.			1½	Dome	45-20K ± 3	15	50		8	11⅞ x 7⅞ x 8⅜	Wal.	White	11	55.00	2-way speaker; bookshelf sys., 6" woofer and Hi accuracy wide disp. tweeter.
ADVENT		10	43	Acous.			¾	Dome	30-20K ± 4	20	100	1,000	8	25½ x 11½ x 14¼	Oil wal.	Cloth Light	44	116.00	Available in wal. finish vinyl-clad. cab.
		8	45	Acous.			¾		35-20K ± 4	15	60	1,500	4	20 x 11½ x 9¼	Wal. vinyl	Cloth Light	30	80.00	
AIR-COUSTIC	PC-12	12	40	PC*	5 x 7	Cone	1	Dome	30-15K ± 4	20	35	400 5,000	4	15½ x 13½ x 27	Wal.	Brown	51	239.00	*12-inch woofer is pneumatically coupled to a 12 x 17 Bass diaphragm.
	PC-8	8	51	PC*	–	–	4	Cone	40-15K ± 5	10	20	500	4	11 x 9 x 19	Wal.	Brown	20	119.00	*8-inch woofer is pneumatically coupled to an 11 x 9 bass diaphragm.
ALLIED	2385	15	–	Reflex	–	Compr. Horn	–	Dome	20-aud.	10	50	1,000 8,000	8	20½ x 14 x 30¼	Wal.	Cloth Olive	20	149.95	VHF tweeter; 2 level contrs.; tuned ducted port; with floor base.
	2370	12	–	Acous.	–	Compr. Horn	–	Compr. Horn	20-aud.	15	35	1,000 5,000	8	25 x 13 x 14	Wal.	Cloth Brown	50	129.95	2 level contrs.; Kit - $99.95.
	2300C	12	–	Acous.	–	Compr. Horn	–	Compr. Horn	20-aud.	15	30	1,000 10K	8	25 x 13½ x 14	Wal.	Cloth Beige	49	99.95	2 level contrs.; Kit - $74.95.
	3030B	12	–	Reflex	6	Horn	3½	Cone	35-17K	10	30	400 5,000	8	24 x 9 x 14½	Wal.	Cane	28	64.95	Fiberglass insulated; Kit - $44.95
ALTEC LANSING	2873A Barcelona Biamp Spkr,	15	40	Inf. Baffle				Compr. Driver	20-20K		90 Tot. 60 Bass 30 HF	500	8	29¾ x 38½ x 24	Oil Wal.	Mld. scpt. pat. brn.	162	750.00	Elec. x-over Bi-amp. built in RMS 90 w.
	2875A Granada Biamp Spkr.	15	45	Inf. Baffle				Compr. Driver	25-20K		90 Tot. 60 Bass 30 HF	800	8	29¾ x 27½ x 24	Oil Wal.	Mld. scpt. pat. brn.	142	650.00	Bi-amp. built in 90 watts RMS.
	848A Flamenco	15	–	Bass Reflex				Compr. Driver	35-20K		50*	800	16	27¾ x 27½ x 19¾	Wal.	Mld. Spanish pat.	105	339.00	High efficiency "The Voice of the Theater" component.
	893A Corona	10		Inf. Baffle			3	Cone	50-18K	15	45*	2,500	8	12¼ x 22 x 9½	Wal.	Brown	22	85.50	Snap-on grille, 3-way high freq. control.
	890C	10	45	Phase Inv.			(2) 6	Horn	60-20K ± 5	5	50	2,000	8	25½ x 14¼ x 14½	Wal.	Brown	38	179.00	

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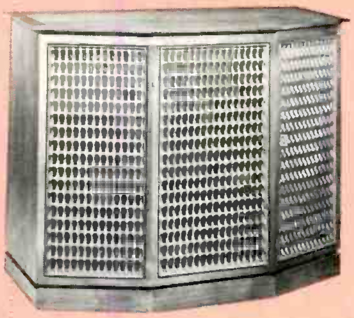
Altec Barcelona



Bose 501

Dynaco A-25

Bose 901

Bozak Tempo 1

MANUFACTURER	Model	WOOFER Diameter, In.	WOOFER Resonance (In System), Hz	WOOFER Enclosure Type	MID-RANGE Diameter, In.	MID-RANGE Type	TWEETER Diameter, In.	TWEETER Type	Overall Freq. Response, Hz to kHz ± ? dB	Ampl. Pwr. for Avg. Room, W	Pwr. Handling Capacity (RMS Cont.)	Crossover Frequency (ies), Hz	Impedance, Ohms	Enclosure Dimensions, W x D x H, In.	Wood Finish	Grille Material & Color	Weight, Lbs.	Price	SPECIAL FEATURES
AMPEX	715	(2) 6	68	Air Susp.	–	–	3½	Wide Dis-persion Air damped	50-* 20,000 Hz ±3	6	40 . 80**	1,400	8	19 x 13 x 9¼	Wal.	Dark brown	45	139.95 pr.	*Typical response. Mutually coupled woofers. Cup-chamber tweeter. **Rec. max. ampl. pwr/chan.
	516	6 x 9 Cone Duo	–	Dist. Port.	–	–	–	–	130-15,000 Hz ±5	2	12 30**	–	8	9 x 14½ x 7¼	Wal.	Dark brown	22	69.95 pr.	High efficiency design. **Rec. max ampl. pwr/chan.
	414	4½	140	Air Susp.	–	–	–	–	90-* 15,000 Hz ±6	5	20 40**	–	8	6 x 6 x 6	Wal.	Dark brown	6	59.95 pr.	*Response with 10-lb boost at 90 Hz. Special high comp. annulus. **Rec. max. ampl. pwr/chan.
AUDIONIC	Ten	10	48	Acous.	–	–	4	Cone	38-13K ±5	10	30	150	8	24 x 14 x 10½	Wal.	Cloth White	38	72.95 79.95*	Hi-temp, 4-layer, 2" v.c. in woofer. *East price.
	Ten Type A	10	48	Acous.	4	Cone	–	Dome	38-20K	–	–	150, 10K	–	–	–	–	40	92.95 99.95*	As above, plus dome tweeter. *East price.
AZTEC	Gauguin III	12	25	Contr. Duct	3 x 9	Horn	2 x 6	Horn	25-20K ±3	10	20	2000 10,000	8	20 x 27⅜ x 15⅞	Wal.	Decor wood grille	65	249.95	
	Petite 1000	8	50	Acous.	–	–	3½	Cone	50-15K ±3	15	30	2,000	8	20 x 10 x 9½	Wal.	White tweed	30	69.95	
BOGEN	LSX	4	–	Port	–	–	–	–	100-15K ±5	5	10	–	8	12 x 5¼ x 8⅞	Wal.	Black	6	60.00 pr.	Sold only as a pair.
	LS10A	6	–	Acous.	–	–	2	Cone	70-20K ±5	10	30	5,000	8	15 x 8¾ x 7	Wal.	Black	9	49.95	
	LS20	8	–	Acous.	–	–	3	Cone	50-20K ±5	10	40	1,100	8	19 x 9 x 10	Wal.	Cloth grn.-blue tweed	18	59.95	
	LS30	10	–	Acous.	5	Cone	3	Cone	40-20K ±5	10	50	600 5,000	8	22 x 11 x 14	Wal.	Cloth grn.-blue tweed	32	99.95	
BOSE	901			Nine full-range 4½ in. Drivers					–	25	270	–	8	20 9/16 x 12⅞ x 12¾	Wal.	White, dk. brn. wal. facings	33	476.00 pr. *	Direct reflecting ® dk, brn. grille or wal. facings opt. Bl. or Wht. ped. opt. *Incls. Act. Rqzt.
	501	Integrated woofer – 2-tweeter combination, balanced for direct and reflected sound.								20	50	–	4	14½ x 14½ x 24	Wal.	dk. brn.	35	124.80 each	Direct reflecting ®
BOZAK	B-410 Concert Grand	(4)-12	40	Inf.	(2) 6	Cone	(8) 2	Cone	28-20K	15	150	400 2,500	8	36 x 19 x 52	Wal.	Silk	225	897.60	Line array.
	B-4000A	(2)-12	40	Inf.	6	Cone	(8) 2	Cone	35-20K	10	100	400 2,500	8	27 x 16 x 44	Wal.	Silk	165	625.60	Line array.
	B-4005	(2)-12	40	Inf.	6	Cone	(8) 2	Cone	35-20K	10	100	400 2,500	8	39 x 20¼ x 30	Wal.	Silk	160	635.00	Line array.
	B-300 362A Mediterramean	12	40	Inf.	6	Cone	(2) 2	Cone	40-20K	6	60	800 2,500	8	24 x 20 x 28	Wal.	Brn. Cloth	120	272.50	Dual cone.
	B-301 Tempo	12	40	Inf.	4	Cone	2	Cone	40-20K	4	40	1,200 3,600	8	14½ x 11½ x 23⅛	Wal.	Brn. Cloth	40	157.50	Single
CLARK	CMS-124	12	58	Acous.	4½	Cone	(2) 3	Dome	30-20K ±5	15	100	300 4,000	8	14½ x 12 x 24	Oil Wal.	Cloth Brown	40	90.00	3-pos. brilliance contr; fin. 4 sides.
	CMS-83	8	70	Acous.	–	–	3	Dome	35-20K ±3	8	35	2,000	8	10½ x 9 x 19	Wal.	Cloth Brown	20	40.000	Fin. 4 sides; changeable grille.
DYNACO	A-25	10	58	Friction Loaded	–	–	1½	Soft Dome	47-20K ±5	15	35	1,500	8	20 x 10 x 11½	Oil Wal.	Linen, nat. beige	20	79.95	Also avail. in teak or rosewood at $89.95.
	A-50	(2)-10	52	Friction Loaded	–	–	1½	Soft Dome	40-20K ±5	15	50	1,000	8	28 x 10 x 21½	Oil Wal.	Linen, nat. beige	40	179.95	Detachable grille cloth.
EICO	HFS-8	8	50	–	–	–	3½	Cone	40-18K ±3	3	20	4,000	8	22½ x 13 x 6½	mah.	Cloth, Tan	17	49.95	

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Buyers Guide

E-V Aries

EMI 92

Empire 6000

EPI 50

Fairfax FX-100

MANUFACTURER	MODEL	WOOFER Diameter, In.	WOOFER Resonance (In System), Hz	WOOFER Enclosure Type	MID-RANGE Diameter, In.	MID-RANGE Type	TWEETER Diameter, In.	TWEETER Type	Overall Freq. Response, Hz to kHz ± ? dB	Ampl. Pwr. for Avg. Room, W	Pwr. Handling Capacity (RMS Cont.)	Crossover Frequency (ies), Hz	Impedance, Ohms	Enclosure Dimensions, W x D x H, In.	Wood Finish	Grille Material Color	Weight, Lbs.	Price	SPECIAL FEATURES
ELECTRO-VOICE	Aries	12	42	Acous.	6	Cone	2½	Cone	25-20K	10	35	400 1,500	8	27½ x 16¼ x 22¼	see note	Various	60	275.00	Deluxe furn. cab. avail. in cont./pecan, trad./cherry and Spanish Oak.
	E-V Four-A	12	47	Acous.	6	Cone	2½	Cone	30-20K	10	35	400 1,500	8	25 x 13½ x 14	Wal.	Cloth, dk. brn.	45	199.95	Ultralinear 12-inch foam susp. woofer.
	E-V Nine	10	50	Acous.	5	Cone	3½	Cone	30-20K	10	35	400 1,000	8	22½ x 12 x 13½	Wal.	Cloth, dk. brn.	30	144.00	Smooth 5-inch mid-range fills out treble range.
	E-V Five-C	10	50	Acous.	–	–	2½	Cone	30-20K	10	35	1,000	8	21¾ x 10⅜ x 12¼	Wal.	Cloth, dk. brn.	22	99.95	Four-layer voice coil for efficiency at low freqs.
	E-V Seven-B	8	75	Acous.	–	–	3½	Cone	40-20K	10	35	1,500	8	19 x 9 x 10	Wal.	Cloth, dk. brn.	19	66.50	Symmetrical tone damping.
	E-V Eleven	6	110	Reflex	–	–	–	–	80-15K	5	15	–	8	15¼ x 6½ x 8¼	Wal.	Cloth, dk. brn.	9	37.00	Low cost dual-radiator system.
ELITE	Magnum-K	12	40	Acous.	4	Cone	4	Cone	30-20K ±5	6	25	1,500 +6,000	8	15 x 11¼ x 24	Wal.	Cloth, charc & white	47	189.00	Vinyl cone susp. Tweeter control and mid-range control.
	Mezzo-II	12	48	Acous.	–	–	4	Cone	40-20K ±5	6	15	2,000	8	19½ x 9 x 12	Wal.	Cloth, charc. & white	20	139.00	Vinyl cone susp. Tweeter control.
	Maxim	4	60	Acous.	–	–	3½	Cone	45-20K ±5	8	12	2,000	8	5½ x 7¼ x 10½	Wal.	Cloth, brn., white	8	59.95	Vinyl cone susp. Extremely compact.
EMI	300	15	53	Acous.	(2) 5	Cone	2	Compr. Type	10-30K	35	100	1,000 7,000	8	26 x 19 x 27½	Wal.	Brown	90	350.00	
(Benjamin)	205	14 x 9	55	Acous.	(2) 5	Cone	–	Compr. Type	25-20K	20	90	1,500 5,000	8	14¼ x 13¾ x 24¾	Wal.	Brown	52	225.00	
	105	14¼ x 8¾	62	Acous.	5	Cone	3⅜	Cone	35-20K	15	80	1,000 4,000	8	13½ x 12¼ x 24½	Wal.	Brown	50	169.50	
	62	10 x 6⅝	91	Acous.	–	–	3⅜	Cone	60-20K	10	35	5,000	8	11⅛ x 10 20½	Wal.	Black	28	79.95	
	92	13½ x 8⅛	83	Acous.	–	–	3⅜	Cone	50-20K	10	60	4,500	8	11¾ x 10¾ x 23⅛	Wal	Cloth, Black	36	109.95	Co-ax with alumin center.
EMPIRE	9000 M	15	20	Inf. oattle	4	Cone	1	Dome	20-20K	10	100	450 5,000	8	22 x 29	Satin Wal.	None	120	299.95	3-way sys.- w.a. lens, marble top.
	7000 M	12	25	Reflex	4	Cone	1	Dome	25-20K	10	90	450 5,000	8	19 x 26½	Satin Wal.	None	75	209.95	As above.
	6000 M	10	30	Reflex	5	Cone	3	Cone w/lens	30-20K	10	75	450 2,500	8	18 x 24⅜	Satin Wal.	None	60	109.95	Marble top. Model 6000 with walnut top, $99.95.
EPI	EPI 150	8	35	Acous.	–	–	1	Cone	35-18K ±3	17	40	1,800	8	11 x 15 x 24	Wal.	Dk. brn.	35	129.00	Unique cabinet design.
	EPI 100 Standard	8	43	Acous.	–	–	1	Cone	40-18K ±3	17	40	1,800	8	11 x 9 x 21	Wal.	Brown	22	89.00	Uniform dispersion ±5 dB. 40-13 kHz.
	50	(2) 6	–	Acous.	–	–	2	Cone	50-18K ±3	14	–	–	–	13 x 10 x 8	Wal.	Cloth Dark	–	55.00	Long voice coils.
FAIRFAX	FE-8	(2) 8	–	Acous.	(2) 8	Cone	(2)-3 (2)-3½	Cone Paper	20-22K ± 3	15	100	750 2K, 7K	8	20 x 12 x 28¾	Oil Wal.	Black	80	249.50	1-in particle board cab.
	FL-34	(2) 8	–	Layb. Folder Horn	3	Cone	3½	Dome	22-22K ±3	10	60	2,000 7,000	8	14 x 12 x 24	Oil Wal.	Black	65	129.50	As above.
	FX-1000	8	–	Bass Reflex	–	–	3	Cone	30-20K ±3 db	10	30	5,500	8	12 x 7⅞ x 21	Oil Wal.	Black	28	79.50	

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The driving amplification of today's electronic instruments offers a new challenge to the capacity of speaker systems. Can they take it? The new Achromatic W25 *can.*

However, absorbing this power and giving it *all* back as *distortion-free, faithfully reproduced* sound is another matter! The new W25 employs a hefty 8" woofer with oversized, specially constructed four layer-wound voice coil assembly for maximum heat dissipation, plus a heavy duty magnet assembly with deep axial length for superior transient response. The tweeter coil is aluminum for low mass, and the cone is ultra-curvilinear for exceptional polar distribution. A professional LCR crossover network minimizes commonplace electrical and acoustical distortions, and the "unitized" construction of the sturdy cabinet avoids buzzes and resonances.

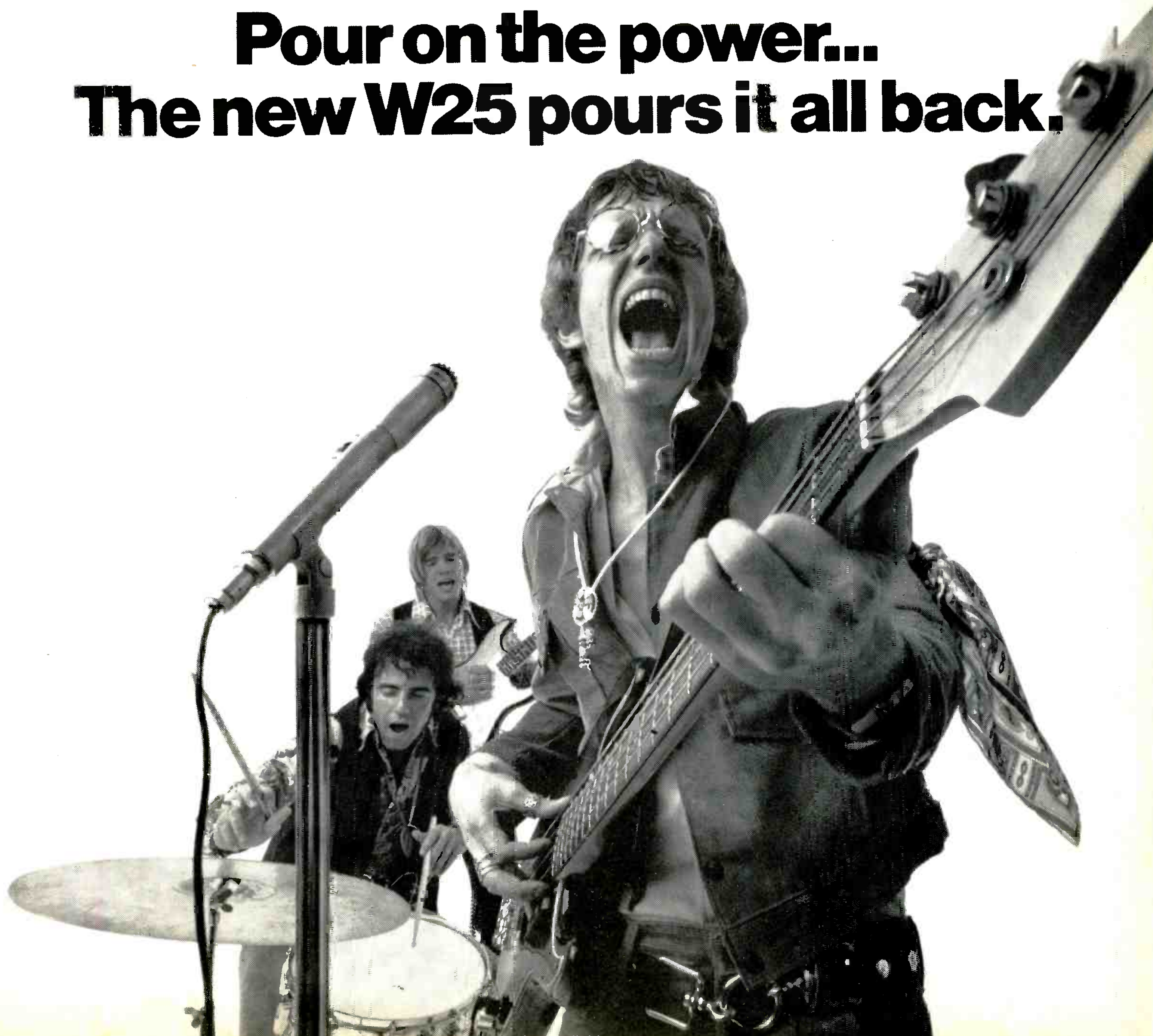
The W25, priced at $58.75 list, is *quality* throughout. It is one of six Wharfedale speaker systems engineered to satisfy every budget, space and performance requirement. For complete catalog, write Wharfedale Division, British Industries Co., Dept. HS-50, Westbury, New York 11590.

Wharfedale

ACHROMATIC SPEAKER SYSTEMS

Check No. 37 on Reader Service Card

Pour on the power...
The new W25 pours it all back.



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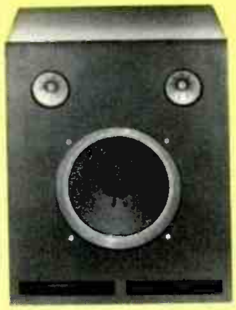
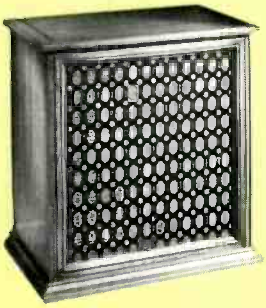
Buyers Guide

Harman-Kardan Citation



Frazier Capsule



Heath AS-102

Fisher WS-80

MANUFACTUER	MODEL	WOOFER Diameter, In.	WOOFER Resonance (In System), Hz	WOOFER Enclosure Type	MID-RANGE Diameter, In.	MID-RANGE Type	TWEETER Diameter, In.	TWEETER Type	Overall Freq. Response, Hz to kHz ± ? dB	Ampl. Pwr. for Avg. Room, W	Pwr. Handling Capacity (RMS Cont.)	Crossover Frequency (ies), Hz	Impedance, Ohms	Enclosure Dimensions, W x D x H, In.	Wood Finish	Grille Material Color	Weight, Lbs.	Price	SPECIAL FEATURES
FISHER	XP-16	(2)12	53	Acous.	8	Cone	1½ ¾	Dome Horn	28-24K	20	60	250 2,500	8	27½ x 31½ x 19 9/16	Wal. Pecan	Cloth, Brn.	105	299.95	Furniture styles in 3 finishes, incl. cherry.
	XP-9C	15	55	Acous.	(2)5	Cone	(2)1½	Dome	28-22K	20	30	500 1,200 5,000	8	16¼ x 27½ x 13	Wal.	Cloth, Brn.	55	199.95	4-way with dome super tweeter.
	WS-80	8	60	Omni.	5¾	Cone	3	Horn	35-20K	10	20	400 1,500	8	18 x 18 3/8 x 11	Wal.	Cloth, Brn.	24	99.95	Model WS-70 with 6" woofer 3" tweeter $79.95.
	XP-55B	8	60	Acous.	–	–	3	Cone	37-20K	10	15	1,500	8	20 x 10 x 7½	Wal. Finish	Cloth, Brn.	18	49.95	Model KP-44B with 6" woofer. $44.95.
	XP-7B	12	58	Acous.	5¾	Cone	(2)3	Cone	30-20K	10	50	350 800 3,500	8	14 x 24½ x 11 7/8	Wal.	Cloth, Brn.	40	149.95	
FRAZIER	MK. VI F12-8W	12	–	Tuned	8	–	(2)3 or	Cone Horn	25-17K	8	25	800 3,300	8	25¾ x 16 1/8 x 29	Oil Wal.	Cloth Brown-gold	90	295.00	
	Super Dixielander F707-1037	10	–	Exp. Horn	–	–	–	Horn	70-17K ±5	0.5	30	800	8	22¾ x 15¾ x 26½	Util Slate	None	65	250.00	
	MK. V F12-2-5T	12	–	Tuned	(2)4	Cone	–	Horn	30-19K ±5	2	25	800 3,300	8	14 x 12 x 25¾	Oil Wal.	Lined Off-White	50	189.95	Also available in black utility model.
	MK. IV F10H	10	–	Tuned	–	–	–	Horn	30-18K ±5	2	25	2,000	8	14 x 12 x 24	Oil Wal.	Lined Off-White	41	99.95	
	Capsule	10	–	Tuned	–	–	(2)3	Cone	30-15K ±5	1	25	1,500	8	16 x 16 x 19	Black	None	35	75.00	
GOTHAM (K&H)	OY	10	20	–	4	Cone	–	Horn	40-16K ±2	–	–	500 8,000	>4700	19 x 9 x 12	Wal. or Gray	Metal Silver	44	550.00	Low-level input; contains 2 30-W ampls. elect. X-over; separate level contrs.
GROMMES	GS-310	10	–	Acous.	6	Cone	3½	Cone	25-20K	20	50	600 3,500	8	13¾ x 23 x 10 1/8	Wal.	Brn.	30	119.85	
HARMAN-KARDON	HK 50	8	35	Acous.	–	–	2¼	Cone	35-20K ±4	20	45	1,500	8	11¼ sq. x 18	Wal.	Dk. Brn.	22	99.95	Omnidirectional 360° dispersion.
	HK 40	10	32	Acous.	–	–	3	Cone	30-20K ±4	20	45	2,000	8	13 5/8 x 10½ x 22 7/8	Wal.	White	35	89.95	Omnidirectional 360° dispersion.
	HK 20	8	40	Acous.	–	–	3	Cone	38-20K ±4	12	20	2,500	8	11¼ x 8¼ x 17¼	Wal.	Brown	20	55.00	
	HK 12	6	43	Acous.	–	–	–	–	40-18K ±4	5	10	–	8	9½ dia. x 13¾	Wal.	Black	2	35.00	360° dispersion.
	Citation	(3)-6	30	Double Chamber Bass Ref.	3	Dome	(2)-2	Dome	30-22K +2	20	60	2K	4	–	Wal.	Light Tan	75	295.00	Omnidirectional type reflectors.
HARTLEY	Concertmaster V & VI (3 spkr.)	24	13	Semi-Inf.	10	Poly Cone	7	5 5/8 cone 2" dome	16-25K ±3	20	50	300 3,000	16	39 x 29 x 18	Wal.	Cloth, brn. & gold	150	730.00 760.00	Mag. susp.; cones of identical material, x-over 12 dB/oct. cast alum. fr.
	Hotton Jr.	10	28	Inf.	–	–	3 Cone & Dome		35-20K ±4	15	30	2,500	8	30 x 15 x 13	Wal.	Cloth, brn. & gold	45	195.00	CO-AXIAL speaker w/pat. moisture proof polymer cones; mag. susp.; dual cones and v.c.'s.
	Zodiac II	8	32	Inf.	–	–	4	Cone	40-18K ±3	20	30	2,000	5	18 x 11½ x 8½	Teak or Rosewood	Slotted Wood	16	99.95	
HEATH	AS-38	12	–	Tube Ported	–	–	2	Piston type dir. rad.	45-20K	7	40 program	2,500	8	23½ x 11¾ x 14	Wal.	Cloth Brown	37	154.95	Kit.
	AS-10W	10	–	Acous.	–	–	Two 3½	Cone	30-15K ±5	10	40 RMS	2,250	16	24 x 11½ x 13½	Wal.	Cloth Cane	28	64.95	Kit.
	AS-16	8	–	Acous.	–	–	3½	Cone	45-20K ±5	25	50	1,500	8	19 x 8¼ x 10	Wal. Vinyl	Cane	15	54.95	Kit.
	AS-37A	8	–	Ducted port	–	–	–	Horn	50-12K	5	25	1,600	8	23 x 11 1/16 x 11½	Wal. Polyester	Cloth Brown	22	41.95	Kit.
	AS-102	12	–	Inf.	6	Cone	(2)2½	Cone	40-20K	20	50	800 2,500	8	27¾ x 19 7/8 x 29 5/8	Pecan	Cloth Gold-Blk	92	259.95	Kit.

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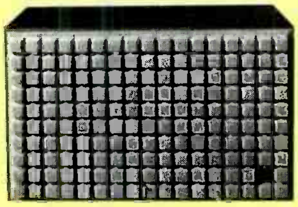
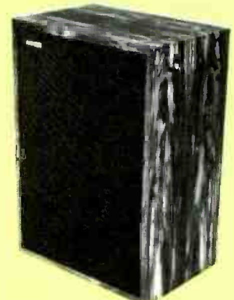


JBL L-100

Jensen 700-XLW

JVC 5303



Infinity 2000

Kenwood KL 5060

MANUFACTURER	MODEL	WOOFER Diameter, In.	WOOFER Resonance (In System), Hz	WOOFER Enclosure Type	MID-RANGE Diameter, In.	MID-RANGE Type	TWEETER Diameter, In.	TWEETER Type	Overall Freq. Response, Hz to kHz ± ? dB	Ampl. Pwr. for Avg. Room, W	Pwr. Handling Capacity (RMS Cont.)	Crossover Frequency (ies), Hz	Impedance, Ohms	Enclosure Dimensions, W x D x H, In.	Wood Finish	Grille Material Color	Weight, Lbs.	Price	SPECIAL FEATURES
IMF	TLS	9 x 12	15	trans. line	5	Cone (trans. line)	2¼ ¾	Comp dr. Dome	20-35K ±3	30	30	350 3,500 12K	8	20 x 17 x 43	gray, rosewood	cloth blk.	140	660.00	For monitoring matched, phased pairs.
	Studio	8	24	trans. line	4	Cone	2	Dome	25-20K ±2	20	60	375 3,500 13,000	8	35½ x 15 x 14	Teak or Walnut	Cloth blk.	70	300.00	
INFINITY	Servo-Statik I	18	*		–	ESL	**	ESL	10-30K ±3	40			40K * ***	****	rosewood or wal.	blk.	167	1,995.00	*Feedback contr. com. bass woofer; **two ESL screens for treble; ***into 110-w ampl., furnished. ****hi f. screens: 28 x 37 x 6½
	Infinity 2000	12		trans. line	4½	Cone		ESL	30-35K ±4	20		375 2,200	4	18 x 12 x 26				279.00	ESL tweeter.
JANSZEN	Z-960	11	42	Inf. Baffle	3 Electrostatic Elements				30-30K	20	100	800 2,000	8	26¾ x 27½ x 14½	Oil Wal.	Cloth Beige	67	299.95	High-frequency switch.
	Z-600	11	46	Inf. Baffle	2 Electrostatic Elements				30-30K	20	100	800 2,000	8	26⅝ x 20 x 13	Oil Wal.	Cloth Beige	65	235.00	
JENSEN	700-XLW	12	20	Acous.	–	Horn	–	Horn Loaded Dome	20-25K	10	40	600 4,000 10,000	8	25½ x 12 x 16¼	Wal.	Cloth, Brown	60	275.00	4-way system, hor. or vert. opt. floor stand Flexair® woofer.
	TF-3C	10	25	Acous.	3½	Cone	–	Dome	25-20K	10	25	2,000 10,000	8	23¾ x 11⅜ x 13½	Dura-syn. wal. ven.	Cloth, Brown	40	128.00	Superflex® enclosure. Sonodome® tweeter. Flexair® woofer.
	TF-25	10	25	Acous.	–	–	2 x 6	Horn	25-19K	10	25	2,000	8	22½ x 8⅝ x 14	Dura-syn. wal. ven.	Cloth, Brown	27	89.50	2-way air suspension, Flexair® woofer, horn-loaded tweeter.
	X-45	8	35	Acous.	–	–	2 x 6	Horn	30-18K	10	25	2,000	8	19½ x 9 x 10½	Wal.	Cloth, Brown	24½	69.50	Flexair® woofer, horn-loaded tweeter.
JBL	Aquarius 3	14		Radial Horn Driver	(2)-5	Radial Horn Driver		Comp. cr.			60	300 1,500	8	18 x 20 x 50	wal. or white	molded polymer	117	657.00	Peripheral radial slot plus multi-lobed high frequency horn.
	Aquarius 2	12		Radial Horn Driver	(2)-5	Radial Horn Driver	1¾	Direct rad.			50	300 3,000	8	18 x 16 x 32	wal. or white	Cloth, charcoal	95	387.00	Diffuse – source system projects sound from peripheral radial slot.
	Aquarius 4	8	60	Radial Horn Driver	–	–	2	Cone			25	2,000	8	40 x 10 x 10	wal. or white	Cloth, Brown	53	168.00	Unique pedestal shape houses twin radial diffraction slots.
	L-100	12	75	Reflex	5	Cone	2	Cone	45-16.5K ±5	15	60	2,500 6,500	8	24 x 14 x 13	wal.	blue, orange or brn.	51	264.00	Identical performance to 4310 std-monitor.
JVC	5340	12	45	Acous.	6½	Cone	3½ 2	Cone Horn	20-30K ±2	20	50	1,500 7K, 10K	8	16 x 15 x 28	wal.	Cloth, gray	47	259.95	Level contr's behind grille.
	5303	(4)-5	35	Acous.			(4)-2		20-20K ±3	20	40	5,000	8	13½ dia. sphere		Metal black	26.4	199.95	Omni-dir. ball system 4 woofers, 4 horn tweeters.
	5304	12	45	Acous.	6½	Cone	3½	Cone Horn	30-23K ±5	15	40	1,500 7K, 10K	8	15 x 13 x 24¾	wal.	Cloth, Brown	35	149.95	Multi-channel input terms for use with multi-ampl. sys.
	5310	6½		Air susp.	2	Cone	2	Horn	40-20K ±5	8	30	7,000 10,000	8	11 x 17 x 7¾	wal.	Cloth, blk.	12	69.95	Free-edge woofer.
KARLSON	X-15	15	40	Spec. Karlson	–	–	2½	Spec.	20-18K ±4	2	100	2,000	16	20 x 14 x 28	wal.	Cloth, blk.		299.00	Sep. switch for organ or instrument use. Utility and portable models avail.
KENWOOD	KL-5060	12	45	Ducted Reflex	6½	Cone	2	Horn	30-22K	10	40	600 5,000	8	15 x 11⅝ x 25½	wal.	Metal dk. brn.	44	139.95	3-way, 4-spkr. system 2 level controls.
	S-606	8	55	Acous.	–	–	3	Cone	50-20K	6	20	2,500	8	11 x 10 x 21	wal.	Cloth, brn.-blck.	30*	119.95 pr.	*pair, 2-way.
	KL-2050	6½	–	Acous.	–	–	2¾	Cone	50-20K	–	20	2,000	8	10 x 8 x 16⅛	wal.	Cloth, brn.	23	79.95 pr.	

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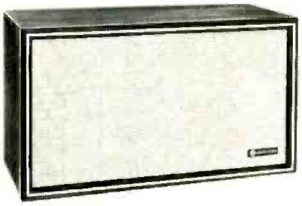

Lafayette Criterion 100B

Marantz Imperial 5

LWE II

Klipsch Heresy

MANUFACTURER	Model	WOOFER Diameter, In.	WOOFER Resonance (In System), Hz	WOOFER Enclosure Type	MID-RANGE Diameter, In.	MID-RANGE Type	TWEETER Diameter, In.	TWEETER Type	Overall Freq. Response, Hz to kHz ± ? dB	Ampl. Pwr. for Avg. Room, W	Pwr. Handling Capacity (RMS Cont.)	Crossover Frequency (ies), Hz	Impedance, Ohms	Enclosure Dimensions, W x D x H, In.	Wood Finish	Grille Material & Color	Weight, Lbs.	Price	SPECIAL FEATURES
KLH	12	12	35	Acous.	(2) 3	Cone	1¾	Cone	–	30	–	600 2500	8	22¼ x 15 x 29	Oil wal.	Boucle off white	114	275.00	4 3-pos level contrs; can be used remotely; changeable grille cloth.
	5	12	44	Acous.	(2) 3	Cone	1¾	Cone	–	25	–	600 2500	8	26 x 11½ x 13¾	Oil wal.	Cloth, lt. brn.	54	189.95	2 3-pos level contrs; fin on 4 sides; changeable grille cloth.
	33	10	56	CAC*	–	–	1¾	Dir. rad.	–	15	–	1500	8	23⅜ x 10 5/16 x 12¾	Oil wal.	Cloth, lt. brn.	33	99.95	*Contr. acous. compliance 3-pos h.f. level contr; fin 4 sides; changeable grille.
	17	10	60	Acous.	–	–	1¾	Cone	–	12	–	1500	8	23½ x 9 x 11¾	Oil wal.	Cloth, off white	27	74.95	3-pos tweeter level contr; fin 4 sides; changeable grille.
	32	8	59	Acous.	–	–	2	Cone	–	12	–	1800	8	19⅜ x 7⅜ x 10⅞	Oil wal.	Brown	16 ea.	93.00 pr.	Available only in double pack.
KLIPSCH	Klipschorn K-347	15	–	Horn	2	Horn	1	Horn	32-17.5K ±3	30	100	400 6,000	16	52 x 31 x 28	Wal. Mah. others	Several	180	571.00 1,020.00	
	La Scala K-447	15	–	Horn	2	Horn	1	Horn	45-17.5K ±3	30	100	400 6,000	16	34 x 24 x 24	Fir.	None	120	550.00	Home version, K-457, $815.
	Cornwall II	15	–	Ducted port	2	Horn	1	Horn	32-17.5K ±4	30	60	600 6,000	16	36 x 24 x 15	Wal. Mah. others	Several	105	469.00 342.00	
	Klipsch's Heresy	12	–	Total encl.	2	Horn	1	Horn	45-17.5K ±4	25	50	700 6,000	16	21 x 15 x 13	Wal. Mah. others	Several	55	258.00 209.00	
LAFAYETTE	Criterion 80	12	25	Acous.	6½	Cone	2 (3) 2 (1½)	paper cone Alum. cone	18-25K ±5	10	75	800 4,500 10,000	8	18 x 12 x 38	Oiled Walnut	Cloth, dk. brn.	66	159.95	Mid and high freq. level controls; 5 yr. warranty.
	5 x B	12		Acous.	6½	Cone	3 (1) 1½ (1)	paper cone Alum. cone	18-25K ±5	10	38	800 4,500 10,000	8	23⅞ x 14⅞ x 11⅝	Oiled Walnut	Cloth, dk. brn.	46	129.95	As above.
	Criterion VI	12	–	ported	5	Cone	2 (3) 2 (1½)	Paper	20-20K	10	50	800 5,000 12,000	8	24 x 12 x 14½	Oil Wal.	Cloth, ck. brn.	42	89.95	Mid and high freq. level controls; 5 yr. warranty.
LEAK	Mark III	13	19	Acous.	–	–	5	Alum. sandwich	30-20K ±5	4	70	900	8 or 15	26 x 15 x 12	Wal. or teak	Cloth Tan	50	199.00	Piston action sandwich cone in both woofer and tweeter.
LOUDSPEAKER DESIGN	Eziekel II	(2) 8		Horn	–	–	2	Horn	27-23K ±4	2	85	175 800 5,000	4	27 x 18 x 22	Wal.	Cloth blk.	57	279.95	Horn loaded system passive electronic network.
	Eziekel I	10		Horn	–	–	2	Horn	45-17K ±4	2	50	175 1,000	8	26 x 11 x 16	Wal.	Cloth blk.	29	159.95	As above.
LWE	1-A	15	Non Res	Sealed	6	Cone	2 x 5	Horn	22-20K ±5	25	50	2,000 5,000	4	25 x 17 x 12	Wal.	Cloth brn.	61	270.00	Elec. susp. feedback; unf. kit. $225.00.
	II	(1) 15	Non Res	Sealed	(2) 6	Cone	2 x 5	Horn	20-20K ±5	40	100	1,000 5,000	4-8	34 x 24 x 16	Wal.	Cloth brn.	141	490.00	Unf. kit $350.00. Elec. susp. feedback.
	VI	8	Non Res	Sealed	6	1	3½	Cone Dome	29-13K ±5	20	25	1,500	8	19 x 10 x 9	Wal.	Cloth Brn.	23	82.50	Elec. susp. feedback; unf. kit $66.00.
	VII	10	Non Res	Sealed			3½	Cone	25-17K ±5	20	40	2,000	4	22½ x 15 x 9½	Wal.	Cloth brn.	35	130.00	Elec. susp. feedback; unf. kit $105.00.
MARANTZ	Imperial I	12	–	Inf. baffle	(2) 4	Cone	(2) 2	Cone	20-20K	–	40	700 6,000	8	22 x 15 x 26	Lacq. Wal.	Cloth brn.	60	299.00	
	Imperial III	12	–	Inf. baffle	2	Dome	1	Dome	30-20K	–	100	1,500 6,000	8	13½ x 12 x 23	Lacq. Wal.	Cloth, brn.	42	199.00	
	Imperial V	8	–	Acous.	3½	Cone			50-15K ±3			2,000	8	23 x 12 x 9½		Cloth brn.	13¾	79.00	
MARTEL	VS1200	12	–	Acous.	5	Cone	3	Cone	35-20K	25	100	1,400 5,000	8	15 x 11¾ x 26¼	Wal.		50	169.00	
	VS1000	10	Cone	Acous.	5	Cone	(2)	Horn	40-20K	25	100	800 3,000	8	13 x 11½ x 23	Wal.		27	89.95	

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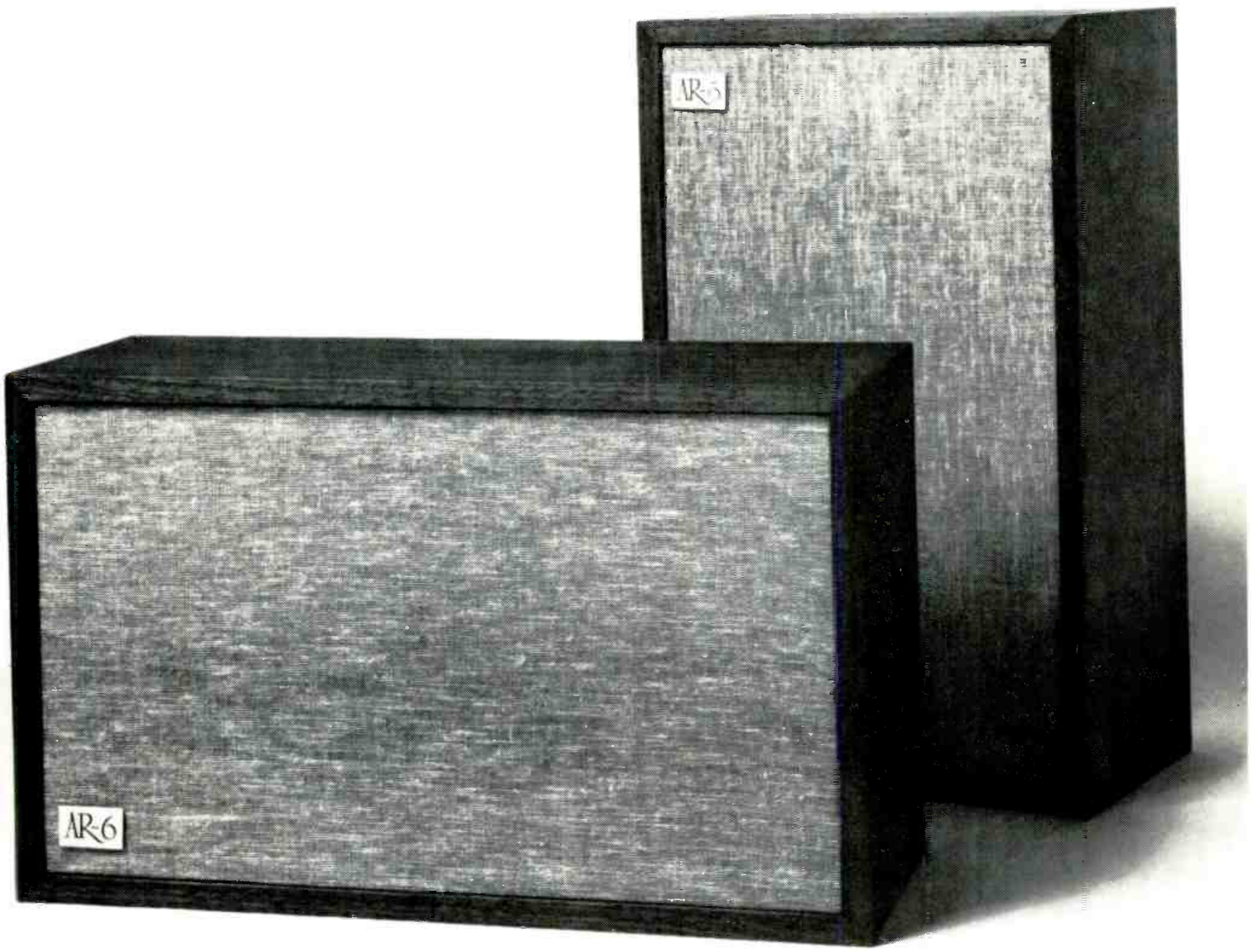
The AR-6.

A new speaker system from Acoustic Research.



"Out-performed a number of considerably larger and far more expensive systems we have tested in the same way . . . We don't know of many speakers with as good a balance in overall response, and nothing in its size or price class has as good a bass end." . . .

Hirsch-Houck Laboratories . . . Stereo Review

Suggested retail price: $81, oiled walnut; $72 unfinished pine. *5% higher in West and Deep South.*

AR
Acoustic Research

Acoustic Research, Inc.
24 Thorndike St., Cambridge, Mass. 02141, Dept. AU-3

Please send a free copy of your illustrated catalog as well as technical specifications on the new AR-6 to:

Name ______________________________

Address ______________________________

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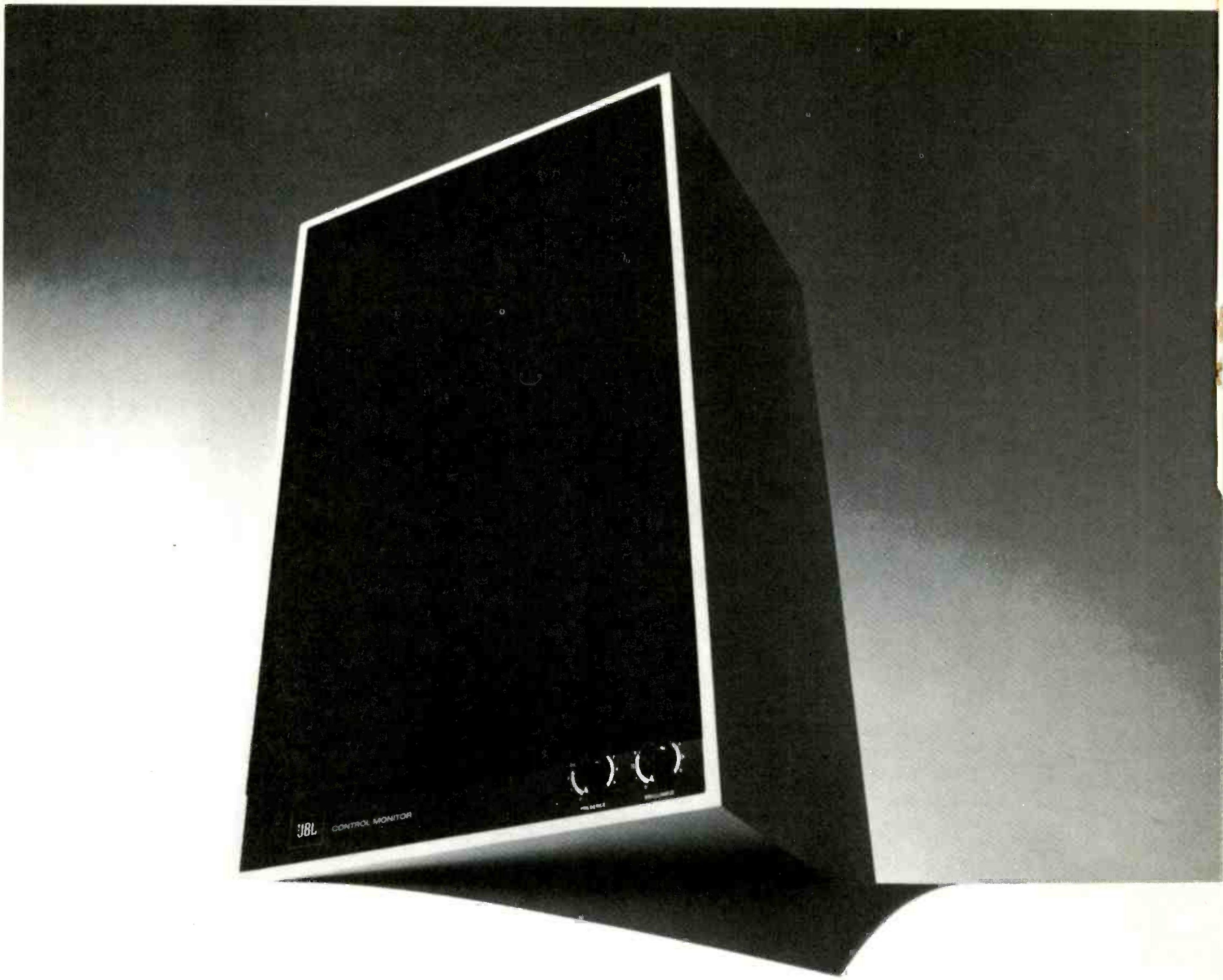

Clark Kent.

The JBL 4310 is especially designed for mastering, control room installations, mix-down facilities, portable playback systems. It's full of good things like:

Wide range response. Full 90° dispersion for vertical or horizontal placement. Power handling capability, 50 watts program material.

Front panel controls for separate adjustment of presence and brilliance.

12-inch long-excursion low frequency loudspeaker, massive mid-frequency direct radiator, separate ultra-high frequency transducer.

Only available through Professional Audio Contractors.

Beneath this mild mannered charcoal gray exterior, is the finest compact studio monitor money can buy.

It should be. The JBL 4310 was developed with the enthusiastic assistance of leading recording engineers. (And they're the only ones who can buy it.)

Now, guess what else the professionals have been doing with the 4310's for the last two years. You're right. They've been taking them home, using them as bookshelf speakers.

That's why we decided to get even.

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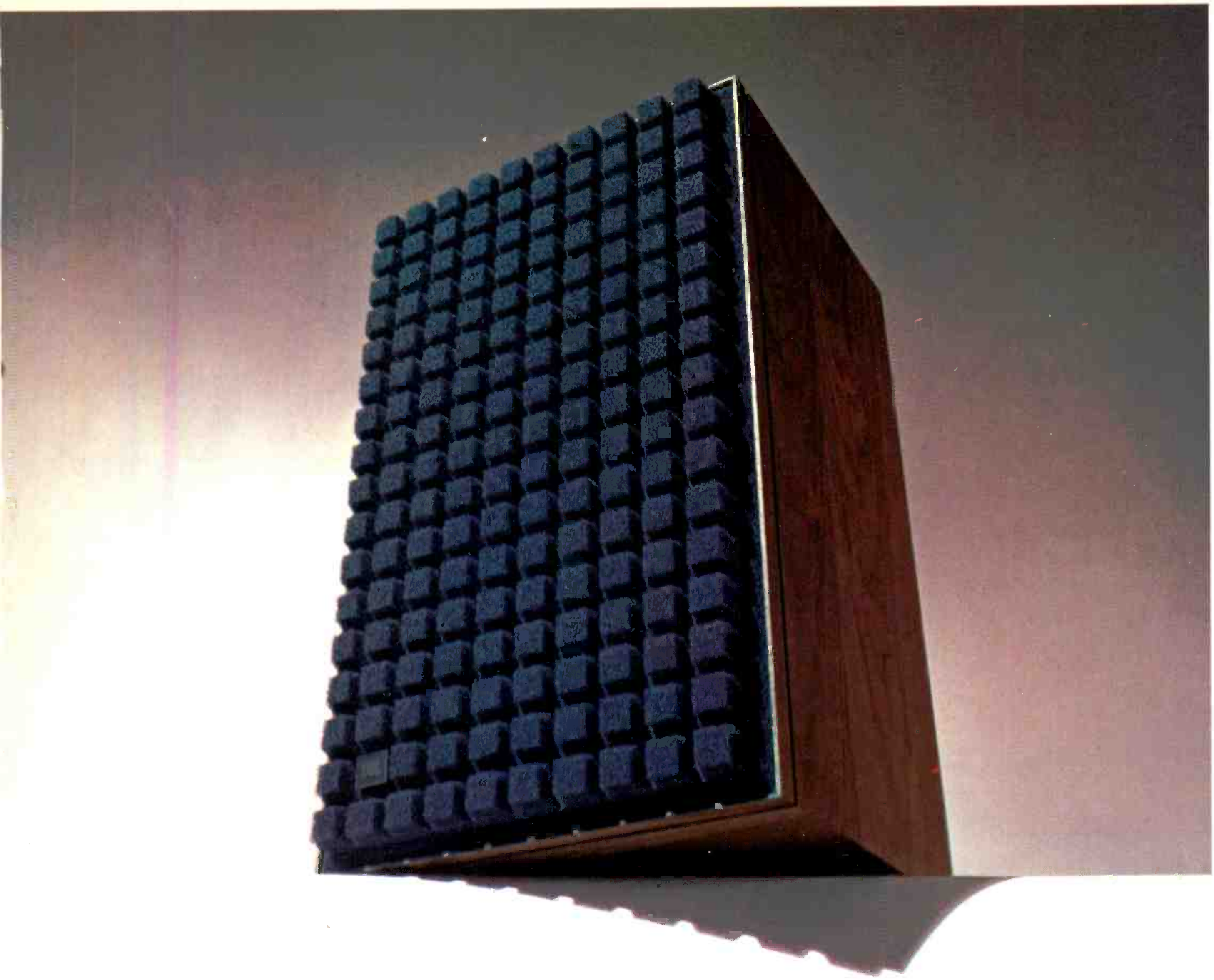

Supershelf.

It's the new JBL Century L100. It would be the finest professional compact studio monitor money could buy except it's not sold to studios. (If that sounds like the JBL 4310, there's a reason. They're twins.)

JBL started with a definition of sound. It's the sound the artist creates, the sound the microphone hears, the sound the recording engineer captures.

Then they added oiled walnut and a new dimensional grille that's more acoustically transparent than cloth but has a texture, a shape and colors like Ultra Blue or Russet Brown or Burnt Orange.

Oh, yes. The JBL Century L100 is the only speaker you can buy with individual controls under the grille so that you can match the sound to the room—just the right presence, just the right brilliance.

And then they checked the rule book.

There's absolutely no law against professional sound looking beautiful.

JBL

James B. Lansing Sound, Inc., 3249 Casitas Avenue, Los Angeles 90039. A division of Jervis Corporation

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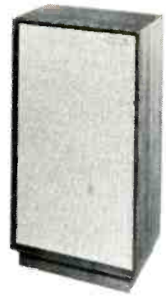
Buyers Guide

Maximus 55

Nikko SS-83



Rectilinear III

Panasonic SB 750

Pioneer CS-66

MANUFACTURER	MODEL	WOOFER Diameter, In.	WOOFER Resonance (In System), Hz	Enclosure Type	MID-RANGE Diameter, In.	MID-RANGE Type	TWEETER Diameter, In.	TWEETER Type	Overall Freq. Response, Hz to kHz ± ? dB	Ampl. Pwr. for Avg. Room, W	Pwr. Handling Capacity (RMS Cont.)	Crossover Frequency (ies), Hz	Impedance, Ohms	Enclosure Dimensions, W x D x H, In.	Wood Finish	Grille Material & Color	Weight, Lbs.	Price	SPECIAL FEATURES
MAXIMUS	Maximus 33	8	55	Air Susp.	–	–	3½	Cone	35-18K ± 5	15	*	2,000	8	11 x 9 x 18	Wal.	Cloth brn.	25	56.00	*Use with any com. amp. designed for music at home. All controls are up front for easy access behind cloth or panel.
	Maximus 55	12	45	Air Susp.	6	Cone	3½	Cone	30-20K ± 5	15	*	2,000 5,000	8	14 x 12 x 24	Wal.	Cloth brn.	39	99.50	Same as above.
	Maximus 1	4	70	Air Susp.	–	–	3	Cone	45-20K ± 5	25	*	1,900	8	7¼ x 5½ x 10½	Wal.	Cloth brn.	12	64.50	Same as above.
NIKKO	SS-83	8	75	Acous.	–	–	3	Cone	30-20K	10	25	4,000	8	9 x 14¼ x 9	Oil Wal.	Cloth, Black	10	89.95	High-compliance woofer.
	SS-85	8	35	Reflex	5	Cone	3	Cone	40-21K	10	25	1,000 4,000	8	14¼ x 18¼ x 9	Oil Wal.	Cloth, brn.	15½	149.95 pr.	High-compliance woofer.
OHM	B	12	47	Acous.	5¼	Cone	1	Dome	38-19K ±4	25		310 3,400	8	26 x 15 x 10¾	Wal.	Cloth, brn.	55	175.00	
	C	10	52	Acous.	5¼	Cone	3	Cone	40-18K ±5	25		325 4,000		25 x 14 x 10	Wal.	Cloth, brn.	48	100.00	
NORELCO	710	10	55	Acous.	3½	Cone	1¾	Cone	32-19,500	20	35	5,000 7,500	8	14 x 11 x 22	Wal.	Cloth, Black	22.5	129.95	
	700	8	90	Acous.	–	–	3½	Cone	40-18,000	10	15	5,000	8	11 x 9 x 18	Wal.	Cloth, Black	13.5	69.95	
PANASONIC	SB-750	12	50	Acous.	(4)6	Cone	(2) 4	Dural Domes	25-20K	10	85	600 5,000	8	19¾ x 11½ x 27½	Wal.	Wood grille	55	219.95	Detachable floor base.
	SB-400	10	65	Acous.		Horn		Horn	35-20K	10	50	650 6,000	8	12½ x 11¾ x 23¼	Wal.	Cloth, brn.	29	129.95	8-cell mod. horn 6-cell HF horn.
	SB-22	8	75	Acous.			3	Cone	38-19K	10	30	2,500	8	10¼ x 9¼ x 20½	Wal.	Cloth, Black	14	69.95	Wide dispersion tweeter.
PIONEER	CS-630X	15		Acous.	(2) 5	Cone	(2) 2½	Cone Horn	20-20K	10	80	770 3.3, 12K	8	18⅞ x 13¹¹⁄₁₆ x 28⅜	Wal.	Wood Lattice	63	259.00	Level contrs. for mid-range & tweeter.
	CS-A-700	12		Acous.	4¾	Cone		Multi-Cell Horn	35-20K	10	60	500 4,500	8	12¾ x 15 x 26	Wal.	Wood Lattice	37	179.00	Bi- or tri-amp inputs.
	CS-A-500	10		Acous.	4¾	Cone	3	Cone	40-20K	10	50	800 6,000	8	13 x 12¾ x 22½	Wal.	Wood Lattice	32	149.00	As above.
	CS-66	10		Acous.	6½	Cone	3	Cone	35-20K	10	40		8	12³⁄₁₆ x 11⁷⁄₁₆ x 22	Wal.	Wood Lattice	29	109.00	Level contr. for tweeter.
QUAD									45-18K	30	60			34½ x 31 x 10½	Wal.	Anod al, bronze		260.00	Full-range doublet; electro-static; dispersion 70 deg. hor, 15 deg. vert.
RECTILINEAR	III	12	40	Ducted Port	5	Cone	(2) 2½ (2) 2	Cone Cone	22-18.5K ±4	20	100	500 8K, 11K	8	18 x 12 x 35	Wal.	Cloth, brn.	70	279.00	Low-mass drivers.
	Xa	10	60	Acous.	5	Cone	2½	Cone	40-18.5K ±4	30	180	100 8,000	4	25 x 14 x 10¾	Wal.	Cloth, brn.	55	199.00	No time-delay distortion.
	XII	10	45	Ducted Port	5	Cone	3	Cone	35-17K ±4	10	85	350 7,500	8	25 x 14 x 10¾	Wal.	Cloth, brn.	40	139.00	High efficiency phase-linear X-over.
	Mini III	8	50	Acous.	5	Cone	2	Cone	50-18.5K ±4	20	70	400 8,000	4	19 x 12 x 9½	Wal.	Cloth, brn.	25	99.50	Low-mass driver, e/c. bass resp.
	XI	10	55	Ducted Port	–	–	3	Cone	35-17K ±4	10	70	1,800	8	23 x 12 x 10½	Wal.	Cloth, brn.	28	69.50	Flat resp; high efficiency.

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You'll like the way they sound because they sound the way it is.

When you come right down to it, you buy a speaker system because you like the way it sounds. And if you're like most people you want to hear music that sounds like the original performance. The full natural sound. Uncolored. Unadulterated. You don't want the bass to blast you out of your armchair or highs that sound like chalk squealing on a blackboard. You want proper balance and a distinct separation of lows, midrange and highs. And that's precisely what you get with Pioneer's speaker systems.

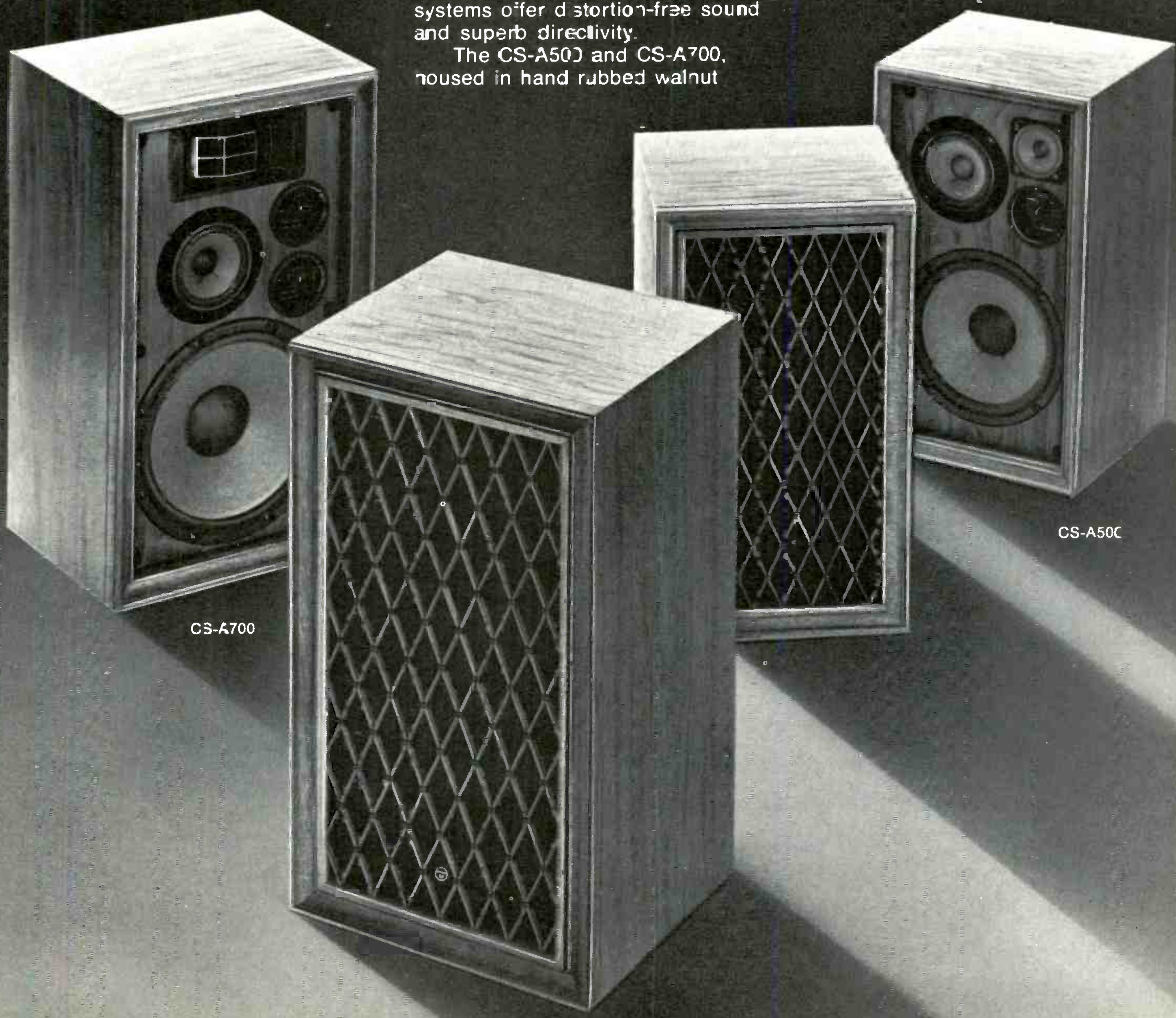
Employing Pioneer's newly developed Free Beating cone, both the CS-A500 and CS-A700 recreate music that sounds as clear and natural as the moment it was born. To keep it that way Pioneer has added a refinement. An easy-to-use level control on both models enables you to adjust the tone of the middle and high frequencies to match the acoustics of any room.

Specifically designed with low crossover frequency points, both systems offer distortion-free sound and superb directivity.

The CS-A500 and CS-A700, housed in hand rubbed walnut cabinets, incorporate Pioneer's latest speaker designs. They are the culmination of three decades of trend-setting audio research to achieve realism in sound. Hear them today at your Pioneer dealer.

U. S. Pioneer Electronics Corp., 178 Commerce Rd., Carlstadt, N.J. 07072

PIONEER



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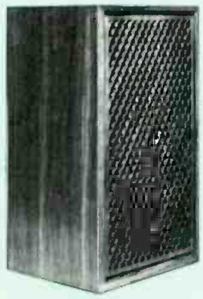
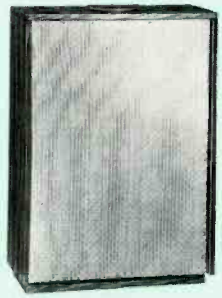
Buyers Guide

Sherwood Berkshire II

Scott S-20



Sansui SP-1001



Schober LSS-10A

Sony SS-9500

MANUFACTURER	MODEL	WOOFER Diameter, In.	WOOFER Resonance (In System), Hz	WOOFER Enclosure Type	MID-RANGE Diameter, In.	MID-RANGE Type	TWEETER Diameter, In.	TWEETER Type	Overall Freq. Response, Hz to kHz ± ? dB	Ampl. Pwr. for Avg. Room, W	Pwr. Handling Capacity (RMS Cont.)	Crossover Frequency (ies), Hz	Impedance, Ohms	Enclosure Dimensions, W x D x H, In.	Wood Finish	Grille Material Color	Weight, Lbs.	Price	SPECIAL FEATURES
SANSUI	SP-2002	12		Duct. Port.	6½ 5	Cone Cone	(2) 1	Dome	35-20K		50	600 5,000	8	15 x 12¾ x 25½	Wal.	Fret-work	46	179.95	Sep. terms for elect. X-over; mid & h.f. contrs; acetate damping material.
	SP-1001	10		Duct. Port.	6½	Cone	1	Dome	35-20K		40	600 5,000	8	14 x 12 x 24½	Wal.	Fret-work	38½	139.95	Sep. terms for elect. X-oper; mid & h.f. contrs: acetate damping material.
	SP-50	8		Duct. Port.			2	Horn	50-20K		25	7,000	8	12¾ x 19¾. x 9¾	Wal.	Fret-work	19¾	79.95	Acetate damping material.
	SP-30	6½		Duct. Port.			2	Sq. Horn	50-20K		20	7,000	8	10¾ x 7⅝ x 16¾	Wal.	Fret-work	10	119.95 Pair	Acetate damping material.
SCHOBER	LSS-100	two 12's	30	Reflex	8	Cone	2 horn 1 horn		30-18K	1	100	150 1,000 3,500	8	32 x 16 x 54	Wal.	Tan Cane	150	499.50 kit	Highest efficiency, extremely low distortion, high power handing auditorium system.
	LSS-10A	12	32	Reflex	8	Cone	Optional 1 horn		30-13K	2	40	250 3,500	8	24 x 16 x 34	Wal.	Tan Cane	60	180.00 kit	Optional tweeter to 18 kHz. High efficiency, extremely low distortion.
SCOTT	Q-100	(2) 8	70	Acous.	–	–	(4) 3	Cone	38-20K	10	80	2,000	8	14¼ x 14¼ x 22	Wal.	Cloth, Dark Brown	37	130.00	Quadrant 360° full range. (Controlled Impedance)
	Q-101	(2) 10	60	Acous.	(4) 4½	Cone	(4) 3	Cone	35-20K	10	100	800 4,000	8	17⅝ x 17⅝ x 22	Wal.	Cloth, Dark Brown	45	220.00	Quadrant 360° full range. (Controlled Impedance)
	S-20	10"	60	Acous.	–	–	3½"	Cone	40-20K	7	50	1,200	8	20 x 11¾ x 11	Antq. Pecan	Cloth Red	21	100.00	Traditional scrollwork grille. (Controlled impedance).
	S-15	10"	60	Acous.	4¼"	Cone	3"	Cone	35-20K	10	50	750 3,800	8	23½ x 11¾ x 9	Wal.	Cloth Dark Brown	24½	119.95	(Controlled impedance).
	S-14	6		Acous.	–	–	3	Cone	50-20K	7	28		8	16 x 10 x 6½	Cont. Wal.	Cloth Tan		45.00	
SHERWOOD	Ravinia III	15	21	Air susp.	5	Cone	3½	Cone	24-22K	10	70	600 5,000	8	25 x 17 x 11½	Oil Wal.	Cloth Brown	50	169.95	Removable grille clutch.
	Berkshire III	12	19	Air susp.	5	Cone	3½	Cone	28-22K	15	60	600 5,000	8	24 x 14 x 9	Oil Wal.	Cloth Brown	40	129.95	Removable grille clutch.
SONY	SS-3100	12	25	Reflex	6½	Cone	2	Horn	30-20K	–	30	400 5,000	8	15¾ x 11⅞ x 26¾	Wal.	Cloth, Black	55	229.50	Sep. sw. for multi-channel use.
	SS-2800	10	30	Reflex	6½	Cone	2	Horn	40-20K	–	20	600 6,000	8	13¾ x 9⅛ x 23¼	Wal.	Cloth, Black	35	124.50	
	SS-9500	(6) 4		Acous.					50-18K	10	50		6	23⅝ x 16 x 14¼	Wal.		30	149.50	Omni-directional.
SOUND-CRAFTSMEN	Lancer SC-6	12	–	Bass energ.	–	Diffuser	–	Flared Horn	18-22K	10	60	1,000 3,000	8	27 x 16 x 14¹/₁₆	Oil Wal.	Cloth, Dark Red Consumer Changeable	57	249.50	Aerodynamic bass energized. 12" passive radiator, cont. var. h.f. contr.
	Lancer SC-3x	12	–	Reflex res. loaded	–	Diffuser	–	Flared Horn	26-22K	10	60	1,000 3,000	8	23½ x 15¾ x 12½	Oil Wal.	Cloth, Dark Red Consumer Changeable	45	199.50	Cont. var. h.f. contr.
	Lancer SC-5	12	–	Reflex	–	Diffuser	–	Flared Horn	28-20K	5	40	1,000 3,500	8	23½ x 15¾ x 12½	Oil Wal.	Cloth, Beige	38	149.50	Cont. var. h.f. contr.
	Lancer 9535-2	12	–	Reflex	–	–	2 x 6	Cone	30-20K	5	35	3,000	8	25 x 14¼ x 11¾	Oil Wal.	Cloth, Beige	34	99.50	Ducted port.

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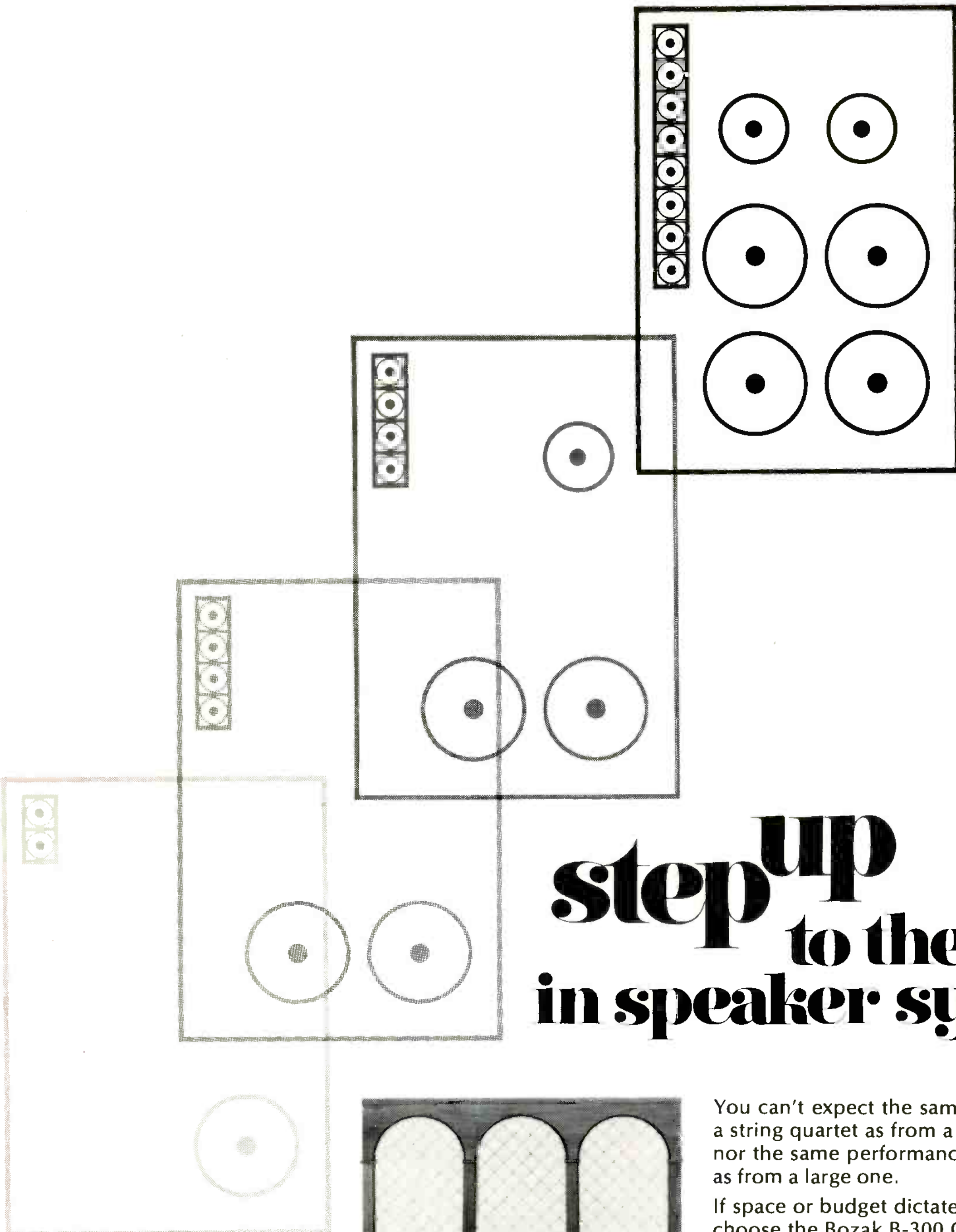
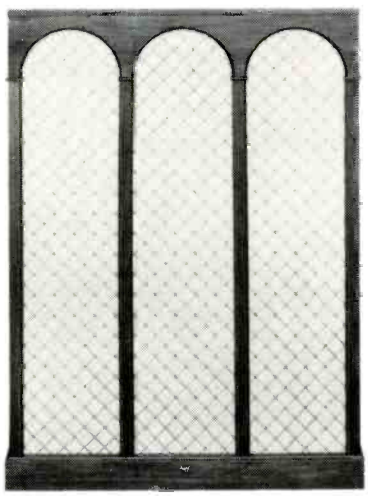


step up to the finest in speaker systems



You can't expect the same full-bodied sound from a string quartet as from a symphony orchestra, nor the same performance from a small speaker system as from a large one.

If space or budget dictate a compact speaker, choose the Bozak B-300 Concerto IV. It's by far the finest in its class. And what's more, you can expand its range and power, step-by-step, into a magnificent Concert Grand in the same way as an orchestra expands — by adding similar instruments, not replacing them with larger ones.

We call it Systematic Growth.

As your hunger for perfection grows and your budget expands . . . as your B-300 builds into a full B-410 Concert Grand, the finest of all speaker systems . . . you preserve your original investment and, at each stage, enjoy The Very Best in Sound possible at the price.

Bozak®

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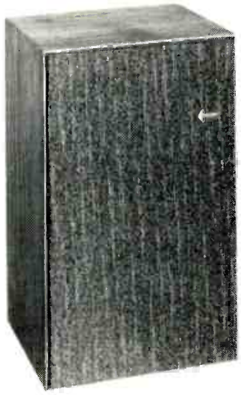
Buyers Guide

Tannoy Orbitus



Trusonic T112-FR

Utah HS

University Presidio

MANUFACTURER	MODEL	WOOFER Diameter, In.	WOOFER Resonance (In System), Hz	WOOFER Enclosure Type	MID-RANGE Diameter, In.	MID-RANGE Type	TWEETER Diameter, In.	TWEETER Type	Overall Freq. Response, Hz to kHz ± ? dB	Ampl. Pwr. for Avg. Room, W	Pwr. Handling Capacity (RMS Cont.)	Crossover Frequency (ies), Hz	Impedance, Ohms	Enclosure Dimensions, W x D x H, In.	Wood Finish	Grille Material Color	Weight, Lbs.	Price	SPECIAL FEATURES
TANNOY	Windsor G.R.F.	15	Cut Off 35	Rear Horn Loaded	–	–	2½	Exp. Horn	35-20K ±4	15	50	1,000	8	23¼ x 17 x 42	Oil Wal.	Dec. Crvd. Wood; Wht. Cloth	120	477.00	Dyn. & frq-bal contr. non-decorator model G.R.F., $420.00.
	Orbitus I	12	40	Reflex	–	–	2½	Exp. Horn	35-20K	20	30	1,000	8	–	Oil Wal.	Dec. Grille	50	245.00	360° omni-dir. sound source (complete integration over aduio spectrum) dyn & freq-bal contrl.
	Mallorcan	12	68	Reflex	–	–	2½	Exp. Horn	45-20K ±5	20	30	1,000	8	23½ x 14 5/8 x 11½	Oil Wal.	Dec. Crvd. Wood; Wht. Cloth	45	219.00	
TEAC	LS-350	12	–	Inf. baffle	4	Cone	2	Horn	35-20K	–	40	700 5,000	8	16 x 25½ x 11¼	–	–	41	–	
TELEX	4400	8	–	Acous.	–	–	3½	Cone	20-20K ±2	–	30	2,500	8	16 x 14 x 5	Wal.	Cloth, Brown	22 pr.	149.95	Two speaker cabinets with built-in 60W stereo power amp; phone jack.
	ES-70	–	–	–	6	Cone	–	–	40-15K	12	–	–	8	11¼ x 11¼ x 5 ea.	Wal.	Cloth, Black	10	69.95 pr.	Built-in stereo pwr. amp; tone and vol. contrs.; phone jack; pilot lt., low-and hi-Zinputs ea.
TRUSONIC	T112 FR	12	–	–	–	–	–	–	–	–	–	–	–	14 x 12 x 23¾	Oil Wal.	–	–	177.00	Incls. 12-inc coaxial. Avail, with 12-in. extended-range spkr, 135.00.
	T-312	12	–	Dual Port	5	Cone	3	Horn	20-25K ±5	12	30	2,000 5,000	8	24 x 12 x 15¼	Oil Wal.	Cloth, Brown	49	129.95	Super toriod tweeter.
UNIVERSITY	Presidio	12	–	Acous.	*	–	**	Dome	25-40K	5	40	1,000 3,000	8	24 x 15 x 23	Wal.	Cloth Lt. Brn.	70	199.95	*Diffusicone® **Sphericon. 12-in. passive radiator.
	Laredo	12	–	Acous.	8	2-way Cone	**	Dome	30-30K	5	40	600 1,500 3,000	8	15¾ x 12 9/16 x 24	Wal.	Cloth Brown	47½	129.95	Brill. & presence contrs; Mustang. components; removable grille. **Sphericon.
	Project M	11	–	Acous.	–	–	2½	*Cone	30-20K	5	60	1,000	8	12¾ x 11 7/8 x 23½	Wal.	Cloth Beige	30	109.95	*Silver-plated al. v.c; high-compl, low res. woofer low distortion.
	Ultra D	10	–	Acous.	4	Cone	3½	Cone	30-20K	3	32	1,000 5,000	8	11 7/8 x 9¾ x 23	Wal.	Cloth Beige	24	89.95	Brill. contrs.
UTAH	AS-6	12	25	Acous.	4 x 10	Horn	1¾	Horn	35-20K	20	30	2,200 5,000	8	25 x 14 x 13½	Oil	Cloth Gold	49	120.00	Credenza; mid. & h.f. contrs.
	HS	12	45	Reflex	2 x 6	Horn	3½	Cone	30-18.5K	10	20	3,500 5,000	8	15 x 25¾ x 14	Oil Wal.	Cloth Gold	46	94.50	Molded Wal. Trim.
	AS-1	10	25	Acous.	–	–	3½	Cone	32-18½K	10	20	3,500	8	24 x 12 x 12	Oil Wal.	Cloth Gold	41	79.95	h.f. cont.
	AS-12	8	–	Acous.	–	–	3½	Cone	40-18K	10	13	4,500	8	18 x 9 x 11	Wal.	Cloth Gold	22	49.95	Bass unit has 1½" v. cont.

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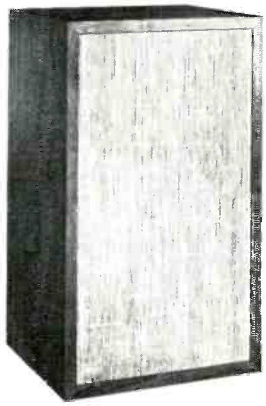
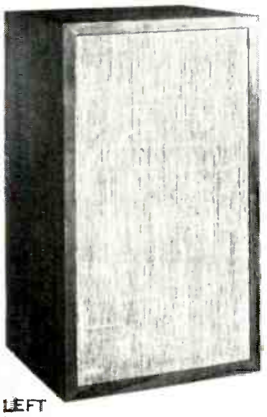
4-Dimensional Stereo

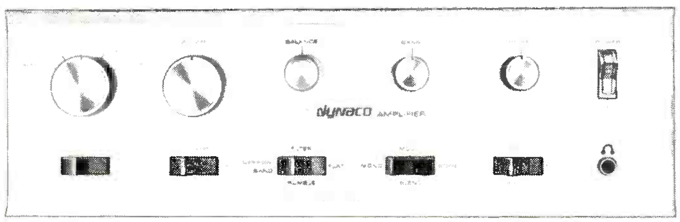


FRONT

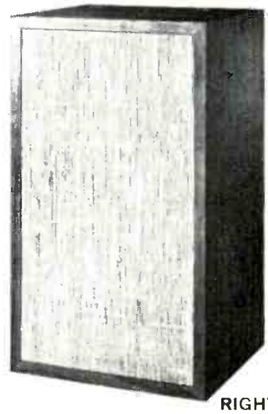
with the Dynaco SCA-80.



LEFT



SCA-80 ($169.95 kit, $249.95 assembled)

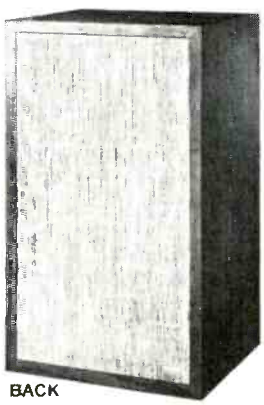


RIGHT

The Dynaco SCA-80 is a high quality two-channel stereo control amplifier incorporating patented circuitry* so you can enjoy the Dynaco system of four dimensional stereo (front and back as well as the usual left and right) by adding just two more loudspeakers . . . just **two** more speakers.

In addition to recordings made specifically for the Dynaco system, many of your **existing** stereo recordings (disc and tape) already include the phase relationships required for four dimensional playback. You can use **present** stereo phonograph cartridges or tape recorders without any modifications. Four dimensional programs are **now** being received by **existing** FM stereo tuners.

*U. S. patent #3,417,203



BACK

The Dynaco four-dimensional system fully utilizes material **already** on stereo recordings. It faithfully reproduces in your own listening room the acoustical environment in which the recording was made.

Dynaco four-dimensional sound can be played back through the SCA-80 (or the PAT-4 or PAS-3x preamplifier and any stereo power amplifier) with a total of four loudspeakers, connected as Dynaco specifies. This configuration is completely compatible with playback of all stereophonic and monophonic recordings, and enhances virtually all stereophonic material.

Write for full details on how you can connect four speakers to enjoy Dynaco four-dimensional stereo.

Dynaco A-25 speakers ($79.95 each—assembled only)

dynaco inc. **3060 JEFFERSON ST., PHILA., PA. 19121**
IN EUROPE WRITE: DYNACO A/S, HUMLUM, STRUER, DENMARK

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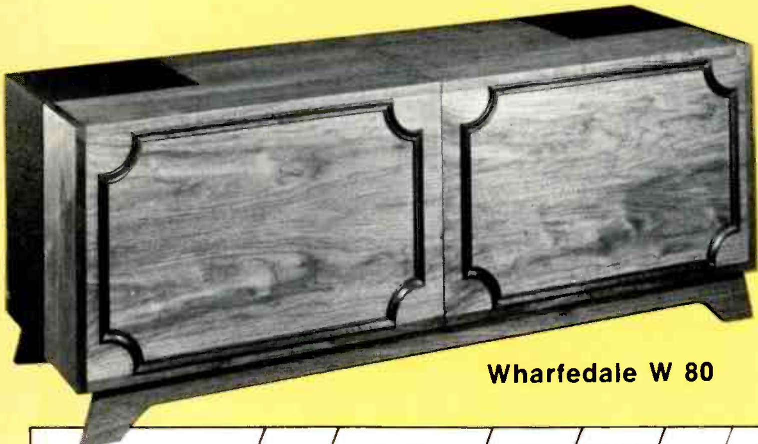
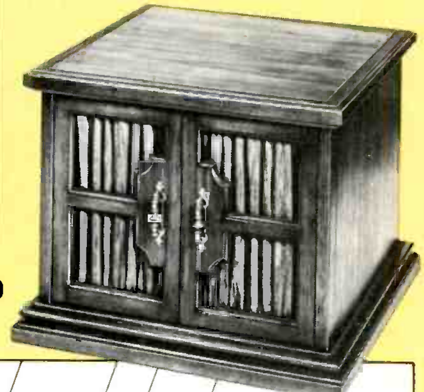


Wharfedale W 80

3M-Wollensak A-2000



VM LS-85

MANUFACTURER	MODEL	WOOFER Diameter, In.	WOOFER Resonance (In System), Hz	WOOFER Enclosure Type	MID-RANGE Diameter, In.	MID-RANGE Type	TWEETER Diameter, In.	TWEETER Type	Overall Freq. Response, Hz to kHz ± ? dB	Ampl. Pwr. for Avg. Room, W	Pwr. Handling Capacity (RMS Cont.)	Crossover Frequency (ies), Hz	Impedance, Ohms	Enclosure Dimensions, W x D x H, In.	Wood Finish	Grille Material Color	Weight, Lbs.	Price	SPECIAL FEATURES
VM	LS-85	8			3½	Cone			35-20K ± 5	10	40	2,000	8	26 x 26 x 20⅜	Pecan	Pecan Ant. Gold	65	210.00	
	LS-84	8			3½	Cone			35-20K ± 5	10	40	2,000	8	19½ x 19½ x 20	Pecalm Elm Inlay	Cane	41	195.00	
	LS-38	5½		Spiral Reflex					60-15K ± 5	4	10			18 x 12 x 12	Oil Wal.	Cloth Black	18	95.00	
	93	10	58	Acous.	4½	Cone	1	Dome	37-22K ± 5	10	40	1,000 5,000	8	23 x 11¼ x 13½	Oil Wal.	Cloth Black	38	129.95	
WHARFEDALE	W90D	12 12	40 45	Acous.	5 5	Cone	3 3	Dome Dome	20 to inaud.	10	50	125 1,000 4,000	4-8	23¼ x 13½ x 30	Wal.	Cloth, Brn. pattern	100	340.00	6-speaker, 4-way system; sand-filled; Div. bass. range.
	W80 Variflex	12	40	Acous.	5	Cone	3 1	Dome Dome	20 to inaud.	15	60	800 2,500 6,000	4-8	17¼ x 17 x 29	Wal.	All wood Front	85	289.95	Reflective sys.; var. acoustic dev.; use use singly or as console.
	W70D Mark II	12	42	Acous.	8 5	Cone Cone	3 3	Dome	25-20K	10	40	175 1,250 5,000	4-8	22 x 13⅝ x 24	Wal.	Cloth, Brn./Gold	73	211.00	Use hi or lo-boy; 4-way sys.; sand filled.
	W60D Mark II	12	45	Acous.	5	Cone	3	Dome	30-20K	8	40	1,000 3,500	4-8	14¼ x 13 x 24	Wal.	Cloth Blk./Brn.	56	153.00	3-way sys.; sand-filled; removeable grille.
	W40D	10	50	Acous.	5	Cone	3	Dome	35-20K	8	35	1,250 3,500	4-8	12½ x 10⅛ x 23½	Wal.	Cloth Mix	37	111.25	Indiv. mid and treble conts; phase-comp. tweeter-diffuser contr.
	W30D Mark II	8	54	Acous.	–	–	–	Dome	40-18,500	10	35	2,000	4-8	10 x 9¼ x 19	Wal.	Cloth Mix	22	69.95	Var. tweeter contr.; Replaceable grille.
	W20D	8	62	Acous.	–	–	3	Dome	45-18K	10	35	1,600	4-8	9¾ x 8½ x 14	Wal.	Cloth Brn./Gold	14	52.95	Var. tweeter contr.; Replaceable grille.
3M/WOLLENSAK	A-2000	8	58	Acous.	–	–	1	Dome	40-18K	20		1,500	5	23 x 10⅛ x 13⅜	Wal.	Cloth	35	159.95 Each	2 controls to voice the woofer in addition to the tweeter control; low/IM distortion.
	A-1000	4	100	Acous.	–	–	–	–	80-12K	10	14	–	8	8 x 5 x 13	Wal.	Cloth Black	4½	49.95 Pair	
	A-1050	4	100	Acous.	–	–	–	–	80-12K	10	14	–	8	7¾ Cube on 5 High Pedestal	Wal.	Cloth Black	4½	79.95 Pair	
YAMAHA	NS-30	25 x 35	Open	Open back	12	Cone	2	Horn		5	30	200 6,000	8	40½ x 29½ x 12½	Oil Wal.	Cloth Beige	77		'Natural sound' piano shaped woofer.
	NS-20	20 x 27		Open back	8	Cone	2	Horn			20	8,000	8	34 x 24 x 12	Oil Wal.	Cloth Beige	51		'Natural sound' piano shaped woofer.
	NS-15	15 x 20		Open back							15		8	23½ x 16½ x 7	Oil Wal.	Cloth Brown	22		'Natural sound' piano shaped woofer.

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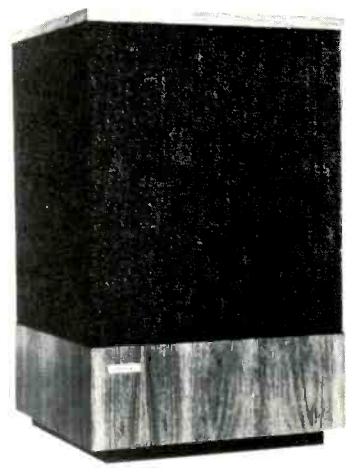

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ELECTROSTATIC LOUDSPEAKERS

George W. Tillett

THE PRINCIPLES of electrostatics as applied to transducers have been known for many years and a complete electrostatic telephone system was actually demonstrated by one Dolbear at the Paris Electrical Éxhibition as long ago as 1881! Electrostatic loudspeakers did not make their appearance until about 1925 and most of the development work for the next fifteen years or so was done in Germany by such pioneer as Ernst Klar and Hans Voght but American physicists like McLachlan, Kellogg and Hanna were also active in this field. In its simplest form an electrostatic speaker consists of a conductive-coated film diaphragm and a metal plate as shown in Figure 1. If a signal is applied between the two, the diaphragm will vibrate accordingly. However, it will always move *towards* the plate as the voltage can only cause an attraction. Consequently, severe distortion will be produced and if a sine wave is applied the speaker will function as a kind of rectifier i.e. both positive and negative pulses will cause the diaphragm to move towards the plate. If a d.c. bias voltage is applied then the diaphragm will be partially compressed and a signal voltage can then cause it to move *both* ways about its biased position. The space between the diaphragm and plate must be very, very small and if an attempt is made to increase the distance so the speaker can can work at lower frequencies then the efficiency falls drastically. Moreover, the distortion will increase due to the force varying with the diaphragm position. Thus, simple 'single-end' electrostatic speakers can only be used for high frequencies. A typical treble unit-popular in Europe in the late 30's and just after the War would measure about 3 inches square and the film diaphragm would actually rest on the metal plate. In operation, such speakers would be connected directly to the anode of the output tube of the receiver, thus using a d.c. bias of some 200 volts.

Some of the more expensive units used two plates in a push-pull arrangement as shown in Fig. 2. Applied force is less dependent on diaphragm position and distortion will be much lower. Obviously, the plates must be perforated to pass the sound. Full-range electrostatic speakers follow the same principles but there are certain problems. To get down to the very low frequencies the gap between the diaphragm and plates must be large enough to allow the diaphragm to move. As mentioned above, this seriously reduces the efficiency. To some extent this can be made up by increasing the bias voltage but we eventually reach a limit determined by a corona or voltage breakdown. The practical maximum voltage is usually calculated by making the breakdown point equal to the bias voltage plus half the signal voltage. Even so, the diaphragm area has to be quite large to radiate enough power at low frequencies with reasonable efficiency. Another problem that worried early designers was the distortion produced by the variation of the diaphragm charge. (See Fig. 3). If a strong signal pulls the film to one side then the capacitances of the two halves will become unequal and the total capacity will be increased beyond the normal C1 plus C2 figure because the net increase is greater than the decrease. This means that the corresponding charge will be higher and the diaphragm displacement will be greater than required. In other words, it would produce a kind of amplitude distortion progressively worse at low frequencies. Fortunately, the cure is fairly simple and it merely entails supplying the charge in the diaphragm via a high resistance. If the time-constant introduced is appreciable compared with the lowest frequency to be reproduced then there can be no significant current flow to or from the diaphragm and the charge is *constant*. Well almost, because there is yet another snag. Figure 4 shows a diaphragm pulled over to one side by the signal with one part nearer the plate P1. It is impossible to maintain 100 per cent accurate spacing and so the charge tends to migrate to a point nearest a plate. What happens then? The voltage would fall elsewhere and so the effect is cumulative and could eventually lead to ionization and actual voltage breakdown-quite apart from causing distortion (1). Again the cure is relatively simple and the answer is to make the diaphragm itself a high resistance so the charge cannot move about. Colloidal graphite or vacuum formed gold are two materials used and typical resistance is between 50 and 100 megohms per inch.

How about dispersion? A push-pull speaker will have a figure-of-eight or doublet configuration although experimental models have been made with the rear radiation suppresed—or partially so. If the width of a flat sound source is equivalent to more than one wave-

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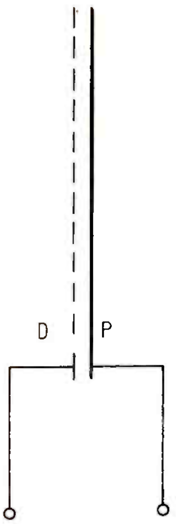

Fig. 1—Showing simple ESL arrangement.

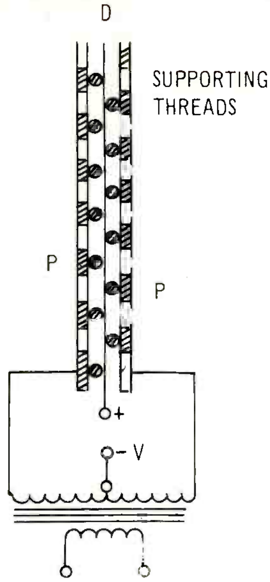

Fig. 2—Push-pull construction. PP are perforated metal plates (sometimes curved) D is the diaphragm.

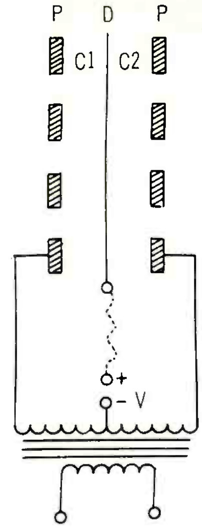

Fig. 3—Push-pull configuration with transformer.

length of the lowest radiated frequency, dispersion will be poor with lobes and beaming. One solution is to curve the radiating surface by using several diaphragms spaced in the form of an arc. Another method is to use narrow strips connected as shown in Fig. 5. All the signal is fed to the center pair and resistors progressively reduce the levels at each side [2]. A separate bass diaphragm would have to be employed and in the Quad model this is in two sections placed each side of the central treble unit. The step-up transformer is specially designed to also act as a cross-over by the ingenious method of using the leakage inductance in conjunction with the capacity of the actual bass unit. Roll-off is about 12 dB per octave.

It has been said that the diaphragm of an ESL does not 'break-up' as it is driven as an entity. This is not true because the mechanical impedance is not constant due to the edge clamping where it is partly stiffness controlled. It can be shown that nodes and anti-nodes do exist-just as in cone speakers [3].

The inherent distortion of an ESL is very low and Professor Hunt quotes figures of less than 0.5 per cent second harmonic under worst conditions of unbalance [4]. Transient response is also extremely good as the moving mass is small. On the other hand, overall efficiency of models at present available is still on the low side-probably not a serious disadvantage-and extreme low frequencies cannot compare with good dynamic systems having 15 or 18-inch dynamic woofers. Because of the doublet configuration, minimum power is radiated at right angles to the axis and so fewer modes of room resonance are excited. In theory, maximum bass radiation will occur when the speaker is placed in the center of a room—in other words the diaphragm impedance is matched better by the lower radiation impedance but in practise the best position is usually two or three feet from a wall. Finally, early ESL's were considerably superior to contemporary dynamic types in respect to coloration. No enclosure—so no box coloration. . . . However, new techniques, better cone materials and enclosure designs have improved conventional systems enormously during the past few years and there are now several dynamic speakers that can stand comparison with the best ESL units. Pros and cons were neatly summed up by Peter Walker, inventor of the Quad speaker some years ago "The horse and the motor car are both effective forms of transport, but the car is not very good at jumping a five-barred gate, nor is it seen at its best in a ploughed field." Æ

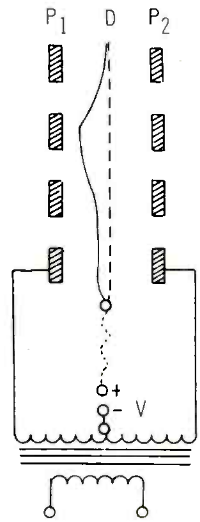

Fig. 4—Showing diaphragm displacement.

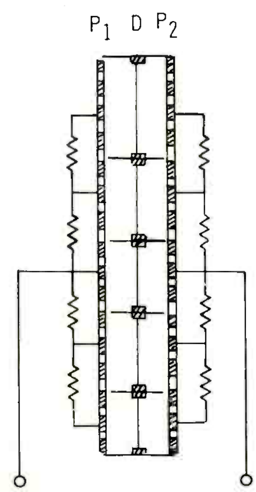

Fig. 5—Method of signal grading or distribution.

1. "Full-range electrostatic speakers". Wireless World. May. June and August. 1955. An alternative design was proposed by H.J. Leak and A.B. Sarkar. This was a reversal of the type shown and the plate is in the middle with a diaphragm each side.
2. Another possibility is the use of diaphragms having a graded resistance. Some models use separate LF and HF transformers which gives some flexibility.
3. "Loudspeakers" by Gilbert Briggs. Cahners Publishing. Boston Mass. See also "Loudspeakers" by E. Jordan, Focul Press, New York.
4. "Electroacoustics" by Professor F. Hunt. Harvard University Press.

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DOPPLER DISTORTION AGAIN?

Roy F. Allison*

The recent resurgence of discussions on Doppler distortion, or loudspeaker FM distortion, is cause for some surprise. One would think that by now most sensible people would realize that it is an imaginary menace in multi-way speaker systems, in much the same way that Tired Blood is a disease invented by the sellers of patent medicines. Jordan (1) has remarked that Doppler distortion "along with the Loch Ness monster, flying saucers and the Yeti, has provided a small band of devotees with an interest in life whilst the vast majority of people have been unaware of it. . .after devoting a quarter of a century to the design and development of loudspeakers I have yet to encounter any significant distortion due to Doppler effect."

For some perspective on the matter we should, first, consider real-life acoustic power requirements. According to Olson (2), a reverberant field of 100 dB SPL will be generated by 0.5 acoustic watt in a room of about 3,300 cubic feet. That is a large living room by any standards; typical dimensions for such a room might be 14 by 30 ft., or 16 by 26 ft., with normal ceiling height.

* Acoustic Research Inc.

To generate peaks of 100 dB SPL, then, each speaker system in a stereo pair must produce peaks of 0.25 acoustic watt (we should be able to assume that very low-frequency signals will be in phase). And allowing a peak-to-average ratio of only 10 dB, the *average* acoustic power output from each speaker system will be .025 watt. These power levels will produce very high sound amplitudes—as high as listeners experience at a good concert-hall seat with a large orchestra playing full blast. Levels much higher than this are likely to cause hearing impairment. Who needs an acoustic watt to live with at home?

Second, let us take a realistic look at the acoustic outputs *obtainable* at very low frequencies. It is the nature of closed-box speaker mechanisms of any size that, for flat electrical inputs, the amplitude of cone motion does not increase below the system resonance frequency. It remains relatively constant. This is an advantage over vented systems in that the speaker will not damage itself by exceeding the permissible excursion of the suspension. It also means, of course, that the output (response) drops off below the resonance frequency—not as rapidly as it does in vented systems or horns, but rapidly enough. But the main point is this: it is meaningless to consider the speaker's performance for 1 acoustic watt output, or even for 0.25 acoustic watt output, at 30 Hz. A speaker simply will not produce that much usable output at that frequency: it will be overdriven. Consequently bass boost (to compensate for the fall-off below resonance) is not a permissible procedure to maintain such a high output level down to 30 Hz.

The most potent low-frequency speaker system I know of is an acoustic suspension direct radiator. It has a system resonance frequency of 44 Hz and a Q of 1. It will produce a relatively clean 0.25 acoustic watt at 40 Hz, but at 30 Hz it requires 100 watts input to produce ¼ watt output, the cone movement exceeds one inch, and the THD is about 30%. For purposes of calculating worst-case FM distortion, therefore, the maximum amplitude of low-frequency cone motion is limited by practical considerations to that for 0.25 acoustic watt at 40 Hz. For most speaker systems it is far less.

With these sobering facts in mind, let us use Greiner's (3) tabular format for a 10" diaphragm and recast FM distortion for realizable cases. The formula used (4) is:

$$D = \frac{2900\, f_2 \sqrt{P_1}}{f_1^2\, d^2}$$

where f_2 = modulated (high) frequency, in Hertz;
P_1 = acoustical power output at f_1, in watts;
f_1 = modulation (low) frequency, in Hertz; and
d = cone diameter, in inches.

The advantage of this formula is that it avoids the need to calculate separately the amplitude of cone motion. For informational purposes, however, the peak-to-peak cone excursion for each case is included in the table.

(Continued on page 56)

FM Distortion for 12" Woofer (10" cone)

	Acoustic Output at Low Frequency			
	0.25 Watt Peaks		.025 Watt Average	
Frequencies	FM Dist.	Cone Movement	FM Dist.	Cone Movement
30 (40) & 300	(2.7%)	0.57" (40 Hz)	1.5%	0.32" (30 Hz)
30 (40) & 500	(4.5%)	0.57" (40 Hz)	2.5%	0.32" (30 Hz)
30 (40) & 1,000	(9.1%)	0.57" (40 Hz)	5.1%	0.32" (30 Hz)
50 & 500	2.9%	0.37"	0.92%	0.12"
50 & 1,000	5.8%	0.37"	1.8%	0.12"
100 & 1,000	1.5%	.095"	0.46%	.030"

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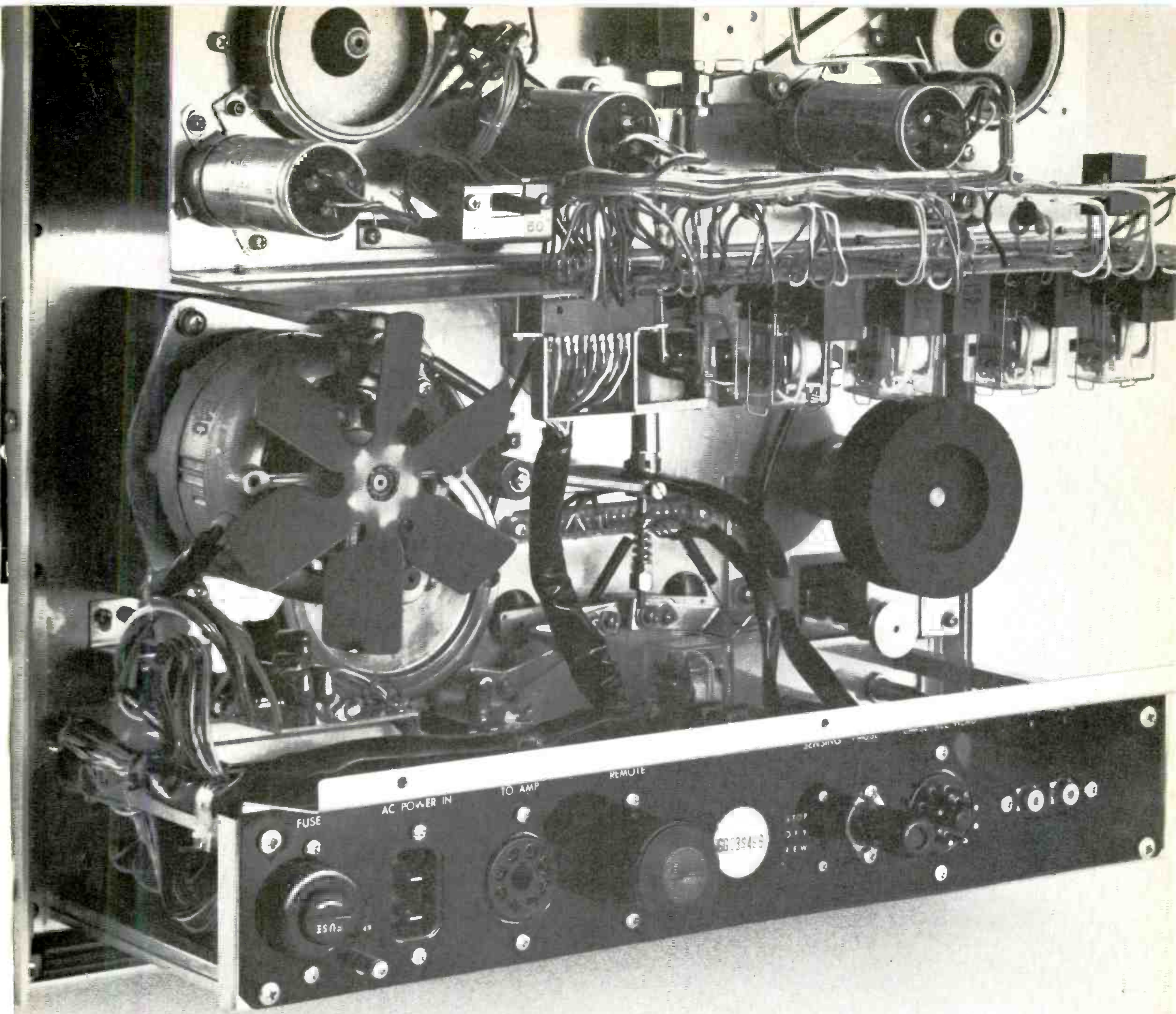

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(Continued from page 54)

It should be kept in mind that these FM distortion figures are those obtained under worst-case conditions—when the speaker system is pushed to its maximum low-frequency capability. This would rarely (if ever) be experienced in home use. But even if the numbers are not as high as those published by Klipsch and Greiner for absurd theoretical conditions, they are still rather large as conventional distortion figures.

Most impartial observers have expressed an inability to reconcile these large numbers with listening experience. It has been pointed out, correctly, (5) that there must be a major difference in annoyance value between FM distortion and some other kinds; otherwise, how would it be possible with such speaker systems to stage completely successful live-vs-recorded demonstrations, involving audibly perfect reproduction of complex live sounds such as that of a string quartet?

This proposition is supported by close examination of a process that everyone has experienced: listening to recorded music. Both tape machines and record players have mechanical imperfections that result in speed irregularities. Tape does not move by the heads at a perfectly uniform speed. A record does not revolve around the spindle at a perfectly constant speed. These deviations in speed are measured as percentages of the mean speed, and the word used to describe them is flutter. Flutter produces FM distortion just as the Doppler effect does.

As applied to loudspeakers, flutter would be the ratio of cone velocity at the modulating frequency to the velocity of sound in air, expressed as a percentage. On these terms, the maximum flutter would occur for two conditions described in the preceding table. Flutter under these conditions would be 0.52% peak, 0.33% average, for 0.25 acoustic watt output at 40 Hz; and 0.22% peak, 0.14% average, for .025 watt output at 30 Hz.

The NAB standard limit for reproducing turntable flutter is 0.1% average. If it is assumed that the flutter is sinusoidal this is equivalent to 0.16% peak. That assumption is not warranted for most turntables—even very high-quality units generate flutter peaks exceeding 0.16%. Moreover, the audio signal on the record has had already superimposed on it the flutter from two or more generations of tape recording and playback, as well as that of the recording turntable. The situation is likely to be worse for playback of recorded tapes. For either medium it is simply not realistic to expect occasional flutter peaks of less that 0.5%. This total amount of flutter produces FM modulation that is operative on all frequencies, even the very highest, and it is present in the same degree regardless of signal level. Yet it is considered to be marginally objectionable if at all.

Thus it is fair to say that *under worst-case conditions, the FM modulation distortion of high-quality direct-radiator speaker systems is comparable in magnitude to, or less than, the FM modulation distortion that is always present in the recorded signal anyway.* If one is not audibly important, neither is the other. My guess is that people who claim to have heard loudspeaker Doppler distortion were really hearing nonlinear distortion in the speaker system, or amplifier overload.

Of course if all other things were equal it would be better to have no FM modulation distortion rather than even a small amount. It would be better to have no nonlinear distortion generated by the very high pressures in horn throats, rather than even a small amount. It does seem inefficient, however, to waste so much time and attention on trivial imperfections when there are important problems to be solved. Æ

(1) **Jordan, E. J., "The Design and Use of Moving-Coil Loudspeaker Units," Wireless World,** November 1970.

(2) **Acoustical Engineering,** Harry F. Olson, p. 524, Van Nostrand, 1957.

(3) Greiner, R.A., Letter to the Editor, **Audio,** December 1970, p. 14.

(4) **Acoustical Engineering,** Harry F. Olson, p. 190; Van Nostrand, 1957.

(5) See **Audio,** October 1971, p. 44.

Erratum
Sound Level Meter, December 1970

The resistor R6 should be 100 K as in the parts list, not 10 K as shown in the schematic. C11 should connect to the "flat" terminal of the switch, but not to C9 and C7. The output of the "A" filter should be taken from the junction of R14 and C5, not from C4 as shown.

(Continued from page 32)

These then are the quantitative expressions of what I have come to call Hofmann's Iron Law(3) *prescribing the amount and direction of change that* must *occur in one or two or three of the remaining terms when any one is changed.*

Note that this law does not say what happens to any one term as a given term is changed, that is, for instance we are not told how efficiency changes if the volume changes. (In fact, it doesn't change at all.)

Once it is decided to vary any term in this statement, it is up to the designer to rearrange physical parameters both to accomplish this change and properly apportion the necessarily resulting change in the other terms to make the most acceptable "new" speaker.

This iron law which shows difficult and frustrating constraints facing an engineer (but apparently not every advertising department) can also console one that the "improvement" one can make over an already properly designed speaker must be nil, independent of his resources or intelligence. A very constructive use can be made of this law by noting not only what it *requires* but what it may *allow*. Physical laws are not inherently malevolent, after all. For instance, we might observe that one could start with a loudspeaker of truly distinguished low frequency performance and keeping FR and FD the same have exactly that same shape of curve in one half the volume at 3 dB less efficiency. Arguing the possible value of such a special speaker is outside the scope of this article; our only intent here is to prove that it is possible and even indicate how the physical parameters should be juggled to achieve the result. Æ

1. Technical articles back to Rice and Kellogg's of almost 50 years ago have described this natural occurence of ideal flat behavior. More recently Audio covered the subject well in the March 1970 loudspeaker issue. Our treatise assumes a vague-to-working familiarity with the content of such tracts. We are just offering a statement of consequences of the facts which have been well reported.

2. This parameter, which occurs in the expression for efficiency (establishing the force delivered to the moving system as a function of electrical power input) is the same parameter that determines the resistance offered to the moving system by a shorted coil in a magnetic field which, although it is an impedance (real), we are calling "damping force." The expression for strength of motor in terms of physical parameters is approximately magnetic field times volume of conductor. Since those terms always occur together in describing performance characteristics, we shall carry them along, describing them solely as "motor." The designer can then decide how he apportions values between magnetic field and volume of conductor to get the required motor and then decide how he subdivides this volume of conductor to get his desired impedance level. To drag along length of conductor, etc., through all which follows would really obscure the picture.

3. Dr. J. Anton Hofmann first introduced the term "damping frequency" about 16 years ago when the author was struggling with the design of the first of this then-new type of loudspeaker, the AR-1. The use of the term as a manipulative device and, more importantly, the expression of the interrelationships of the "value in use" characteristics that the use of this term revealed were a powerful tool that permitted the designer easily to systematize the design of low frequency loudspeakers. Dr. Hofmann later lent his initial to another loudspeaker company and subsequently has become treasurer and chief-enforcer-of-rigor of Advent Corporation.

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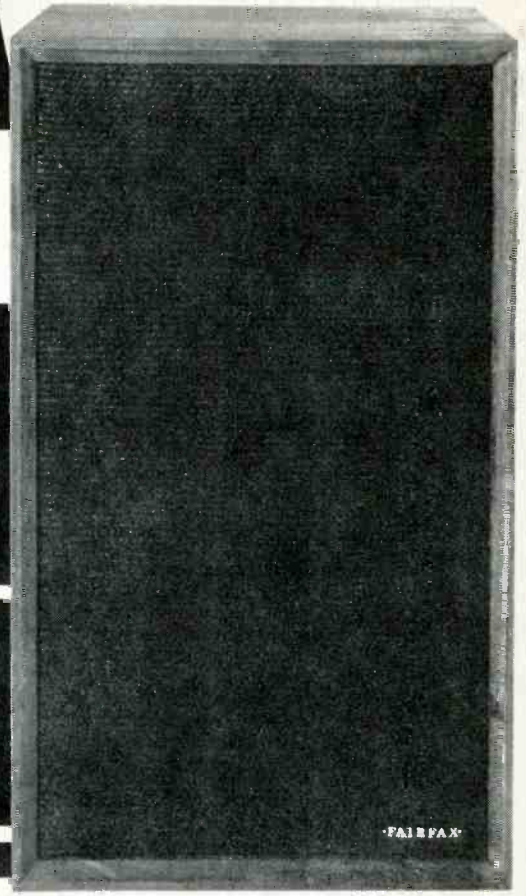

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Canby Looks At Multi-Channel Systems

Recent four-channel excitement has greatly pepped up our interest in that perennial problem, the listening room—pending the magic moment when four-channel sound breaks forth and transports us straight out of our home environment into sonic nirvana. While we wait (and most of us will) there are some instructive and amusing things we can do to fix up the old place into a semblance of paradise to come. I hereby offer a few personal comments on a few of them that you may have read about and perhaps even tried. We'll trade notes.

For all our talk of 3-D stereo these many years, the fact is that until now our room sound, for our ears, isn't even *in* the room; it's out there on the other side of the wall. An invisible red plush velvet rope is draped from one of our speakers to the other, marking the front edge of the space we think we hear beyond. The idea now is to stretch that rope forward, over our heads and right out through the back wall. True four-channel does its best. But there are other ways to do it too.

We should give thanks to Dave Hafler of the Dyna Company for at least one of his altruistic suggestions towards deriving extra channels out of two-channel sound. Not his fancier system, which I will call Dyna 1. It's the simple-minded circuit, Dyna 2, that I like, even if I did blow an amplifier setting it up.

The trouble with his four-channels-out-of-two Dyna 1, which places a speaker in front, one in back, and one to each side, is that like all the new systems for deriving four channels out of two, it requires a complementary sound source, a record or broadcast done via its system, in order to be heard at all. Dyna 1 does have the virtue of costing nothing—aside from the second pair of speakers and amplifier. No black boxes. But when I had it set up in my living room there was only one Dyna demo disc, an item which intoned such interesting information as "Now you hear me in the back speaker" (I did). But the music on it was unfortunate and the sound so irrelevantly scratchy that one playing was enough. So I took the system apart again. (Dyna has another and better demo disc en route.)

But ah!—Dyna 2. Much more rudimentary and far more practical for you and me, pending real four-channel. This is the system where a single additional speaker is hooked into your present stereo and placed behind your listening spot, with an L-pad volume control for adjustments, to play ordinary stereo records and broadcasts a three-way sound spread. All you need is that old extra speaker in the attic and a length of wire, plus the L-pad. Pennies. But it can reproduce a surprising variety of interesting effects, all out of the sound material you already have on hand. I have the Dyna 2 semi-permanently installed, though I often turn it off in favor of straight stereo or for neutral news and the like.

The hookup is simple, if you haven't seen it before. Just add your extra speaker connections to the two "high" (non-ground or non-common) speaker terminals, on each half of the stereo amplifier, and run them through the L-pad to the third speaker. Leave all else the same. One **WARNING: Do Not wire the L-pad in backwards!** I did, and blew out a tired channel A amplifier and its speaker all in a flash, *splat.* Right way 'round, the L-pad keeps an even electrical load on the amplifiers (usually 8 ohms) while varying the extra speaker's volume. Backwards, it shorts the speaker out at one end of its turn, which makes both halves of your amplifier extremely unhappy. Only one of mine survived. But the replacement amp unit seems happy enough now that I have corrected the error.

It is fascinating to browse through stereo with Dyna 2. There is an amazing difference in the amount and quality of "L-R" (left minus right) sound, the stereo difference information in the signal that is selectively syphoned off by the rear speaker. In some stereo sources there is very little, hardly enough to be noticed even with the back speaker wide open. In others, the extra speaker suddenly booms out and you must turn it far down. In some recordings there is merely a discreet reflected-background effect, spreading

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the whole sound demurely into your room. In others that same speaker is a loud third point-source, or it wrenches parts of the stereo image into odd positions around the room, maybe off to an unexpected Northwest quadrant, so to speak, or strongly to one side—an interaction between rear and one side speaker. I listened, off-center, to the Beethoven Trios one night and found Eugene Istomin's piano very positively located in front, well beyond my regular stereo speakers, Leonard Rose and his cello sitting to my right rear and Isaac Stern's violin coming straight out of the left front speaker. Definitely, they had me surrounded And this from a regular stereo record!

A "live" broadcast of the Boston Pops concert, on the other hand, produced a fine expanse of surround sound all over the place; you could hear the plates and spoons and beer glasses clinking on all sides. I speculated that this was thanks to an original four-channel set-up, even though the broadcast came via two-channel stereo from New York. Some of the four-channel spatial-difference information had been preserved and was retrievable even with this simple arrangement and a single amplifier.

Generally, "live" mike pickups (usually recorded, but miked "live") make the best effect via Dyna 2, probably because there is much random out-of-phase or difference information available for the back speaker—unintentionally for the most part, like the clinking beer glasses. Studio and hall recording sessions are more carefully controlled.

Since the difference information is out of phase, you will get an odd effect if your regular stereo is accidentally or intentionally reversed in phase. Virtually all the sound, the entire mono complement, goes to the rear speaker, which takes over the room. Interesting, if irrelevant. And a good phase test. Mono sound goes to the front speakers alone with only a small leakage into the rear speaker. Out-of-phase mono goes straight to the rear, an even more positive phasing test.

I am as much for the new values in four-channel recording as I was last summer and the summer before. I increasingly enjoy the format even without specific recordings made deliberately to match it. But the long delay in effective commercialization that has *already* occurred as I write is not, I think, to be blamed on any inherent lack of value of the idea of quadraphonic sound.

Instead, it is technological, and precisely the inverse reflection of the growth of tape. The trouble has been, very simply, that we have been unable to produce that precise compatibility which is now becoming a feature of standard two-channel recordings: The ability to release one and the same master recording in various formats without major differences in the result, whether via tape or disc. Quadraphonic systems have lamentably divided into those which reproduce four *equal* channels of information and those which, often with ingenuity and subtlety, recreate four channels out of two with varying degrees of *inequality* and/or non-literalness.

This is not to argue for or against either approach. What matters is the lack of *parallel compatibility* between the different approaches, the equal-channel quadraphonic systems and the not-quite-equal and/or not-quite-literal systems. In comparison, compatibility between quadraphonic, two-channel, and mono is a much lesser thing. That will take care of itself, one way or another. The large differences between *parallel* systems is the joker. For we cannot, as of now, think of them as *alternative* media for the same basic sound—as we do in the established formats now on the market.

If, as may happen, we can find an aesthetic compromise so that we are indeed able to do that very thing, treat the alternative systems as acceptable variants on the same theme, all will be well. Differences, yes, but not too drastic for assimilation, like the minor difference between standard stereo releases in alternative tape and disc formats. But can we? Will any currently offered disc system offer an effect close enough to that of a four-equal-channel tape system to be considered as an alternative release?

Can we assume, for instance, that a basic four-channel recording of the Beethoven Ninth Symphony, or "Kismet," or the Rolling Stones, can go out on tape, cassette or cartridge, and also be released on four-channel disc (whichever system) under the same name as *the same recording?* That is the crux. That is the sort of compatibility which has in fact been achieved as between disc, LP and 45, and tape in four-track, eight-track, reel-to-reel and cassette. Six different formats, different but approximately equal. If not equal, then complementary, each with its own mildly differing values. Can quadraphonic sound achieve the same via presently offered alternative systems short of a Teldec-type disc? I wonder.

Audities

‡ On the musical side, we should note that in these last two years or so there has been a quiet but enormously important musical revolution going on: The death of many of the last great wave of purely "symphonic" orchestral conductors—those who have specialized in the bravura art of conducting the old-fashioned symphony orchestra. Many of the outstanding men of our time went out during the postwar years: Toscanini, Bruno Walter, Furchtwängler, Koussevitsky, Sir Thomas Beecham, Pierre Monteux, Fritz Reiner—pardon me if I omit a few dozen more. But there are many left to carry on the old traditions: The durable Stokowsky, for instance, who began conducting somewhere around 1910 and took over the Philadelphia Orchestra in 1912; Klemperer, Angel's prize man, whom I remember as an older-gentlemen conductor doing some of the very first Vox releases in the late forties; Ormandy, who took over the Philly from Stoky about a thousand years ago.

But now they are dying, if not like flies, then like elderly conductors who are merely human. George Szell! And it was a shock to hear that Sir John Barbirolli, the ultimate Englishman (in spite of the Italian name), had died this last summer of 1970. He was that poor little Britisher who had the unlovely job of taking over the New York Philharmonic when Toscanini dramatically stepped down in 1936, soon to have the fabulous NBC orchestra built for him.

Another revolution is just now getting underway. Leonard Bernstein started it, at least in these parts. First, he was a plain American, minus the fancy accent and the European tongue-twister designation. And he was young! Unheard-of. But more sensational and a lot more significant was the fact that, at long last, he was not *only* a conductor. He was a practicing pianist (rather than an ex-player.) He was a classical composer of importance, an astonishing thought for our generation, if not for the dim, distant past. But—phew!*@!—he also wrote *popular music!* You can't imagine, if you are youthful now, what a sensation that made. The Beginning of the End.

No matter that "Lennie" has become something of a conservative in his present interpretations and is heavily frowned on (as might be expected) by all the young pros in the business, he did it first. He started the New.

You see, today most of the new young conductors fulfill that role only part time (and very often with several orchestras a half-world apart). They compose. They perform. They go in for all sorts of things not directly intended for old-fashioned symphony orchestras, like tape music. Can the orchestras themselves (and their usually conservative audiences—not to mention their trustees) be far behind? Not very, unless they want to be left altogether out of sight. Æ

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Equipment Profiles

Marantz Model Nineteen FM Stereophonic Receiver

MANUFACTURER'S SPECIFICATIONS:

FM SECTION: **IHF Sensitivity:** 2.0μV. **S/N:** 73 dB. **THD:** (Mono and Stereo): 0.15% maximum. **Frequency Response:** 20 to 15 kHz ± 0.5 dB. **Stereo Separation:** 45 dB @ 1 kHz. **38 kHz Supression:** 65 dB. **67 kHz Supression:** 65 dB. **Selectivity:** 50 dB.

AMPLIFIER SECTION: **RMS Power Output:** (both channels driven): 50 watts per channel at 4 or 8 ohms; 30 watts per channel at 16 ohms. **THD:** 0.15% Maximum. **IM:** 0.2% maximum. **Power Bandwidth:** 7 Hz to 40 kHz. **Hum and Noise:** high level, -80 dB; phono, 1 μV. equivalent input (74 dB below a 5-mV. signal input referenced to full output). **Damping Factor:** 80 at 8 ohms. **Frequency Response:** high level, 20 Hz to 20 kHz ± 0.5 dB. **RIAA Equalization on Phono:** + 0.5 dB. **Input Sensitivity:** high level, 100 mV.; Phono, 1 mV.

GENERAL: **Overall Dimensions:** 18¼ in. W. x 6⅛ in. H. x 16 in. D. **Shipping Weight:** 46 lbs. **Suggested Retail Price:** $1000.00 (walnut cabinet optional extra).

In reviewing a $1000.00 receiver, such as the new Marantz Model Nineteen stereophonic receiver, one almost has to take a completely new perspective. *Of course* a receiver such as this meets all of its specifications with plenty of margin. Certainly, the construction, choice of components, chassis layout, and styling leave practically nothing to be desired. The real question, it would seem to us, is, "In what ways does this receiver justify its price tag as compared with, say, the next lower-priced group of receivers?" The answer involves so many extraordinary features (some obvious, some subtle) that a goodly portion of this review will be devoted to them.

To begin with, the front panel is constructed of heavy gold-anodized aluminum into which has been set a long, black, molded bezel, surrounding the tuning dial, horizontal tuning flywheel, and the oscilloscope display and its associated controls. The flywheel tuning control has appeared on Marantz products before, and whether you use your thumb or your forefinger to spin it, it is still just about the smoothest and neatest tuning control extant. The action involved in using this control somehow lends a measure of precision and control of tuner setting not possible with the more conventional "twist and turn" tuning knobs. Moreover, this is obtained without sacrificing speed of getting from one end of the dial to the other—human engineering at its very best. With fewer mechanical linkages involved (the flywheel has the dial string wound directly on its shaft), the "feel" of this tuning mechanism has just got to be smoother than most others—and it is. Other familiar trademarks are the large, matching, metal-turned knobs used for signal-source selection, balance, volume, bass and treble, and speaker selection. The tone control knobs are dual concentric, providing individual bass and treble adjustment of each channel. The speaker selector switch has positions for MAIN, REMOTE, or BOTH sets of speakers, as well as an OFF position for headphone listening. There are 10 push-buttons arranged horizontally across the front panel expanse. All are the push-to-actuate, push-to-release type, and they control such features and functions as the various scope operations, TAPE MONITOR, MONO/STEREO, phono input choice (there are two), high-frequency blend (for noise elimination during noisy stereo broadcasts), low and high frequency filters, and an FM muting on/off switch. At the extreme right of the panel is an ANTENNA ATTENUATOR switch for use in overly strong signal areas. Power is applied to the unit by means of a separate switch located at the right of the panel, above the usual stereophone jack. DUBBING-IN and DUBBING-OUT front panel jacks for use with a tape recorder (without having to get at the back of a custom-installed receiver) are not new, but in this Marantz version, the DUBBING-IN jack has a built-in switch which automatically disconnects the rear panel TAPE INPUT jacks when you insert a standard three-conductor phone plug. Thus, the playback of an extra tape recorder via this front jack is made possible without any interaction, impedance loading, etc. even if another permanently installed tape recorder is connected to the rear TAPE INPUT jacks. The DUBBING-OUT jack, on the other hand, is connected in parallel with the TAPE OUTPUT jacks on the rear panel. Thus, it is possible to record into two tape recorders at once, solving the problem of long-duration programs involving the use of more tape than your reels can hold and avoiding the loss of critical passages during reel changing.

Along the bottom edge of the rear panel of the Model Nineteen are a three-terminal barrier strip for connecting either a 75-ohm or a 300-ohm antenna transmission line, an eight terminal barrier strip for main and remote speaker pair connections, a line fuse, input jacks for PHONO 1, PHONO 2, TAPE, AUX 1, AUX 2, and the TAPE OUTPUT jacks previously referred to. A convenience a.c. outlet, as well as a ground binding-post terminal, are also provided on this panel.

Since the model Nineteen is equipped with a quick-acting output protection circuit, no other fuses (such as speaker-line fuses) are required.

Interior views of the chassis clearly illustrate the well shielded construction of both the r.f. front-end and the i.f. sections of this receiver. The low-level magnetic preamp circuitry is also enclosed in a metal shield.

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Circuitry

The block diagram is reproduced from the well written customer's illustration manual supplied with the Marantz Nineteen and represents the basic circuit blocks of *one channel only.* The r.f. amplifier utilizes a MOSFET dual-gate transistor which is a.g.c. controlled. The i.f. section is modified Butterworth-type filter configuration which requires no alignment and which results in a phase-linear 200 kHz pass band with sharp cut-off slopes. This pass band characteristic provides improved selectivity as well as excellent stereo separation. A multi-stage limiter amplifier feeds the FM detector circuitry from which the composite audio signal is fed to the scope display circuits, as well as to the stereo multiplex circuitry. The latter circuits feature automatic triggering of the stereo indicator light located in the dial calibration area, as well as the stereo demodulator circuits.

Audio signals, routed by the selector switch, are fed through the various control circuits and to the tone-control circuits, which use a continuously variable Baxandall feedback configuration whose response curves closely approximate the Fletcher-Munson loudness contour curves. For this reason, Marantz chose *not* to incorporate a LOUDNESS CONTOUR switch in the Model Nineteen.

Beyond the input of the predriver stages, all succeeding amplifier stages are direct-coupled through to the loudspeakers providing instant recovery from overdrive or short circuit conditions. Upon turning the unit on, the constant current supply for the prediver input stage provides a few seconds of delay before the circuit is activated. In this way, turn-on pops and pulses are effectively eliminated. The output stages themselves are push-pull, complementary-symmetry transistor pairs.

An electronic circuit senses the peak output current and voltage across the output transistors and limits the current to the driver stages to a safe predetermined value. This limiting protects the driver and output stages under overdrive and short circuit conditions and prevents the driver and output transistors from exceeding safe operating conditions. In addition, a relay protection circuit automatically disconnects loudspeakers and headphones in the event of a failure of the output or driver circuits. The presence of any significant amount of d.c. voltage at the output terminals will activate this relay, since normally, the balanced dual power supply would result in negligible d.c. voltage at this point.

Fig. 1—Showing the rear panel.

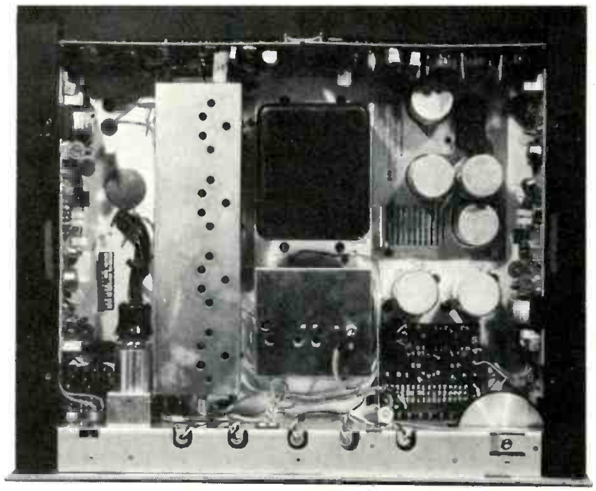

Fig. 2—Top view of chassis.

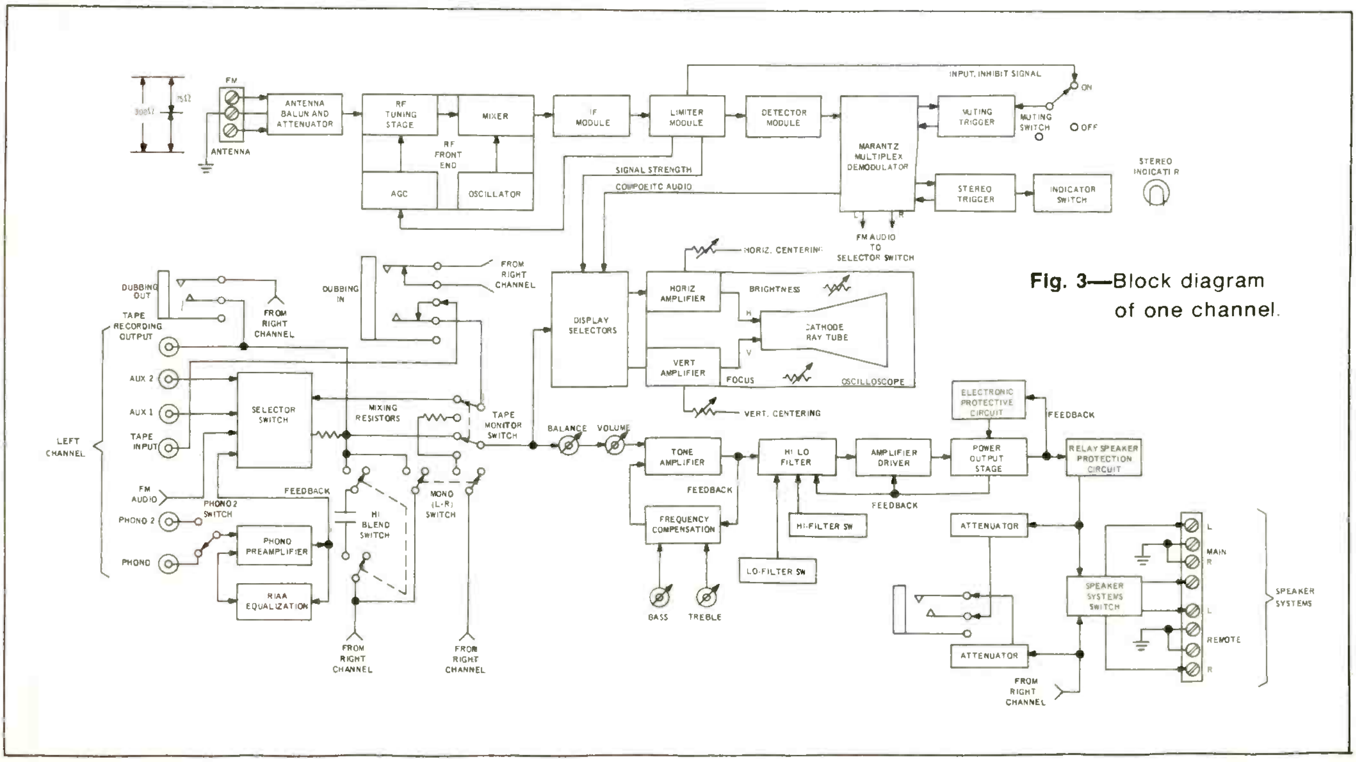

Fig. 3—Block diagram of one channel.

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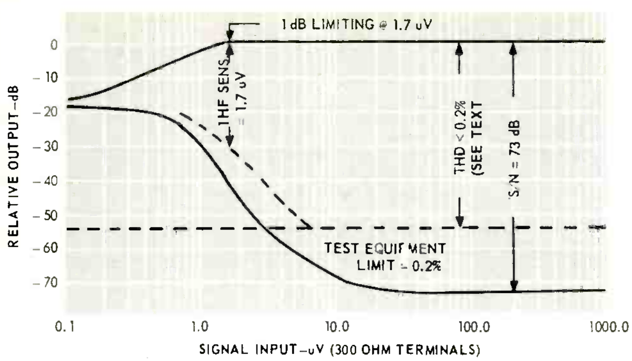

Fig. 4—FM characteristics.

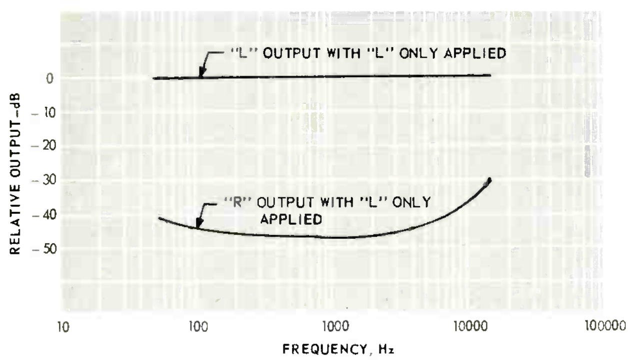

Fig. 5—FM separation characteristics.

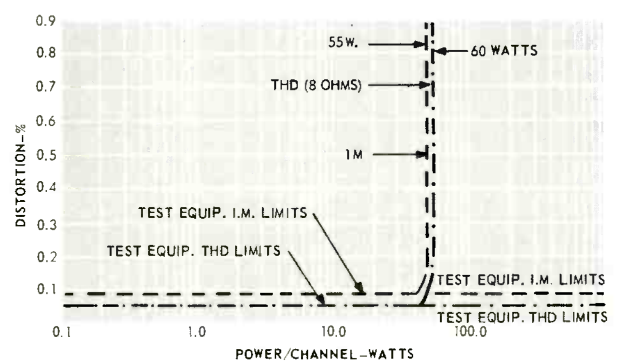

Fig. 6—THD and IM distortion.

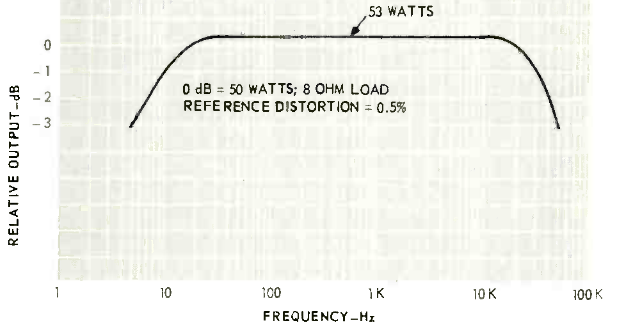

Fig. 7—Power bandwidth.

Test Measurements

Some of the receiver's FM characteristics are shown in Fig. 4. An IHF sensitivity of 1.7 μV. is, of itself, not that remarkable. Other receivers have done as well. What is more important is the fact that at 2 microvolts of signal input, quieting has already reached -50 dB, and at 5 μV. the quieting has reached the incredible value of -63 dB. Incidentally, in typically conservative fashion, Marantz claims only 2 μV. IHF sensitivity and a 55 dB quieting figure for 5 μV. The ultimate signal-to-noise ratio reached a value of 73 dB, exactly as claimed, and it reached this figure at a mere 50 μV. signal input. One dB limiting occurred at 1.7 μV., the same figure as IHF sensitivity. As for THD, we had to express our findings as "less than 0.2%" since that is the known residual distortion of our recently recalibrated FM generator. Marantz claims that maximum THD in either mono or stereo is a maximum of 0.15%—and since we can't prove otherwise, we certainly believe them. Note, too, that the figures are the same for mono or stereo. How many manufacturers even list THD figures for stereo—where it usually tends to be higher because of additional interposed circuitry?

Stereo FM separation is plotted in Fig. 5, and again, the results are superlative. We've seen sets with 45 dB separation capability at 1 kHz—but it's that 30 dB figure at 15 kHz that is so amazing, not to mention the 40 dB of separation available at 50 Hz. Would that some of our local stereo FM stations maintained these parameters in their transmitters!

Thus, if we had to summarize the FM performance advantages of the Marantz Nineteen compared with lower priced competition, these are the areas of perfection we would talk about—good quieting, low distortion in mono and stereo, and unusually fine stereo FM separation. Would you be able to hear the difference? That's a whole discussion in itself, but the success of Marantz products over the years suggests that enough people care enough or hear enough or are convinced that they hear enough to justify the higher price tags.

Audio amplifier measurements were equally impressive. Again, our test equipment could not measure up to the extremely low THD and IM figures exhibited by this receiver at all but overload levels. Thus, as shown in Fig. 6, we must simply say that THD was "below" 0.05% at ALL power levels below about 48 watts per channel, reaching a discernible 0.1% at 52 watts (Marantz claims 0.15% at 50 watts), while IM distortion was "below" 0.08% (our test equipment limits) at all power levels below 45 watts per channel, reaching 0.13% at 50 watts (as opposed to 0.15% claimed by the manufacturer). As the curves indicate, at 60 watts per channel, THD is still under 1% while IM is below 1% even at 55 watts per channel.

Power bandwidth extends from 5 Hz to 50 kHz, considerably greater than the 8 to 40 kHz claimed, but it should be pointed out that our reference was a distortion level of 0.5%, rather than the 0.15% used by Marantz. Over most of this bandwidth, 53 watts of continuous power is available at any frequency from about 27 Hz to 27 kHz at 0.5% distortion or less. In this context, it is interesting and gratifying to note that Marantz did not find it necessary to resort to "music power" or "peak power" or "± 1 dB" power ratings. All they quote is the continuous rms or sine wave power in their published specifications. Evidently, the reasoning is that anyone ready to spend $1000.00 on a quality receiver is sophisticated enough not to be impressed by "inflated" power figures—and in our opinion, they're quite correct!

Tone-control characteristics, as well as low and high frequency filter characteristics, are plotted in Fig. 8, and the latter have a slope of 12 dB, making them quite effective in actual use. With tone controls set to mechanical center, we found perfect correspondence to electrical "flat" or center

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with frequency response remaining within ± 0.5 dB from about 12 Hz to 35 kHz. Square wave response at 100 Hz and at 10 kHz are shown in the scope photos of Fig. 9, and there is no evidence of overshoot or ringing at either of these end frequencies.

Listening Tests

You have undoubtedly surmised by now that we think $1000.00 is not too much to spend on a stereo receiver if you crave the kind of features and performance that can be had with the Marantz Model Nineteen receiver, but the real proof was in its use and in listening to it. Frankly, in our experiments with FM reception, we found two of the controls to be superfluous—the HIGH BLEND control and the ANTENNA ATTENUATOR switch. In other words, all of the stations received (and there were some 57 of which 28 were stereo) were received perfectly without the use of either control. We experienced no overload and the noise level was always far enough in the background so as not to require the use of the HIGH BLEND control which would have reduced separation if used. Of course, we are in good signal area and use a multi-element directional antenna with a rotator in our tests, but the results obtained with this receiver are as good or better than those obtained with any units tested at this location to date. There is no point in resorting to superlatives with regard to the audio performance. Suffice it to say that there was ample power for driving any speaker system connected and that we (and several qualified listeners) could detect no form of distortion from this receiver in any of our listening tests. With that conclusion out of the way, we really began to enjoy the many control features of the Marantz Nineteen, the most important of which, by far, is the built-in oscilloscope display. It has appeared on Marantz tuners and receivers before (Model 18 receiver and Model 20 tuner) and even been reviewed in this magazine before, but for the benefit of newer readers who are unfamiliar with its versatile applications, we shall describe it with the aid of some illustrative diagrams from the owner's manual. By depressing the TUNING pushbutton and the SCOPE ON button on the front panel of the receiver, the scope trace appears as a short vertical line as you tune in an FM station. When the vertical line is centered, the station is perfectly tuned. This application is shown in Figs. 9-A. When the TUNING button is released and the MULTIPATH button is depressed, the display becomes a horizontal trace. The width of the trace determines modulation amounts, as shown in Figs. 9-C, whereas the shape of the trace determines the presence or absence of multipath interference, as shown in the diagrams. Minimum multipath is achieved by rotating the antenna while observing the scope display.

When both the MULTIPATH button and the TUNING button are released, the scope provides still another series of displays, as shown in Figs. 9-D. In this setting, it is possible to analyze separation of any of the signal sources heard on the receiver. (It is also possible, incidentally, to detect stations that broadcast in stereo while actually playing monophonic records!) Interestingly, when last we used this facility (in reviewing the Model 18 in an earlier issue), we found at least a couple of stations which were inadvertently broadcasting stereo with channel signals out of phase. Evidently, station practice in this regard must have improved over the past year, since we found no such errors this year.

In all, this scope display alone is worth the differential between this receiver and its closest priced competition. Combined with the excellent performance specifications which are both measurable and discernible, the $1000.00 receiver has so very much going for it that the price does not seem as high as you might have imagined. *L.F.*

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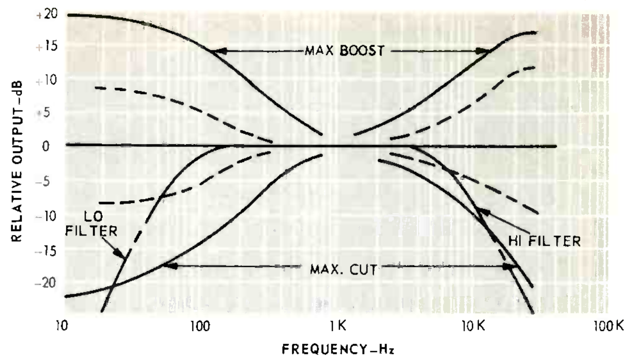

Fig. 8—Tone control and filter characteristics.

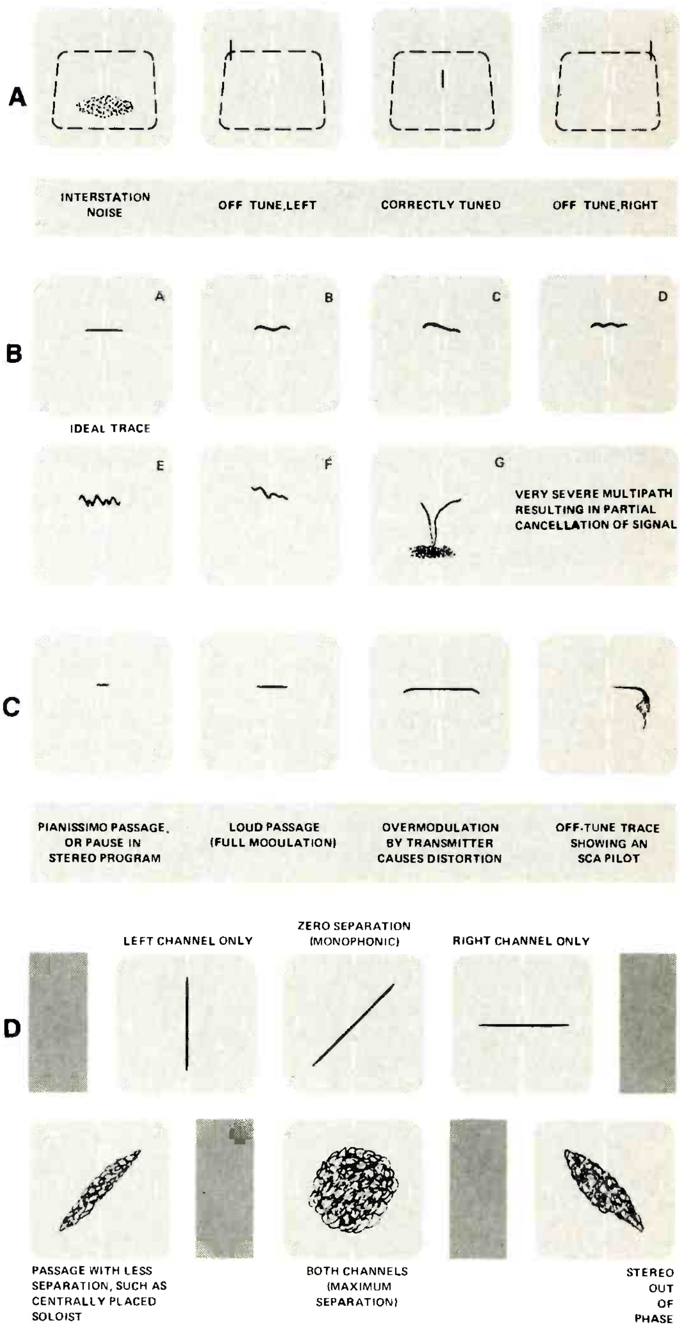

Fig. 9—Analysis using the built-in oscilloscope. **A**—center-of-channel tuning. **B**—antenna orientation. **C**.—modulation characteristics. **D**—stereo separation.

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Tandberg Series 3000X Stereo Tape Deck

Maximum Reel Size: 7 in. **Speeds:** 7½, 3¾, and 1⅞ips. **Heads:** Erase, Record, Crossfield Bias, and Playback. **Motor:** 4-pole induction (asynchronous). **Erase and Bias Frequency:** 85.5 kHz. **Inputs:** Mic, Line high and line low. **Frequency Response:** 40-20,000 Hz ±2 dB at 7½ ips; 50-16,000 Hz ±2 dB at 3¾ ips; 50-90,000 Hz ±2 dB at 1⅞ ips; **Amplifier,** 50-18,000±3 dB. **Wow and Flutter:** Better than .07% at 7½ ips; better than 0.14% at 3¾ ips; better than 0.28% at 1⅞ ips. **Signal-to-Noise Ratio:** (7½ ips) 60 dB (weighted); 55 dB (unweighted). **Dimensions:** 15½" wide, 12⅜" deep, 6½" high (over controls). **Weight:** 20 lbs. **Price:** $299.00.

Several months ago (July, 1970), we profiled the Tandberg 6000 Series with the conclusion that it was the "top-of-the-line in the Tandberg tradition." Now comes the 3000 series, priced $200 less than the 6000, but retaining practically all the performance of its bigger (in price) brother.

The principal differences between the two machines are that the 3000 is simplified, and does not have all the features of the 6000. For example, it does not accommodate magnetic cartridge inputs with suitable equalization. We do not consider this an important difference since anyone with a "system" would already have a "tape out" facility on his receiver or preamp. It does not permit mixing between microphone and line inputs; it does not accommodate a remote control; it uses an induction motor instead of a hysteresis synchronous drive; it does not incorporate a limiter, and it does not have a playback level control.

But, and it's a big but, it does give performance which is comparable with the 6000 model and at a price enough lower to attract many audiophiles who have always wanted a Tandberg, but couldn't quite fit one into their budget. Many of the features of the 6000 are undeniably desirable, but is a Cadillac always necessary when a Chevrolet will get you there just as well?

The two models are similar in appearance. At the top of the panel is the speed-control knob with its three positions that change equalization as you change speeds—the latter by raising or lowering a three-step pulley on the motor shaft. At the lower left are the two record-level controls, with meters above them. The meters are illuminated when recording on both channels, with only one being illuminated when recording on either channel separately. Next comes the head assembly, with easily removable covers for access to the heads for cleaning. A knurled wheel protrudes slightly from the front of the cover to permit listening to the tape while fast winding—it simply pushes the tape toward the playback head mechanically. Below the left end of the head cover are the two microphone jacks, and to their right are the two record buttons for the individual channels. These buttons lock when depressed as the operating lever is put in the play mode, and if only one is depressed, the other is locked in the up position. The instantaneous start/stop knob is next, and next to it is the output selector with five positions: OFF, STEREO, LEFT, SOURCE, and RIGHT. The headphone jack is at the lower right corner of the panel.

Above this jack is the four-position operating lever. Pulled forward, the machine is in the play or record mode, depending on the position of the record buttons. To the right it is in fast forward and to the left it rewinds, with the center position being the rest. To facilitate threading, the lever has a fourth position upward—or backward, if the machine is in the horizontal position—which releases the reel spindles from the drive mechanism. On the rear panel are three pairs of phono jacks for low and high line inputs and for line output, a three-position sound-on-sound switch, and the line-cord input. The line is not fused, but there is an internal fuse in the secondary of the power transformer. The machine may be used in the horizontal position "as is," or in the vertical position with two plastic feet to stabilize the unit. These feet slip over the cabinet, and are attached permanently by two screws through the walnut-finished housing.

Circuit Description

Since no input mixing is involved, the three inputs all feed into the two-transistor mic/line amplifier, with the high-level inputs being fed through a 1-megohm resistor, the low-level line inputs through a 47 k ohm resistor, and the microphone inputs direct. The preamp is followed by the record-level control and a two-stage buffer amplifier which feeds the output selector and is connected to the sound-on-sound switch, as well as to the equalized record amplifier—a three-transistor section which feeds the record head from the output emitter follower, and also the one-transistor meter amplifier stage.

The equalized playback amplifier employs three transistors, followed by the output selector switch which feeds the two-transistor booster amplifier with the output from the second stage which is an emitter follower. The output feeds the headphone jack as well as the two phono output jacks.

The bias oscillator employs two transistors in a balanced push-pull arrangement, with the secondary of the oscillator transformer feeding a three-transistor amplifier ending in a complementary-symmetry output stage. The 6-volt 85-kHz output is resonated with a capacitor in series with the erase heads to put 90 volts across them, while the bias heads are fed from the same point through a bias-adjusting pot. The meter-illuminating lamps are fed from the d.c. supply to the bias oscillator so that they are lit whenever the bias oscillator is energized.

The power supply uses a bridge rectifier which furnishes 42 volts to a three-transistor d.c. voltage regulator which drops the supply to the amplifiers and the oscillator to 27 volts. The complete unit requires 34 transistors, six diodes, and one Zener. All three lamps—the two for the meters and one which illuminates the digital counter—operate from the 27-volt d.c. supply. When the deck is used in the vertical position, a formed metal plate covers the back—which is then the top—panel to provide a neat appearance. The primary of the power transformer is wound in two sections, permitting rewiring for operation on 220 volts as well as the customary 117 common in the continental U.S.A. To change to 50 Hz, the motor pulley must be replaced with another to maintain standard speeds.

Operation

The two line-input jacks—high and low—make it possible to record from a variety of sources. The high-level inputs are suitable for the usual output signals available from receivers or

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tuners, while the low-level inputs can readily accommodate the "detector output" signals commonly available from European radio units. Record players with ceramic or crystal cartridges can be fed into the high line-input jacks since the input impedance—1 megohm—is high enough for such a source. When recording mono, the input amplifiers are connected in parallel so that either input jack can be used at will, with the channel on which the recording is being made selected by the proper record button. More about this later.

The head assembly consists of the erase head, the record head, the bias head (which is positioned directly opposite the record head at the back of the tape), and the play head. Between the record and play heads is a scrape-flutter filter roller, and a pressure pad provides sufficient drag on the tape to maintain good contact with the heads, which have no pressure pads against them. An automatic-stop provision in the tape path shuts off the motor when tape runs out.

The advantages of the crossfield head system of recording are fairly well known by now, but in any case it should suffice to know that better high-frequency response usually results from this method of applying bias.

While "mixing" between microphone and line sources in the same channel is not possible, it is possible to mix a microphone and a line source in mono, or to mix two line sources in mono. In fact, if an external mixer is used to mix the high and low line sources in each channel, four line sources can be recorded in mono. Similarly, one microphone and two pre-mixed line sources can be recorded, or two microphones can be mixed and recorded *in one channel*—not in stereo. In addition, either channel can be recorded on the other with the sound-on-sound switch, and a simulated echo may similarly be produced. On the whole, the Tandberg 3000 is quite a flexible machine in spite of its seeming simplification.

Performance

We made the usual performance tests on the deck, and found frequency response to be within specifications, as shown in Fig. 2. Distortion was found to be 0.5 per cent at indicated "0" level, rising to the 3-per cent point at +3.5 dB relative to the indicated zero. Signal-to-noise ratio was measured at 55 dB, unweighted, or 62 dB under the "A" weighting curve. Distortion at various frequencies was well under 1 per cent from 50 to 20,000 Hz at zero level. As is customary in Tandberg tape equipment, the meters indicate the actual signal being recorded *after* the high-frequency boost is applied. This may be disconcerting to anyone used to monitoring with a flat system, but it more definitely indicates the point at which distortion starts, which is the important reason for the level indicators anyhow.

Input signals of 205 mV and 9.4 mV are required respectively (at 1000 Hz) to obtain a "0" level with the record volume control at maximum; in the microphone position, the required signal was a low 0.2 mV. Line output level for a "0" recorded level at 1000 Hz was measured at 0.95 V. Microphone input impedance is 1000 ohms, suitable for better-quality mikes with impedances anywhere from 50 to 600 ohms. Bias/erase oscillator frequency was measured at 81 kHz.

Wow and flutter was measured at .06 per cent at 7½ ips, 0.12 per cent at 3¾, and 0.19 per cent at 1⅞, all below specifications. Fast rewind and fast forward times were found to be 125 seconds for 1800 feet of tape. The 3000 series is designed to be used with low-noise tape, and these measurements were all made with Scotch 203.

In trying the machine at various frequencies and voltages, we found that it ran 3 per cent slow at 90 volts, and that it wouldn't start at under 75 volts. Frequency changes did not affect the speed—only the variations in voltage.

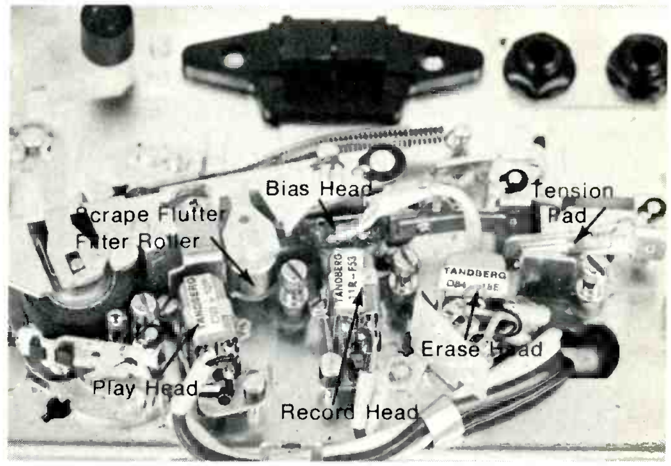

Fig. 1—Head assembly showing the scrape-flutter filter roller. Pad at left puts sufficient tension on tape to provide good head contact without the use of pressure pads on the heads.

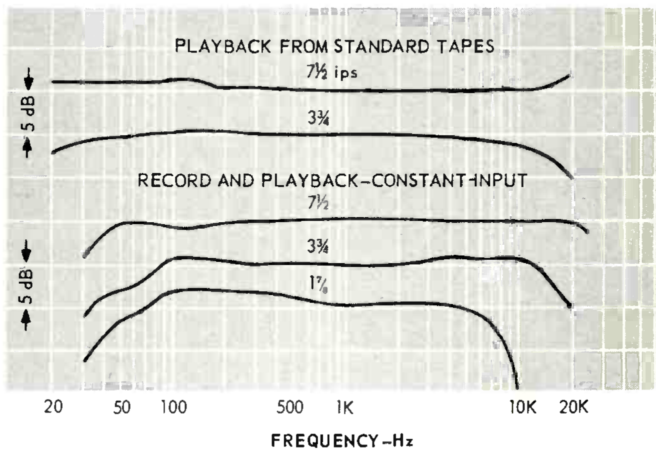

Fig. 2—Response curves.

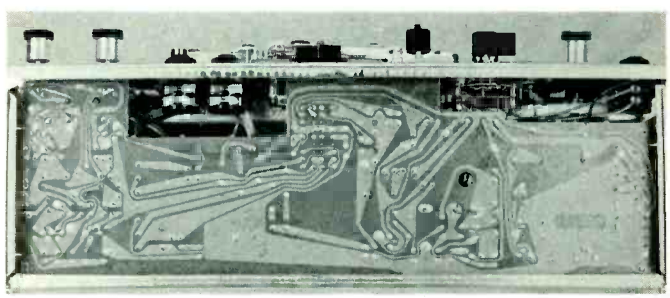

Fig. 3—Showing the foil side of the board containing mic/line amplifiers, buffer amplifiers, oscillator section, and d.c. voltage regulator. This board is covered by a shield and is mounted under the front edge of the chassis.

This is the first time, in our memory, that a Tandberg could be purchased at this low a price, but it appears that there has been no diminution in quality and that the buyer will have a fine instrument in this model. And because we did not consider it very important, we did not mention that the deck can be used as a preamplifier, just in case you should need one. This might work up into a PA system with the addition of a power amplifier. And you don't even have to use tape for this application.

C.G. McP.

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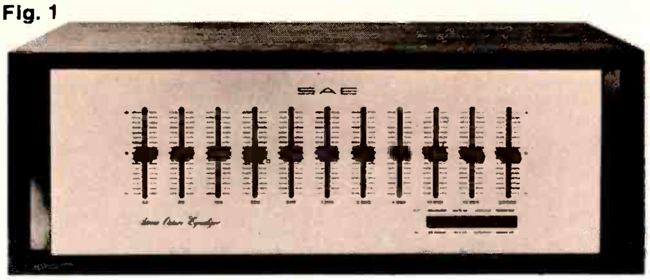
Fig. 1



SAE MARK SEVEN STEREO OCTAVE EQUALIZER

MANUFACTURERS SPECIFICATIONS

Ranges: 40, 80, 160, 320, 640, 1,280, 2,500, 5000, 10,000, 15,000 and 20,000 Hz. **Lift and cut:** plus or minus 16 dB. or plus or minus 8 dB. **Slope:** 12 dB per octave. **Input impedance:** 100 k ohms. **Output impedance:** 200 ohms. **Frequency response:** plus or minus 0.25 dB. 20 to 20 kHz. **Maximum output:** 7 volts. **Distortion:** IM and THD less than 0.1% at 2.5 volts output. **Hum and noise:** 90 dB. **Dimensions:** 17 inches wide by 7 inches deep and 5¼ high. Price $450.

The only thing equalizers, as a family of equipment, have in common is that they all operate on the frequency response of the signal passing through them. At one extreme we have the garden variety of tone controls which shape the frequency spectrum broadly and coarsely. While on the other extreme there are equalizers which can control a narrow band of just a few Hertz in calibrated decibel steps. Some equalizers give boost as well as loss to the passing signal; others just loss. Some work in one particular region, serving a special purpose, while others operate throughout the audio frequency spectrum with varying degrees of frequency resolution. For sound reproduction, the narrowest band useable is 1/3 octave wide because the ear doesn't resolve anything much narrower. The broadest we want are regular tone controls.

There are three good reasons and two bad ones for using equalizers:
1. to change the program material; 2. to change the frequency response of the audio system; 3. to compensate for the absorption inequities created by room acoustics; 4. to compensate for loudspeaker deficiencies; and 5. to compensate for hearing loss.

Reason No. 1 is a good reason to use equalizers because individual taste as to what constitutes correct or proper balance between musical sounds can now be excercised when desired. While in most cases we prefer to let the recording team do their thing by dictating frequency balance, sometimes things get out of whack by the time their creation gets reduced to disc, tape, or tape cassette, and is about to be played. Reason No. 2 is a good reason because it is so very difficult to obtain flat frequency response in a system, advertising claims to the contrary, notwithstanding. Reason No. 3 is also a good reason because equalizers can eliminate unavoidable imperfections of our listening environment to a large extent. Reason No. 4 is a bad reason and one which is often misunderstood. If a loudspeaker system rolls off at 50 Hz, it means it is incapable of operating below that region. Boosting the input to the loudspeaker below this frequency will distort the sound. If it were not so, all the loudspeaker manufacturers would have to do is reduce the efficiency of the upper frequency range drivers and we would thereby get more bass by driving the loudspeakers harder. It is fair to assume that loudspeaker manufacturers have already considered the limitations of their designs and optimized the frequency response of their product—at least as far as the frequency extremes are concerned. It is possible to boost the extremes somewhat if the loudspeaker has high power handling capability and we don't play it at its loudest. Compensation for the loudspeaker's inaccuracy in the mid-range is also tricky because it can cause ringing and play havoc with its transient response.

Finally, Reason No. 5 is a good reason because if we compensate for a known ear deficiency, during listening to music at home, who will compensate the orchestra during listening to live music? After all, to the ear, regardless of deficiency, the live orchestra is the reference. To compensate for this deficiency during playback only, will therefore disorient the listener when he's hearing the real live thing. The use of equalizers is fascinating, but like most good things, frought with danger. Equalizers need to be used with discretion that comes from learning how to use them. Used well, equalizers can significantly improve the perception by most listeners of reproduced sound. Misused, however, equalizers can ruin the balance beyond recognition, mislead diagnosis of a system malfunction and damage loudspeakers.

The SAE Mark Seven Stereo Octave Equalizer, as it is called, is the best stereo program equalizer for home use that we've so far come across. Since the equalization is done in octave bands and both stereo channels are acted upon with one lever, the unit is intended and best used as a program equalizer, explained above as Reason No. 1. It might possibly be used for the second reason, but for the third—not so well. Reason No. 1 is enough, however, since the Mark Seven does this superbly. Having been thoughtfully designed and skillfully assembled, the equalizer is a natural to use and after five minutes of diddling with the smoothly gliding levers, one never wants regular tone controls again.

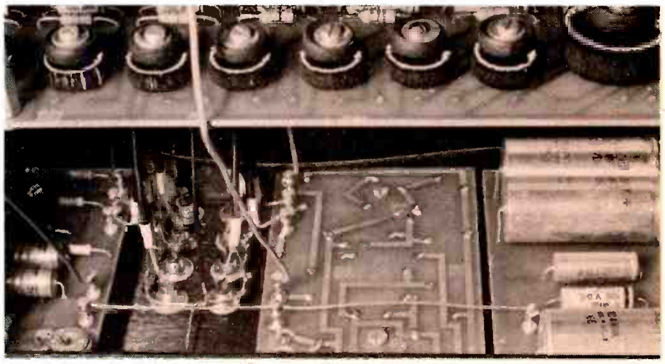


Fig. 2—Showing filter coils on a circuit board mounted behind the front panel. The active electronic circuits and power supply are mounted on boards visible in the rear.

There are ten filters with center frequencies one octave apart, starting at 40 Hz, and an eleventh one at 20,000 Hz, which is a half octave above the tenth at 15,000 Hz. 30,000 Hz would have been wasteful. Four push-buttons at the lower right corner control the operating modes. Besides the on/off and bypass controls expected, there is a range-halving control plus a tape monitor switch. See Figure 1. The range selection increases resolution of the control while the tape monitor button replaces the one on the preamp, which must now be engaged if the Mark Seven is connected in the tape loop. An alternate connection is to put it between the preamplifier and the power amplifier. For use with receivers and integrated amplifiers, however, it must go into the tape loop. That is, it receives its input from the receiver's recorder output signal and injects its output into the receiver's tape play or monitor high level input. The four stereo pairs of phono jacks at the equalizer's rear panel facilitate hook-up.

The control levers glide past eight graduations above the detented center position and eight graduations down. Each mark represents one or two dB, depending on whether the range-halving push-button is depressed or left in its out position. There is no on-off indicator, which sort of understates the equalizer's effect. In time, equalizers such as this one will augment systems so proudly that nothing short of blinking lights will seem appropriate. Or looked at differently, the only way to achieve incognito participation will be to hide it under the table. The highly pleasing appearance and cushioned feel of the curved attenuator lever knobs of the Mark

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Seven say that the unit be proudly displayed.

Each lever, which has a long throw of 2⅜", controls a filter network centered around the frequency, silk-screened onto the anodized brushed aluminum chassis. The circuit utilizes coils, capacitors, and resistors, resonating at the eleven specified frequencies. Transistors are used before and after the filters for impedance and gain matching.

The filter circuits are all mounted on a large printed circuit card close behind the sliding potentiometers, as shown in Figure 2. The front filters circuits are far away from the rear-mounted electronics, which probably accounts for the phenomenally low amount of noise introduced into the system by this device.

Figure 3 shows the Mark Seven's response to input signals from 30 Hz to 20,000 Hz, as plotted on a graphic level recorder automatically coupled to an audio oscillator. The line is the effect of the unit with all controls in their neutral position. There is a slight roll-off below 1000 Hz, and an overall loss of 1 dB between input and output. The two curves show the response at the lever extremes, showing the action of the controls. Since there are so many possible combinations of filter lever positions, we've chosen a representative few for the graphs. Figure 4 and 5 show several such settings and gives an idea of the unit's tremendous equalization capabilities. Figure 6 and was indistinguishable from the input waveform. Its response to square waves fared no worse, as shown in Figure 7. Figure 8 shows the effect of increasing degrees of boost at 2 dB intervals, per the panel markings. The maximum input voltage that the unit could handle before clipping, when its filter controls were all set to maximum, was 1.5 volts rms. With levers flat, it can take 10 volts in. With levers set for average use, it will handle up to 5 volts without distortion. Maximum output of the unit is 10 volts, which is more than any amplifier needs.

We were unable to measure harmonic or IM distortion within its normal operating range, that is, both are below .05%. Signal to noise with all controls flat was measured at 93 dB and with controls in an average compensating configuration, 83 dB. What these figures mean is that used with discretion, the Mark Seven is a virtually distortionless device.

We connected the unit to a high quality stereo system already equalized for the listening room with 1/3 octave equalizers. Playing various types of records and tapes, we switched the preamp's tone controls out of the circuit and played with the Mark Seven equalizer controls. After a little practice, we were able to adjust it without even looking at the controls. It sort of became intuitive and definitely improved some of the records. We then took the 1/3 octave room equalizer out of the circuit and attempted to compensate for the room with the SAE unit. We first tried by ear, then used the pink noise calibrated microphone technique. In both cases, and as we expected, we achieved only limited results for two reasons. First, the two channels require different compensation which the Mark Seven has combined; and second, one octave resolution is too coarse for correcting room modes. So we went back to using it as a program equalizer, which is its intended purpose. With this capability we were able to correct for such common recording defects as overly bright brass, wiry strings, and deficient fundamental bass. To cymbals, we were able to add sheen which somehow had gotten lost.

The SAE Mark Seven Stereo Equalizer will find a fitting place in any elaborate audio system, and while not inexpensive, will certainly make its presence heard. Pun intended.

The Mark Seven is also useful for the serious recordist who wants to salvage tapes that were made under adverse conditions or somehow went sour in the process. It can thus serve in post-recording equalization. *A.R.*

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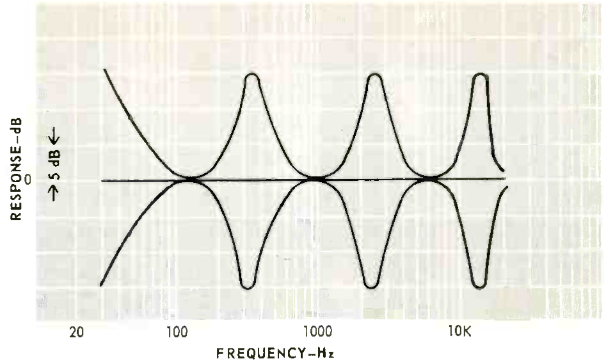

Fig. 3—The upper curve was obtained by placing controls 1, 4, 7, and 10 at maximum with the rest at center. The lower curve was obtained with controls 1, 4, 7, and 10 at minimum and the rest at center. The line is a neutral setting.

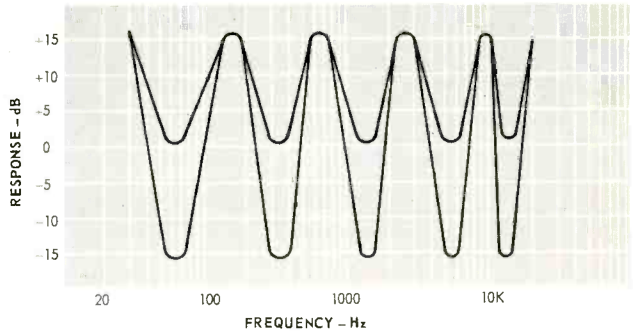

Fig. 4—The upper curve shows results of placing controls in alternate maximum and center positions; the lower curve shows response with controls at maximum and minimum settings.

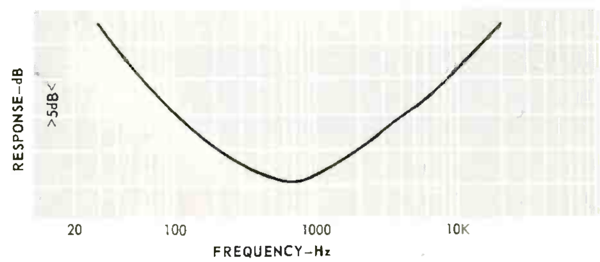

Fig. 5—This curve represents extreme compensation of low and high frequencies.

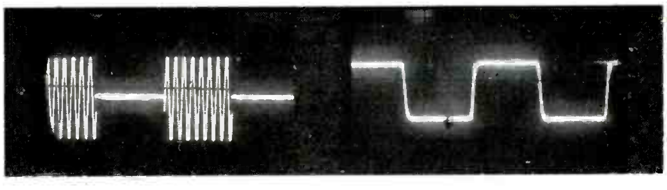

Fig. 6—Tone burst response at 1500 Hz.

Fig. 7—Response to 10 kHz square wave.

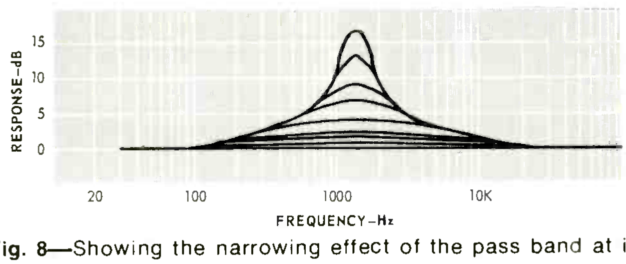

Fig. 8—Showing the narrowing effect of the pass band at increasing degrees of boost. Each curve was plotted with the 1280 Hz filter raised by two dB.

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Classical Record Reviews

Edward Tatnall Canby

Prokofiev: Cantata for the Twentieth Anniversary of the October Revolution (1937). Shostakovich: The Sun Shines on our Motherland (1952). RSFSR Russian Chorus, Moscow Philharmonic, Kondrashin. **Melodiya/Angel SR 40129** stereo ($5.98).

Angel's monopoly on current official Russian production is bearing remarkable fruit. Here are two Cantatas by the two big Russians, both new to us, the Prokofiev unperformed for almost 30 years after its composition in 1937, the Shostakovich dating from a much later date but composed in a more conservative style. Both are gloriously performed in the grandest Russian manner.

The Prokofiev, composed on texts by Lenin, missed out on performance for logistic rather than political reasons. With four orchestras and two choirs, one pro, the other amateur, it required some 500 performers, apparently more than the Anniversary could provide. It is a big work and the sounds are marvelous, for this is Russian big-time drama at its most exciting. Old hands will note with interest that this work is of the same period and closely related to the celebrated cantata "Alexander Nevsky," out of the film of the same name. Many of the same starkly dramatic traits and all of the strength of the better known work turn up in this more imposing opus.

The Shostakovich Cantata celebrated a similar later occasion, the 35th Anniversary of the Revolution. As always, Shostakovich seems to today more positively to the state musical party line than Prokofiev—this Cantata is bland and unctuous, as consonant as a Sunday hymn tune. Nice music but it can't hold a Soviet candle to the Prokofiev.

Both texts are given complete in translation. Unless you know Russian, you'll soon get lost.

Performances: A *Sound:* B+

Computer Music. (J. K. Randall, Barry Vercoe, Charles Dodge). Columbia and Princeton Univ. Computer Centers. **Nonesuch H-71245** stereo ($2.98)

Charles Dodge: Earth's Magnetic Field. Realizations in Computed Electronic Sound. Columbia Univ. Computer Center. **Nonesuch H-71250** stereo ($2.98)

Let's try an analogy. It's 1975 and baseball has changed. The boys still play the game but the diamond is a super-polygon with X bases and the players move by computer: they huddle over in one corner of the field and intercept the enemy's radar. Yet whoever heard of a baseball game with no audience—and no sports reporters? So they still work out there under the lights and the crowds still yell—you see, they just sent these records to me as a musical reviewer. I'm supposed to pass judgment (and so are you). You are supposed to buy tickets. I mean, put out cash for the discs, take 'em home and enjoy the game. I merely opine.

OK. I'm the sportswriter. I really don't quite get all of the new rules, but I'm an old pro at this and I seem to have fairly strong ideas as I listen. It *is* the same old game. And that is perhaps the trouble as well as the virtue of computer music. Nothing wrong *per se* and why shouldn't they modernize the rules? But are they really thinking of us as an audience? And, under all this fancy computerization, is it sometimes (to change analogies) like the old story of the Emperor's clothes? It often has been in ages past.

I like the first record very much. I just like it. I like to listen to it, which is the only reason I would ever buy it. I even like the very long "Changes" by Charles Dodge which fills the entire second side. (Mr. Randall's items, in contrast, range from 1:21 to 6:57.) Simple reasons. An interesting variety of sounds, really quite "imaginative" (even if the computer, in theory, has the imagination—maybe. Who cares?). Randall's short pieces, "Quartets in Paris," "Quartersines" (made out of quarter sine waves), and the oddly named "Mudgett" with a tiny soprano voice who sings high up wonderfully accurately along with the beeps and, at the same time, speaks various languages (Schoenbergian *Sprechstimme*) in a lower pitch range. Barry Vercoe's "Synthesism" (a nice name), with attractive little rushes of fast notes, all breathless; and the Dodge immensity, all clanging chords and drummy-sounding rustles and wheeps and sneezes, very audibly organized into a tight variation-type format, even to a casual ear. These are nice because they do appeal to eternal fundamentals of organized sound—rhythm, color, pitch contrast, sonic organization into patterns that are sensed if not analyzed. Like Beethoven. My ear says yes. So will yours.

But Mr. Dodge's solo commissioned piece (by Nonesuch) got me down. Not quickly but slowly—it's very long. This magnetic field stuff! Ugh. I never did like program music (music with extra-musical connotations) even when Richard Strauss imitated windmills, sheep, and whole gales not to mention deaths and transfigurations. This one purports to be based (I gather) on the pattern of fluctuations in earth's magnetic field under the influence of the solar wind, specifically as registered in the Kp index. You can, of course, set any old graph to music, like a graph of the potholes in my somewhat decayed driveway as the protesting tires bounce along it. But solar wind sounds a lot better. More modern, definitely. Yet what somebody in this outfit doesn't know about the solar wind sets my

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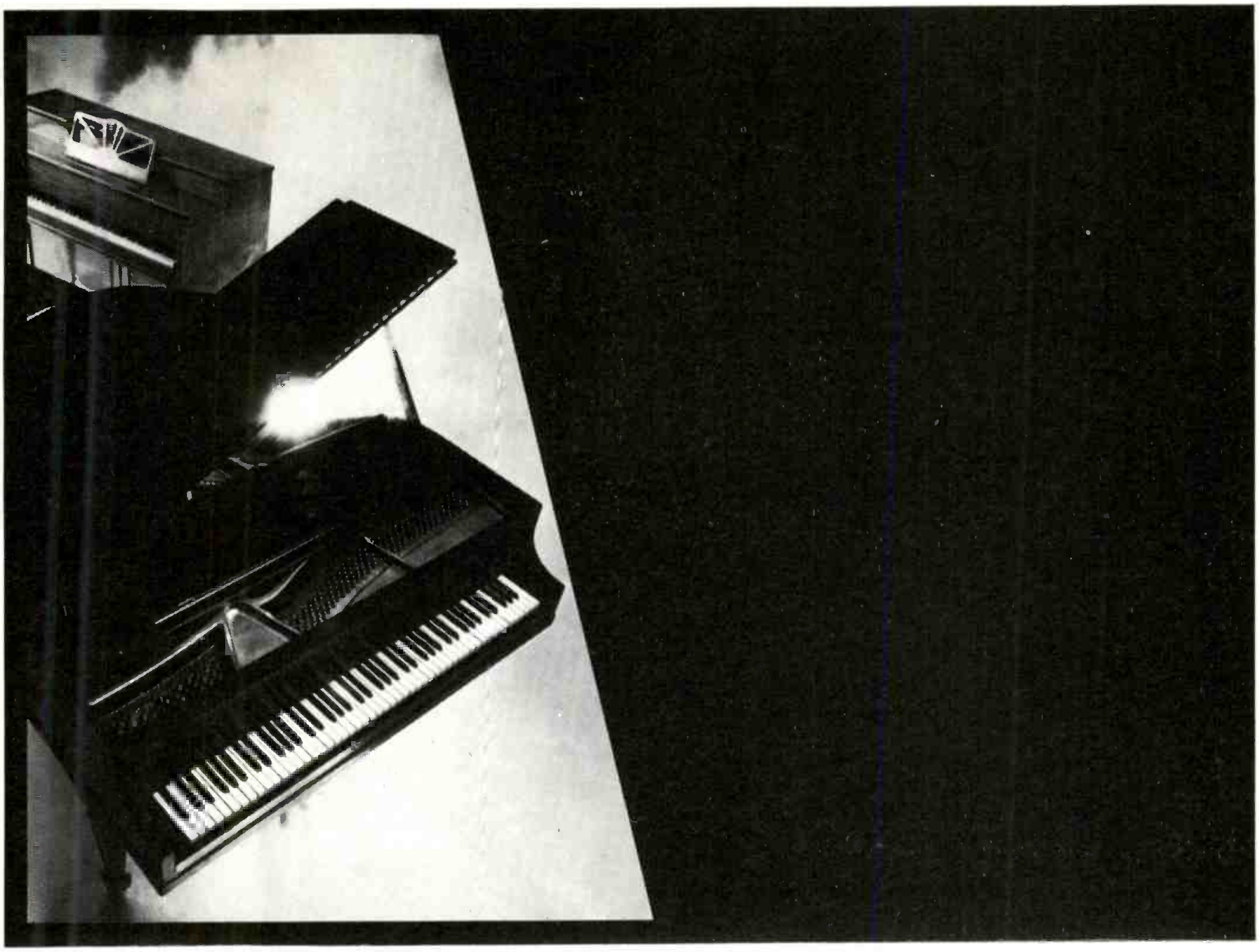
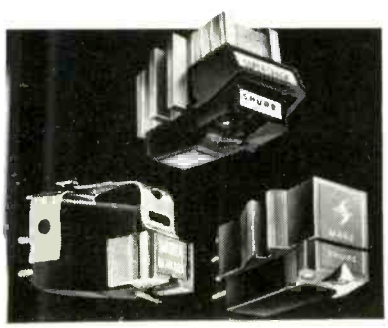


To each his own.



Not *everybody* needs a concert grand piano, nor does everybody *need* the best cartridge Shure makes to enjoy his kind of music on his kind of hi-fi system. Eventually, you'll want the renowned *V-15 Type II Improved,* the peerless cartridge for advanced systems and ample budgets. But, if your exchequer is a little tight, consider the *M91E,* widely acclaimed as the *second best* cartridge in the world. With a sharply circumscribed budget, all is *far* from lost. Choose any of the four models in the *M44 Series,* built for optimum performance in the easy-to-take $18-25 price range. Write for a complete catalog: Shure Brothers Inc., 222 Hartrey Avenue, Evanston, Illinois 60204.

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Classical Record Reviews

(Continued from page 68)

amateurish teeth on edge. Look, fellows, if you're going to get technical, then stick to the rules.

Solar wind? Somebody here evidently thinks it's a blast of Pyrofax that the sun sends out periodically and if it weren't for earth's magnetic field we'd all be roast turkeys. A *gas*, fellows? I'd say more of a plasma. And it travels, you say, at several hundred miles *an hour?* Maybe they meant to say miles a *second*—that would be closer. And, though I'll admit that solar Pyrofax as well as earthly Pyrofax is *very* explosive when mixed with earth's air, I somehow doubt that the solar wind is ever going to blow us up with a loud pop.

Look, these guys have taken the shape of a graph on paper and made it into a musical theme. Period! Please forget all the rest of the stuff they put out. Just listen.

Side one, the naked graph, sounds like an interminably strung out Bach Invention in C major. It is, indeed, in C and it never goes anywhere else. Boring is what I thought after two minutes or so.

Side 2, where the graph gets elaborated in more sophisticated fashion, is a lot better—but why side 1 in the first place (that is, for our listening and our cash)? The whole thing is overly pretentious and long winded. (These people aren't at all immune to that sort of thing just because they are into computers instead of French horns and bassoons.) But I could be wrong; try it for yourself.

Or buy the first disc, "Computer Music." It's easier to enjoy.

P.S. This sort of synthetic material is really excellent on the three-way "Dyna 2" home hookup, with a rear speaker tapped off the "high" terminals of a stereo amplifier. All sorts of precise three-dimensional placements, in every part of your room. Adds a lot to the impact. The precise synthetic phasings, uncluttered by random "live" background sound pickup, account for it.

Performances: Fortran B, etc. *Sound:* A

Arthur Grumiaux, Clara Haskil: Beethoven, Sämtliche Sonaten für Klavier Und Violin (The Violin Sonatas). Philips 6733 001 (4 discs) stereo ($17.96).

Thank you, Beethoven, for being born 200 years ago; otherwise Philips might not have been able to swing this excellent reissue, four whole discs, of one of the more modestly first-rate performances ever put down. Wispy little Clara Haskil, tiny, bent, and diseased, just barely managed to keep playing—and finally didn't, after a minor fall in a railroad station just before a concert. She was one of the greatest pianists around, if not the loudest. Her equally unassuming violin companion, Arthur Grumiaux was a perfect teammate and the two often toured, impeccably, though neither one produced even the beginning of a visual charisma.

Philips got the sonatas down with a very modest stereo and a mild bit of scratchiness in the fiddle but, in compensation, a fine balance between the two instruments. It is not what you would call a "modern recording" but the transference of musical sense is nevertheless excellent. It may take awhile to catch onto Clara Haskil's astonishingly perfect playing, every note precisely right, every phrase shaped and jewel-like. The Grumiaux violin, similarly, is no great virtuoso shakes but matches Haskil's line exactly. This was no fly-by-night teaming.

Performances: A *Sound:* B-

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Beethoven: Complete Piano Trios. Zukerman, Du Pré, Barenboim. **Angel SE-3771** stereo ($29.90).

This is a bit delayed—for a very natural reason. How many Trios can one pair of musical ears absorb at a time? After experiencing the rival album from Columbia via Istomin, Rose, and Stern, recently reviewed, I simply quailed at the thought of still another deluge. Sorry 'bout that. Sometimes unexpected guests are mighty useful—mine pulled out this album like a flash and put it on the machine. That did it! And wouldn't you know: Though I have not really enthused about this playing group in many cases before, excepting the Mozart violin concerti (Zukerman, with Barenboim conducting), I was immediately entranced by their combined Beethoven, the husband and wife (Barenboim, Du Pré) on piano and cello, Zukerman again on fiddle. It is a very young group, as players of this sort of big-time music go, but the sound is exactly what it should be and, for my taste, far ahead of those "sounds of genius" issuing so portentously from Columbia's press department in the other recording. Take due note. You'll have to stand up against some pretty hefty critical acclaim if you turn Columbia down.

How and why? First, there is a really surprising verve and enthusiasm here, the sort that is youthful, yet experienced, the best of both worlds. The tasteful approach is what amazed me (the Mozart is dismally unstyled) and the accurate, beautifully worked-out ensemble, as though these three had been playing the music for years. In a sense they have, for youth learns fast when the learning's good.

Equally important—and in great contrast to Istomin-Stern-Rose in the same works—this is real chamber music playing rather than amplified, blown-up trio projection out of some vast, symphonic concert hall. This one gives us the right sense that the music is basically "close-up" music, however forceful its meaning; whereas Istomin-Stern-Rose make gargantuan (if very musical) efforts to fill up a vast space, before a vast audience, with us listeners sitting uncomfortably a few feet away. The Angel sound, you will find, is immediately at home in *your* home. And sized to fit.

Finally and perhaps most important (for a record album), Angel has recorded these three—at last!—with the perfect trio balance. The piano leads, as it historically should. The violin and cello, working closely with it, are nevertheless blended, subordinated in the sound, yet perfectly clear in every required way. Superb! Perhaps it's merely because the pianist, Barenboim, happens to be the biggest cheese. (On Columbia, big-cheese Stern seems loudest.) Never mind! It works. And the longer you listen to these 10 LP sides, the more you will bless the engineers for their foresight.

(Continued on page 72)

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Canby's Capsules...

Title	Content	Sound
Notable Reissues **Flagstad - Wagner: Immolation Scene & other arias, Wagner, Beethoven, Weber.** Phila. Orch. Ormandy. **RCA Victrola VIC 1517** mono ($2.98) **Wagner: Tristan** (highlights). Flagstad, Suthaus, et al. Philharmonia, Furtwängler. **Seraphim 60145** mono ($2.98).	Here are two reissue phases of the three in the fabulous Flagstad recorded history, both excellent—they'll take you back if you were there. (Phase 3 is late London recordings.). The leaner, early Flagstad on RCA (1937) is more flexible, with less majesty, than in her later work; the Immolation (Götterdämmerung), very long, was never released—why? Superb. Other items—"Ah, Perfido!" etc., I well remember; she was best in Wagner, bit heavy in the earlier composers. Unlike dismal San Francisco recordings with Melchior, these are properly balanced, voice at some distance, orch. audible. But how thin! The E.M.I. job from 1952, still mono, shows immense strides in technique—a richer, fuller, more immediate sound. She is even better than in 1937, not yet beginning to deteriorate; Suthaus is a mild Melchior; Furtwängler's orch. is grade A Wagner, marvelously plastic. From complete version, still available on Angel.	
Sibelius: Symphony No. 2 Boston Symph., Koussevitzky. **RCA Victrola VIC 1510** mono ($2.98)	Sibelius is back in style—but who can perform him? This splendid, lean, natural-sounding version shows how he was in the original—before the "revival." The music lives! New and modern.	Recorded in 1950 though musically it represents the sense of the 1930s, K's heyday in Boston. Thoroughly modern sound, exc. for stereo, bit harsh at high levels.
Josef Lhevinne - Master of the Romantic Piano (Chopin, Schumann, J. Strauss, Debussy). **RCA Victrola VIC 1544** mono ($2.98). **Josef Lhevinne Plays Concert I. Klavier KS 104** stereo ($5.98).	Ha! Just compare these. The RCA is a "real" recording (1928-36), the Klavier job is via an Ampico player piano, in full modern stereo. Lhevinne, great didactic master of piano, scarcely recorded at all. Now, his music is fabulous but old fashioned—much lovely, out-of-date rubata, personalized flexibility. Klavier's player job is apparently done with much care—one piece (Chopin Op. 10, No. 11) is common to both recordings, sounds remarkably the same. RCA's piano is a bit thin and buzzy, with hiss, but wholly intelligible.	
Josef Hofmann - Chopin. RCA Victrola VIC 1550 mono ($2.98).	Another "first release" from RCA, out of the fabulous past; I'd guess maybe minor technical faults, once important, now no longer matter in the historical format. Hofmann, like Lhevinne, was never a major recording artist. But his span of top-virtuoso playing ran from before 1900 through the Fifties. Looks like a businessman, pudgy; all fingers and little stage magic. But if you want technical pianistic miracles, try him.	
Mahler: Das Lied von der Erde. Miller, Häflinger; N.Y. Philh. Bruno Walter. **Odyssey Y 30043** stereo ($2.98).	Walter's Mahler, always tops, now sounds lean and intense alongside more more portentous and heavier later conductors. It *is*, indeed, tops!	An entirely modern stereo recording, this. The two voices are a bit distant (an earlier stereo style) but it is good for the musical whole. (We now edge back to close-up voice recording.)
Russian Ballet **Prokofiev: Cinderella Suite.** Moscow Radio Symph. Orch., Rozhdstvensky. **Melodiya/Angel SR 40138 stereo** ($5.98). **Suite from Tchaikovsky's Swan Lake.** (Same) **Melodiya/Angel SR 40137 stereo** ($5.98). **Ballet at the Bolshoi (Swan Lake, Seasons, Red Poppy, Limpid Brook, Cinderella, Carmen Ballet).** Bolshoi and Moscow Radio Symph. Orchs., assorted conductors. **Melodiya/Angel SRC 4114** (3 disks) **stereo** ($17.94).	Such well-disciplined playing! The sound of thorough rehearsal in this official Russian orch. Noticeable after some famed West-Europe orchs that are out for hire to all comers, makes records without adequate rehearsal. There's enthusiasm here, too, for the home-grown music. Good. A fat three-record album in case you want more of the same (but you only get half as much Cinderella and Swan Lake, one side each). Familiar music and some that is practically unknown here—Limpid Brook of Shostakovitch.	Russian stereo has a curiously special sound—rather fat and tubby, with a heavy bass, an impressive but (oddly) rather dry spaciousness. Partly in the acoustics and miking, but could also be in recording "curve" and a still slightly thumpy transient response in loud passages.

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Classical Record Reviews

(Continued from page 71)

An interesting dividend is the Op. 11 Trio with clarinet, played by a sterling artist, Gervase de Peyer.

Performances: A- *Sound:* A

Mauricio Kagel: Ludwig van. Carlos Feller, bass, Wm. Pearson, baritone, instr. ensemble. **Deutsche Grammophon 2530 014** stereo ($5.98)

Berio: Sequenza VI; Chemins II; Chemins III. Walter Trampler, viola; Juilliard Ensemble, London Symphony Orch., Berio. **RCA LSC 3168** stereo ($5.98).

Here's a brace of oddly conceived modernity to keep you busy for an evening. "Ludwig van," composed without any doubt to celebrate and capitalize upon the 200th, is a most curious work, a musical mosaic made up entirely of fragments from actual Beethoven, the textures patched together and played simultaneously as a wholly new structure. Sounds crazy but in fact it is unexpectedly interesting, not merely because it sets up a fascinating guessing game in which you can recognize dozens of chamber and vocal pieces if your ear is good, but more legitimately because the juxtaposition of fragments in various different keys and rhythms, sets up a new twentieth-century dissonance that is remarkably consistent as the work progresses. I found that it made considerable "sense" on its own for my somewhat post-Beethoven ears.

As the long—very long—work progresses, however, it becomes something else and still more modern. Voices appear, and waver in and out. Pulsings, cuts, raucously thick textures begin to imply a tape collage, and the work is indeed a collage of bits and pieces though by no means all of it is tape-edited; a good deal is played, simultaneously. Towards the end there are even bits of rehearsal discussion (in German) and tuning up. The "live" aspect of the performance adds a lot of power and interest, as does the "chance" element arranged for some of the playing, done in bits and pieces. Yes, it is a "fundamental modernity, a modernity of relationship" as the composer puts it, a concept composition of patterned rearrangement. I think I like it. I only wish I could figure out whether maybe *all* this weird collage was played live and at the same time! It would take the concentration of a genius to perform thusly.

(Continued on page 74)

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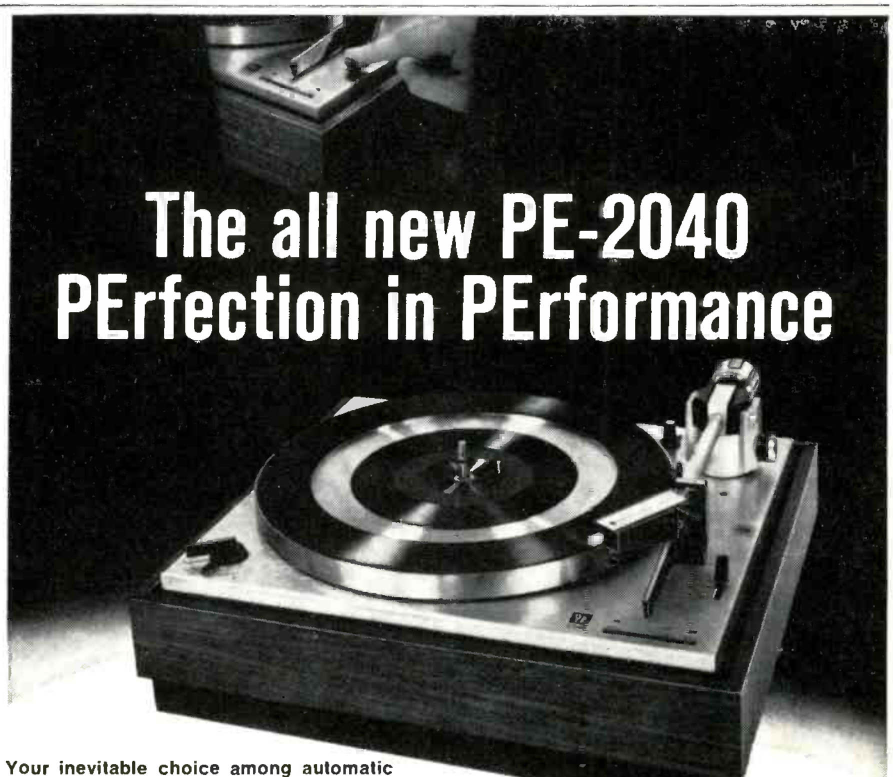

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The Berio work is harsher and more directly structured. "Sequenza VI" is a piece for unaccompanied viola (as commissioned by Walter Trampler, the performer); "Chemins II" (where is Chemins I?) is a recomposing of the same with a chamber ensemble added, "Chemins III" is a further re-working with a full-sized orchestra. The relationship between the three is not difficult to hear. The transformation technique is not unlike that of the third movement of Berio's now celebrated *Sinfonia* into which a movement of a Mahler Symphony is incorporated, at length. Berio's thinking is thus not too far removed from that of Mauricio Kagel, and the two of them are clearly on the well-trod avant-garde track that is becoming the main drag towards our musical future.

Performances: B? *Sounds:* B

Beethoven: Fidelio. Jones, Mathis, Crass, King, Schreier, Talvela; Rundfunkchor Leipzig, Chor der Staatsoper Dresden, Staatskapelle Dresden, Karl Böhm. **Deutsche Grammophone 139288/90** (3 discs) stereo ($17.94).

Beethoven won't be 201 until next December, time a'plenty for you (and me) to catch up with the inordinate floods of 200th anniversary music. This "Fidelio" had me bemused, for DG already had a "Fidelio" in stereo, only a half dozen-odd years old. There was, to be sure, a Böhm-conducted live

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version going on in the USA this year, which would tie in neatly. But, now that I've listened, I see there are better reasons.

The old version, on only two discs (I assume it is cut but have not checked in detail) had good singers–Rysanek, Seefried, Fischer-Dieskau, Häfliger–and a well known director, Ferenc Fricsay. It is basically an all-German performance (in spite of a few geographical anomalies), the sort that, though originally envisioned by the composer, is no longer very much in style. We prefer the more brilliant international performance with singers jetting to the recording scene from all over the world. Moreover, under Fricsay the Beethoven music comes through musically but with a surprisingly low voltage, bordering at times on the inadequate. Somehow, it is unimaginative, lacking in drive. Finally, the stereo sound is already antiquated, lacking in presence and clarity of definition. Perhaps, I suspect, because it comes from the early stereo period when microphone techniques were more "pure" and less colorful than is now customary. Sort of flat and uninteresting though nothing is specifically wrong.

The new set is in every way a contrast. First, it is definitely of the new international sort, with a vengeance, and brilliantly so. After the other, this one will positively jolt you out of your easy chair. Musically, thanks to Karl Böhm, it is full of explosive vitality and the climaxes (zu Freiheit, zu Freiheit!) positively crackle with high-voltage excitement. On paper the voices are surely not superior to those in the old version but they, too, are energized with excitement and do their best, which is better than the superior voices do when under-inspired.

Finally, the new version is enormously–there is no other word–superior to the old in recording technique. The voices fairly jump out at you, loud but utterly undistorted, vast in dynamic range; the background silence is startling and the "soft" passages so low in volume you will flounder to find a good over-all setting. The presence and separation of musical elements are vastly ahead of the old version. Even the problematical spoken dialog is taken in good stride–by a separate set of actors. (The international cast, after all, can hardly be expected to chatter volubly in German between numbers, a problem that Beethoven did not envision.) A new trick: the dialog is mostly at a very low level, whispered and conspirational. Good, for it sets off the music with much less of a jarring contrast than in the usual recorded versions of sing-and-talk operas.

Performance: A- *Sound:* A-

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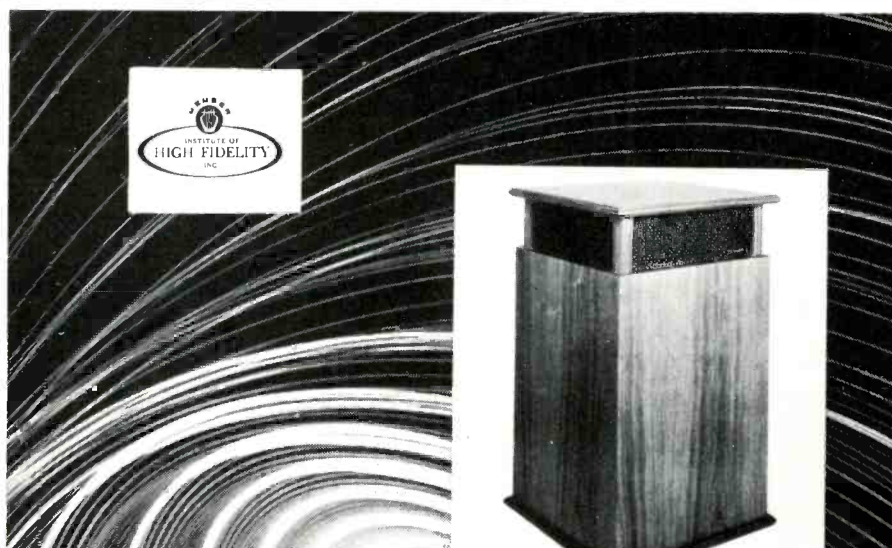

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A couple of questions, however, come to mind: Would you buy a record to slip into the middle of your teenybopper's stack of rock extravaganzas if it promised a respite? Would you play a record containing 19 minutes of silence (and one minute of applause) on each side so you could contemplate, in peace, your navel or whatever?

This disc allows just that—for it is the Nth degree of escapism, perhaps the best kind, maybe even an answer to Simon & Garfunkel's plea, via their "Sounds of Silence," for true communication.

Sure, it's a put-on, evidenced, if by nothing else, by the "Gone-If Records" notation on the back of the dustjacket. (It's a not-too-subtle play on words: "gonif" is the Yiddish term for thief.)

But to remove any doubt, you need only one look at the liner notes. For instance, according to the jacket of the LP, which was conceived and produced by Michael Viner, "Spiro Agnew called this album the quintessence of euphony, cacophony, and salacious ecstasy."

And, "Otto Preminger vows that this record contains the moral significance of all the movies he has made."

And, "George Wallace said, 'It's dirty, isn't it?' "

The concept of the album is clever, but there's more than a touch of sadness when we realize that in a world once filled with natural beauties and resources we often must pay for bottled water, purified air—and silence.

* * *

Danny Kaye may not have been around quite as long as the 600-year-old character he portrays in the newest Richard Rogers musical, but it's difficult to remember a time when show business wasn't graced by his talent.

Regardless, the skill with which he handles a song, or a performance in general, is quickly seen on TWO BY TWO (Columbia, S30338), an original Broadway cast album. For the comedian solos on "Why Me?"—the first number—and then appears alone and with others a total of 10 more times before the LP, part of the "Masterworks" series, closes.

The show, based on Clifford Odets' "The Flowering Peach," a poetic retelling of the Noah's ark Biblical legend, obviously is in the Rogers mold. Musical entries fit the book, always helping the storyline move forward or adding to character insight, yet also stand on their own for the most part. The overall tone is one of lightheartedness, tempered by humor and a casual folksiness. Still, as in much of the Rodgers musical archives, there is a seriousness that underlies everything, helped by lyrics (by Martin Charnin) that make their point succinctly. And despite the antique theme, much of the musical is relevant to today's problems, especially in the area of human relations (both on a broad and a personal scale).

Orchestration, not incidentally, is by Eddie Sauter, whose daring escapades atop many a clef made the big band era all that more exciting.

If there are chartbusters among the score, however, they have yet to emerge. Perhaps that is because the power of the star tends to overshadow everything else.

Kaye somehow seems everpresent, even if he is not participating in a song. On stage, of course, it is more nearly a one-man show than anything else. No matter the medium, "Two By Two" is A-O-Kaye.

* * *

Odetta hasn't as big a name as Kaye, celestially speaking, but her talent easily compares. She, too, has been performing a long time, starting with a classically-trained voice and moving through the folk and blues trends with ease. Now she has gathered all past styles, with the emphasis on black-oriented motifs, and compiled her best vinyl outing, ODETTA SINGS (Polydor, 24-4048).

The singer's throaty voice is simultaneously poignant and soulful on each of the 10 tracks, but especially seems appropriate as she delves into the latest pop trend incorporating religion into music. "My God and I," the longest cut (4:28), is perhaps the best example, with its heavy gospel-like aura (replete with chorus). Despite the fact that some of the words are partially obscured by a weighty piano, organ, and drums, a huge impact is there—probably because the honest feeling and excitement are almost overwhelming. James Taylor's "Lo and Behold" is another composition with distinct church influence.

Odetta, whose unused last name is Gordon, makes sure her repertoire includes plenty of influential tunesmiths on this, her first recording for Polydor. The Beatles, for instance, are represented by Paul McCartney's "Every Night," a contemporary art ballad with folkish overtones. And the Rolling Stones find themselves covered via the Mick Jagger-Keith Richards offering, "No Exceptions," at once a soft and slow, mournful, and haunting piece.

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Elton John, around whom a new cult is growing, provides "Take Me To The Pilot," another gospel-oriented work with blues and soul underpinnings seamed by Odetta and the chorus. And Randy Newman's "Mamma Told Me Not to Come" becomes a soft rock success.

To these, Odetta adds a pair of her own, "Hit or Miss," a catchy blues-soul winner spotlighting an Afro-jazz beat, and "Movin' It On," a bouncy, up-tempo soul rocker.

Finally, she sings "Bless the Children," a meaningful message song with a steady Latin-rock beat (but rendered in what is almost oldtime rhythm 'n' blues fashion), and "Give a Damn," the theme song of the New York Urban Coalition, that here is given strict enunciation and underplayed instrumental so that the words shine through and linger in the mind.

James Last is a guy who thinks in terms of combining the days of the Dorseys and the days of Blood, Sweat & Tears—namely, the old and/or the new—but always with the big band sound. Witness EL CONDOR PASA (Polydor, 24-4509), an LP with a dozen tracks that prove that jazz-pop can transcend time itself.

Highlighted is Last's own composition, "Happy Brasilia," the music of which is obviously just what its title indicates.

The bandleader also has updated some traditional melodies, rearranging, for instance, "Kumbayah," "Washington Square," and "John Kanaka." And he shows that swinging jump tunes weren't something that existed only when Glenn Miller was around: His renditions of Paul Simon's "Cecilia," Bob Dylan's "Blowin' In The Wind," Simon's Americanizations of the title tune, and Lenon-McCartney's "Give Peace A Chance," for instance, all are mod-ernized sounds that small combos henceforth will sound shallow playing. Certainly, when it comes to instrumentals, Last is not least.

* * *

For those who want a sign of stability in their ever-changing lives and someone who is familiar enough to be one of the family (if the family consists of musical talents, that is), ROGER WILLIAMS GOLDEN HITS (VOL. II) is just what the psychiatrist ordered.

There are 11 tracks on the album (Kapp, KS 3638), tunes arranged by Williams or Ralph Carmichael, and all are recent chartbusters. If that's not enough to calm your jangled nerves,

(Continued on page 79)

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BERT WHYTE

Recorded Tape Reviews

The Anita Kerr Singers Tribute To Simon and Garfinkel — Ampex/ Happy Tiger M81016, 8 **Track Cart.** $6.95.

This is a real sleeper. One might never pay anything any attention coming from a label with the outlandish name of "Happy Tiger." However the name of Anita Kerr is not exactly unknown, and if you want to hear some really top-flight group singing, this will fill the bill. A more well-balanced melifluous sounding group I haven't heard in ages. They're not short on precision either, and their attacks are right on the nose . . . no lack of "togetherness" here! The arrangements moreover are more than the usual pap . . . someone with a keen ear for vocal/ instrumental balance was at work here. The sound is the best part of the package . . . very forward in projection, with a lot of presence, very clean and smooth. The tape hiss is also pleasingly low, but there was a shade of print-through. In a bevy of typical Simon and Garfinkel numbers such as the ubiquitous "Mrs. Robinson" and "Parsley, Sage, Rosemary and Thyme," the Anita Kerr singers are a joy to the ear. This is a really top quality production.

Tchaikovsky — Romeo and Juliet Fantasy Overture, 1812 Overture, Zubin Mehta conducting the Los Angeles Philharmonic. Ampex/London- **Dolbyized cassette** M10227, $6.95.

This is Ampex' second release of Dolbyized cassettes, and this time they chose music which was recorded with the Dolby A301. The results are very impressive indeed, both musically and technically. Mehta turns in one of the most spectacular performances ever, of the old warhorse 1812 Overture. Real cannon fire is by now *de rigeur* on recordings of this work, and they are here, along with huge bass drums and tympani, scads of clangorous chimes and bells and at the conclusion a great organ pedal. In the Romeo and Juliet, Mehta pulls out all stops and milks the score for every ounce of drama. Might be a mite too lush for some, but one can't deny the string playing of the L.A. Philharmonic isn't simply gorgeous. You could hardly ask for a better work than Romeo and Juliet to demonstrate the effectiveness of Dolby noise reduction. The opening passages are so quiet and there are so many rests, that if any tape hiss were present it would come roaring through and swamp us with noise. Happily, even at 100 dB peaks, the tape was virtually silent. Of course this opens up the dynamic range, which is very considerable in a work like the "1812." The overall sound was pretty clean, but there were some moments of overload distortion, especially when all hell is busting loose in the "1812." Methinks this work is still a bit ambitious for the cassette format. Still, it is quite remarkable what a tremendous outpouring of sound comes from this skinny little tape! Mechanically there was some problem. In order to get a smooth wind to minimize "burbling" and wow and flutter, the tape was put through fast foreward and rewind several times. After that, everything was O.K.

Ampex/American Airlines Astrostereo — Popular Program W-70 Open reel 3¾ ips, $26.95.

The latest of these three-hour monuments for background listening, and one of the best balanced programs by far. Perhaps this feeling is heightened because it features some of my favorite pop people. There is that always excellent song stylist, Jack Jones; old "Satchmo," Louis Armstrong; Roger Williams, and the Burt Bacharach orchestra. In the three hours you can hear just about every hit number that has been on the charts the past few years and some good "oldies" as well. When Jack Jones was on the Kapp label they always gave him outstandingly good sound, and they do the same for Roger Williams. Since their numbers on this tape are from that label, the quality is better than is usual with these tapes. With few exceptions, the sound quality of the other artists is good too. Good tape processing with the hiss level almost inaudible if played at the appropriate background level. If you are interested in these long players, I would strongly suggest you acquire this program.

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Weingarten

(Continued from page 77)

Williams' piano technique, whether it incorporates classical flourishes, jazz riffs, or Muzak mediocrities, insists on middle-of-the-road approaches—never anything avant garde or the least removed from the ordinary listener's frame of reference. Result: Easy listening.

Spotlighted are a pair of Jim Webb tunes—"Galveston," with its slow intro, featuring a cocktail-type piano, leading to a stringed melody, and "Up-Up and Away," a breezy, glossy arrangement, then a pair of evergreens by the Bachrach-David team—"Alfie," including the kind of ornamentation which is Williams' trademark at the keyboard, and "This Guy's In Love With You," which utilizes a light jazz access.

Others on the initial side include John Hartford's "Gentle On My Mind," with a comparatively fast tempo; "Theme from 'Zorba, the Greek,' " a frenzied, exciting number that includes a midway segment so slow that you momentarily think the song is done; "Happy Heart," a lilting, romantic ditty that is slowed more than are the usual arrangements, and "The Impossible Dream," containing all the drama you would expect from an extract from "Man of La Mancha" and with a sharp contrast between the soft and loud sections.

On the flip side are "A Taste of Honey," brisk and moody simultaneously, all tied neatly with touches of light jazz, and "Love Theme from 'Romeo and Juliet,' " and "Softly, As I Leave You," both velvety, lovely pieces.

* * *

Behind the Scenes

(Continued from page 12)

and clean. At a level of 100 dB on peaks, the cassettes were almost completely free of hiss . . . one had to consciously listen to hear any. It seemed to me the tiny residual amount was apparent compared to the Decca/London cassettes because of the better high end. Both cassettes sounded incredibly clean, with just a trace of overload distortion in the vocal works, and it is claimed that this distortion is on the master. Mechanically they were very good, free-winding, and smooth. A slight cyclic ticking noise in the last few minutes of the Rubinstein concerto turned out to be static discharge, which was not evident in another copy of this cassette. One thing is certain and that is once you start listening to Dolbyized cassettes, you can't stand the "escaping steam" hiss of standard cassettes!

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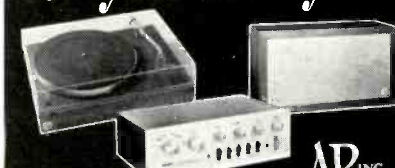

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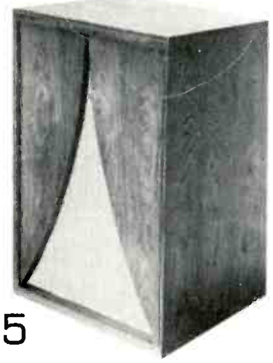

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