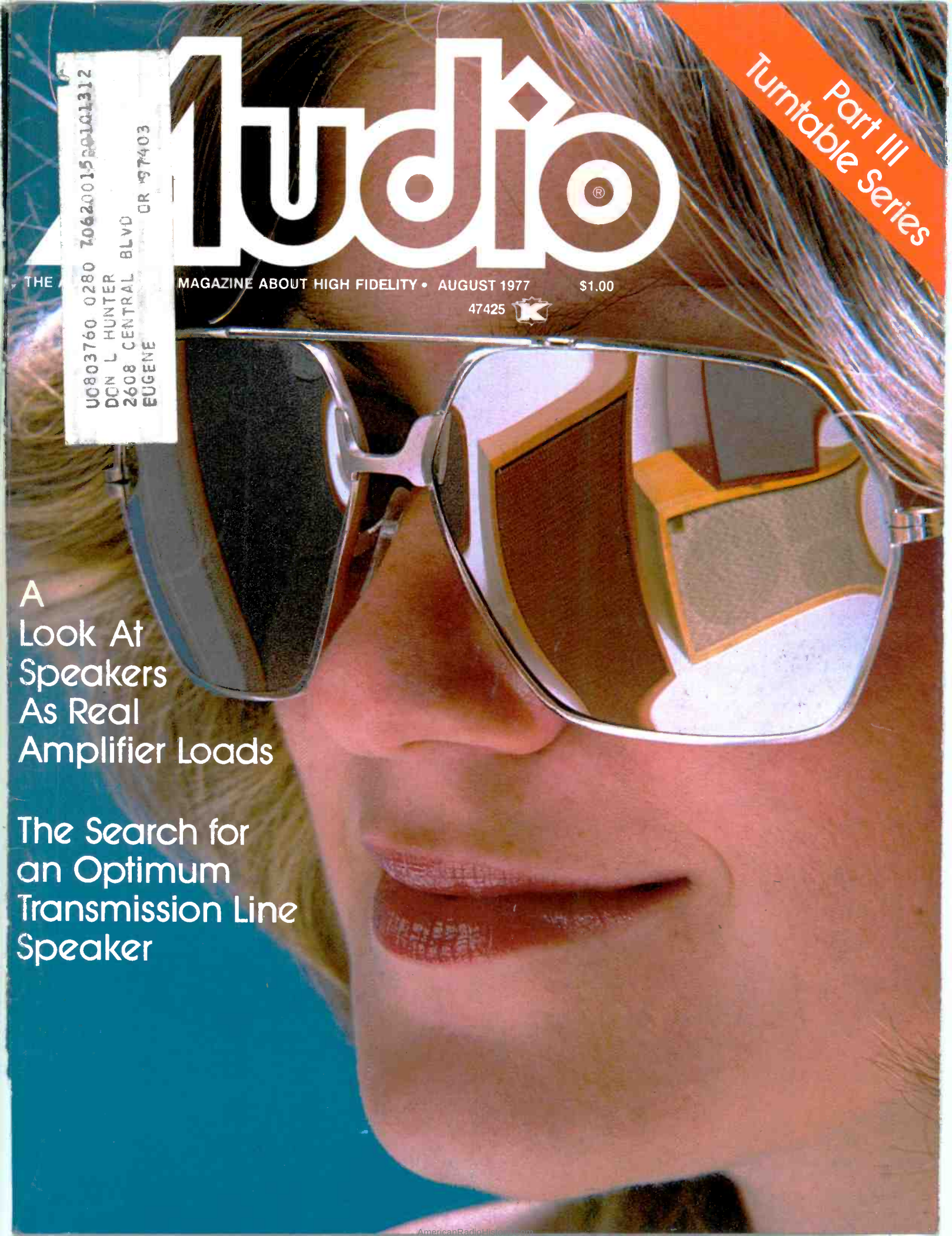
audio

THE MAGAZINE ABOUT HIGH FIDELITY • AUGUST 1977 $1.00
47425

Part III Turntable Series



A Look At Speakers As Real Amplifier Loads

The Search for an Optimum Transmission Line Speaker

ESENTS ACT II.
EST AND MADE THEM BETTER.

to let you get everything out of your tuner. Perfectly.

Our output stage, for example, features a new parallel push-pull circuit that reduces total harmonic distortion to less than 0.1%. Again, well below anything you can possibly hear.

To all but eliminate cross-talk, the SA9500II comes with a separate power transformer for each channel, instead of the usual single transformer for both.

And where some amps give you two, or three tone controls, the SA9500II gives you four. Two for regular treble and bass, and two for extended treble and bass. They're calibrated in 2 decibel click stops, which means you have a virtually endless variety of ways to get the most out of your music.

But that's only the beginning. To get the most out of your cartridge, the 9500II has a switch that lets you "tune" the amplifier to the cartridge manufacturer's optimum capacitance. And to get the most out of your records, our three-stage phono equalizer features an incredibly high phono overload level of 300 millivolts. With no more than 0.2 dB variation from the RIAA curve. So even the most complicated passage on one of today's highly engineered records will sound exactly the way it was recorded in the studio.

Obviously, both the SA9500II and the TX9500II are very sophisticated pieces of equipment. But all of the engineering skill that went into making them has also gone into every other tuner and amplifier in our new series II. No matter what the price, no matter what the specifications.

And that's something you don't have to be an expert to appreciate.

	SA9500II TX9500II	SA8500II TX8500II	SA7500II	SA6500II TX6500II	SA5500II TX5500II
POWER MIN. RMS, 20 TO 20,000 HZ	80	60	45	30	15
TOTAL HARMONIC DISTORTION	0.1%	0.1%	0.1%	0.1%	0.5%
PHONO OVERLOAD LEVEL	300mV	250mV	200mV	200mV	130mV
INPUT: PHONO/AUX/ TAPE	2/1/2	2/1/2	1/1/2	1/1/2	1/1/1
SIGNAL TO NOISE RATIO	95dB	95dB	95dB	93dB	87dB
FM SENSITIVITY (IHF '58)	1.5uV	1.8uV	not applicable	1.9uV	1.9uV
SELECTIVITY	(wide) 35dB (narrow) 85dB	(wide) 35dB (narrow) 80dB	not applicable	60dB	60dB
CAPTURE RATIO	(wide) 0.8dB (narrow) 2.0dB	(wide) 0.8dB (narrow) 2.0dB	not applicable	1.0dB	1.0dB

U.S. Pioneer Electronics Corp., 75 Oxford Drive, Moonachie, New Jersey 07074.

*Minimum RMS continuous power output at 8 ohms, from 20 to 20,000Hz, with no more than 0.1% total harmonic distortion.

High Fidelity Components
PIONEER®
WE BRING IT BACK ALIVE.

TX9500II
SA9500II

TX6500II
SA7500II

E NEW PIONEER AMPS AND TUNERS.

Enter No. 26 on Reader Service Card

LAST YEAR'S REVIEWS PRESENTED US WITH A TOUGH ACT TO FOLLOW.

"IT CANNOT BE FAULTED."

SA9500 — *Stereo Review*

"AS NEAR TO PERFECT AS WE'VE ENCOUNTERED."

TX9500 — *Popular Electronics*

"CERTAINLY ONE OF THE BEST... AT ANY PRICE."

TX9500 — *Modern Hi Fi*

PIONEER PR
WE STARTED WITH THE BE

Last year, the experts paid Pioneer's integrated amps and tuners some of the highest compliments ever.

The challenge was obvious: to build even better amps and tuners. Amps and tuners that would not only surpass anything we'd ever built before, but anything anyone ever built before.

Here's how we did it.

THE NEW PIONEER TX9500II TUNER: EVEN CLOSER TO PERFECT.

When Popular Electronics said our TX9500 tuner was as "near to perfect" as they'd encountered, they obviously hadn't encountered our TX9500II. It features technology so advanced, some of it wasn't even perfected until this year.

Our front end, for example, features three newly developed MOS FETs that work with our 5-gang variable capacitor to give the TX9500II an incredible FM sensitivity of 8.8dBf. In mono. In English, this means you can pull in beautiful FM reception no matter how far you live from the transmitter.

Where most tuners give you one band width for all FM stations, the TX9500II gives you two. A wide band with a surface acoustic wave filter to take advantage of strong stations, and a narrow band with five ceramic filters to remove all the interfe and noise from weaker ones. (Distortion measur stereo at one kilohertz is an incredibly low 0.07 the wide band; and 0.25% in the narrow band. B well below the threshold of human hearing.)

Where conventional multiplex circuits cut ou some of the frequencies that add depth and pres to music, the multiplex circuit in the TX9500II doesn't. It features an exclusive integrated circui that's far more accurate than anything else arou Plus a multipath switch that lets you align your antenna perfectly without an oscilloscope.

And where you simply have to guess about t proper recording levels off most tuners, the TX95 provides you with a tone generator that lets you set the recording levels on your tape deck before broadcast starts.

So your tapes can sound just as clear and beautiful as your tuner.

THE NEW SA9500II AMPLIFIER: HOW TO GET THE MOST OUT OF THE BEST.

After building one of the world's best tuners, had no choice but to create an amplifier that cou match it.

The result is the new SA9500II. An 80* watt integrated amp that was designed

TX8500II
SA8500II

TH
TYPE II

Audio®

August 1977 "Successor to RADIO Est. 1917" Vol. 61, No. 8

About the Cover: Loudspeakers, which reflect the music we love, all too often add some distortion as well. For a fresh look at the loads speakers really present to amps, read Jeffrey Johnson's article starting on page 32.

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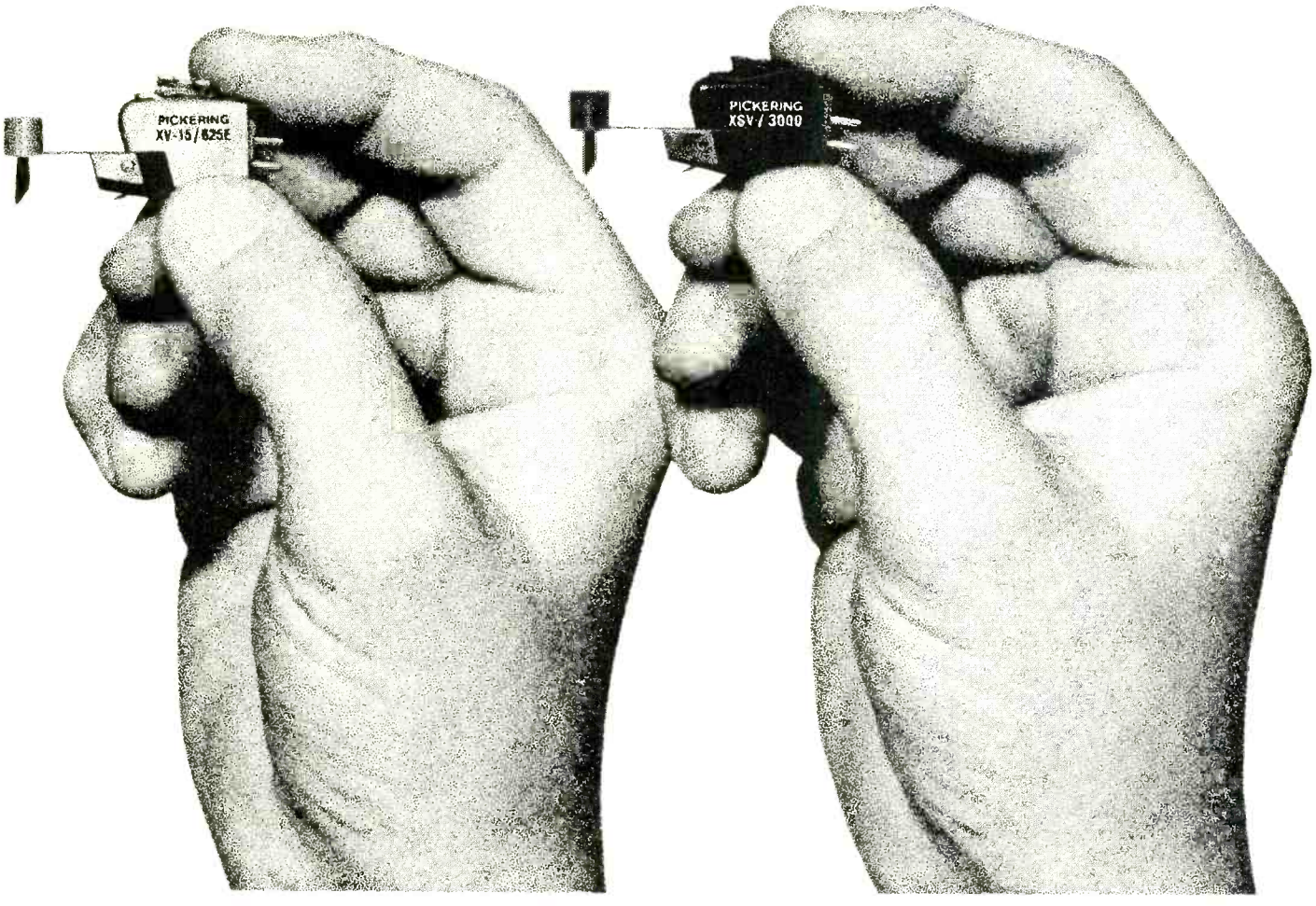
Two sources of perfection in stereo sound.



Match one to your equipment

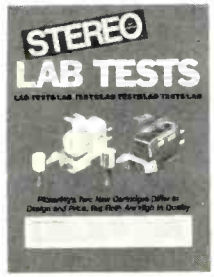
"The right Pickering Cartridge for your equipment is the best Cartridge money can buy."

We've been saying that for years; and tens of thousands of consumers have profited by applying this principle in assembling their playback systems.

If you have a fine manual turntable, the XSV/3000 is a perfect choice.

If you have a high quality automatic turntable, then installing an XV-15/625E in its tone arm is a perfect choice.

The summary advice of **Stereo's** Lab Test, in an unusual dual product review, we think brilliantly states our position: "The XV-15/625E offers performance per dollar; the XSV/3000, the higher absolute performance level." That makes both of these cartridges **best buys!**



FREE!

Pickering's new XSV/3000 is a remarkable development. It possesses our trademarked Stereohedron Stylus Tip, designed to assure the least record wear and the longest stylus life achievable in these times with a stereo cartridge. Its frequency response is extraordinarily smooth and flat; its channel separation is exceptional; its transient response affords superb definition. It represents a whole new concept of excellence in stereo cartridges.

Read the whole evaluation report. Send for your free copy of the ***Stereo*** *"Lab Test" reprint; write to Pickering & Co., Inc., 101 Sunnyside Blvd., Plainview, N.Y. 11803. Department A*

PICKERING

"for those who can hear the difference"

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Tape guide

Herman Burstein

High End Fallout

Q. I have a tape deck and am not satisfied with its recording performance, specifically the high end. According to the Sony Manual the frequency response at 3-3/4 ips should be 20Hz to 17 kHz. I have tested the playback frequency response at this speed and it seems to be about 20 Hz to 15 kHz ± 3 dB, using the standard test tape. However, when I record a test record on tape, I find that the frequency response above 10 kHz is extremely poor. I have checked my phono system and receiver, and these are not at fault. If I return the deck to my local dealer, will he be able to change the bias to optimize the frequency response, without an increase in distortion?—Robert Simpson, Reston, Va.

A. Your tape machine might be supplying excessive bias current to the record head. Reducing bias to extend the treble response is a relatively simple matter for a technician. However, you should be aware that as bias is decreased, there is a rise in the distortion, or to keep distortion as before will result in a decrease in the signal-to-noise ratio, i.e. you have to reduce the recording level. I feel that at 3-3/4 ips you should not aim at a response beyond something like 12 to 15 kHz, depending upon your hearing acuity. Anyway, few adults can hear much above 13 kHz.

High Speed Dubbing

Q. At one time you stated. . . "Little if anything is lost in the process of high speed dubbing of tapes." Assume we record a 15 kHz signal on tape and then dub it onto another tape at high speed. If the playback heads have a -3 dB at 15 kHz, the response will be a lot lower at 30 kHz—the corresponding frequency at twice the normal speed. Then the playback and record preamps would have trouble passing a 30 kHz signal. Also, on the decks used to copy, the record heads would have to record a 30 kHz signal. In my opinion, quite a bit is lost in high speed dubbing. What do you think?—James Harvey, APO, San Francisco.

A. You are correct in the fact that the heads and amplifiers have a larger task to perform in high speed dubbing since they have to permit a more extended treble response. However, modern technology does provide heads and amplifiers capable of handling frequencies up to several times 15 kHz, which means that good dubbings can be made at several times the original speed. Keep in mind that treble loss of a high quality playback head is chiefly due to gap width relative to *recorded wavelength*; so as frequency rises and wavelength grows shorter, the loss increases. But if a 15 kHz frequency is played at twice the normal speed, the recorded wavelength on the tape stays the same, and the loss due to gap width is not increased. The loss is greater as a result of the head's winding and cable capacitance, but these can be kept minimal through use of high quality playback heads and short, low-capacitance cable.

Speed = Frequency Response

Q. When recording, why should the tape speed determine the frequency response? — Howard Wong, Jackson Hgts., N.Y.

A. In recording on tape, losses are a function of the wavelength recorded on the tape; so the shorter the wavelength, the greater the loss owing to what is sometimes called self-demagnetization or self-erasure, that is, a short recorded wavelength has its opposite poles close together, and the closer these poles are to each other, the more they tend to cancel each other out in terms of their external magnetic field.

At a high tape speed, a given signal frequency produces a relatively long wavelength on the tape because much tape passes the head during a

ANNOUNCING THE SPEAKER NO ONE WAS WAITING FOR.

APPLAUSE?

When people think of us, they think of receivers, tuners, amps, cassette decks and turntables. No one thinks of us for speakers.

But with the major advancements we've made in our components, we wanted to make sure they would sound the way they were supposed to sound.

We tested and listened to the best three-way speaker systems and found that almost all of them had remarkably inefficient mid-range speakers. And because 90% of the sound that you hear is in the mid-range, those inefficient speakers were making singers sound slightly nasal and applause sound like rainfall.

RAINFALL?

So we developed our new LS-408A. Our goal was to eliminate the nasal sound, and make sure an ovation sounced like applause instead of rain on the deck of Noah's Ark.

You, of course, had no idea we were up to this.

With the help of computers, holographic analysis, and the sensitive ears of our engineers we built an efficient mid-range speaker that could do those things. Then we put that technology to work building a woofer whose cone eliminates mumbling, along with a tweeter whose higher output would reproduce the sound of the singer's lips and breath.

It's everything a $325 speaker should be, except it costs less than $250*.

And, as crazy as this may scund, it was worth the wait.

For the Kenwood dealer nearest you, see your Yellow Pages, or write Kenwood, 15777 S. Broadway, Gardena, CA 90248.

*Nationally advertised value. For information purposes. Actual prices are established by Kenwood dealers. Cabinetry is walnut veneered with particle board rear panel.

KENWOOD

given amount of time, hence there is little loss due to self-erasure. But at a low tape speed, the same frequency results in a short wavelength because little tape passes the head during the same time span, so now there is considerable loss due to self-erasure. In summary, a reduction of the recording speed results in decreasing treble response, and all other things remain the same.

Variable Transformer

Q. I would like to vary the speed of my Sony tape recorder. Would it be possible to run the motor current through a variable a.c. transformer to alter the speed? If not, can you think of another method that won't damage the motor?—Terry Black, Springfield, Ill.

A. The most feasible method I can think of is to build yourself a power supply with variable frequency. These have been described in electronic literature.

Meter Calibration

Q. Is there any precise way to calibrate a tape recorder's VU meters?—Frederick Kistler, APO, San Francisco.

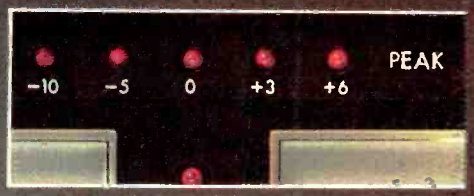
A. The VU meter should be adjusted to read 0 VU when a 400 Hz signal is recorded at a level that produces 1 per cent harmonic distortion on the tape, as checked in the playback.

Reel Warpage

Q. I have Sony tape on seven-inch plastic reels, and when they are placed on a flat surface they don't lie flat. On my machine when it is playing left-to-right everything is fine, but when the deck is in automatic reverse and the tape is moving right-to-left the tape can be heard scraping against the side of the reel. Alignment of the machine has been checked. What can I do about this scraping noise? —Timothy Svec

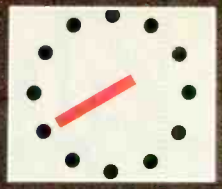
A. The first thing I suggest is that you buy new reels and transfer your tapes onto these. Of course, first check the new reels for trueness. Then you might contact Sony, and, perhaps, they will replace the reels if they are defective. What may have happened is that your reels came from one particular lot which suffered a manufacturing defect. This can happen with any product.

If you have a problem or question on tape recording, write to Mr. Herman Burstein at AUDIO, 401 North Broad Street, Philadelphia, Pa. 19108. All letters are answered. Please enclose a stamped, self-addressed envelope.



5 LED peak level indicators help eliminate distortion.

Long life Sen-Alloy head improves performance, reduces distortion.



Automatic recording when you're not there.

Dolby reduces tape hiss.

Bias and EQ switches for all types of tape.

No cassette deck can give you better performance without all these recording ingredients.

Most quality cassette decks look pretty much alike on the outside. So at first glance you might take the new JVC KD-35 for granted.

But take a second look. You'll see something no other make of cassette deck has—five peak-reading LED indicators. With a faster response than VU meters, or even peak-indicating meters, they help you avoid under-recording and they eliminate tape saturation and distortion. It's as close as you can come to goof-proof recording.

Then there's JVC's exclusive Sen-Alloy head for record and playback. Designed to give you the best of two worlds, it combines the truly sensitive performance of permalloy with the ultra long life of ferrite.

Of course, the KD-35 has many other features like Dolby, bias and equalization switches, and automatic tape-end stop in all modes. It's also possible to go from one operating mode to another without going through Stop. What's more, you'll never have to miss taping a favorite broadcast because you're not there; just connect the KD-35 to a timer and switch to automatic record.

And yet, with all this built-in capability, at $260,* the KD-35 is priced just above the least expensive model in JVC's new cassette deck lineup. Just imagine what our top model is like.

JVC America Company, Division of US JVC Corp., 58-75 Queens Midtown Expressway, Maspeth, New York 11378 (212) 476-8300. For nearest JVC dealer call toll-free (outside N.Y.) 800-221-7502. Canada: JVC Electronics of Canada, Ltd., Scarborough, Ont.

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JVC

We build in what the others leave out

*Approximate retail value. Dolby is a trademark of Dolby Labs, Inc.

Audio etc.

Edward Tatnall Canby

Webcor. Remember the name? If you don't, you soon will. A new line of Webcor products is being launched into the great consumer market, after a Webcor-less hiatus of a good many years. The new firm, however, is an extremely distant relative of the old, and so it is interesting to see this once familiar trade mark, beloved by so many of us oldsters, being revived for a quite different group of items that does not even include a separate record player—the staple of the old Webcor line of popular products.

The reasoning of the new management, Leisurecraft Products, is that research indicates to them that the name "still has a very high consumer recognition and is associated with high quality equipment by dealers, buyers, and consumers." True, at least above a certain age. In my own "hi fi book," first published in 1952, the very first recommendation for a home separate unit turntable was, I see, the Webcor. Excellent quality, if in a modestly priced area. And a good history of satisfaction in use by thousands of us back in those days. Those old Webcor changers powered the front end of vast numbers of modest early home hi-fi systems, and I must say I feel a lot of nostalgia at the mere thought. Who *didn't* own a Webcor? Their heyday came right along with the first blossoming of componentry, through the late '40s and into the '50s, and in those times you could buy a top-of-the-line Webcor for maybe $45 (or a V-M or Garrard), minus cartridge, while the low priced leaders went for $20 or even less. Optional mounting base, $5 extra.

The new Webcor line is aimed squarely at a sales area which —allowing for two things, inflation over a quarter century and the immense increase in sophistication of all our equipment over the entire spectrum—is precisely where the old Webcor brand was immensely successful. What finer reason for reviving a good name?

Now, of course, that price region is not up in the hi-fi stratosphere, the price-no-object area that seems to be so inordinately expanding right now. Heavens no! For the cost of one state-of-the-price amp (no name need be cited) you could buy one each of the entire new Webcor line, if with a few duplications here and there. Webcor isn't even in the "affordable" area—which means less than you

thought (but much, much more than you can afford). So how shall I phrase it? Let's say for the moment that neither Nakamichi nor Yamaha, nor McIntosh, Lux, Phase Linear, Sansui, Technics, Scott, Fisher, Crown—I could go on & on—not one of these estimable hi-fi lines is going to be discounted downwards far enough to compete directly with the new Webcor equipment. Webcor has 'em beat, pricewise.

Low in cost, really down there. And yet there is no end to the miracles we can do now in our home-type equipment, at least as far as externally useful features are concerned. You should gander this Webcor stuff. Quite stunning and no other word for it, though perhaps a wee bit reminiscent of other brands. Of course, there's only one way to get beneath the shiny surface of hi fi and that is not *my* job. Testing, testing! But I was indeed impressed and astonished, at Webcor's premiere showing, by the visible outward impact of this new line with the old Webcor name. It would be hard to believe that such a handsome and well turned out exterior could hide, as they used to say, a mess of pottage. Price for price, it's got to sound good.

Separates & Consoles

Back in the old days, we used to feel that a big distinction between acceptable high fidelity and "ordinary" home stuff was between the then-new component *separate* units, as we called them, and the vast bulk of low-cost mass produced soundware of the radio-phonograph sort, mostly one-piece including the (mono) speaker. Ours was the old loving-care argument. Separate components, we said, were basically hand made and produced in small quantities (!) with quality standards impossible for any mass factory operation. We pointed with scorn to the monster manufacturers of radios and phonographs, the arch-producers of lo-fi, and generally we were right. The American people were quite happy with the sound they got out of their millions of radios, phono attachments, consoles and portables, and we in the new hi-fi field had to find ourselves a small place somewhere alongside the professional and public address audio industries—a bit below the pro but maybe a wee bit above public address. Class A, instead of AB.

We didn't know how lucky we were. The mass-production equip-

Do-it-yourself JBL.

Take the guts of what makes JBL JBL and adapt it to your own ideas of what a loudspeaker system should be.

Mix and match with forty-seven individual JBL components—horns, lenses, dividing networks, transducers, everything.

And when you've found your perfect sound, we'll help you find somewhere to put it: The JBL Enclosure Construction Kit, with complete plans for building your own loudspeaker enclosure from scratch.

See your authorized JBL Loudspeaker Components dealer for the start of a great new team in sound: You and JBL.

JBL

James B. Lansing Sound, Inc. 8500 Balboa Blvd., Northridge, Ca. 91329

ment makers obliged by ignoring us with total unconcern. Thus, their products and ours remained easy enough to tell apart. Our hi fi looked suspiciously like public address (remember Bogen's pioneer models?), utilitarian and all too professional. Theirs was still Second Empire or Regency or Maple Moderne (and still is today in plenty of areas!). No conflict. Not that the prices didn't overlap—if you really tried, you could buy a roomful of Regency for thousands of bucks. But you could also, so to speak, buy for a song. A cube radio—remember?—for $5 & up and a record player attachment, 78, for not much more.

On the other side, our hi-fi side, you could put away your Webcor and acquire a non-changing, non-stopping manual-play Rek-O-Kut table for the fi of it. The name explains itself. The Rek-O-Kut, one of the first "hi-fi" tables, was a massive affair with a big hysteresis motor and enormous rubber rollers directly adapted from a line of professional studio tables often used for disc cutting. It had one major advantage, aside from hi fi; when that table was turning you could put your whole weight on it via a hand and it would merely sprain your wrist without slowing down. Such muscle! Superb for cueing up.

Look Alikes

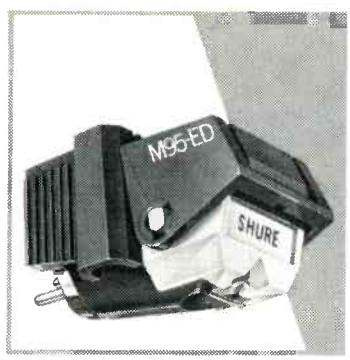
Later on, hi-fi componentry began its well-remembered expansion, though, to be sure, the basic principle of separate and carefully made units exists to this very day and with remarkably few compromises, considering our volume of production. This, needless to say, at last began to catch the interest of the Regency-type outfits. Not that they could do very much on their scale of operations, nor wanted to. (Those who tried were doomed to failure, proving our point handily.) But a certain handwriting was to be seen on the wall, namely, that at least the outward and important conveniences of good hi fi equipment were beginning to impress a great many people including manufacturers of Maple Moderne.

We have now passed through the worst of the imitation that followed. For years, every department store had rows and rows of "hi fis," ranging from updated Regency with shiny knobs through an immense mass of sleazy look-alikes, with impressive speakers mounted in cardboard, to such reputable name-brand hi fi as Scott and Fisher. Imitation, in fact, has simply run its course and come out the other side. There is now a large scale blending, and no two ways about it. No longer is there a dividing line of any sort. Equipment for home sonics ranges seamlessly from top to bottom.

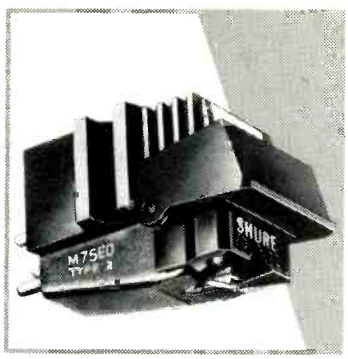
Of course, there are still hi-fi horrors and sometimes they look pretty good, too. But there now exists a very legitimate new area, a large one, in which many of the virtues of mass-produced home audio have been neatly assimilated into legitimate points of hi-fi componentry, money for money, value for value, the good along with the bad. It is an increasingly important area, if not state-of-the-art hi fi; and decidedly it is not one where we can afford to stick our noses in the air. It is always *possible*, you realize, that we are ourselves becoming somewhat over priced for the values we offer. A matter of opinion—and sales—but it won't do for us to be complacent just because we do have state-of-the-art equipment. Ingenuity and price competition can

V-15 Type III . . . critics called the Type III the finest cartridge ever when it was introduced. The ultimate test, however, has been time. The V-15's engineering innovations, the uniform quality, and superb performance remain unsurpassed by any other cartridge on the market today. 3/4 to 1-1/4 gram tracking force.

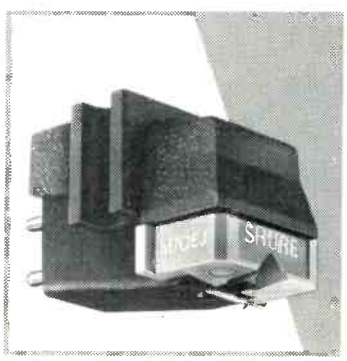
M24H . . . the cartridge that does not compromise stereo reproduction to add four-channel capability. Superb stereo trackability and quadriphonic carrier signal retrieval. New hyperbolic stylus tip, high energy magnet, and low-loss laminated electromagnetic structure. 1 to 1-1/2 gram tracking force.



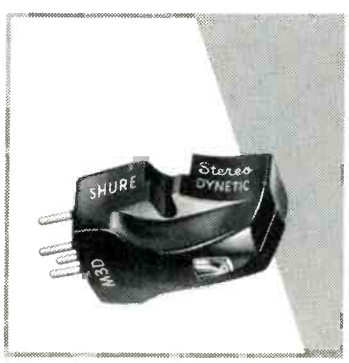
M95ED . . . second only to the V-15 Type III in stereo reproduction. A thinner, uninterrupted pole piece minimizes magnetic losses. Its 20 to 20,000 Hz response remains essentially flat across the entire frequency range for excellent sound quality. 3/4 to 1-1/2 gram tracking force.



M75ED Type 2 . . . excellent trackability at a lesser price. The M75ED Type 2 features a built-in snap-down stylus guard and a smooth 20 to 20,000 Hz frequency response. 3/4 to 1-1/2 gram tracking force.



M70EJ . . . the easiest way to upgrade your hi-fi stereo system without straining your budget. Basically flat response is comparable to other brand cartridges costing twice as much. 1-1/2 to 3 gram tracking force.



M3D . . . the original famous Shure Stereo Dynetic® Cartridge. The M3D provides extremely musical and transparent sound at a rock bottom price. 3 to 6 gram tracking force.

The People's Choice-World-wide.

From Singapore to London to New York, Shure hi-fi pickup cartridges outsell every other brand — according to independent surveys. And for good reason: Shure cartridges, no matter where they're purchased, are guaranteed to meet the exacting published specifications that have made them the Critics' Choice in every price category.

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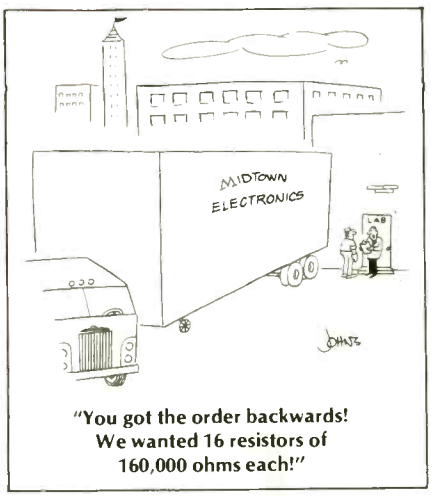
bring forth incredible ingenuity in the market place. Our low-priced competitors keep learning and, just maybe, might give us a run for our component money with their own products.

Without so much as an audible sound from (new) Webcor, I think you can look at their new line and see what I mean. Everything is there that the sophisticated buyer (not particularly hi-fi oriented) could want, really covering the field. Cassette decks? Of course. And with two meters, choice of bias and equalization, built-in Dolby B, and all the proper in/out connectors plus click-type volume controls, solid up-down switches like those on Phase Linear (and in other models, horizontal sliders), all the very latest in hardware and most pleasing to the touch. Stereo receivers—one has a built-in 8-track record/play and the other a devilish device that plays both cassettes and 8-track through the same front slot without adjustment. These models are finished off in handsome brushed silver but there is also a matched pair á la Nakamichi in jet black with thin white lettering, an integrated stereo amp, 17/17, and an AM/FM tuner. And so it goes. A svelte and knowing line of goods if I ever saw one.

To be sure, the two speakers that come with some of the units are unidentified and (as I noted) *extremely* compact in size. And the two receivers in the line give forth with, respectively, 5 watts and 1½ watts per channel, which can't quite match the latest power in price-no-object fi. You will doubtless find other economies appropriate to Webcor's low prices. But if this new Webcor line doesn't give a lot of other makes a run for their hi-fi money I will be surprised. It neatly bridges the gap that isn't there any longer. *A*



"You got the order backwards! We wanted 16 resistors of 160,000 ohms each!"

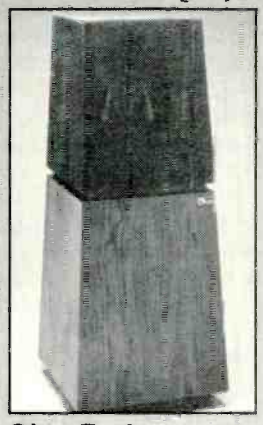
U.S. PATENT 3,424,873

In 1969, the United States government issued a patent for a loudspeaker design that was as different from an ordinary loudspeaker as a laser is from an ordinary lightbulb.

It was a loudspeaker that could accurately reproduce the entire audio frequency range with a single dynamic driver operating as a wave transmission line. Because of this unique configuration, the loudspeaker would be free of the phase, time, and transient distortions common to all conventional multi-driver "piston-type" speaker systems. In other words, the first loudspeaker that wouldn't sound like a loudspeaker.

Today, U.S. patent 3,424,873 is embodied in the Ohm F coherent sound loudspeaker. (Incidentally, a second U.S. patent, 3,935,402, has recently been issued for the voice coil used in the Ohm F.)

To appreciate the magnitude of the accomplishment, you have to listen to music played through a pair of Ohm F's. There's nothing quite like it this side of Philharmonic Hall.



U.S. Patent 3,424,873. It means that no other company can make loudspeakers like the Ohm F, even if they know how.

If you're interested in finding out what international hifi experts have to say about the Ohm F, please write to us at the address below. Or visit your Ohm dealer. A 24-page full-line brochure is also available.

Ohm

Ohm holds the patent on great loudspeakers.

Ohm Acoustics Corp. 241 Taaffe Place Brooklyn, N.Y. 11205 Ohm Canada Ltd. Ontario

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Behind the scenes

Bert Whyte

The annual Los Angeles convention of the Audio Engineering Society is always held early in May and has become one of the "rites of spring" for the audio engineering fraternity. This year, the 57th convention of the AES took on added significance, since it coincided with the 100th anniversary of Thomas Edison's invention of the phonograph and also the 100th anniversary of Emile Berliner's invention of the microphone.

Thus, it was most fitting that the underlying theme of the 57th AES convention was "100 years of sound recording and reproduction," and a number of special events were scheduled in honor of the occasion. The indefatigable Jack Mullin was on hand with his Audio Museum. First shown several years ago, this fascinating display of historical artifacts and memorabilia of audio recording and reproducing equipment has been considerably augmented. In addition to the working model of the seminal Magnetophon, there was the lathe used to cut the 16-in. discs for the Vitaphone sound movies, plus one of the earliest optical sound on film projectors. From the consumer side of audio was an absolutely massive RCA Orthophonic phono console, circa 1927, which was in working order and featured an automatic changer which played both sides of the record, intermixed 10- and 12-in. records, and boasted a 12-ft. folded horn! With magnificent cabinetry, this monster sold for $1000, and that was a lot of bread in 1927. In honor of the Edison centennial and through the good offices of Mr. Oliver Berliner, grandson of Emile Berliner, the Smithsonian Institute loaned the original models of a number of pieces of historical audio equipment. Perhaps the most fascinating was the Berliner Microphone ... according to the publicity release it was constructed on March 4, 1877, and used a toy drum to demonstrate the "loose contact" principle now employed by all telephones throughout the world. This was the first practical demonstration showing that electrodes need not touch to pass current. (Electrodes in this "drum" microphone have a thin air-gap separation.) Another item was the original Alexander Graham Bell "liquid" telephone through which he uttered the immortal words ... "Mr. Watson, come here, I want you" ... on March 10, 1876. Barney Pisha, Audio's resident phono cartridge expert, and I were with Jack Mullin and Oliver Berliner before the official opening of the Audio Museum, and we actually spoke into the Berliner microphone and registered a response on a VTVM!

Photo: Copyright Stanton Magnetics

In addition to the historical equipment display, another feature of the Edison centennial was a series of talks entitled "Our Audio Heritage." Oliver Berliner, grandson of the inventor of the microphone and the disc record, talked about the early days of the record business. Rex Isom, President of the Audio Engineering Society, spoke about milestones in the history of sound recording; audio pioneer John Hilliard reviewed electro-acoustics in the years up to 1945, and Marvin Camras, one of the major contributors to the science of magnetic recording, summarized the pioneering work done in this field during the 1940 decade. Jack Mullin spoke about the professional acceptance of magnetic tape recording beginning with Bing Crosby using it for his radio show in 1947, and how he eagerly awaited the arrival of Ampex recorders Serial Number 1 and 2, and how 78 rpm records (!) were cut from tape masters. Finally, Harold Lindsey, who along with Alexander M. Poniateff put Ampex into the tape recorder business, summed up 30 years of progress since the pioneering Model 200.

Exhibits

Having duly acknowledged our "roots," let us move on to what was new and significant at the 57th AES convention. As usual, the major exhibit areas were crammed with the tools of the audio trade. It is now clearly obvious that the big mixing consoles have become so complicated that automated mixdown facilities are becoming a necessity rather than a luxury option. There were so many portable mixing consoles displayed, one wonders where all this remote location recording is going on. Digital delay systems are fast becoming a "must" for many studios, and their cost is coming down as evidenced in new models from Lexicon and Eventide. At the risk of bringing imprecations on my head, I must note that many of the items at the show were updates and evolutionary refinements of existing models. This was true of most tape machines and test equipment. Of course, there were new items, some from unexpected sources. For example, Crown International, where they were lamenting the phasing out of their tape recorder manufacturing, had a prototype of a real-time analyzer, intended for use with their new EQ-2 equalizer, which is expected to sell for less than $3000. And speaking of real-time analyzers other than the CRT screen type, Ivie is now in production of their clever hand-held unit which uses LEDs. Another of this breed, somewhat larger, but still a portable unit, is that made by White Laboratories, while yet another was demonstrated by Bob Thurmond during his paper.

As is becoming more apparent every year, many of the new items of interest are on demonstration in the sound rooms on the main and the 4th and 5th floors. UREI President Bill Putnam, one of the greatest recording engineers in this country, along with inventor Ed Long, demonstrated their new studio monitor speaker which utilizes Mr. Long's "time align" technique. As you no doubt know, a number of speakers are on the market which have their drive units physically "staggered" or arrayed so that they all

It's time for everybody else to start playing catch-up. Again.

From the very beginning, experts have acclaimed the performance and feature innovations of Yamaha receivers as nothing less than spectacular.

But now, we've outdone ourselves.

Yamaha is introducing a new line of receivers with such unprecedented performance, it's already changing the course of audio history.

Real Life Rated!™ While traditional laboratory measurements provide a good relative indication of receiver performance, they simply don't tell you how a receiver will sound in your living room in actual operation. So Yamaha developed a new standard for evaluating overall receiver performance under real life conditions. It's called **Noise-Distortion Clearance Range (NDCR).** No other manufacturer specifies anything like it, because no other manufacturer can measure up to it.

We connect our test equipment to the phono input and speaker output terminals, so we can measure the performance of the entire receiver, not just individual component sections like others do. We set the volume control at −20dB, a level you're more likely to listen to than full volume. We measure noise **and** distortion together, the way you hear them.

On each of our new receivers, Yamaha's Noise-Distortion Clearance Range assures no more than a mere 0.1% combined noise and distortion from 20Hz to 20kHz at any power output from 1/10th watt to full-rated power.

Four receivers, one standard. On each of our four new receivers, Yamaha reduces both THD and IM distortion to new lows—a mere 0.05% from 20Hz to 20kHz into 8 ohms. This is the kind of performance that's hard to come by in even the finest separate components. But it's a single standard of quality that you'll find in each and every new Yamaha receiver. From our CR-620 and CR-820 up to our CR-1020 and CR-2020.

What's more, we challenge you to compare the performance and features of our least expensive model, the CR-620, with anybody else's most expensive receiver. You'll discover that nobody but Yamaha gives you our incredibly low 0.05% distortion and −92dB phono S/N ratio (from moving magnet phono input to speaker output).

You'll also discover that nobody else starts out with such a variety of unique features. Independent Input and Output Selectors that let you record one source while listening to another. A Signal Quality Meter that indicates both signal strength and multipath. The extra convenience of Twin Headphone Jacks. Or the accurate tonal balance provided at all listening levels by Yamaha's special Variable Loudness Control.

More flexibility. It's consistent with Yamaha's design philosophy that you'll find the same low distortion throughout our new receiver line. Of course, as you look at Yamaha's more expensive models, it's only logical that you'll find the additional flexibility of more power, more functions, and more exclusive Yamaha features.

For example, there's a sophisticated tuner, with unique negative feedback and pilot signal cancellation circuits (patents pending), that makes FM reception up to 18kHz possible for the first time on a receiver. Plus other refinements like a Built-In Moving Coil Head Amp, Fast-Rise/Slow-Decay Power Meters, and Yamaha's own Optimum Tuning System.

Now's the time to give us a listen. Our new receiver line is another example of the technical innovation and product integrity that is uniquely Yamaha. And your Yamaha Audio Specialty Dealer is an example of uncommon dedication to faithful music reproduction and genuine customer service. It's time you heard them both.

If your Yamaha Audio Specialty Dealer is not listed in the local Yellow Pages, just drop us a line.

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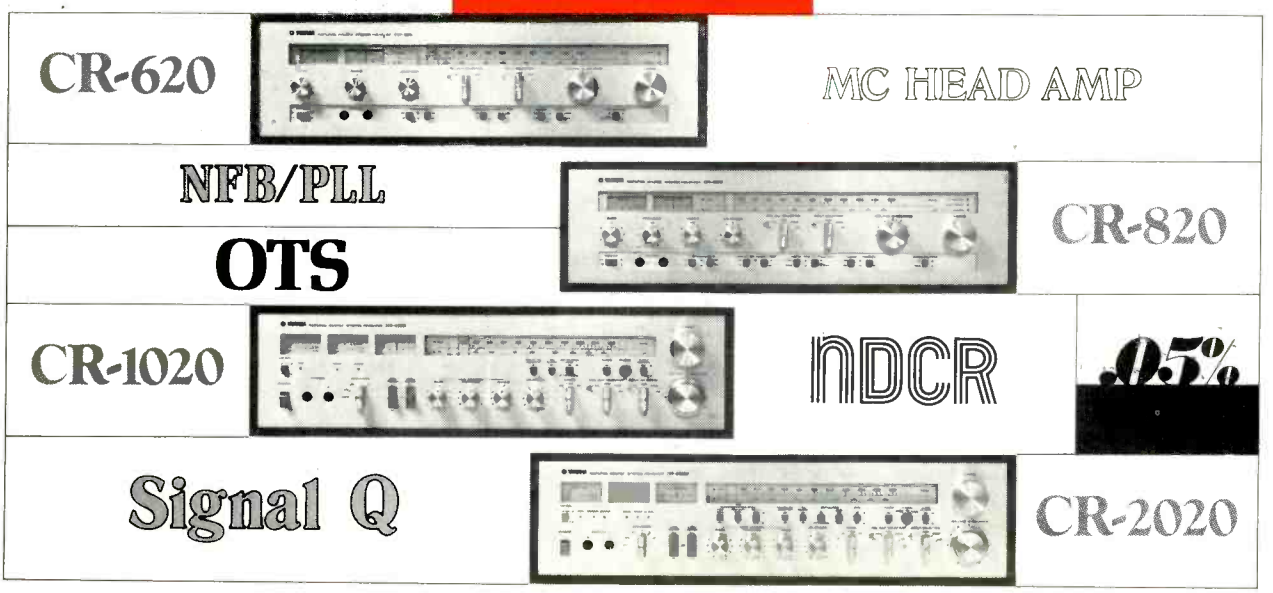

lie in a common acoustic plane, thereby avoiding distortion due to time delay. Mr. Long has managed to accomplish this electronically in the crossover network of the UREI speaker. Switching back and forth between the conventional network and the "time align" network revealed a dramatic difference in sound quality, especially noticeable with male speech. The "time align" sound was very smooth and articulate, whereas the other sounded quite colored, almost as if there were a boost in the mid-frequencies.

As I reported on the 55th AES convention in New York, digital recording continues to advance. The first technical papers at this 57th convention were on digital recording, and they were very well attended. Up on the 4th floor Dr. Tom Stockham and Dick Warnock of Soundstream were demonstrating their digital recorder. This was a far better demonstration of the capabilities of their recorder than we heard in New York. The sampling rate has been increased and the full 16-bit system is in use. In a recording of some percussion music, the sound quality was really fantastic . . . super sharp transient response, ultra clean, with modulation noise blissfully absent, not a smidgen of distortion, and on a cymbal roll that began at bare audibility and increased to triple fortissimo, the 90-dB dynamic range available with this system was very apparent. Needless to say, this also afforded a recording with a dead silent background.

Mitsubishi was also showing a digital recorder, in their case a stereo PCM unit, using quarter-inch tape at a speed of 15 ips. A stationary head is used, and necessary bandwidth and bit density are achieved by encoding the audio signal in PCM and allocating the signal to nine tracks in parallel. The sound of this recorder was quite clean and quiet, but perhaps because of the music and/or the speakers that were being used, it just did not sound as impressive as the Soundstream recorder. On the other hand, at the projected price of $10,000, it is far less expensive than the Soundstream machine.

In the dbx suite, they were demonstrating their noise reduction units and the new 3BX dynamic range expander. I mistakenly reported in a recent column that this was a single-pass noise reduction unit. It is a three-band dynamic range expander, and while of course there is some noise reduction with this type of device, that is not its main function. We will report on this unit before long.

Stamper Stylus

One of the real surprises at this convention was the introduction by Stanton of a new stylus system, Model 681BPS which can perform the remarkable function of the playback of metal record stampers and matrices. The stamper is a negative, and as you can see from the accompanying photograph, the stylus is a sort of "saddlebag" affair which straddles the ridge made by the groove. To play back, there must be a special turntable which rotates counterclockwise to the normal direction. All this is in aid of being able to check the plating quality of a stamper before records are produced, and if slight defects are noted, there are methods of physically correcting these defects. I should add that actual playback of the stamper was impressive, with a very clean top end, and really excellent transient response, probably due to non-deformation of the metal, as compared to the vinyl of the standard recording. Stanton also introduced a new professional calibration standard cartridge, the 881S that uses their new Stereohedron stylus, samarium cobalt magnets, and a new suspension system.

In spite of the sad estate of quadraphonic sound, development work continues, probably in anticipation of what will happen when the FCC finally makes a decision on the choice of system for broadcasting. Thus, it was that JVC introduced a new demodulator that has what they call PTL . . . Phase Tracking Loop. This is said to give better S/N ratio, wider frequency range, and improved tolerance to worn records in CD-4 recording. What I heard was impressive, and I was told that the system could be reasonably adapted to chip form if the need arose. In the CBS room, the long-awaited Tate SQ chips from National SemiConductor finally made their appearance. A claim of 35-40 dB of separation is made for this matrix system, and I must say it certainly did a good job, with none of the "speaker jumping" that characterizes most of the logic system decoders. One could stand well off to the side with this Tate system decoder and still get positional information from each of the speakers. Sansui has not made any changes recently in their Variomatrix QS decoders, but say there are many more records now becoming available in QS. They were showing an integrated amplifier of a new type, with particular emphasis on phase linearity. It should be on demonstration at the CES.

Pioneer was driving their brute Spec 15L monitor speaker (200 watts) with their new M-22 Class-A amplifier. Although only 30 watts per channel, such is the efficiency of the speaker, that it was achieving very clean high power outputs.

Of all the technical papers presented, that by C.K. Hunyar of Phonopress, Inc., on various problems of record pressing, was perhaps the most controversial and was even shocking to some. He went into such areas as non-fill and warping, talked about the possibilities of such new record plastics as polystyrene and polyproplyene. Finally he talked about record storage and . . . of all things . . . condemned the time-honored practice of storing records vertically! He stated that due to "cold flow," records stored in this manner get "out of round" and eventually cause problems. Well!

Two other highly important papers were presented by John Hoge and Don Keele, who detailed the application of the Thiele/Small speaker system analysis to horn type systems. Previously, this sort of analysis had only been applied to closed and vented boxes, and it was for his contribution in this area that Dick Small was awarded the Publication Award at this year's Banquet.

"Slewing Induced Distortion and its Effect on Audio Amplifier Performance" was the title of a paper given by Craig Todd, of Dolby Labs, for coauthors Walter Jung and Mark Stevens. This has been a highly controversial subject over the past couple of years, to say the least, and this paper presents detailed listening and measurement studies of many different op amps. The authors end up by giving us a criterion for negligible slew rate distortion in audio circuits — "the circuit, including all possible loading conditions, should possess a slew rate of 0.5 V/μS (minimum) to 1 V/μS (conservative) per peak output volt . . . if the slew rate is symmetrical and the input stage has a smooth transfer characteristic." One thing you must say for Mr. Jung and his colleagues, no matter where you stand on this question, they take a hard-nosed, "let's go into the lab and measure" approach.

The banquet speaker, quite appropriately, was Les Paul, that old master of multi-track recording and originator of the overdubbing process. His reminiscing and telling of anecdotes had the capacity audience fascinated.

Why Micro-Acoustics 2002-e owners enjoy music more than you do.

If you're listening to music with any of the other high-quality stereo phono cartridges on the market today, there's a very good chance you're missing something. Something that's earned us unanimous praise from 2002-e owners: *a significant improvement in sound quality* which can only come from major advances in cartridge design.

Twin-pivot dual-bearings. Perhaps the most unique feature of the 2002-e is its direct-coupled transducing system, which was granted U.S. Patent No. 3952171. Unlike conventional single-pivot cartridges, which can only be optimized for tracking or transient ability, our unique twin-pivot/dual-bearing design is optimized for *both* characteristics—which are equally vital for precise reproduction.

Twin pivots insure superior transient ability, enabling the 2002-e to accurately follow even the most complex waveforms. And dual bearings maximize tracking ability, so that even difficult high-level passages can be accurately tracked at very low stylus forces.

Beryllium cantilever. The 2002-e's precisely-formed cantilever is made of beryllium—an exotic space-age substance that is 35% lower in mass than conventional stylus bars. As a result, the cartridge boasts far lower moving mass, contributing further to its superior transient ability and unusually 'transparent' sound. By dramatically reducing moving mass, the 2002-e also reduces record wear to vanishingly low levels.

Low cartridge body weight. More and more tone arm designers are discovering the importance of cartridge weight, especially in tracking warped records. Since over 95% of today's records are warped to some degree, a lighter cartridge means more effective tracking at lower stylus forces. At *less than half the weight* of most high-end cartridges, the 2002-e enables you to enjoy records that couldn't be tracked by other cartridges.

The mismatch problem: solved. Until now, an exact match between phono cartridge and preamp (or receiver) input impedance was required for flat frequency response. The 2002-e's built-in passive microcircuit *eliminates* mismatch problems by automatically controlling output impedance. This microcircuit also makes the cartridge immune from the effects of cable capacitance, so the 2002-e may be used with all types of tone arms—even those lacking low-capacitance cables.

Critical acclaim/popular acceptance. Few contemporary high-fidelity products have received such unanimous critical acclaim. And no other stereo phono cartridge has been so successful in satisfying the critical demands of today's sophisticated, dedicated music lovers.

But don't take our word about why 2002-e owners enjoy music more than you do: the proof is waiting at your Micro-Acoustics dealer. Or contact us for more information.

Hear the difference. To help you evaluate and compare cartridge tracking and transient abilities, we've developed a unique demonstration/test record which is itself enjoying widespread critical use and acclaim. (For a postpaid copy, send $3.95 to the factory.)

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Micro-Acoustics
"Because good tracking isn't enough."

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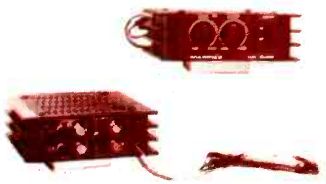
$119.00, suggested list.

what's new

Royal Sound Car Stereo Amp.

The Model RS-55 is a mobile stereo amplifier with a 15 W output operating on a 12 V d.c. negative ground. The unit features separate bass and treble controls, an On/Off switch, an indicator light, and quick-connect terminals. Price: $90.00.



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Micro-Acoustics Phono Cartridge

The Model 282-e phono cartridge is designed with special attention to tracking warped records as it reduces sensitivity to the tonearm-cartridge interaction, and can therefore be used with any quality turntable's arm. The elliptical stylus has a stated frequency response from 5 Hz to 20 kHz, with a tracking force of 0.75 to 1.5 grams, a cartridge weight of 5.2 grams, a nominal channel separation of 25 dB @ 1 kHz and 15 dB @ 10 kHz, and an output voltage of 3.5 mV in each channel @ 5 cm/sec peak recorded velocity. Price: $89.00.

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B&K Catalog

The free Short Form Catalog is a 36 page listing of Bruel & Kjaer's full line of transducers and instrumentation for sensing, measuring, and analyzing all aspects of sound and vibration are listed and briefly described.

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Dynaco Integrated Amplifier

The SCA-50 is an integrated stereo preamp/amplifier rated at 25 watts per channel into 8 ohms from 20-20,000 Hz at less than 0.5 per cent THD and less than 0.1 per cent IM distortion at any power level. The bass control has a variable turnover characteristic so that small changes in boost or cut affect only the lowest frequencies first and not until the bass control is advanced considerably will it affect the lower midrange. The treble control has a fixed turnover, but its hinge frequency is higher than usual, allowing both controls to be altered to nearly their extreme positions without affecting the midrange response. Measuring 13 ½ in. W x 12 in. D x 4 ½ in. H, the unit weighs 15 lbs. Price: $249.00 factory assembled, $149.00 in kit form.

Enter No. 83 on Reader Service Card

ADS Car Speaker

The ADS 200C is a miniature loudspeaker system which conforms to the DIN 45500 standards for "high fidelity." Measuring 4.25 in. H x 6.85 in. W x 4.65 in. D, and weighing 4.6 lbs, the unit is equipped with one four-in. long excursion woofer and a one-in. soft-dome tweeter, with both drivers acoustically suspended. The frequency response is 85-20,000 Hz ±3 dB with a power rating of 30 W rms and an impedance of 4 ohms. Price: $110.00 ea.

Enter No. 84 on Reader Service Card

Akai Cassette Deck

The Model GXC-730D is a bi-directional record/play cassette deck with three heads, including a centrally positioned GX record/play head, an A.D.R. (automatic distortion reduction) system, and Dolby circuitry. Other features include a peak level

indicator which illuminates at +7 dB to warn of excessive input, illuminated VU meters, an output level control, front panel microphone and headphone jacks, separate left and right channel recording level controls, and front panel switches for low noise, chrome or FeCr tapes in addition to rear panel recording level calibrators for other special tapes. Price: $500.00.

Enter No. 85 on Reader Service Card

Marantz Receiver

The 2285 AM/FM stereo receiver features a three-zone tone control with selectable turnover, a Bessel-derived 18-dB-per-octave high filter, a dual gate MOS-FET FM front end, phase-lock loop multiplex demodulator, a complimentary direct coupled amplifier section, and tape-to-tape copy facilities with the ability to dub from any tape deck to another while listening to a third source such as phono or FM. The unit produces 85 watts per channel rms into 8 ohms from 20-20,000 Hz with no more than 0.08 per cent THD. Price: $670.00.

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WHY MOST CRITICS USE MAXELL TAPE TO EVALUATE TAPE RECORDERS.

Any critic who wants to do a completely fair and impartial test of a tape recorder is very fussy about the tape he uses.

Because a flawed tape can lead to some very misleading results.

A tape that can't cover the full audio spectrum can keep a recorder from ever reaching its full potential.

A tape that's noisy makes it hard to measure how quiet the recorder is.

A tape that doesn't have a wide enough bias latitude can make you question the bias settings.

And a tape that doesn't sound consistently the same, from end to end, from tape to tape, can make you question the stability of the electronics.

If a cassette or 8-track jams, it can suggest some nasty, but erroneous comments about the drive mechanism.

And if a cassette or 8-track introduces wow and flutter, it's apt to produce some test results that anyone can argue with.

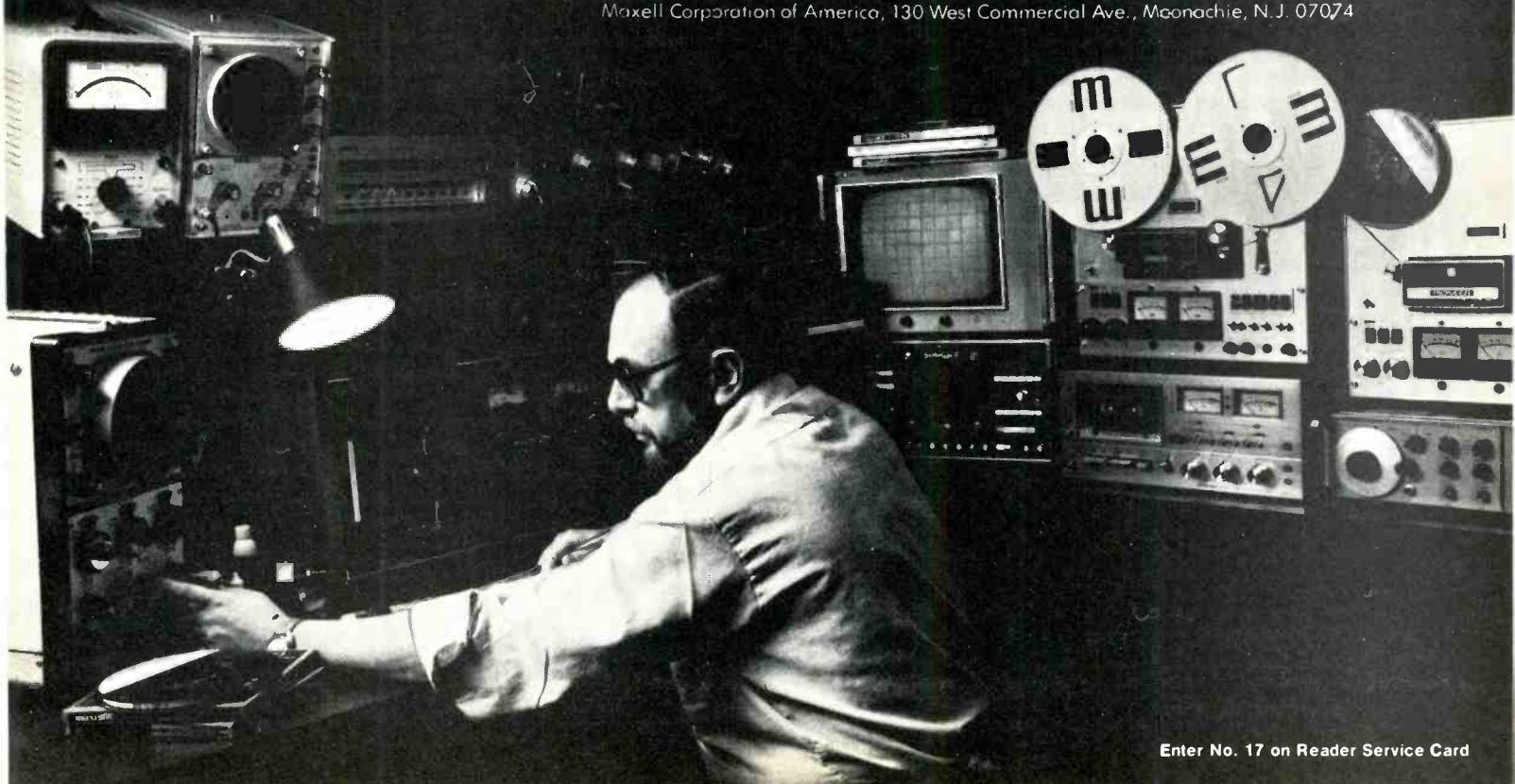
Fortunately, we test Maxell cassette, 8-track and reel-to-reel tape to make sure it doesn't have the problems that plague other tapes.

So it's not surprising that most critics end up with our tape in their tape recorders.

It's one way to guarantee the equipment will get a fair hearing.

MAXELL. THE TAPE THAT'S TOO GOOD FOR MOST EQUIPMENT.

Maxell Corporation of America, 130 West Commercial Ave., Moonachie, N.J. 07074



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Audioclinic

Joseph Giovanelli

Record Grooves

Q. I assume that the record industry has standardized the specification for the pitch of a record cutting lathe, also the number of grooves per inch along the radius of the record. What is that number and what is it called?—Mark Hutchenreuther, Oxnard, Cal.

A. There is no standardized number of grooves per inch in a cutting system, and it is not possible to standardize this parameter. What is often done to make maximum use of the space available on the disc is that groove geometry and the number of grooves per inch are made to vary in accordance with the amount of volume present on the disc at any given time. In a case where the dynamic range is wide and where there are long passages of soft playing, the number of grooves might be compressed during those soft passages to better than 350 per inch. During the loudest passages they would expand to 150 grooves per inch. This would enable a good match between the maximum permissable recording time, recording level, and the bass response.

FM Drift

Q. What would cause my receiver to go off frequency even when the AFC has been switched on? This does not happen on weekends, only during the week, and as late as 10 p.m. I live in a business-residential area in downtown New York City. What can the problem be?—Bernard Friedland, New York, N.Y.

A. Are you sure your receiver drifts off frequency? Perhaps something else is wrong. If the equipment has a tuning meter, you can see this at a glance. Of course, even without a meter, if retuning the dial improves audio quality, then frequency drift is the problem.

The chances are, though, that your equipment is functioning normally and the problem is really one of power line voltage variations. If the voltage drops below a certain critical point, the regulators in your equipment will become ineffective, and frequency drift and reduced power will be the likely results of this. I suggest that you check to see just how much voltage change takes place using an a.c. voltmeter which costs between $5- and $10.00. Your power supply company should be consulted in the event this condition does exist.

Also, the probable reason that your equipment works best on weekends is because the industrial users are not consuming enough power to cause a serious voltage loss in your home.

There are devices known as "constant voltage transformers" which can be used to steady line voltage, but these are quite expensive. But this condition should not go uncorrected because, as you have seen, low voltage can adversely affect the performance of a sound system.

Speaker Phasing

Q. I wish to wire two identical 4-ohm speakers in series. Please explain how this is done so the speakers will be in phase?—Stanton Vollman, Bronx, N.Y.

A. To wire two identical speakers in series and know they are in phase, connect the common of speaker A to the common amplifier output terminal, the hot terminal of speaker A is connected to the common terminal of speaker B, and the hot terminal of speaker B is connected to the hot amplifier output terminal.

If this hookup is to be made with two or more channels, each channel must be wired in the same manner. All the speakers will then be in-phase as long as all amplifiers are in the same phase relationship. This will be true if all speakers employed are of the same make and model, but if various speakers are used then the phase relationships will have to be checked.

If you have a problem or question on audio, write to Mr. Joseph Giovanelli, at AUDIO, 401 North Broad Street, Philadelphia, Pa. 19108. All letters are answered. Please enclose a stamped, self-addressed envelope.

Two Bold Statements:

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Total System Price	Recommended Synergistics Loudspeaker
Under $450	Model S-12A
Under $500	Model S-22A
Under $600	Model S-32A
Under $700	Model S-42A
Under $850	Model S-52A (Tower)
Under $1,100	Model S-62A (Tower)
Under $1,500	Model S-72A (Array)

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SYNERGISTICS

For More Information Write To: Synergistics, P.O. Box 1245, Canoga Park, California 91304.

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Dear editor

Lirpa I Retest

Dear Doktor:

After Mr. Dennoc was arrested and sent to the "house on the hill" with the psychiatrists, a group of us here in Texas tested your "thing."

We found the 100 watt pilot light too bright and threw it away. The Lirpa I looks much better in total darkness anyway. We are still looking for the "destruct" button. The muting switch still allows noise to come through. Local FM stations, even the rock things, disclaim any knowledge of either you or your Lirpa I. When asked, the hi-fi stores just moaned and hung up the phone.

The report by Dr. I.M. Toidi is obviously edited by you just to make it sound good. Nonsense, it is worse than that. And you know about anybody from California. U.R. Dennoc needs new hearing aids, for both ears! However, we found it sounds better with either the speakers or headphones *not* connected.

The surprise was that you made the Lirpa with a single burstanic, denotramertecum, or zoptanuporumbactiocoryuist in the ptuidic assembly, yet still got nothing.

We offer to purchase it...the price? Fifteen cents is way out of line. Our bid is one genuine U.S. nickel. Take it or leave it.

With pity and hope...

R.R. Cunningham
Cunningham Assoc.
Houston, Tex.

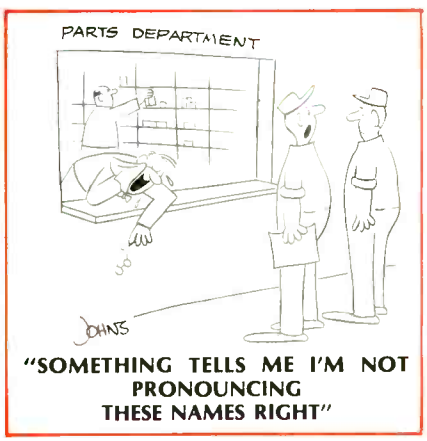
Editor's Note: Unfortunately we already have a much better offer...two brand new 1914 Chinese pennies which were recently found along the banks of the Olt River in the Transylvanian Alps of Dr. Lirpa's homeland, Rumania.

Audio Accolades

Dear Sir:

I am a new subscriber to *Audio* Magazine and I just read the April 1977 issue. I am very delighted and impressed with your article on "The Compleat Microphone Evaluation." I should add that I have been a subscriber to *Stereo Review* Magazine for the last five or six years, and while I have learned a lot from that magazine, it is refreshing to be part of fresh and different audio topics and points of view.

Your microphone article was particularly timely for me since I now own a Dokorder 7140 tape deck and I am about to purchase a pair of mikes for general use in serious recording of both solo and small group vocals, as well as occasional orchestras and larger choral groups. I have read all the mike selection articles in old *Stereo Reviews*, and I have searched all the newsstands for all the information on mikes I can find. By doing this I have learned a lot about some aspects of choosing and using mikes, but I still face a bewildering choice of mikes.



"SOMETHING TELLS ME I'M NOT PRONOUNCING THESE NAMES RIGHT"

The refreshing thing about your mike reports project is, that at last, we buyers will have some access to *Real Live Test Reports* on mikes, and unbiased at that! That in itself is almost unbelievable and long overdue. Nobody else seems to be interested in testing mikes, and if they are, the bottom line of the report always reads something like..."This mike is a fine value and would be a worthy addition to any system, etc., etc."

Dr. Scott C. Suly DVM
N. Hampton, N.H.

Lirpa Ardor

Dear Sir:

Radio station WKIK, along with most AM broadcast stations, spends a lot of money to provide a clean, wide range signal which far exceeds the frequency response limitations of most AM receivers. Many broadcast engineers have written letters pointing this out, and the review in the January issue of *Audio* on the vintage E.H. Scott receivers also bears this fact out.

There are many fine FM tuners available, but only one AM that I know of which can reproduce the full range of a contemporary AM signal. Perhaps, the folks who produce the Lirpa I receiver reviewed in the April issue will soon deliver an AM receiver for testing, a receiver that can match their FM set in quality.

The management has authorized me to order a Lirpa I FM receiver, and I am sure that as soon as a Lirpa 2 AM receiver comes on the market, many engineers at FM stations will order them. Just imagine the value of a receiver that can show your competition at its worst! Of course, I understand that certain control functions will have to be revised. For example it would be helpful to have adjustments for hiss, co-channel beat, noise, adjacent channel (10 kc) whistle, a device to accentuate skip interference, and, of course, a "mud control" like the one on the Lirpa I FM receiver would be essential..."See how muddy they sound!" people buy advertising on that.

Thanks for the best and most straightforward test report I've seen today.

Frank S. Miner III
Director of Engineering
WKIK Radio
Leonardtown, Md.

Alternatives to Bad Records

Dear Sir:

I would like to urge Mr. Robert H. Lacher (letter to "Dear Editor," May 1977 issue) not to sell his $5000 system because the inferior quality of most records makes listening less than pleasurable. With Stereotape of California (and soon Barclay-Crocker of New York) issuing absolutely stunning Dolbyized reel-to-reel tapes, there is no reason to settle for sloppily made records. Stereotape is now issuing RCA and London, and I understand that DGG will soon be added.

Sometimes it just doesn't add up

What you want is better sound. But, the expense of replacing your whole system just isn't reasonable. MXR has a way to upgrade your sound significantly, without starting from scratch. MXR's Stereo Graphic Equalizer and Compander can give you the right sound at a cost that is much easier to take.

The MXR Compander can double the dynamic range of most open reel and cassette tape decks to allow professional results in home recording. The Compander increases the overall fidelity of your system while reducing noise. The softest sounds can be heard, while musical peaks can be reproduced without distortion.

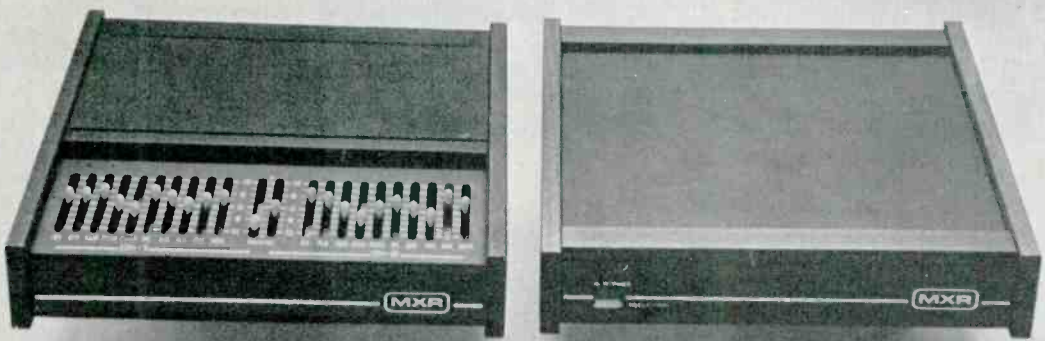
The Compander compresses the dynamic range of the signal going onto the tape and expands it upon playback at a two to one ratio. The resulting increase in dynamic range allows your present system to produce the depth of sound that you want to have when you record.

A natural companion, the MXR Stereo Graphic Equalizer is designed to provide precise compensation for aural discrepancy that may be caused by room acoustics, speaker inadequacies or program source. The Stereo Graphic Equalizer allows you to tailor your sound to your own tastes. At the touch of a slide control, you can customize your playback to suit any number of variables. It can provide you with enough control over your present system to give you the sound that you want to hear.

The Compander, at $129.95, and the Stereo Graphic Equalizer at $199.95, with the equipment you already have, can add up to the sound that you want, at a reasonable price.

For more information see your nearest MXR dealer or direct inquiries to MXR Innovations, Inc. 277 N. Goodman St., Rochester, New York 14607 (716) 442-5320.

MXR Consumer Products Group



Enter No. 21 on Reader Service Card

Barclay-Crocker will soon offer the Musical Heritage Society line, among others. There IS hope for those of us who demand quality.

William T. Wingo, Jr.
Sulphur Springs, Tex.

Lirpa Lover

Dear Kindly Editor:

Thanks for the copy of the April issue of *Audio*. My good friend R.M.S. Watts has bought one of the Lirpa I receivers. I have enclosed his comments, as perhaps you would want to share them with your gentle readers.

Robin
W.J.J. Hoge
Boy Wonder

After reading Professor Lirpa's review of his receiver, I went out and bought one. It is a significant advance in the audio art, perhaps, even a major breakthrough. I have found the performance to be superior to my previous reference unit, a homemade 500 W amplifier which uses 50 2A3 thermionic vacuum valves in a parallel/push-pull, Class A circuit which is direct coupled to the loudspeaker.

I did not experience the Doppler effect problems reported by Mr. Toidi. I suggest that a higher caliber cartridge, such as the Remington High-Velocity .357 Magnum, would match his pace. Also, I did not have Mr. Dennoc's loudness problem. This is because I am using the Hurtz & Associates Ultimate LSH (1) system (in mono, of course) with the Lirpa I. This system requires 1200 W input power to produce 88 dB SPL at one meter.

(*Editor's Note:* We believe that there is a misplaced decimal point here. The system produces 0.88 dB SPL at one meter, or 88 x -10^{-2}.)

I have found a way of reducing the TIM distortion in the amplifier to a level which should be inaudible to Professor Lirpa. A non-alignment tool (available from Third-World Elektronik, Gmbh.) is used to adjust the non-user-adjustable control for an output of 16.67 furlongs/fortnight with a 4 kg load. Great care must be taken to avoid overtweaking, or the resulting grounded-base operation will cause excess acidity which will consume 47 times its weight in dome tweeters.

I have only one complaint with the Lirpa I...the sound type selector does not have a TN button. How can I play my country music records from that city named after my hometown?

R.M.S. Watts B.S.
Nashville Audible Group, Ltd.
Nashville, IN

(1) O. Gadfly Hurtz, "The Ultimate LSH Loudspeaker" *Journal Audio Engineering Society*, March 1974.

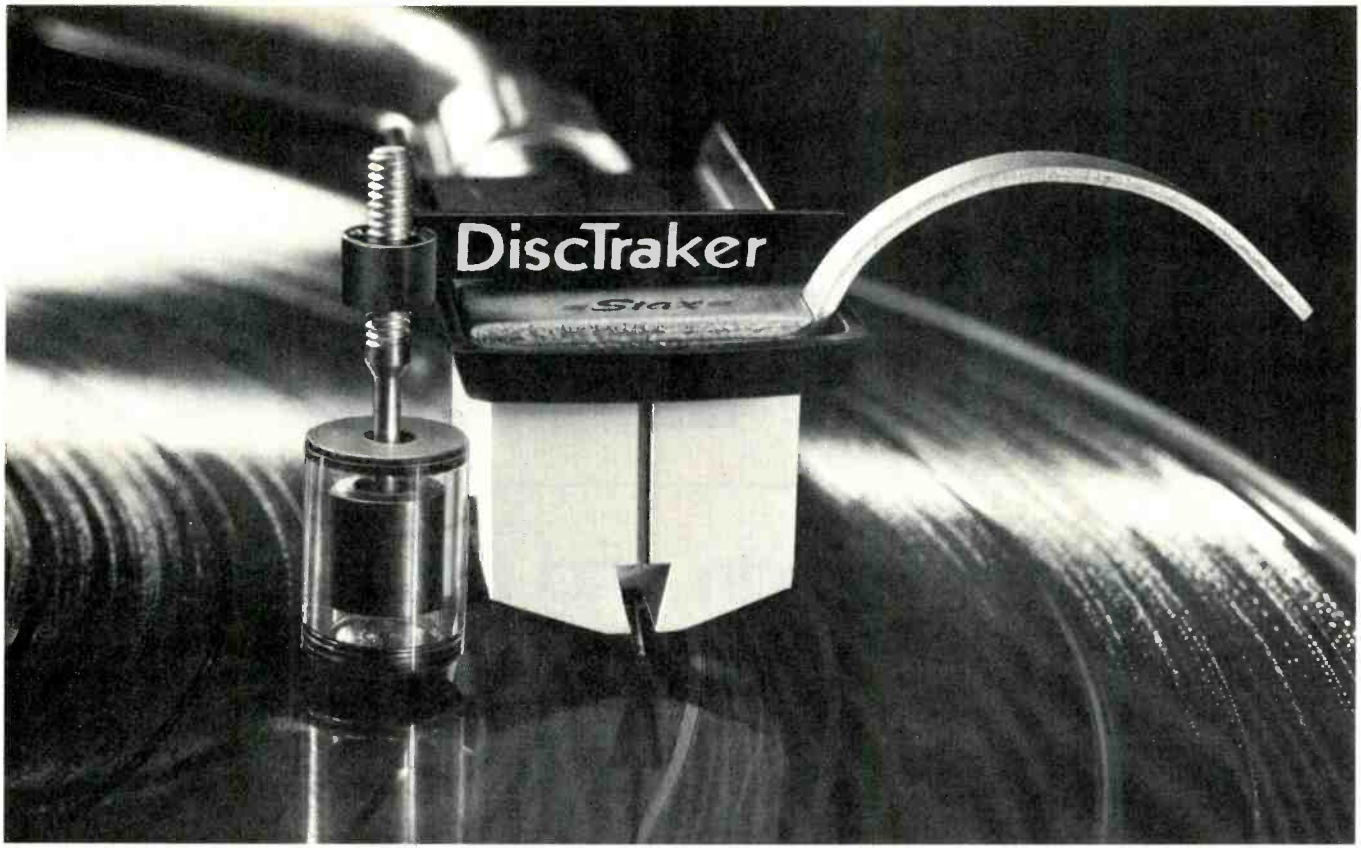
Lirpa Kudos

Dear Sir:

I have long awaited such a major audio breakthrough as the Lirpa I and to say that I am ecstatic is the understatement of the year. May I congratulate your editorial staff for this recognition and for being the first to review it.

There is, however, one facet of this receiver that really bothers me. A quite pedestrian lock is shown with a very ordinary-looking key, and sure as hell someone is going to turn that thing on. So, may I respectfully suggest that you notify the manufacturer that there are 12-button combination locks available that not even my very talented cousin, who is presently in San Quentin, can pick.

R.W. Armstrong
Gold Beach, Ore.



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PART III

TURNTABLES

Tonearm Design and Other Things

Joseph F. Grado*

The last article discussed the effects that the turntable's mechanical drive system has on the tonearm. As we see in Fig. 1, vibrations travel from the drive mechanism through the turntable chassis to the base of the tonearm, then from the tonearm base (A) through the tonearm (B) and finally reaching the phono pickup (C). We already know that these same turntable drive vibrations can also reach the phono pickup via the turntable platter. However, we will concern ourselves only with those turntable drive vibrations that are picked up by the tonearm base and how they interact with the pickup.

Since the connecting link between the tonearm base and the tonearm itself is the tonearm's pivot system, this pivot system must be designed to decouple the tonearm base from the tonearm proper. It would also be a good idea to make the base as massive as possible (if it is stationary, its mass will not contribute to the mass of the arm at the pickup) and to damp, as much as possible, the mechanical vibrations coming from the turntable drive (Fig. 2).

Tonearm pivot and bearing designs generally fall into one of several commonly used categories. The simplest design is, of course, the unipivot system (Fig. 3A). Others are (Fig. 3B) the double gimbal, (Fig. 3C) lateral shaft and bearing with vertical knife edge pivots, or (Fig. 3D) the lateral shaft and bearing with a vertical, cylindrical pivot and bearing. The pivot and bearing designs generally are cone or cylindrical pivots working in conjunction with ball bearings, sleeve bearings, or cone bearings.

Keeping in mind that we want to decouple the tonearm base vibrations from the arm proper, it becomes obvious that the contact area between the tonearm pivot and the base bearing should be as small as possible. Looking at the various types of pivot arrangements available, it is easy to see which of them will provide maximum decoupling of the arm base from the tonearm itself—the unipivot. It is optimum for many reasons; it does an excellent decoupling job, it is the only pivot system which operates with a constant zero mechanical tolerance, it has the lowest friction both laterally and vertically, and it allows the pickup to be easily adjusted for vertical azimuth (Fig. 4).

To review, then, we have discussed keeping the mechanical vibrations away from the base of the tonearm by using a turntable which utilizes a rigid, massive main plate. We have seen the importance of isolating whatever mechanical vibrations do get through to the tonearm base. These vibrations must not enter the tonearm proper for there are other mechanical vibrations coming from the pickup end of the tonearm on a direct collision course with those vibrations coming from the tonearm base (Fig. 4). It sounds very complicated but it really isn't and neither are the solutions.

Let us look at the tonearm itself (Fig. 6). On the left in our drawing is the pickup mount (A) which is connected to the tonearm proper (let us call it a tube since this is easier to illustrate, though we should remember it could take any of several design configurations). The tubular arm ends on the right side (C) and is mounted into a massive block (D), whose action will be described shortly. What shape should the tube be? Straight or "S" shaped? Strangely enough, whether a tonearm is straight or "S" shaped, it will still act as though it were a straight arm (Figs. 7A and B). The lever factor of the arm tube is governed, not by the "S" (Fig. 8), but rather by the straight pivot-stylus distance between points A and B (Fig. 9). If the "S" in the tube is rigid between points A and B, then the lever factor is exactly the same as if a straight tube were used between points A and B. As a matter of fact, it really doesn't matter what the shape of the arm is between points A and B; it could be "S", "V", "U", or any other shape but it would still react as a straight tube tonearm. However, if the "S" in the arm is in some way flexible, then the ratio of the distance between Points A and B and the curving length of the "S" would vary. But if the tonearm were flexible, one would not consider it a good tonearm for use in any quality system. To repeat, if the tonearm flexes in any direction, it cannot be considered for use in a high quality system. A tonearm must be absolutely rigid over its full length if it is to properly transport the pickup.

*Grado Laboratories, Inc.
4614 Seventh Ave. Brooklyn, N.Y. 11220

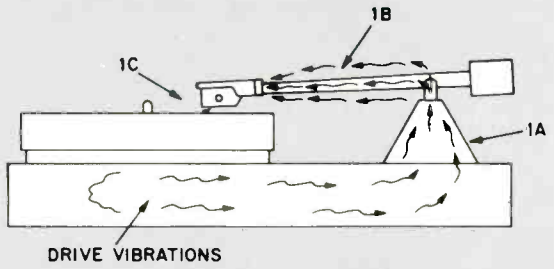


Fig. 1—Vibrations from the drive system can easily travel through the tonearm base (A), through the tonearm tube (B), to the pickup (C).

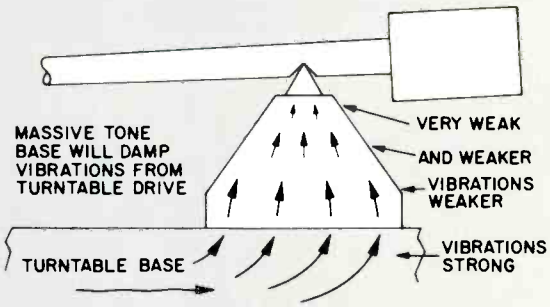


Fig. 2—A massive tonearm base will damp vibrations from the drive system.

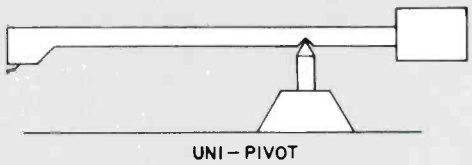
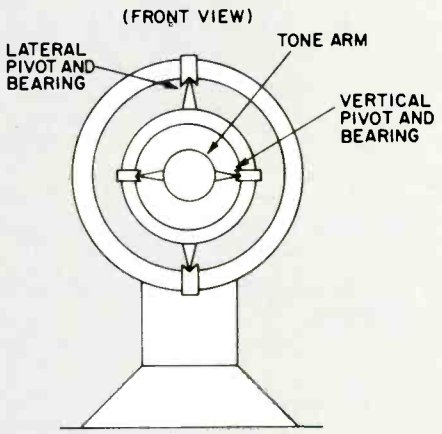
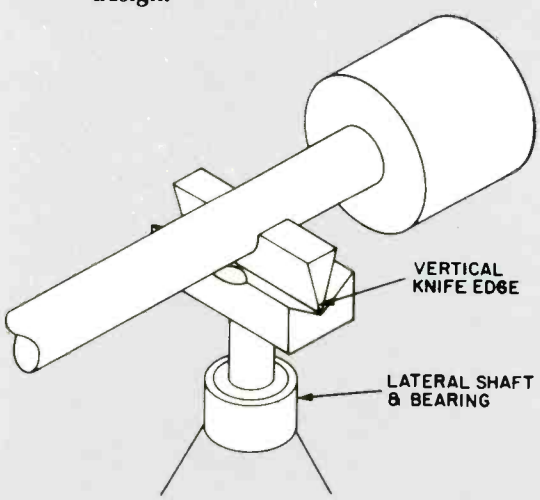
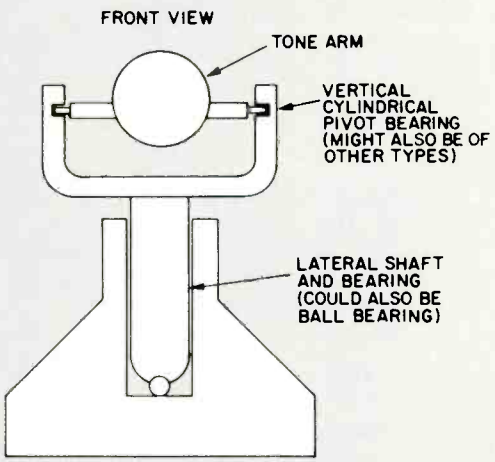


Fig. 3—Tonearm suspension systems; A, a uni-pivot design; B, a double-gimbal design, C, a knife-edge design, and D, a cylindrical pivot and bearing design.







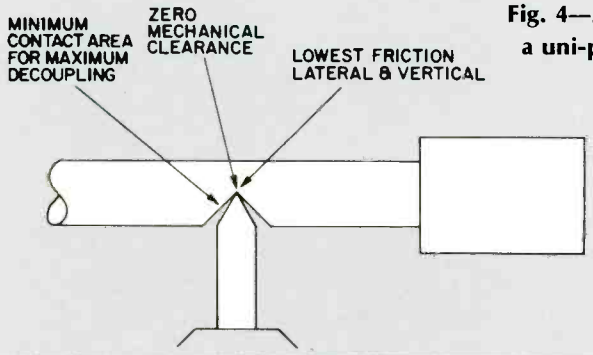
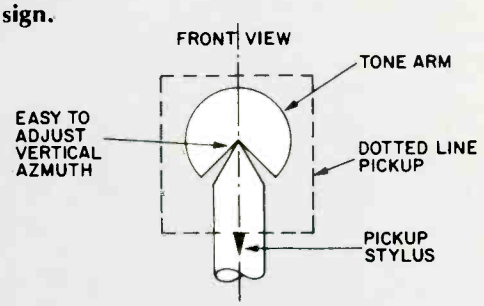


Fig. 4—Advantages of a uni-pivot design.



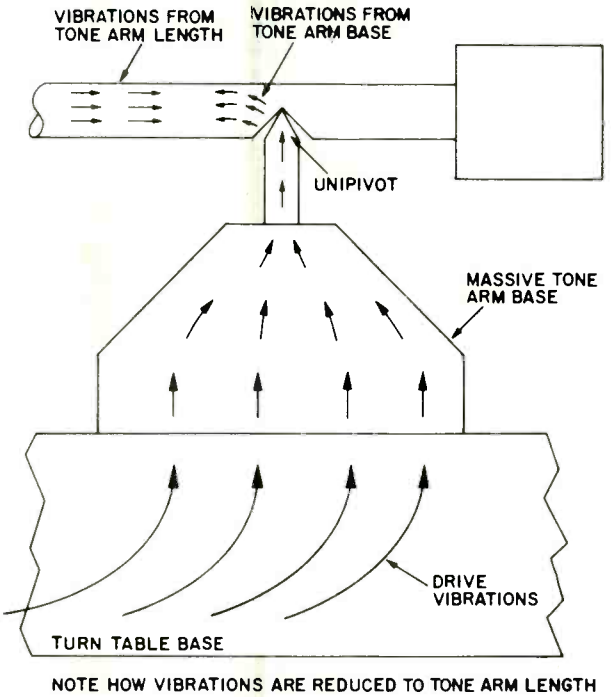


Fig. 5—Movements and levels of vibrations.

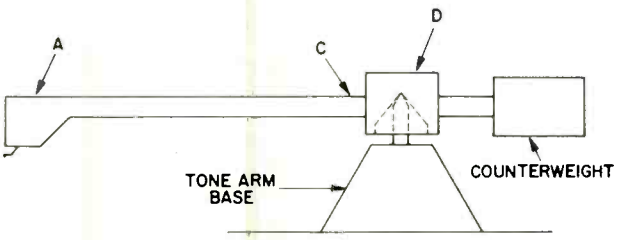


Fig. 6—Sections of a tonearm include A, the cartridge mount; B, the tonearm tube; C, entry point of the tube into the pivot block, D, and E, the counterweight.

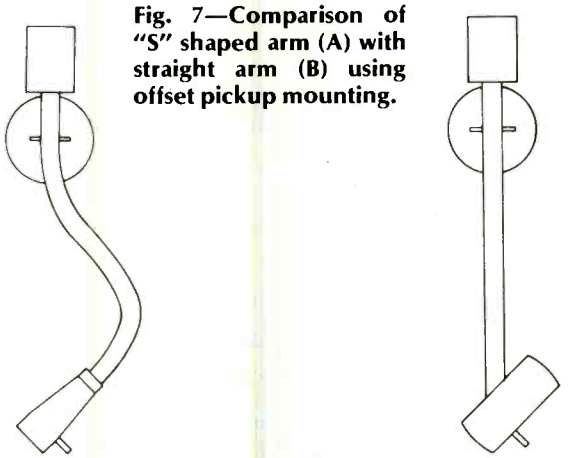


Fig. 7—Comparison of "S" shaped arm (A) with straight arm (B) using offset pickup mounting.

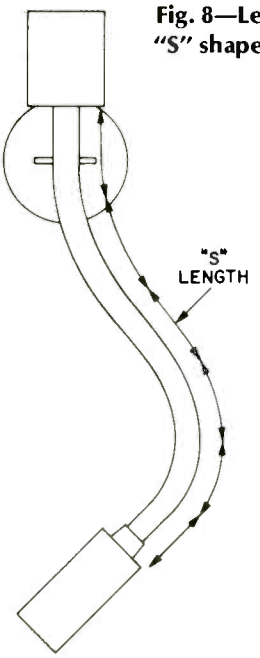


Fig. 8—Length of "S" shaped arm.

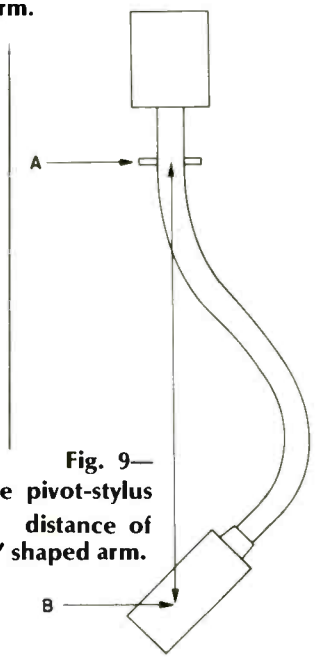


Fig. 9—True pivot-stylus distance of "S" shaped arm.

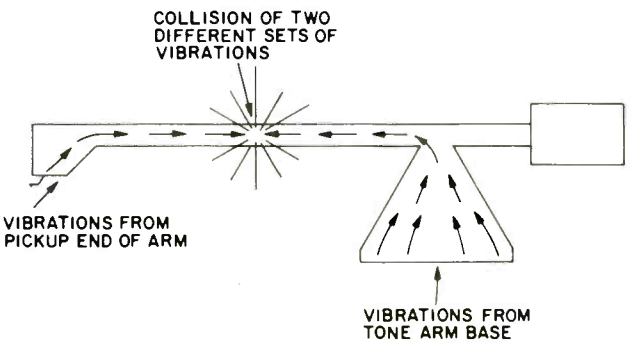


Fig. 10—Conditions which set up cycles of composite distortion products.

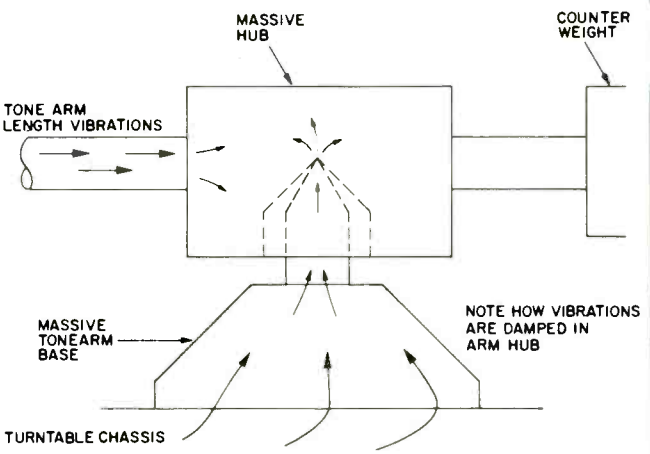


Fig. 11—Use of massive pivot hub and base greatly damp vibrations.

If the effective arm length is actually determined by the rigid length between points A and B, then why are tonearms designed with "S" shapes? Generally the "S" design is used either for proper mass distribution around the vertical and lateral pivots, to make the vertical pivot angle and the arm offset angle coincide, or in an effort to standardize the headshell configuration. In addition, the "S" shape is used to determine the offset angle for the various arm designs. Standardization is to be admired, but at the same time we must be wary of the design limitations which restrict state of the art design. Please do not assume, however, that a straight tonearm is better; it may not be.

There are many other factors in tonearm design that determine whether a tonearm is top notch. As a matter of fact, one of the best arms today is an "S" shaped arm. If the "S" shaped arm is rigid and of the proper mass (*Note:* proper, which is not necessarily light) and the straight arm flexes, then the "S" shape would be better.

The tonearm itself, whether it be tubular or otherwise, must be rigid, and yet it must be nonresonant. In addition, the arm proper should not, if possible, act as a conductor of vibrations! Since the arm (Fig. 10) receives vibrations of the pickup's mechanical action and the residual vibrations of the tonearm base, it can be easily seen that the two vibrations coming from opposite directions will meet on a collision course somewhere along the arm's length. This results, of course, in the composite of the two signals reversing direction after their collision and going back to the opposite ends of the arm tube. The vibration going to the pickup end intermodulates with the signals the pickup happens to be producing at that moment and a distortion product results. If the pickup mounting shell is not as rigid as the Rock of Gibraltar, then this mechanical resonant condition is amplified. The other composite vibration travels to the rear or pivoted end of the tonearm tube, and if the arm is light weight at that end, rattling of the pivots takes place. New mechanical vibrations from both ends start traveling the length of the tonearm tube to once again collide somewhere along the arm, and this situation cycles over and over again, creating distortion galore. Fortunately, there is a manner in which this problem may be minimized.

Let us again trace the mechanical vibrations from the cartridge end; however this time we will visualize the tonearm tube of a material which does not flex or resonate. Certain woods are a perfect material for a tonearm, since wood is rigid, light, damps its own resonance, and is beautiful. Aluminum is also excellent if fabricated properly; it should be in a soft state, coated on one side, large diameter, and thin walled. With today's technology, it is a simple matter to taper an aluminum tube, making it super rigid. Coating such a tube internally damps surface resonances, and using it in a soft state further reduces surface resonances. Anodizing the metal allows the aluminum to stay soft but makes the outer surface sapphire hard which further stiffens the arm.

Reducing Vibrations

Now we have a tonearm tube which reduces the intensity of the vibrations coming from the pickup end of the tonearm, and by the time the pickup vibrations reach the pivot area of the tonearm, they are reduced tremendously.

But wait, didn't we say that the vibrations from the base of the tonearm were still on a collision course? Yes, but we can easily take care of that. You will recall that the vibrations from the turntable drive system were almost totally absorbed by the massive turntable chassis before they reached the tonearm base. You will also recall that a proper tonearm pivot arrangement would help decouple the residual tonearm base vibrations from the tonearm tube. Thirdly, we saw that if the mass of the tonearm at the pivot was light that the pivots would rattle.

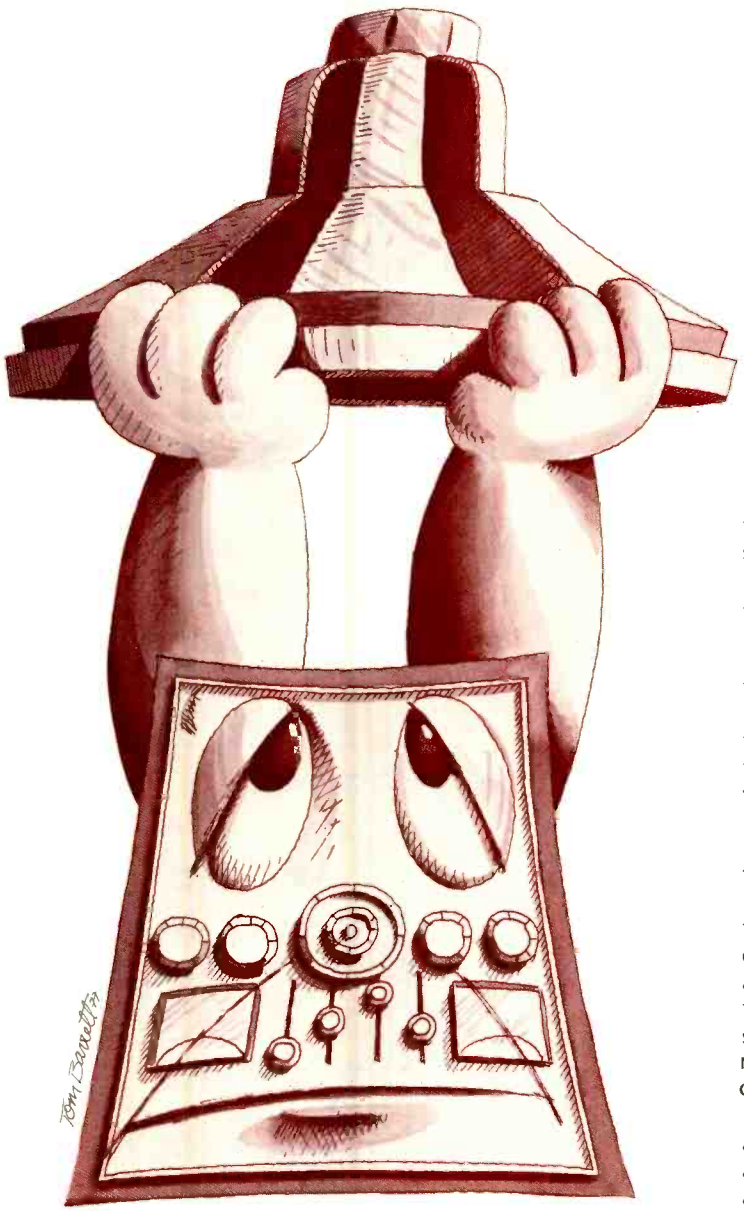
A single solution virutally eliminates all three problems. If we put a heavy mass at the hub of the arm (Fig. 11), the mass of the tonearm at the pickup end will remain virtually unchanged. However, this hub mass will absorb the residual mechanical vibrations from the arm tube, it will absorb the residual mechanical vibrations which come from the tonearm base, and it will act as a positive force to assist the tonearm pivot contact. With one design addition, we have greatly reduced or eliminated three large problems.

The next article will discuss tonearm mass, and we'll see that a light mass tonearm can create more problems than it solves. We'll discuss rear weight design, and try to get into antiskating and why it really isn't necessary. This will also lead into a discussion of straight line tracking arms and the inertial effects causing tracking error.

Power Amplifiers and the Loudspeaker Load:

Jeffrey H. Johnson*

Some Problems and a Few Suggestions



The story is told of the English child during the war who, on learning of an impending bread shortage, remarked that this wouldn't bother him as he always ate toast. Something of the same outlook has all too often been evident in the attitude toward the amplifier-loudspeaker interface. We measure amplifiers with well-defined resistive loads, but we listen with loudspeakers, and loudspeakers present anything but a constant, well-behaved load to the amplifier. This can lead to a number of problems, and it is becoming widely recognized that an amplifier which "works just fine" on the test bench may not perform so well in actual operation. To see what some of the effects of non-ideal loads on amplifiers are is the purpose of this article.

The Loudspeaker

Loudspeaker manufacturers specify a nominal or "rated" impedance for their products, usually 4 or 8 ohms. This specification is not without value, but we shouldn't forget that the impedance of a loudspeaker actually exhibits considerable variation with frequency. Partly this is determined by the designer's choice of crossover network parameters, etc., but it is also to some extent inherent in the physical principles of operation of the loudspeaker mechanism itself. Figure 1 shows the measured impedance of a typical three-way air suspension system rated at 4 ohms.

Now, at first glance, it might seem that these impedance variations would be very undesirable from the standpoint of the power available from the amplifier. Since an amplifier is very nearly a constant-voltage source, the power output is inversely proportional to load impedance; the higher the impedance, the smaller the available power. For example, if the unit shown in Fig. 1 is driven at 6.32 V—or 10 W into the rated 4 ohm impedance—a power meter would show that the actual power would vary from about 11 W to about 1 W, depending on frequency. This might seem highly undesirable, but in fact it is not. Loudspeakers are designed for flat frequency response with a constant drive *voltage*, not constant power. There is no problem here, except that amplifier meters labeled in watts are meaningless. (For a further discussion, see refs. 1, 2, 3.)

The problems caused by impedance variations come from a different direction, namely from the fact that an impedance which varies with frequency exhibits a *reactive*, as well as a resistive, component. A reactance is non-dissipative; it can only store energy, not put it to use. Such stored energy

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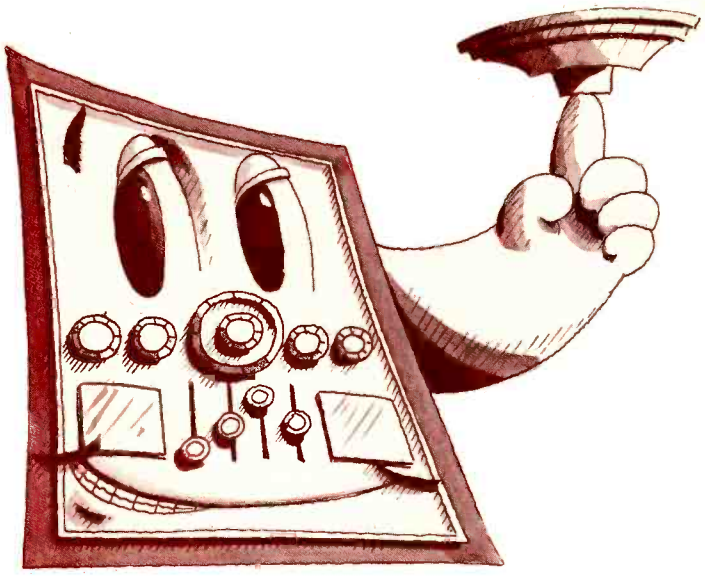
is unavailable for conversion into acoustical energy. What's worse, this stored energy must go somewhere, and that somewhere is back into the amplifier, where it can cause trouble.

Before we look at what some of these troubles are, we need to take a moment to clarify some terminology. Impedance is a complex quantity; that is, it has *two* dimensions, not just one. We can express this by saying that it has a real (or resistive) part and an imaginary (or reactive) part, and write this as $Z = R \pm jX$ where R is resistance and X is reactance. A very useful alternative expression is to give the magnitude (or modulus) of the impedance: $|Z| = \sqrt{R^2 + X^2}$. The other dimension is then expressed as a phase angle: $\angle Z = \tan^{-1}\frac{X}{R}$. What we usually offhandedly call "impedance" is actually only the magnitude of the impedance: to be completely accurate we should also give the phase angle. The impedance in Fig. 1 is thus *both* curves taken together. Habitually speaking of the magnitude only makes it easy to overlook the reactive component.



Small-Signal Effects

Reactive loading can affect both the large-signal and the small-signal performance of an amplifier. The small-signal effects have to do chiefly with the feedback stability and the dynamic response of the amplifier.

An amplifier can be modeled by a forward gain path A_{VOL} with an internal impedance Z_o, enclosed in a feedback loop giving a closed-loop overall gain of A_{VOL} (Fig. 2) (Z_o here should not be confused with the output impedance of the complete amplifier, which is Z_o divided by the loop gain.) For stability the phase shift at unity loop gain must not exceed 180°, and for satisfactory dynamic (transient) response, some phase margin is necessary, limiting the loop phase shift to 120° or perhaps 135°. In terms of the familiar Bode plot, Fig. 3a, this means that the curve of the forward gain must intersect the curve of the closed-loop gain with a slope not much greater than 6 dB/octave, and all higher breakpoints must lie some distance above this frequency.

The feedback voltage is taken from the junction of Z_o and the load, point X in Fig. 2. Z_o, which may be comparable to the load impedance depending on the circuit configuration, forms a voltage divider for the feedback in conjunction with the load impedance. Suppose now that the load is inductive, so that its impedance increases with frequency. Unless Z_o is quite small, this means that the feedback voltage will also increase. With luck, this can provide a degree of lead compensation, but more often the result is that the loop bandwidth is extended so that higher frequency poles begin to contribute to instability, as depicted in Fig. 3b. Alternately, a capacitive load will tend to roll off the feedback with increasing frequency, and so the slope of the forward gain curve is increased and instability results (Fig. 3c).

As if this were not enough, in many circuits Z_o is not constant but rather increases at higher frequencies due to h_{fe} falloff in the output transistors, etc. Z_o will thus have an inductive component, and should the load be capacitive, a second-order LC filter will be formed for the feedback signal, contributing an additional 12 dB/octave rolloff. This leads to oscillation. Often a fairly small capacitance (10 nF to 0.1 μF) will be more troublesome than a large capacitance, since the latter may spread the poles farther apart and give a less rapid rolloff.

The cure for these woes is the addition of load isolation or stabilizing networks to the amplifier output. The simple RC network in Fig. 4a loads down the amplifier at high frequencies, avoiding the situation of Fig. 3b with inductive loads (which are typical of moving-coil loudspeakers), and with the rise in A_{VOL} which some configurations exhibit without load. A more thoroughgoing method is the use of the LCR network. A series inductor with rising impedance at higher frequencies is added to prevent capacitive loads from loading down the amplifier too much. The preferred form of this network, Fig. 4b, can be made to effect a smooth transfer of the amplifier from the external load to the resistor R at a suitable frequency above the audio range (Ref. 4). Load isolation networks are sometimes accused of ringing, but with proper design this is not so; most of the ringing is attributable to reduced feedback phase margin in the amplifier.

The small-signal effects are manifested mostly at frequencies well above the audio range. The nature of the loudspeaker load is consequently quite important in this region also. Loudspeaker impedance is usually measured only to 20 kHz, but for some time now one manufacturer has been measuring all new designs out to 1 MHz after it had been discovered that an unexpected impedance dip around 200 kHz had been causing problems with a certain amplifier.

Large-Signal Effects

The major difficulties arising from reactive loading are associated with the large-signal area. Unlike the small-signal case, where the amplifier as a whole is involved, the large-signal effects are confined almost entirely to the output stage.

One of the most important effects of reactive loading is its influence on the power dissipation in the output devices of an amplifier. Probably the best way to see how this happens is to examine the load line, which is a plot of V_{CE} and I_C for a specified load.

If the load is resistive, the load line will consist of straight line segments as in Fig. 5b (here, and in what follows, an ideal class-B circuit is assumed). The line 1-2 represents all values of V_{CE} and I_C during the "on" half-cycle, and the line 1-3 shows that $I_C = 0$ during the "off" half-cycle. The slope of the line 1-2 is determined by the load; if the solid line represents 4 ohms, for instance, the dashed line would show 8 ohms.

An important property of the load line graph is that it also implicitly shows the power dissipation of p_T in the output device, since it relates V_{CE} to I_C and $p_T = V_{CE}I_C$. During the "off" half-cycle, p_T is obviously zero. During the "on" half-cycle, p_T is small when the output voltage V_o is near zero (point 1 in Fig. 5b). As the output voltage begins to increase, current flows into the load and I_C increases. At first p_T increases, but since V_{CE} decreases as V_o increases, p_T begins to fall, and when the crest of V_o is reached (point 2 in Fig. 5b)

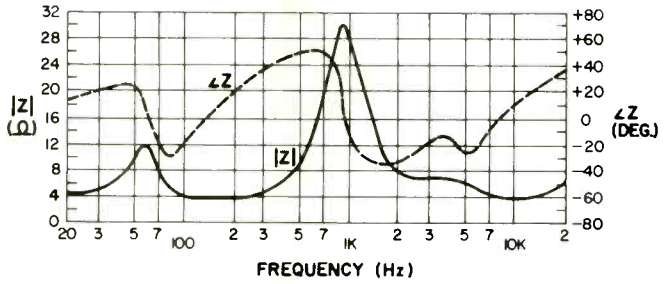


Fig. 1—Impedance of a typical loudspeaker system.

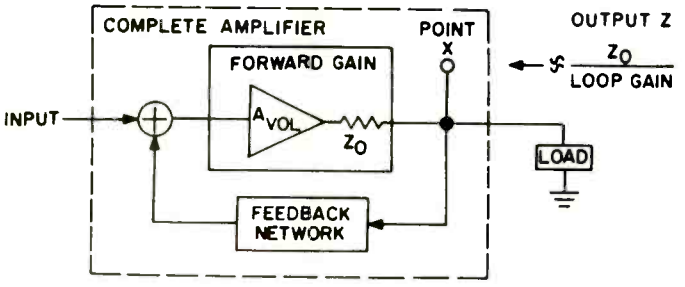


Fig. 2—Model of a power amplifier.

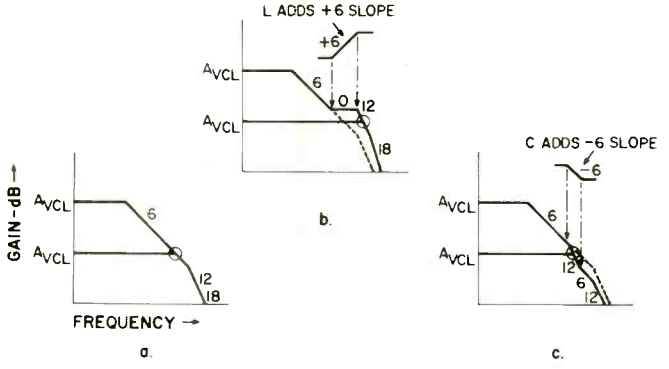


Fig. 3—Bode plots for (a) resistive load, (b) inductive load, and (c) capacitive load.

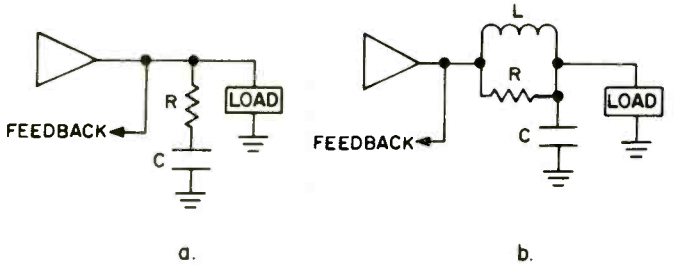


Fig. 4—Load isolation networks, (a) RC and (b) LCR.

p_T is again very small. The overall dissipation is thus comparatively small, and the operating conditions of the output device are quite favorable.

The situation is much different if the load is reactive. In a resistance, current and voltage are in phase; but in a reactance, the current and voltage are displaced from one another by the amount of the phase angle, and the minima and maxima of the current and voltage waveforms no longer coincide. If such a load line is plotted, the resulting curve is not a straight line but becomes elliptical. As the phase angle increases, the ellipse becomes broader (Fig. 6).

A comparison of these elliptical load lines to the resistive case yields some unwelcome facts. Consider the point of zero V_o, where $V_{CE} = V_{CC}$. For a resistive load, p_T is zero (point 1 in Fig. 5b), but for a reactive load there is a significant flow of I_C at this point, and hence considerable dissipation. Or take the "off" half-cycle; here again there is a substantial flow of I_C in the reactive case compared to zero for a resistance. This is particularly undesirable, since the combination of high V_{CE} and high I_C can initiate secondary breakdown, resulting in a catastrophic destruction of the output transistors.

Additional insight can be gained if the curve of the maximum permissible dissipation—the "safe operating area" (SOA) curve—is added to the diagram. This is done in Fig. 7. The resistive load line (a) remains comfortably within the SOA. But a reactive load of the same impedance magnitude (b) fills and even somewhat exceeds the SOA. Reactive load lines in general use the available territory less efficiently; they bulge out just about where the SOA curve dips inward.

It is a little difficult to get a quantitative picture from the load line diagram, so in Fig. 8 the dissipation p_T has been plotted over one complete cycle, normalized to a peak output of 1 W (or 1 VA). The dissipation is seen to increase substantially as the load phase angle increases. With a purely reactive load (90°) the maximum p_T is over five times as great as for a resistive (0°) load. Integrating or averaging p_T over time gives the average dissipation p_T, which determines the heat sink requirements of the amplifier. This is shown in Fig. 9, with a resistive load taken as unity. Here again there is a significant, if not quite so dramatic, increase in dissipation as the load becomes more and more reactive.

It is now time to introduce a complicating factor. So far, operation at full output has been assumed, but in fact the dissipation is a function of output level. We can include this factor by introducing a "drive factor" k, which varies from 0 to 1 (or 0 to 100 per cent). Note that k is in terms of voltage, not power. The dissipation as a function of k is shown in Fig. 10. For a resistive load, the greatest dissipation occurs at k = 63 per cent output (40 per cent of maximum power output). As the load becomes increasingly reactive, the dissipation increases, and the decline in dissipation near full output also disappears.

It should by now be abundantly clear that operating an amplifier into a pure resistive load is far kinder, far less demanding, than is operation into a reactive load like a loudspeaker. And these relationships apply, let it be added, regardless of whether the output devices used are tubes, transistors, or FETs. To put it another way, an amplifier which is to operate without difficulty into highly reactive loads must be more conservatively designed than would be expected on the basis of purely resistive loading. It must also be borne in mind that the efficiency of real-world amplifiers is less than the ideal case assumed in this discussion.

And speaking of real-world situations, it ought to be noted that this discussion has tacitly assumed sinusoidal signals. For a variety of reasons, such signals have great usefulness in analysis, but they don't correspond very closely to either speech or music. Since the energy content of pro-

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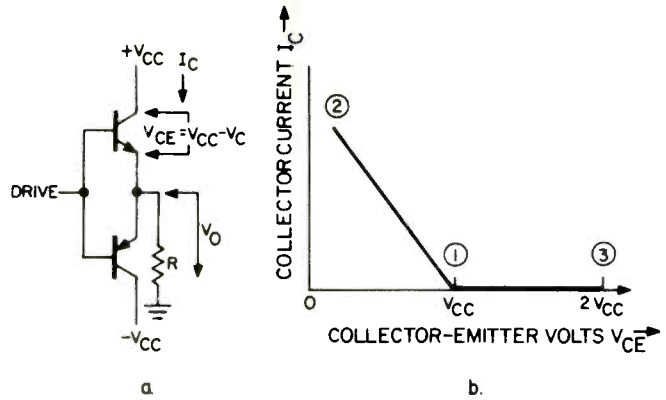

Fig. 5—Load line graph.

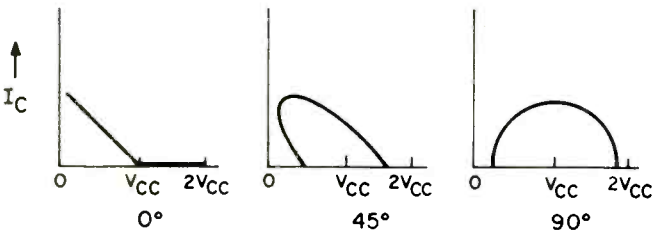

Fig. 6—Load lines for several load phase angles.

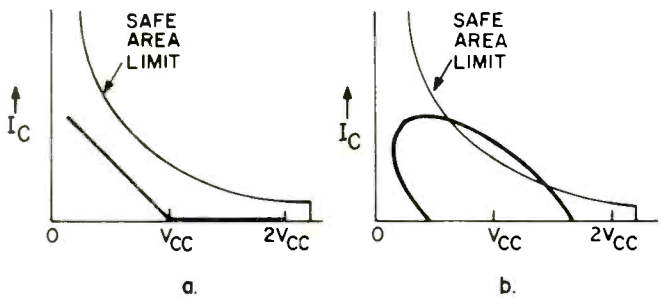

Fig. 7—Load line graph with transistor SOA curve, (a) resistive load and (b) reactive load.

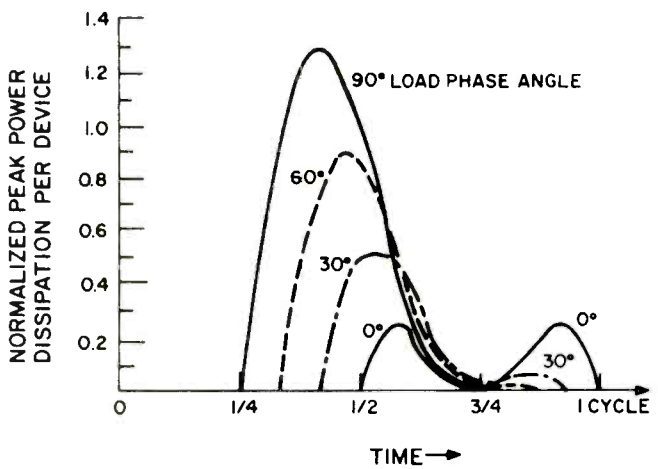

Fig. 8—Instantaneous collector power dissipation over 1 cycle of output waveform.

gram material is generally less than a sine wave of equal peak amplitude, the dissipation will in many cases be less than the curves we have seen would suggest. Unfortunately, it is simply not possible to say *how much*. There are random signals which can model program material quite well, it is true; but strictly speaking impedance is defined only in the frequency domain, and the only signals which would not involve treating a band of frequencies are the exponential and the sinusoid. And once we have to look at a band of frequencies, the precise nature of the load (its impedance versus frequency) would have to be specified, making a general solution impossible.

A Special Case

Before we leave the subject of output stage dissipation, there is an interesting special case that ought to be considered. So far we have allowed the phase angle to vary while holding the magnitude of the impedance constant. A different picture emerges if, instead, we require only that the *real part* of the impedance remain constant. This is equivalent to saying that the magnitude of Z is allowed to increase as we increase the phase angle, and is shown by the dash-dot line in Fig. 11. The dissipation in this case is shown also in Fig. 11. The solid curve represents the worst-case dissipation, obtained by letting k be whatever value gives the greatest dissipation. The result is interesting; the dissipation with any arbitrary reactive load under these conditions never exceeds the value of dissipation observed for a resistive load. In fact, for highly reactive loads (over about 51°), it actually is less. We saw earlier that for reactive loads, the dissipation was greatest for k = 1, and this condition is shown by the dotted line. Here again the worst-case resistive load dissipation under these conditions would never be greater than it would be for a resistive load equal in value to the *minimum real part* of any complex load. The significance of this will be discussed later, for it forms the basis for a rationalized loudspeaker impedance rating.

The Protection Problem

Another important set of large-signal problems springs, somewhat ironically, from what ought to be a good idea, output transistor protection circuits. The kind of circuit which causes problems seeks to clamp I_C to some value which is a function of the V_{CE} at that instant. Such a circuit, whose threshold characteristics are shown in Fig. 12a, permits the SOA to be nearly fully utilized. A short on the output is clamped as in Fig. 12b, and a purely capacitive load is prevented from exceeding safe limits as in Fig. 12c.

Things are altogether different if the load happens to be inductive. Should the protection circuit be activated in this case, an annoying and potentially dangerous very loud popping sound results. These are the notorious "flyback impulses" illustrated in Fig. 13. The impulses are usually short (tens of microseconds) but of considerable amplitude. Since they contain large amounts of high-frequency energy, damage to tweeters is not unknown. These impulses can occur under seemingly unobjectionable conditions, for example when the magnitude of the load impedance is fairly high and hence the amplifier is only lightly loaded. All that is required is that the load be inductive (i.e., the impedance is increasing with frequency) and that it activate the protection circuit at some point.

Such flyback impulses come neither from the load nor from the amplifier alone, but rather from the combination of the two. The ultimate culprit is the negative slope of the protection circuit threshold. When the current flow into the

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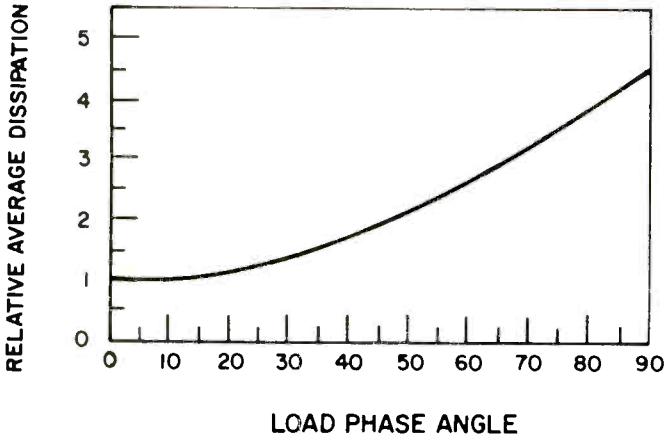

Fig. 9—Average collector power dissipation as a function of load phase angle.

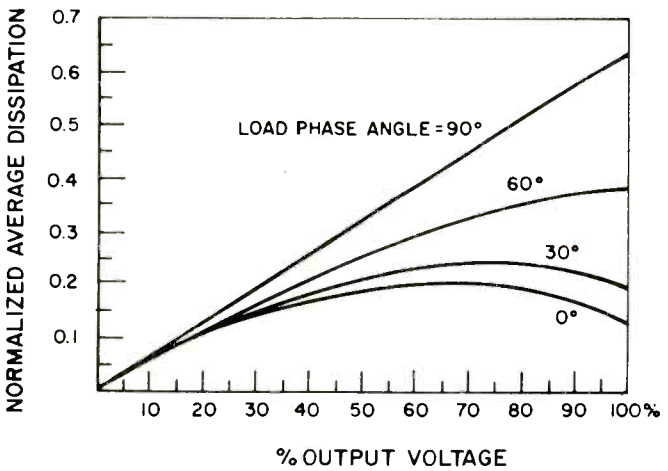

Fig. 10—Average dissipation as a function of drive for several load phase angles.

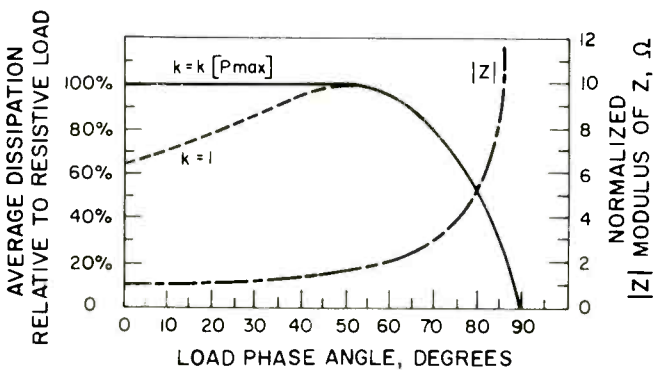

Fig. 11—Average dissipation as a function of load phase angle for constant real part of load impedance.

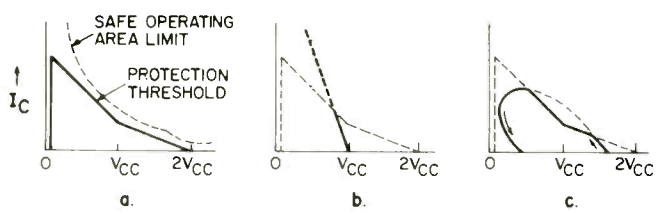

Fig. 12—Protection circuit characteristics, (a) threshold curve, (b) with shorted output, and (c) with capacitive load.

load is stopped by the clamping action of the protection circuit, the tendency of the inductive load to produce a reverse-polarity voltage forces the protection circuit into even greater limiting. Suppose the output were positive-going at some point, and so V_{CE} were decreasing. If now the current into the load is clamped, the sense of the resulting load voltage will be negative-going. This implies an increase in V_{CE} that in turn reduces the current clamping level to a smaller current. A regenerative situation exists, and the end result is that the output voltage of the amplifier tends to slam into the clipping region with the opposite polarity. If one such event does not dissipate the energy stored in the load, several pulses may follow one another in rapid succession.

A number of solutions to this problem have been advanced. The basic idea is to avoid having a negative-slope threshold at signal frequencies. One approach places large capacitors in the protection circuit to slow it down ("delayed limiting"), avoiding a regenerative situation. Another method is to use pure current limiting. A glance at the SOA curves shows that this places heavy demands on the output transistors, even when the current limit is made a slowly varying function of signal level. For this reason, paralleled heavy-duty output transistors must be used. The ultimate expression of this line of attack is to use a great many, very rugged transistors in the output stage so that protection circuits can be eliminated entirely. (Tube amplifiers, of course, fall naturally into this category, since tubes can withstand very large short-term overloads.) And finally there is the "solution" of simply making the protection threshold larger, but leaving the output stage as is, on the assumption (or hope) that the overloads encountered in "normal use" will be small enough not to destroy the poorly-protected transistors.

The Practical Conclusion

We have seen some of the effects that reactive loads can have on amplifiers, and we have noted some of the problems that can occur. The question remains, what can be done about them?

The small-signal problems can be avoided by sound design and thorough verification of an amplifier's stability before the design is released for production. Amplifiers from reputable manufacturers are usually free of problems.

Large-signal behavior is another matter. It would be easy to say that any amplifier should be able to cope with highly reactive loads. But here we come up against economic limitations. Power sells, and to remain competitive, the temptation is very great to design the amplifier for very high power into a resistive load at the expense of adequate and costly "elbow room" for operation into reactive loads.

One possible solution would be for prospective purchasers to become more aware that the usual power rating *per se* is only a part of the story. The test reports in the several hi-fi magazines could be of real service here by including reactive load measurements. Heavy capacitive loading has often been used, but inductive loading seems conspicuously absent. A reasonable approach would seem to be to use a set of loads at each rated impedance and at several frequencies. These could be 1) a real load R equal to the magnitude of the rated impedance Z_r ; 2) an inductive load $Z_{(L)} = 2Z_r \angle +60°$, and 3) a capacitive load $Z_{(C)} = 2Z_r \angle -60°$. (In other words, R + j0 and R ± $j\sqrt{3}X$ where R and X equal Z_r at the frequency of measurement. Proposals of this kind have appeared in the literature (Refs. 2, 5).

Another very worthwhile endeavor would be a clarification of the rather nebulously defined "rated impedance" applied to loudspeakers. The most logical approach would be to specify the minimum value of the real part of

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The Ditton 66 was in fact developed by Celestion to serve as an authentic monitor speaker, which means that it was designed to neither add nor subtract anything from the original program material. Recording engineers aren't interested in "hi-fi effects"—they want to hear exactly what's on the master disc or tape with minimum sonic contribution by the speaker.

When the British publication, *Hi-Fi Answers* needed a concert monitor they found the Ditton 66's "...sufficient to cope with the loudest orchestral climaxes available (or even required)...when we wanted to provide concert levels in a large hall, 110 feet x 55 feet with a 25-foot ceiling. A most impressive performance..."

Since most listening rooms are somewhat smaller, the shape of the Ditton 66 should be of special interest. Though its internal volume is three cubic feet, it needs only 1.2 square feet of floor space. It is 15" wide, 11" deep and 39½" high.

Another thoughtful aspect of the enclosure: the drivers are mounted on a finished baffle board. So those who like to operate their speakers with the grille off, for whatever reason, can do so happily.

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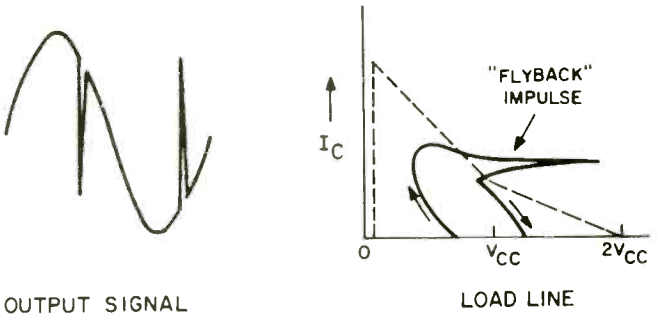

Fig. 13—Flyback impulses with inductive load.

the loudspeaker impedance, as suggested by Pramanik (Ref. 6). We have seen that the amplifier dissipation with reactive loading will not exceed the dissipation observed with the minimum real part of the impedance. Accordingly, such a specification represents a useful and meaningful measure of the loading produced by the loudspeaker on the amplifier. Since this specification would not in itself alert a prospective user to possible protection circuit problems in the case of a highly reactive loudspeaker, there would continue to be a need for impedance data, in reviews if not in spec sheets. Such data should include the angle as well as the magnitude of the impedance, or, as in *Audio*, the real and imaginary parts.

These proposals are suggested as possible ways to avoid or at least minimize some of the problems we have seen in connection with the amplifier-loudspeaker interface. It is hoped that in the discussion, some light was shed on the origin and nature of the problems as well as on some of the possible solutions. The ultimate resolution of these problems depends, however, on the user. Those who use amplifiers must become aware that presently used specifications do not tell the whole story, and be ready to insist on complete specifications. And perhaps we should also be content with an amplifier that appears a little less powerful on paper, but which makes music come alive through a loudspeaker and does so reliably and without fuss.

Acknowledgements

I would like to thank all those within the industry with whom I have discussed these problems. For particularly interesting and illuminating discussions I would like to thank Peter Walker of Acoustical Manufacturing (Quad), S. K. Pramanik of Bang and Olufsen, and Gerry Margolis of JBL; and for bringing to my attention the "delayed" protection circuit I thank J. H. Michel of Gerätewerk Lahr (Thorens/EMT). A

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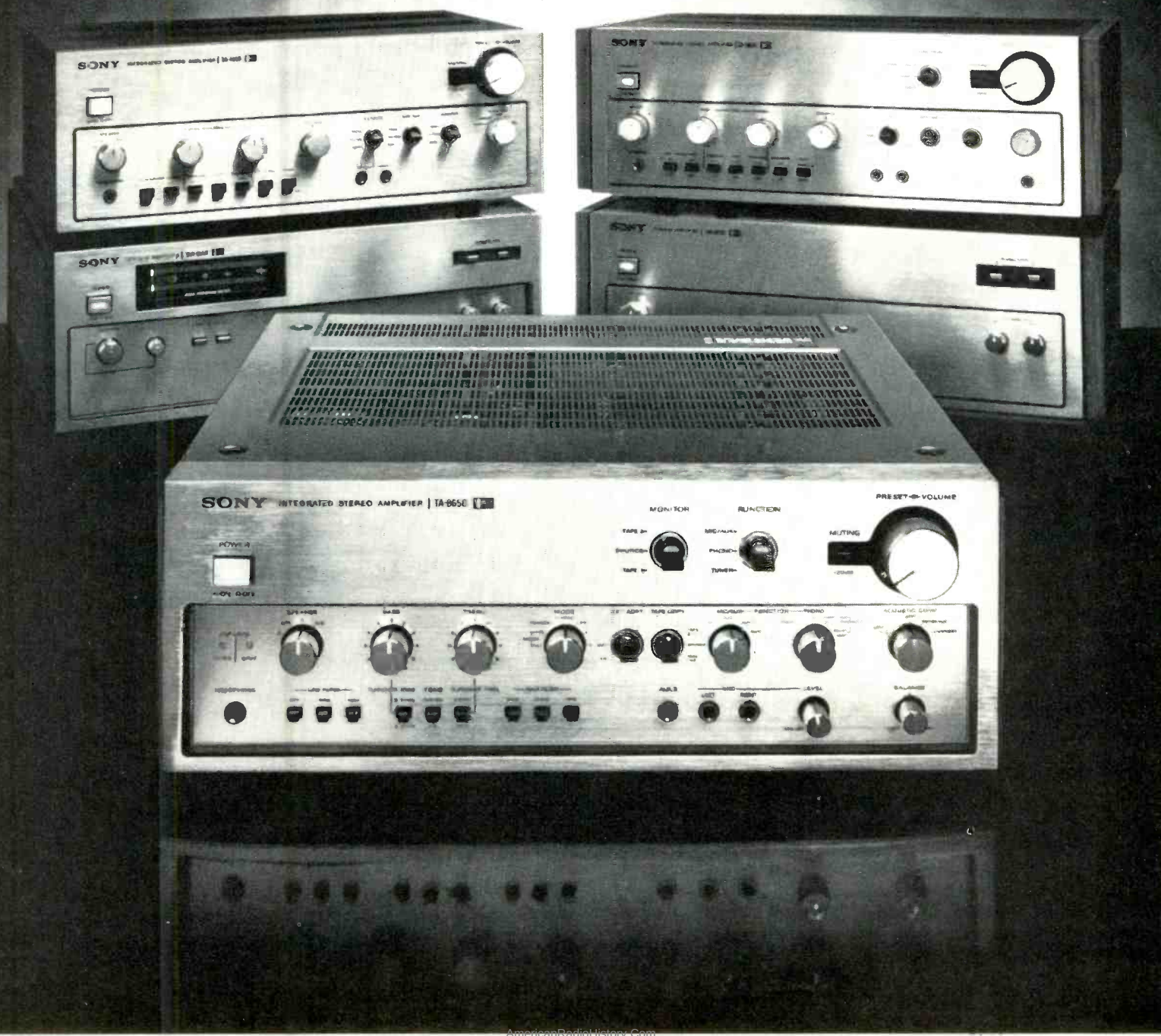

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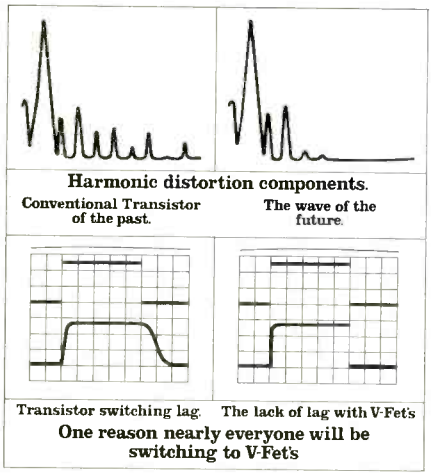

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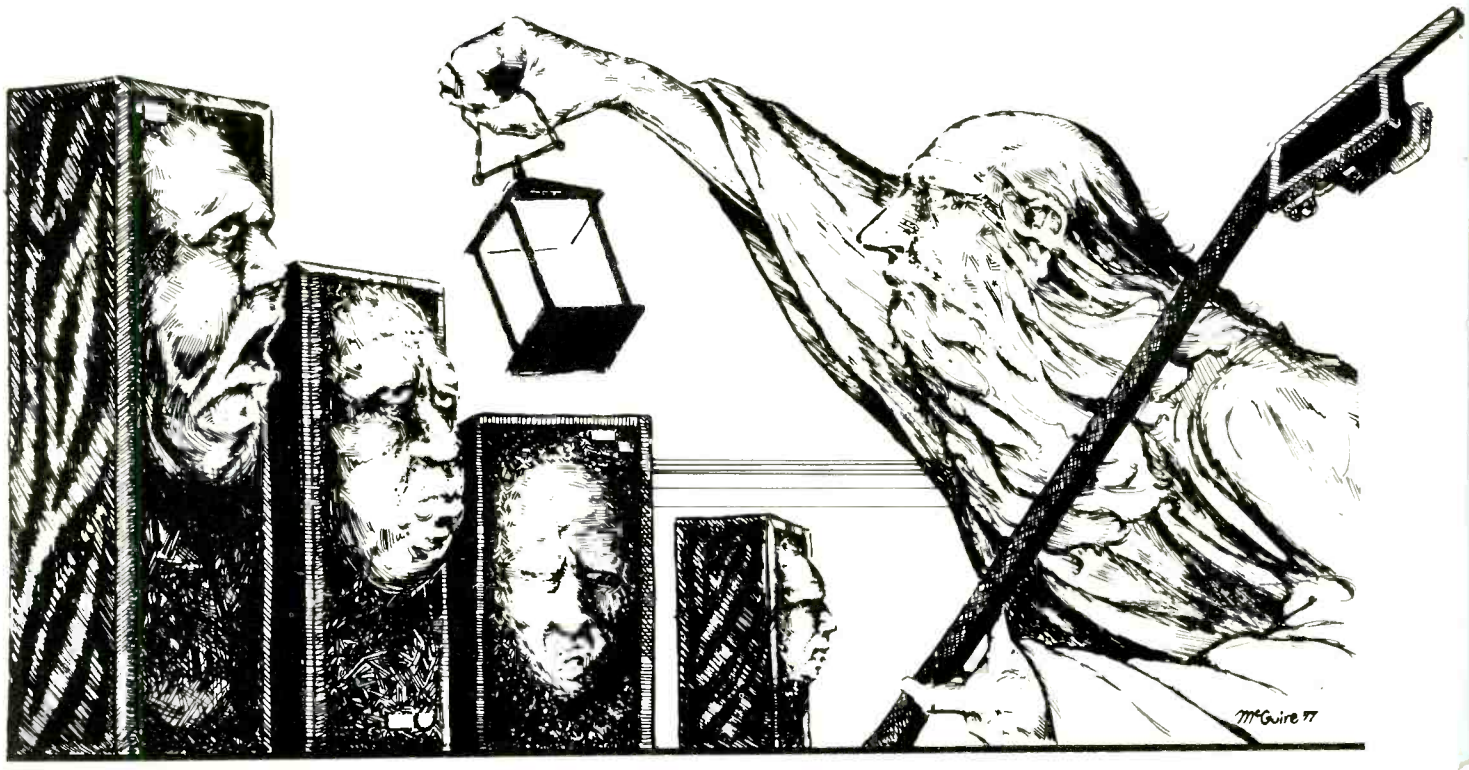
The Search for an Optimum Transmission Line Speaker

W. J. J. Hoge*



The first description of what is normally called a transmission line loudspeaker was published in 1936 by Benjamin Olney (1). The system was the "acoustical labyrinth" which he patented in 1934 (2) and represented an attempt to overcome the poor performance of the open-back cabinets of console radio sets. Olney's employer, Stromberg Carlson, produced the system for a few years during the '50s until they left the component high fidelity market. Transmission line systems did not really begin to catch on until after 1965. In that year A. R. Bailey published a transmission line system construction article (3). Since then, several manufacturers have placed such systems on the market.

In the past few years the performance of direct-radiator loudspeakers has been well analyzed and methods for synthesizing optimum design specifications have been developed (4, 5, 6). These techniques have been successful in many applications (7, 8), however, until very recently, the theory of transmission line loudspeakers has not been very well understood (9).

Direct-radiator loudspeakers are divided into three types, closed-box, vented-box, and passive radiator systems. Similarly, there are three types of transmission line systems. For the sake of brevity, let us call them Type A, Type B, and Type C. In Type A systems, the back side of the driver radiates into a sealed enclosure, while the front is coupled to a transmission line. The system output is solely from the output end of the line.

Type B and C systems allow the front side of the driver to radiate into the listening area, while the rear of the driver is connected to the transmission line, usually via a coupling volume. For Type B systems, the far end of the line from the driver is blocked. Type C systems have an aperture at the far end of the line so that the signal in the room is the sum of the outputs of the driver and the transmission line. What goes on in these systems, and is one better than the other? To answer these questions, we must analyze the systems.

Using Signal Flow Graphs

There are several common techniques for system analysis. The most popular is the dynamic analogy method which allows an equivalent electrical circuit of the loudspeaker to be drawn. However, another method, state-variable analysis, is this author's favorite. This method uses signal flow graphs instead of equivalent circuits (10).

That's nice. What's a signal flow graph?

Well, a signal flow graph is a way of writing a set of equations for a system and then interconnecting them so that the system can be analyzed. Consider the system in Fig. 2. (Kindly Editor's Note: This is the newly designed symbol for the U.S. Patent Office.) A voltage is applied to the lamp by the battery, and a resulting current flows. If the battery potential is E volts and the resistance in the current is R ohms, then the current I is given by Ohm's Law:

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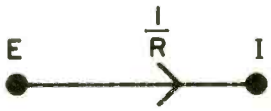
$$I = E/R \qquad \text{(Eq. 1)}$$

A signal flow graph of the equation would look like this:

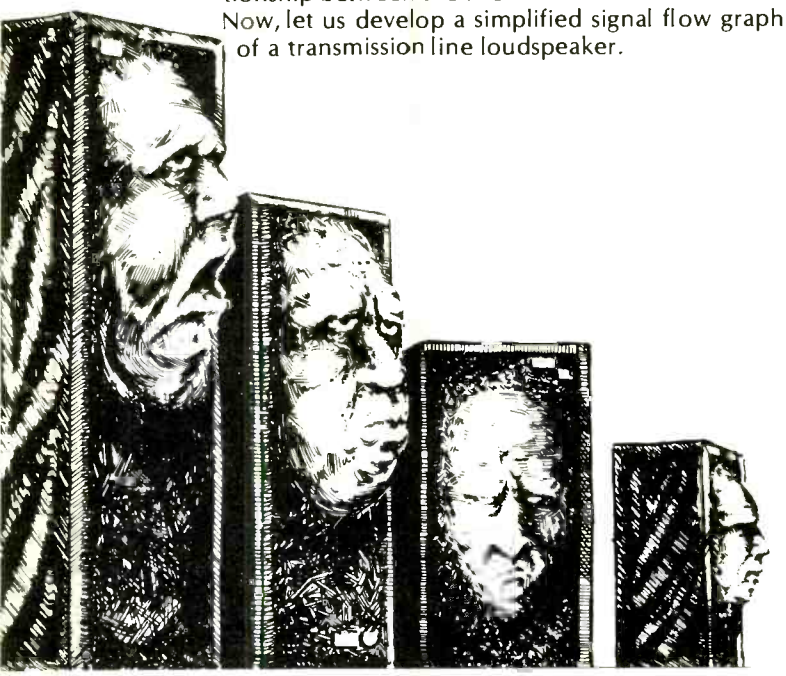


(Sfg. 1)

The dot

is called a node. The line with the arrow

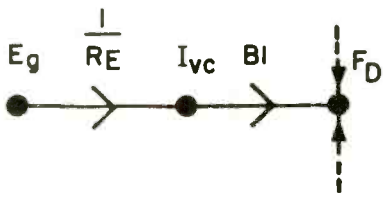
is called a branch. A node represents some physical quantity in which we are interested, while a branch shows the relationship between the two nodes which it connects. Now, let us develop a simplified signal flow graph of a transmission line loudspeaker.



We start with the electrical input from the generator E_g. It causes a current in the voice coil I_{VC}. If R_E is the voice coil resistance, then we have

(Sfg. 2)

The current in the voice coil interacts with the magnetic field to produce a driving force on the diaphragm F_D. If B is the flux in the gap and l is the length of the wire in the gap, then

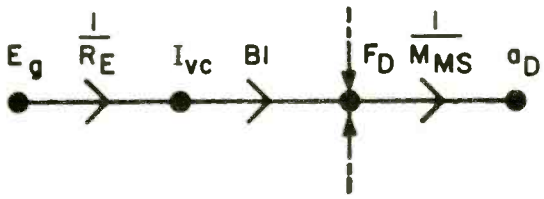


(Sfg. 3)

Note that some additional branches are entered in the F_D node. This is because other parts of the system are "pushing" on the diaphragm and contribute to the total force. We'll crank them in a bit later.

Newton's Second Law of Motion tells us that if we push on something, it will accelerate. The acceleration of the diaphragm a_D with effective mass M_{MS} is given by

(Sfg. 4)



The velocity of the diaphragm u_D is found by the equation

$$u_D = \int a_D \, dt \qquad \text{(Eq. 2)}$$

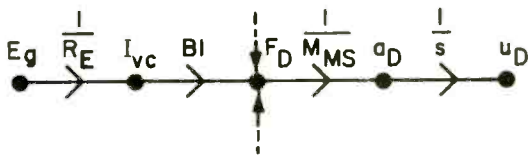
At this point we hear screams of dispair from those Gentle Readers who did not take calculus (and some who did and know that integral calculus is a pain in the neck, or perhaps someplace lower). But have no fear! The author has a trick up his sleeve. Under certain conditions (This Engineering technique is known as "arm-waving" and is usually accompanied with the magic words, "It can be shown that..."), of which this is one, we can turn calculus into simple algebra by saying that

$$s = d/dt \qquad \text{(Eq. 3)}$$

If this is true, then

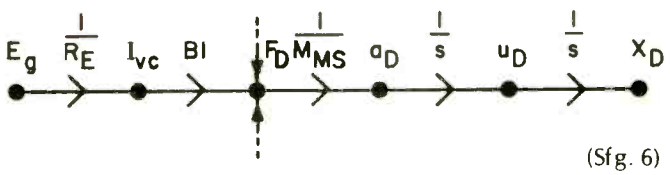
$$1/s = \int dt \qquad \text{(Eq. 4)}$$

Thus, it can be shown that



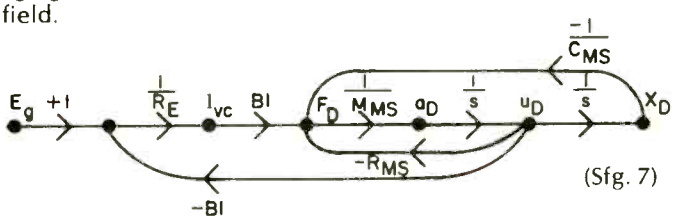
(Sfg. 5)

In a similar manner we integrate u_D to find the displacement of the diaphragm x_D.



(Sfg. 6)

We can complete the signal flow graph for the driver by adding a branch from x_D to F_D to give the restoring force from the compliance of the suspension C_{MS}, a branch from u_D to F_D to give the force opposing motion of the diaphragm caused by mechanical losses R_{MS}, and a branch from u_D back to the voice coil circuit to represent the voltage generated when the coil of wire moves in the magnetic field.



(Sfg. 7)

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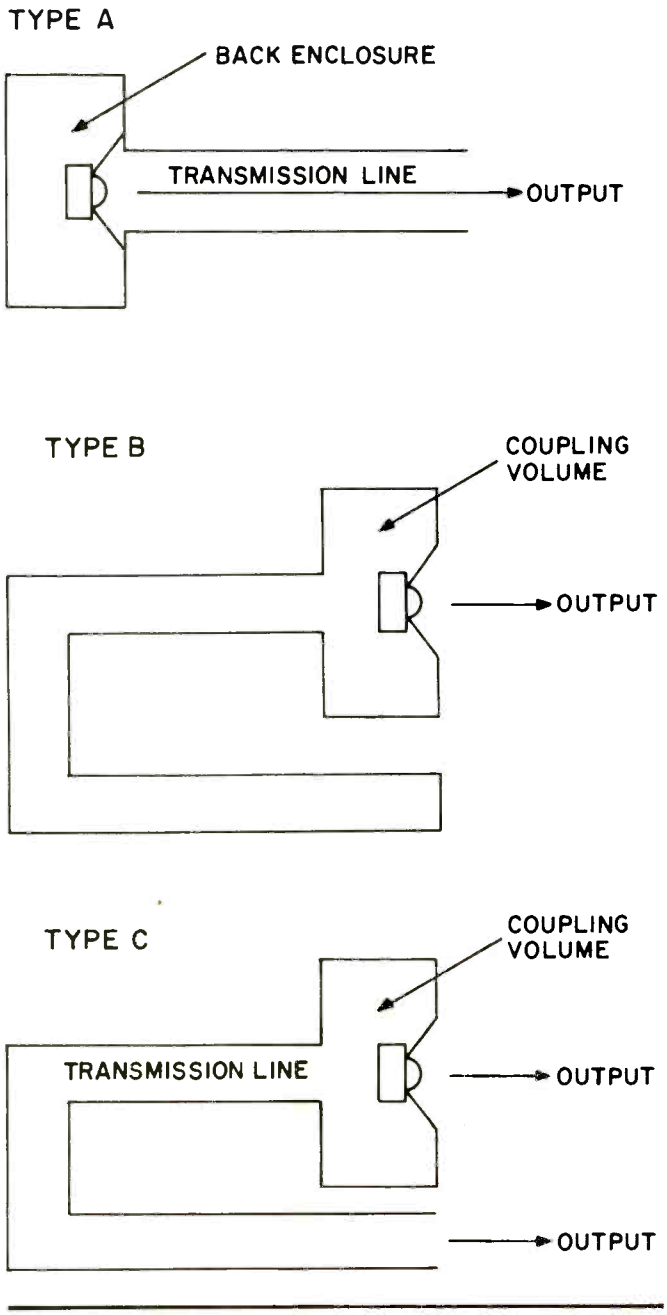
The minus signs indicate that the restoring force and the losses oppose the driving force and that the voltage generated by coil motion opposes the input signal.

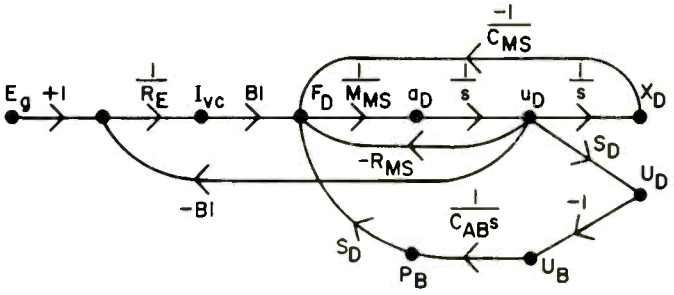
The mechanical motion of the diaphragm causes a current of air (or volume velocity) U_D to flow into the room. Also, a volume velocity U_B flows into the enclosure. Obviously, U_D is 180° out of phase with U_B, but the two are of equal magnitude. U_B causes a pressure variation p_B in the enclosure given by

$$p_B = 1/C_{AB}\int U_B \, dt \qquad \text{(Eq. 5)}$$

where C_{AB} is acoustic compliance of the air in the enclosure (or coupling chamber). If S_D is the area of the diaphragm, then

Fig. 1—Transmission line enclosure types.





(Sfg. 8)

which is the signal flow graph of a closed-box loudspeaker. To get a Type A system, we need only add the throat impedance z_{AT} of the transmission line to the system. We can then find the throat pressure p_T and the system output power, P_A. Fig. 3 gives the signal flow graph of a Type A system.

For the type B and C systems z_{AT} is connected to the back of the diaphragm. See Figs. 4 and 5.

Analyzing System Types

Now that we've got an analytical picture of the system, we should be able to figure out how it works. Type B is the simplest case. Note that we have used an italic z rather than a plain Z for z_{AT}. This is to signify that z_{AT} varies with frequency. What effect does this have on performance? Consider the case of a constant diameter tube for the line. The behavior of the driver is easily determined at various frequencies. Acoustic waves from the driver travel down the line and reached the blocked end. The sealed end is an infinite acoustic impedance (a situation analogous to an open-circuited electrical line) (24). This termination of the line yields a reflection coefficient of -1. At some frequency, the line length is equal to a quarter-wavelength of the acoustic signal. The reflected wave travels back down the line and strikes the driver diaphragm in such a way as to assist its motion. This produces a peak in the output. At twice that frequency, the line is a half-wave length long. In this case, the reflected wave opposes diaphragm motion and system output drops. Whenever the line length is equal to an odd number of quarter-wavelengths, there is an increase in diaphragm output. When the line is some multiple of a half-wavelength, the diaphragm output drops. Since the diaphragm is the only source of output, the response has many peaks and dips. This is certainly unsuitable for high fidelity reproduction.

The response may be smoothed by filling the line with some sort of damping material (e.g., fiberglass or long-fiber wool). This turns z_{AT} into a resistor. It also makes the system perform like a leaky closed-box system, and low efficiency results. A simple, well-designed closed-box system would clobber a Type B system of equal cabinet volume. So, Type B systems are not the optimum approach.

Type C systems, however, have some possibilities. As in a vented-box direct-radiator system, we have an additional source of output (the line mouth) to assist the driver. Once again, the line throat impedance z_{AT} varies with frequency. The line is terminated with an open aperture which has a relatively low acoustic impedance (analogous to a shorted electrical line). The behavior is opposite of the Type B; the reflection coefficient is essentially +1. When the line is an odd number of quarter-wavelengths long, the line presents a high acoustic impedance to the driver and most of the driver's output is delivered to the line.

When the line is an odd multiple of a half-wavelength long, the reflected wave will assist the driver and the driver

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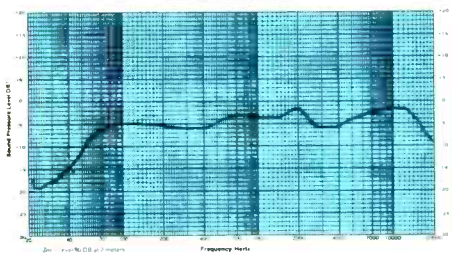

About as flat as you can get...and that's good. The Frequency Response Range is an admirable 25 to 25,000 Hz.

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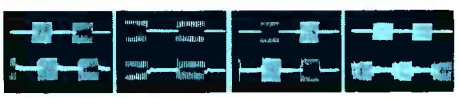

"Blurring" and "Overshoot" are reduced to a minimum in this acid test of transient response. The Spectrum 540 reproduces each waveform accurately with low distortion.

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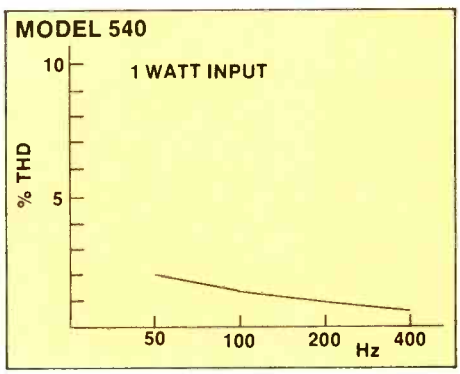

Distortion is kept to a minimum in Jensen Spectrum Speaker systems.

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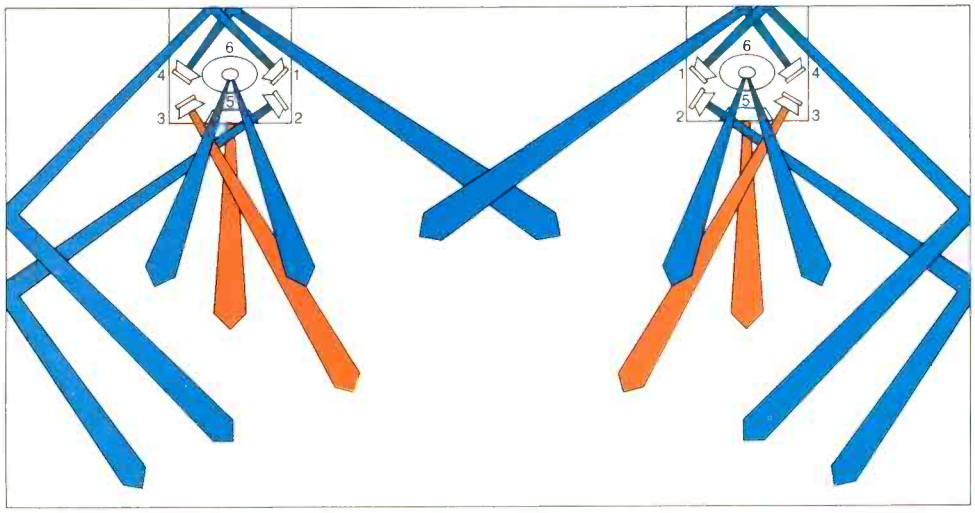

This complex pattern of reflected and direct sound is the key to the spatial realism of the Model 601.

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The Concept Behind Bose Direct/Reflecting® Speakers.

Like the 901 Series III (the most advanced development of Bose design concepts and state-of-the-art manufacturing techniques),the Model 601 is a Direct/Reflecting® speaker system. It's designed to reflect the greater part of its sound output off the back and side walls of the room, surrounding the listener with the same kind of balance of reflected and direct sound experienced in a live performance.

The result is an open, spacious sound and a feeling of realism which can not be achieved by conventional speakers with front-mounted drivers beaming directly at the listener. Such conventional designs are aimed almost exclusively at producing accurate frequency response, while largely ignoring the spatial qualities so critical to the impact of a live performance.

In the Model 601, these important spatial qualities are accurately reproduced through the careful positioning and orientation of all six drivers in each speaker enclosure.

The Tweeters.

Three tweeters in each enclosure (1, 2, and 4) provide reflected sound, creating a feeling of spaciousness, while one tweeter (3) radiates the smaller proportion of direct sound needed for a strong center image and crisp, sharply defined details.

Two of the tweeters are also positioned to radiate sound upward through the acoustically transparent top grille, thus avoiding interference from furniture in the room.

The Woofers.

There are two 8-inch woofers in each Model 601 enclosure, one aimed forward (5) and one angled upward (6) to contribute an important component of reflected sound. The use of two smaller woofers provides a cone area equal to that of a single much larger driver, while offering important performance benefits at low and middle frequencies.

Each high-output woofer is capable of better dispersion and smoother midrange performance than a larger woofer, while they work together to provide bass response of exceptional power and clarity.

Accuracy of Tonal Balance.

With all four tweeters covering the same upper frequency range and the two woofers covering the same lower range, small response irregularities of individual drivers are averaged and smoothed in a way that can not be duplicated using single drivers.

Efficiency.

The Model 601 is also a highly efficient speaker that can deliver superior reproduction of all kinds of music using an amplifier or receiver having as little as 20 watts of power per channel.

The Proof.

For a detailed description of the concepts and technology that make possible the superior performance of the Model 601, write for a full-color brochure to Bose, Dept. AU8, The Mountain, Framingham, Mass. 01701. But for the real proof—your listening enjoyment—just visit any authorized dealer and ask him to introduce you to the newest Bose Direct/Reflecting® speaker system.

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Better sound through research.

Cabinets are walnut veneer. Patents issued and pending.

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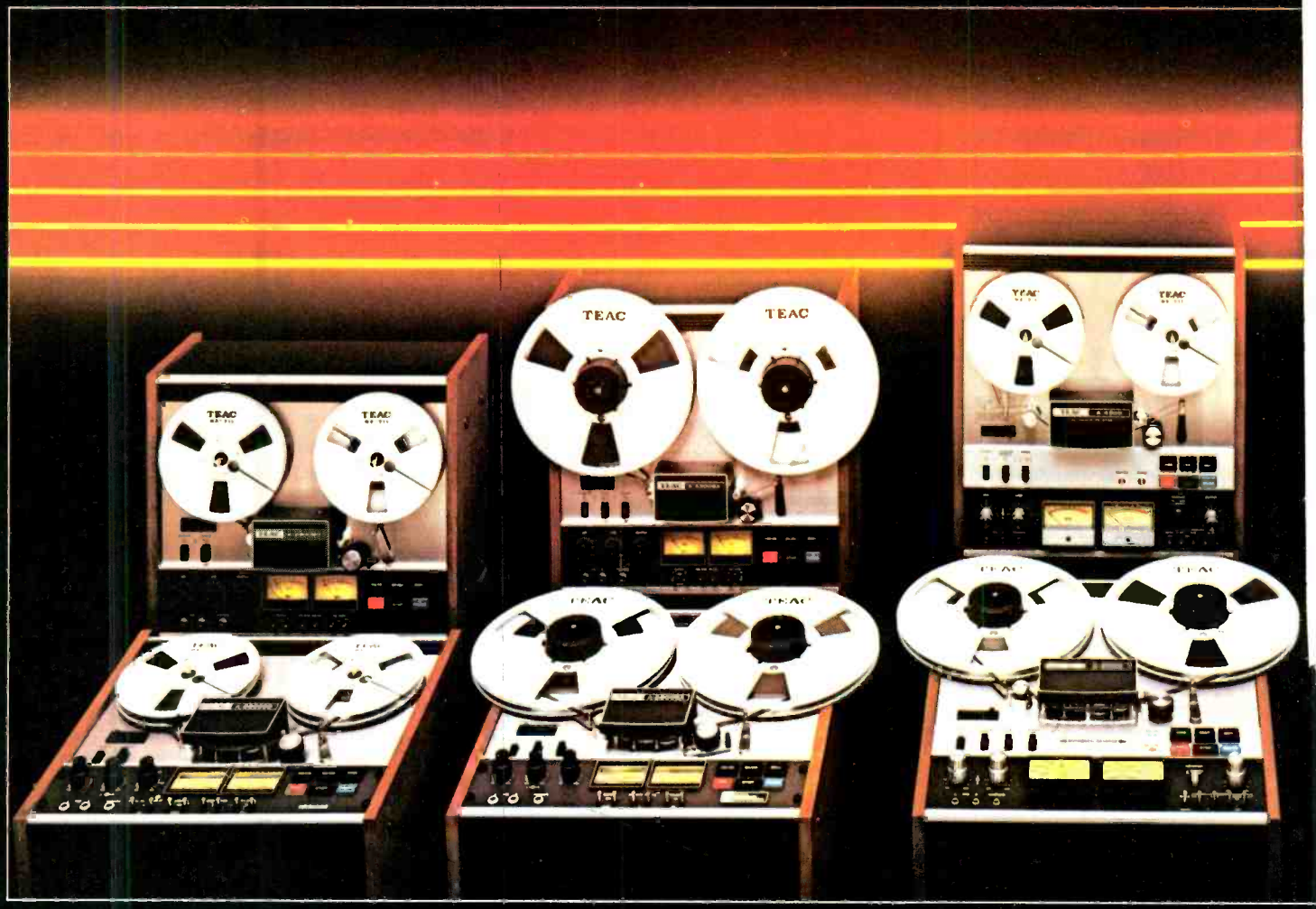

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One of the reasons is that we've been *making* them for a long, long time. In 1955, TEAC came on the scene with the first in a long line of fine open reel tape recorders.

Since then, of course, we have developed a sister line of cassette decks. But our first love remains open reel tape recording equipment: the truest method of sound reproduction available today.

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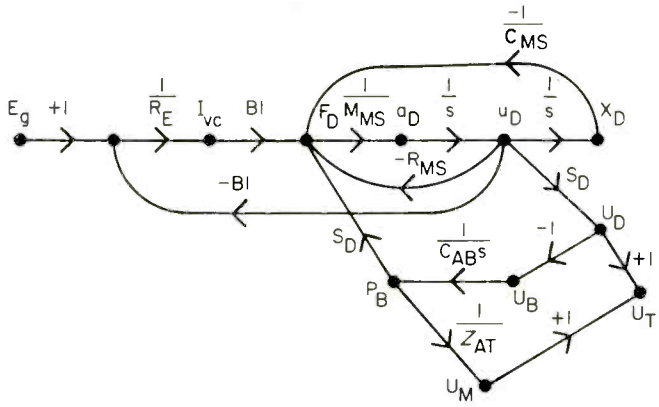

Fig. 5—Signal flow graph of a Type C transmission line loudspeaker.

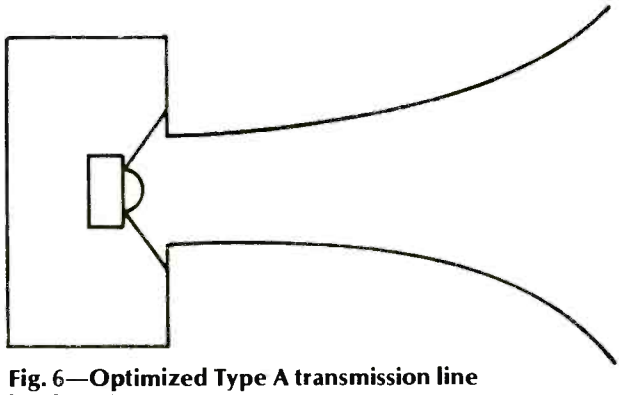

Fig. 6—Optimized Type A transmission line loudspeaker.

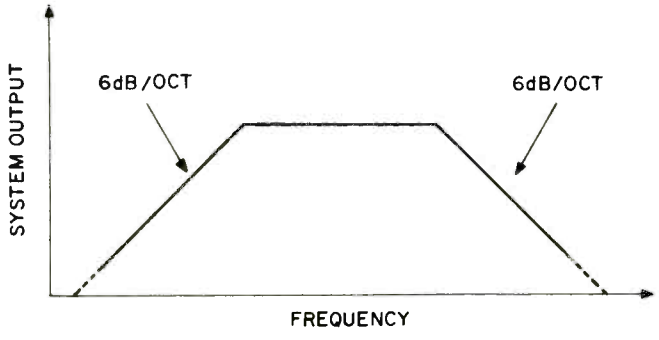

Fig. 7—Frequency response of the simplified model.

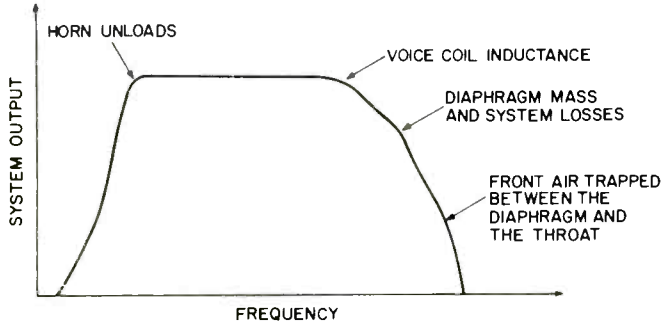

Fig. 8—Frequency response of the more complete model.

distortion are the *only* considerations, a horn-loaded Type A system is optimum. If size and price are part of the picture, then a vented-box direct-radiator (at least for the woofer) may make some sense.

Acknowledgements

The analysis of the Type B and C transmission line systems was based on a method developed by G. S. Letts. The horn analysis was based on a model originally developed by D. B. Keele, Jr., whose comments, along with those of R. H. Small, J. R. Ashley, and W. M. Leach, were most helpful.

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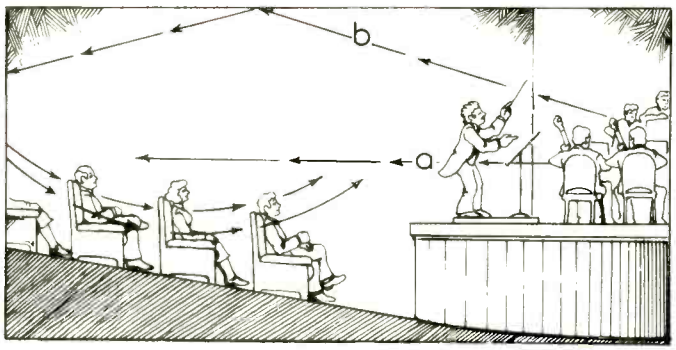
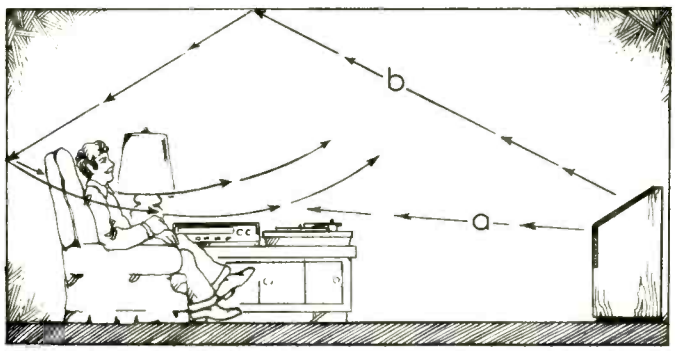
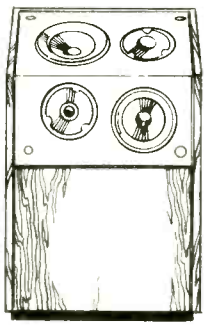


The way sound travels at Carnegie Hall.



The way sound travels from the Epicure 20+.

If you're shopping for a pair of speakers in the upper price range, you'll hear a lot of claims about "concert hall" sound.



The speaker's front-firing and top-firing modules.

So it only makes sense to check those claims out by actually going to a concert and hearing what that concert hall sound is really all about.

You'll discover that the sound comes to you from virtually every direction:

From straight ahead, as sound from the orchestra reaches you directly: "first-arrival" sound (a). From above you, behind you and around you, as sound from the orchestra is reflected from the various surfaces of the concert hall: "second-arrival" sound (b).

The Epicure 20+ radiates sound in several directions.

Epicure's Model 20+ is a handsome, floor-standing loudspeaker with a dual-module design: a front-firing module and an angled, top-firing module. Each features our celebrated 1-inch air-spring tweeter and 8-inch low-frequency transducer.

The two modules work together to create a sound field not unlike the sound field you'd experience center row, Carnegie Hall:

There's direct sound, radiating from the front-firing module. And reflected sound, radiating from the top-firing module, then reflecting from the ceiling and walls of your listening room.

In other words, the Epicure 20+ successfully integrates first-arrival and second-arrival sound. For a first-rate musical experience.

And what a sound it is.

Like every Epicure speaker, the Model 20+ delivers only pure, accurate sound: from 20,000 Hz, all the way down to those deep, bass notes at 35 Hz.

So if it wasn't in the concert, it won't be in your listening room.

On the other hand, if it was in the concert, it'll be everywhere in your listening room. Just the way it would be in Carnegie Hall.

There are plenty of speakers that claim to deliver concert hall sound.

The Epicure 20+ actually does.

The Epicure Twenty+

Epicure is a product series of Epicure Products, Inc., Newburyport, Mass. 01950.

TIME ALIGNMENT™ in loudspeakers

Edward M. Long

Recently there has been a new interest in the performance of loudspeakers as it relates to the time vs. frequency domain. The amplitude vs. frequency response data of loudspeakers is relatively easy to obtain and "frequency response" curves are seen quite regularly in literature put out by manufacturers and in publications which review loudspeaker performance. However, data showing the performance of loudspeakers in the time vs. frequency domain is not as widespread. This is because the equipment which will allow time vs. frequency data to be produced is either very expensive or the tests, using less expensive equipment, are very time consuming. This article will attempt to describe a little of the history of investigations into the time domain, clarify the interrelationship of time and phase vs. frequency, and describe the Time-Align™ Technique as it applies to loudspeaker design.

The importance of having the different elements of a loudspeaker arranged to avoid a double sound or echo is certainly not a recent discovery. John Hilliard describes an event which occurred in 1934 while developing a theater sound system.[1] Dancer Eleanor Powell was rehearsing on a music stage. Hilliard and others could hear two distinct taps coming from the monitor loudspeaker as it reproduced the sound of her dancing feet. The high frequency driver of the two way monitor loudspeaker system was moved back until its acoustical position was essentially lined up with that of the woofer and the double taps could no longer be heard. Some experimenting to determine at what delay the echo could be heard was carried out. Depending upon the person making the judgment, a one to two foot path differential between the high frequency and low frequency drivers was determined as the point at which the echo could be just perceived. Hilliard states that a delay of 1 millisecond then became the criterion for future designs as the maximum allowable delay between drivers.

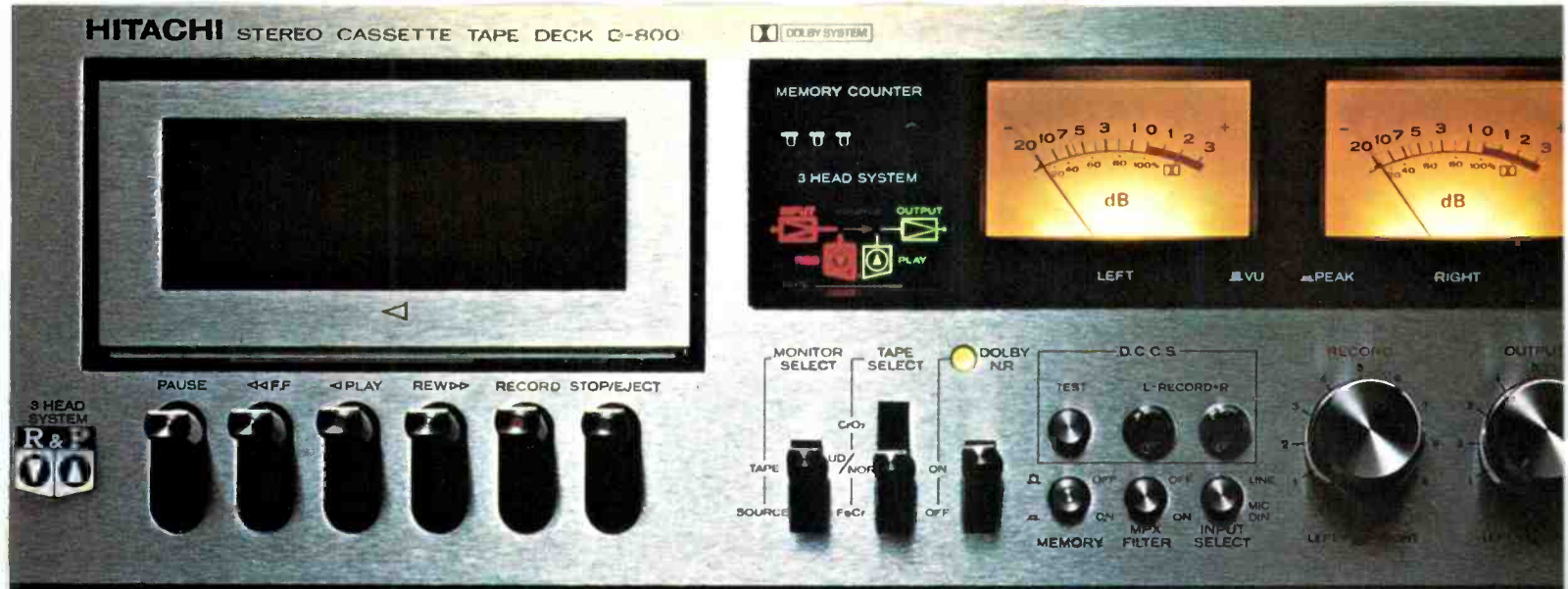
About eight-and-a-half years ago, Richard C. Heyser published a paper on phase and time delay characteristics of loudspeakers.[2] Anyone seriously interested in the subject should definitely read this article and others he has written dealing with the problems of loudspeakers related to performance characteristics in the time vs. frequency domain. Quoting from his 1969 article: "...the acoustic position of a loudspeaker should, on average lie behind its physical position by an amount that is some inverse function of its high frequency cutoff. The acoustical position of woofer will be further behind the physical transducer than that of a tweeter. This important fact is quite frequently overlooked by engineers who consider that spatial alignment of voice coils is sufficient to provide equal-time path signals from multirange loudspeakers." A further proof of this high frequency cutoff interrelationship to acoustical position is shown in a paper, by the author, given at the Audio Engineering Society Convention in May 1976.[3] In this case, the high frequency cutoff of a midrange driver was lowered in frequency by changing one component in the crossover network which was feeding it. The increase in time delay is clearly visible in Fig. 12 of this paper. This shows that the apparent acoustical position of this midrange driver is further back after the change in the network lowered its cutoff. The acoustical position of a driver is not only a function of its high frequency cutoff but of the cutoff network feeding it.

*E.M. Long Assoc.
4107 Oakmore Rd., Oakland, Cal. 94602

The Definition of Time-Align™

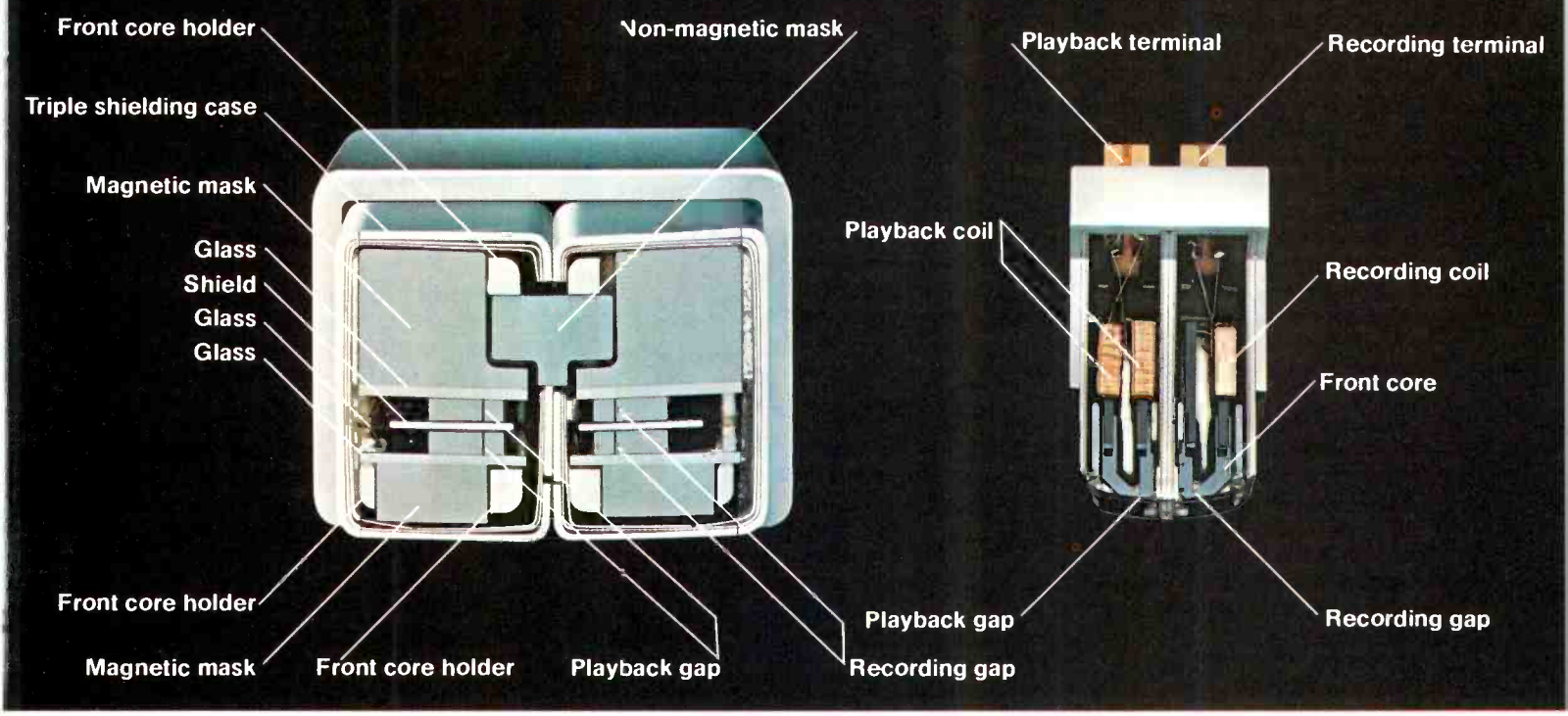
Time-Align™ Technique, as applied to loudspeakers, is a real-time design method, utilizing proprietary instrumentation, which allows the acoustic output of a multi-way loudspeaker system to be adjusted so that the fundamental and overtones of a complex transient arrive at a listener's ears with the same time relationships they had in the electrical signal at the loudspeaker's input terminals. The time vs. frequency characteristics of the individual drivers of a multi-way loudspeaker system play an important role in determining the uniformity of the total time delay characteristics of the complete loudspeaker system. It would be well to point out that uniform time delay of a complete signal is not a bad thing. If it were, we would not enjoy recorded programs! We can play back performances which were recorded years before. It is at any instant in time, during the playback, that all of the complex overtones and the fundamental of a signal must be in the proper time relationship.

In designing such a Time-Aligned™ loudspeaker system, it is necessary that the time differential between various frequencies produced by a given driver, which is to be used in the system, be as small as possible. This requires that each driver be used only in what is called, by loudspeaker designers, its piston band. Of course, in any given design, the allowable tolerance of the time delay will



D-800

Frequency response:	*30—18,000Hz ±3dB*	*Heads:*	*Record and Playback combination: ferrite head*
S/N ratio:	*More than 55dB (Dolby off)*	*Motor:*	*Phase-controlled DC servo motor*
	More than 63dB (Dolby on)		
Wow & flutter:	*0.05% W.R.M.S.*		



Three heads above other cassette decks.

Hitachi's R&P Head.

Two-head decks are compromise performers, because they use a single head for both record and playback.

To insure no-compromise performance, Hitachi developed the R&P 3-Head system. It uses 3 heads, like professional reel-to-reel decks. And these unique record/playback heads have separate and optimum gap widths extending both dynamic range and frequency range significantly.

The Hitachi R&P head is capable of playback monitoring, so you can compare the original source with your tape, a moment after it's recorded. And as an added benefit, its single housing eliminates height and azimuth adjustment problems.

Add up the benefits. You'll agree that Hitachi's decks are three heads above other cassette decks.

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determine the quality of the total system. This is similar to the effect upon quality, of the allowable amplitude vs. frequency response tolerance. At some point in the future it may be an ordinary thing for both the amplitude and time vs. frequency response plots of a loudspeaker to be shown, even on the same graph. This would most certainly be a very valuable way to display these interrelated characteristics.

After the individual time vs. frequency characteristics of each driver to be used in a particular loudspeaker system design are determined as being uniform, the design of the total system may begin. An interesting concept which may help to explain how a loudspeaker system is designed using the Time-Align™ technique is to compare it to splicing a magnetic tape recording. A good splice is virtually undetectable because the amplitude and time characteristics of the program at the point of the splice are very carefully matched. The same thing can also be said of the Time-Align™ technique as applied to loudspeaker design. Both the amplitude and time characteristics vs. frequency are carefully adjusted, with particular attention paid to splicing the time characteristics of any two adjoining frequency ranges. Thus, as the acoustic output of the driver covering the lower frequency portion of a given range of frequencies is reduced in amplitude by its network, the acoustical position of driver covering the next higher range of frequencies including the parameters of the network feeding it are adjusted to provide a virtually undetectable splice in both the amplitude and time vs. frequency domain.

Since there are both physical and electrical methods available which can be used to properly adjust the acoustical position vs. frequency and therefore the Time-Alignment™ of acoustical output of a multi-way loudspeaker system, it is worthwhile to look at some different loudspeaker systems which are Time-Aligned™. Figure 1 is a photograph of three Time-Align™ loudspeakers, manufactured by Sonic Energy Systems. The smallest, the TA-10, on the right, is a Bookshelf system employing a 25 cm (10 in.) woofer and a 3.8 cm (1.5 in.) tweeter. The physical offset between the woofer and tweeter in this system is less than that of the woofer and the midrange of the TA-12, shown as the middle system of Fig. 1. This is because the upper cutoff frequency of the 25 cm (10 in.) woofer is higher than the 30 cm (12 in.) woofer of the TA-12. This means that the acoustical position of the 30 cm (12in.) woofer is further back than that of the 25 cm (10 in.) woofer. Generally, the larger the diameter of a driver, the lower its cutoff frequency and therefore the further back its acoustical position, when compared to their physical positions. Since the cutoff characteristics of the network feeding a driver can also effect its cutoff, a smaller driver can have an acoustical position behind that of a larger driver if its cutoff is at a lower frequency. The method used to Time-Align™ the Sonic Energy Systems loudspeakers combined both the physical placement of the drivers relative to each other and the adjustment of the network parameters while looking at the acoustical output of each system in the amplitude vs. frequency and time vs. frequency domains. Both the physical locations and network parameters were adjusted simultaneously in real time.

Figure 2 shows the Sonex Model Two loudspeaker which, while designed using the same method described above, employs a different approach than usual for producing the bass frequencies. Two small diameter, 16 cm (6 ½in.) bass drivers are employed down to approximately 60 Hz where a rear mounted passive radiator takes over to produce the next lower octave to 30 Hz. Because of their small size and relatively high cutoff frequency, (about 3 kHz), the relative time delay characteristic, across

Fig. 1—Time-Align™ loudspeakers by Sonic Energy Systems. Left to right: the Model TA-10F floor standing system with passive radiator, the Model TA-12 three-way floor system, and the Model TA-10 two-way bookshelf speaker system. All drivers in these systems are physically offset from each other in the front to back plane.

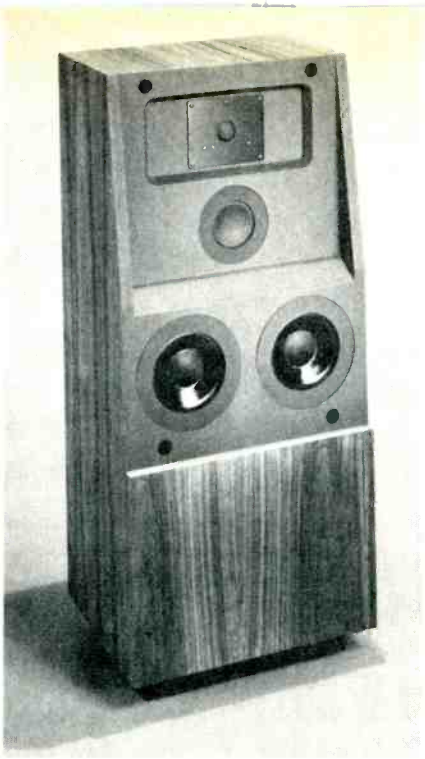


Fig. 2—The Sonex Model Two Loudspeaker System. This system uses two small bass drivers with a passive radiator in the rear for fast response. The physical offset between the bass and midrange drivers is less than between the drivers in Fig. 1.

the range which they are required to produce, is quite good. As can be seen, the relative physical offset between these two bass drivers and the midrange driver mounted above them, is relatively small. The trade off made in the design of the Sonex Model Two is to sacrifice high acoustical output capability for greater accuracy, especially in the time vs. frequency domain.

Figure 3 shows the Model 813 Time-Align™ Monitor by UREI (United Recording Electronics Industries) designed for use in recording studio control rooms. A recording studio monitor is required to produce high level acoustical output and to be efficient. The interesting point in this design is that it utilizes an Altec 604-8G dual concentric driver in which the high and low frequency producing elements are physically locked together. This precludes adjustment of the physical positions of the low and high frequency drivers which was part of the method used to adjust the acoustical position vs. frequency in the designs of Figs. 1 & 2. The method used to accomplish the Time-Alignment™ of the Altec 604-8G is purely electrical and uses a passive time delay network as well as a crossover network. The two networks are designed as a composite, once again using the real time method of the Time-Align™ technique. The second 38 cm

Fig. 3—The UREI Model 813 Time-Align™ Monitor for use in studio control rooms. The 604-8G high and low frequency drivers are locked together and are, therefore, Time-Aligned™ by a passive time delay plus crossover network.

(15in.) woofer in this system also receives its signal via a time delay/crossover network. Besides offering the 813 Time-Align™ Monitor as a complete system, UREI also supplies Time-Align™ crossover networks for the Altec 604-8G and the older 604-E.

Because these networks can be substituted directly for the networks ordinarily used with the Altec 604-8G and 604-E loudspeakers, an interesting demonstration was conducted by UREI at the most recent Audio Engineering Society Convention (May 1977). By selecting between the Time-Align™ network and the network ordinarily used with each driver, the value of Time-Alignment™, if any, could be determined without changing the driver, enclosure, or position, thus allowing a really valid "apples to apples" comparison to be made. Tests conducted to determine "if phase is important" tend sometimes to cloud the issue. Usually, these tests are conducted to prove that phase is relatively unimportant. At the recent Audio Engineering Society Convention (May 1977), the author was told by two people independently, that they had been present at demonstrations in different parts of the world which were designed to show that phase was unimportant. Each said that they heard a clear difference between the two examples presented. The persons conducting the demonstrations proclaimed that no difference could be detected. In one case, no one said anything to the demonstrator. In the other case, people in the audience said they could hear the difference. In the second case, the demonstrator has since reduced the amount of "phase

Fig. 4—Relationship of the time delay vs. frequency for constant phase delays.

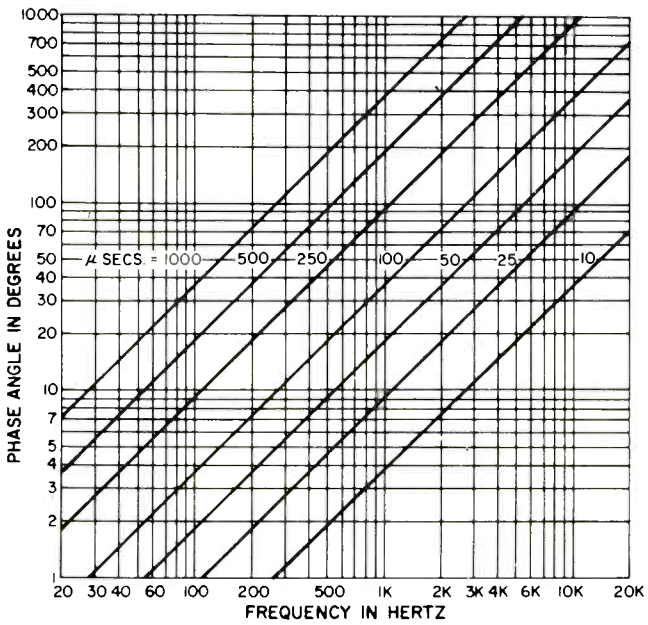
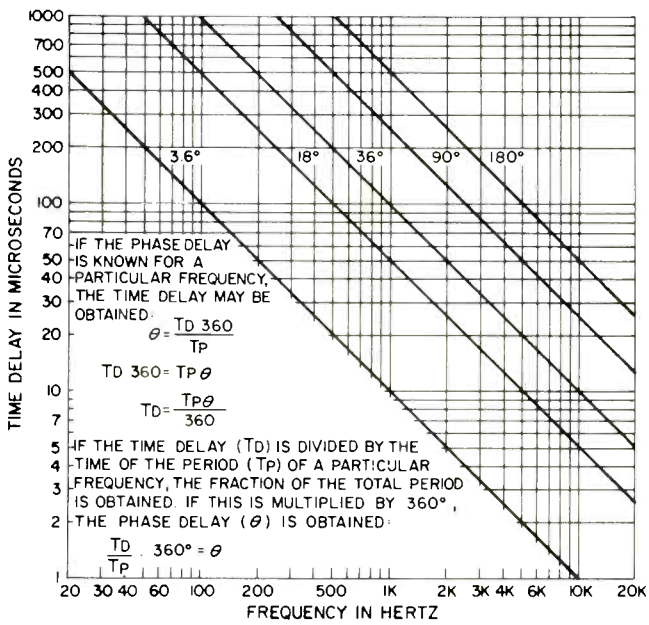


Fig. 5—Relationship of phase angle vs. frequency for constant time delays.



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Further, the straight-line tubular design (for maximum rigidity and lowest mass) and the settings for zero balance, tracking force and anti-skating are, like the gimbal, identical in every Dual tonearm. The tonearm establishes and maintains the correct cartridge-to-groove geometry, and allows the stylus to trace the groove contours freely, precisely and with the lowest practical force. In short, flawless tracking.

Advantages of the Vario-belt drive system.

Another important inheritance is the Vario-belt drive system. This drive system comprises a high-torque synchronous motor, a precision-machined Vario-pulley, a precision-ground belt and a machine-balanced, die-cast platter. The Vario-pulley simply expands and contracts for reliable fine-speed adjustments. There are no complicated mechanics or electronic circuitry, which add nothing but cost.

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Everything we've described applies to the 1237, which is, incredibly enough, our lowest-priced model. And where the 1237 ends, the 1241 and 1245 begin. With an even higher degree of performance. And very handsome, contemporary, low-profile bases.

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Dual 1237: less than $135; base and cover less than $30 additional.
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delay" which so far has still been detectable by some listeners.

Phase vs. Time

At this point, it would be worthwhile to show the relationship between phase and time as they relate to frequency. Since the term "Linear Phase" is used to describe certain loudspeakers, it might be well to clarify what is meant by this term. Most people would probably imagine that "Linear Phase" vs. frequency would mean that the phase at any given frequency would be the same value, and therefore linear. Figure 4 is a graph which relates the time delay vs. frequency for a constant or linear phase. As can be seen for a constant phase delay of 3.6°, the time delay varies from 500 microseconds at 20 Hz to 0.5 microseconds at 20 kHz. This is a time delay difference of 1000:1. Obviously, this is not what is meant by the term "Linear Phase". What must be meant is a linear change of phase vs. frequency. Another way of looking at this relationship is to compare two frequencies separated by a decade. The period of 1000 Hz is ten times as long as the period of 10 kHz. 10 complete cycles of 10 kHz can exist during the period of one cycle of 1000 Hz. This means that 10 kHz can go through 3600° while 1000 Hz goes through only 360°. Figure 5 is a graph of phase angle vs. frequency for a constant time delay. If all frequencies are delayed by the same amount of time, the phase will change linearly with frequency. For a constant time delay of 50 microseconds the phase delay at 100 Hz, 1000 Hz and 10 kHz will be 1.8°, 18° and 180° respectively. To be completely accurate in describing the desired condition, the term "Linear Phase" should be "Linear Phase Change."

During the demonstration of the Time-Align™ networks vs. the normal networks with the Altec 604-8G and 604-E loudspeakers, at the Audio Engineering Society Convention (May 1977), comparisons were made by having the demonstrator speak using a half inch condenser microphone. This microphone has a uniform time delay of about 10 microseconds which should not cause it to obscure the time information in normal speech. Lack of time offset between the low and high frequencies with a Time-Align™ network should allow the consonants, Ss, Ts, etc., to line up more accurately with the vowel sounds of speech. The reaction of listeners was quite dramatic. Of course, no claim is made that this was a scientific experiment. However, many people said that they were convinced that Time-Alignment™ was very worthwhile and that the reproduced speech was much more accurate with the Time-Align™ network. The fact that many recording companies have already expressed their desire to install Time-Aligned™ monitors in their control rooms may bode well for the future in terms of much clearer recordings with more judicious use of limiters, compressors, etc. Time will tell!

References:

1. J. Hilliard, "Historical Review of Horns Used for Audience Type Sound Reproduction", J.A.S.A., Vol. 59, No. 1, page 1, (Jan 1976).

2. R. Heyser, "Loudspeaker Phase Characteristics and Time Delay Distortion, Part 1", J.A.E.S., Vol. 17, No. 1, page 30, (Jan 1969).

3. E.M. Long, "A Time-Align™ Technique for Loudspeaker System Design", A.E.S. 54th Convention, May 1976, Preprint No. 1131.

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Equipment profiles

Sony Model STR-6800SD Stereo AM/FM Receiver

MANUFACTURER'S SPECIFICATIONS

FM Tuner Section
Usable Sensitivity: Mono, 1.7 μV (9.8 dBf).
50 dB Quieting: Mono, 3.5 μV (16.1 dBf); Stereo, 45 μV (38.3 dBf).
S/N: Mono, 73 dB; stereo, 68 dB.
Frequency Response: 30 Hz to 15 kHz, +0.2, -1.5 dB.
Capture Ratio: 1.0 dB.
AM Suppression: 54 dB.
I.F. and Spurious Rejection: 100 dB.
Image Rejection: 75 dB.
THD: Mono, 0.2 per cent @ 1 kHz, 100 Hz, and 10 kHz; Stereo, 0.3 per cent @ 1 kHz & 100 Hz, 0.6 per cent @ 10 kHz.
Stereo Separation: 40 dB @ 1 kHz, 35 dB @ 100 Hz & 10 kHz.
Sub-Carrier & SCA Rejection: 60 dB.
Muting Threshold: 5μV (19.2 dBf).

AM Tuner Section
Usable Sensitivity: 250 μV/M (internal antenna).
S/N: 50 dB.
Selectivity: 35 dB.
Image Rejection: 40 dB.
I.F. Rejection: 35 dB.
THD: 0.5 per cent.

Amplifier Section
Power Output: 80 watts per channel continuous, 8 ohms, 20 Hz to 20 kHz.
Rated THD: 0.15 per cent.
Rated IMD: 0.15 per cent.
Damping Factor: 40.
Frequency Response: Phono, RIAA ±0.5 dB, High Level, 10 Hz to 30 kHz, +0, -2 dB.
Input Sensitivity: Phono, 2.5 mV; High Level, 250 mV.
S/N Ratio: Phono, 72 dB "A" Weighted; High Level, 90 dB "A" Weighted.
Bass & Treble Control Range: ±10 dB @ 100 Hz and 10 kHz.
Filters: 6 dB/octave above 5 kHz or 10 kHz, and below 50 Hz or 25 Hz.

General Specifications
Power Requirements: 120 V, 60 Hz, 225 watts.
Dimensions: 19¼ in. (48.9 cm) W x 6 9/16 (16.67 cm) H x 16¼ in. (41.2 cm) D.
Weight: 36 lb., 7 oz. (16.52 kg).
Price: $600.00

Sony's Model STR-6800SD receiver is the highest powered of the three units introduced recently by that company. The receiver represents quite a styling departure for Sony, resembling neither that company's earlier receivers nor most of today's competitive units. Control layout may take a bit of getting used to, in that on first impression, things seem to be a bit upside down, but upon closer examination and use, one quickly discovers that the control layout of this receiver has been very logically organized for ease of use.

At the upper right side of the unit are the two most frequently used rotary knobs, the tuning knob and the master volume control. The latter control is calibrated in dB, and adjacent to it is a -20 dB audio muting switch. At the upper left are a rectangular power *On/Off* pushbutton switch and signal-strength/multipath and center-of-channel meters. Two indicator lights near the center-tuning meter denote Dolby FM selection and stereo FM reception.

The long dial scale opening, framed in a dark color, is centered on the panel, and FM calibration marks occur at every 100 kHz in linear fashion. Controls just to the right of the dial area include a tape-copy selector (with positions for copying from one tape deck to another, while at the same time listening to any other program source), a tape monitor selector for either of the two tape monitor circuits, and a program selector switch with settings for two phono inputs, FM, AM, or AUX.

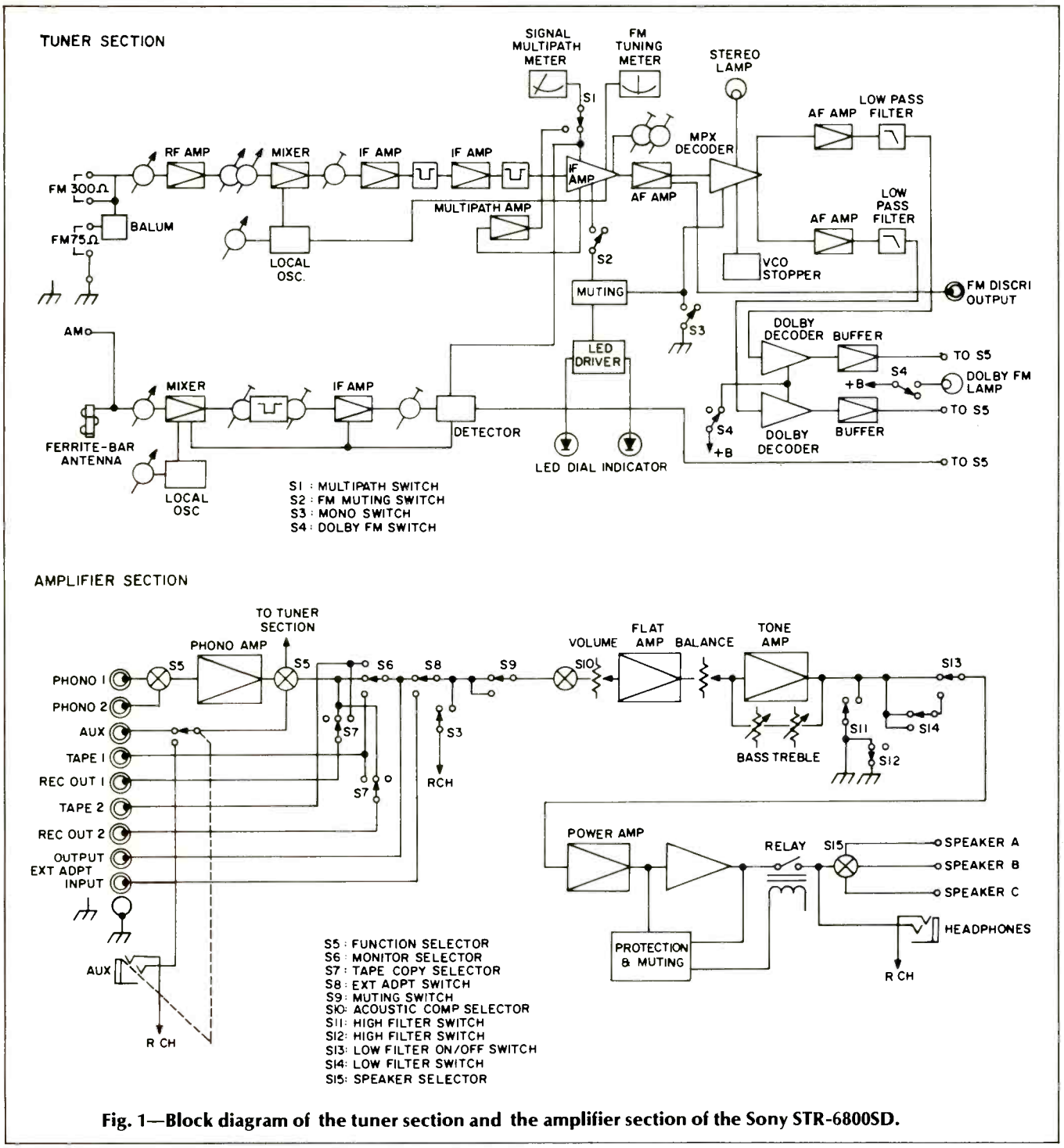


Fig. 1—Block diagram of the tuner section and the amplifier section of the Sony STR-6800SD.

The lower portion of the panel contains a headphone jack, speaker selector switch (three pairs can be connected, of which any one or two pairs can be switched on), four high and low cut filter buttons (providing two cut-off points for each filter), concentrically mounted bass and treble controls for individual channel adjustment, a balance control, and a new control which Sony calls an *Acoustic Compensator Selector*. When set to "low," this control introduces bass boost by a fixed amount. In the "presence" position, mid-range frequencies are boosted, while in the "loudness" position, conventional loudness compensation is introduced. Push-button switches at the lower right handle FM muting, Dolby *On/Off* (the receiver has built in Dolby decoding circuitry plus automatic switching from 25 μS to 75 μS de-emphasis), switching of the signal meter to multipath indication, mono/stereo selection, and external adaptor selection (a third circuit interruption point like the tape monitor circuits). A stereo phone jack duplicates the AUX inputs on the rear panel, and connection to it of an auxiliary source gives it priority over the rear panel AUX jacks.

The rear panel of the STR-6800SD has three sets of speaker terminals located at the right, along with three unswitched a.c. receptacles. Speaker connections are of the spring-loaded "key" type which accept the stripped ends of the speaker cables. Screw terminals for external AM and 300-ohm FM antennas are provided, as is a 75-ohm coaxial con-

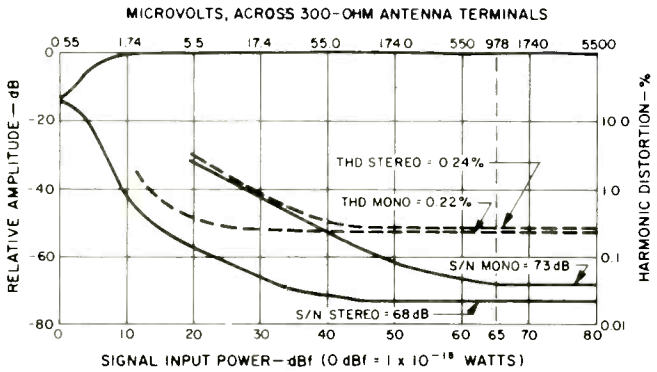


Fig. 2—FM mono and stereo quieting and distortion characteristics.

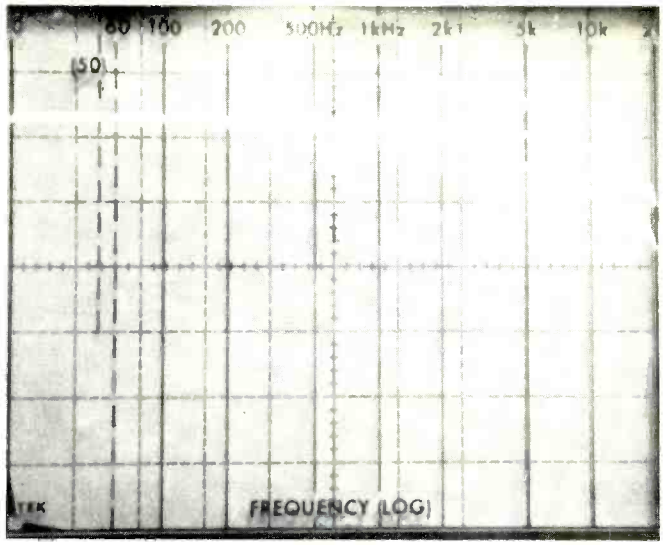


Fig. 4—The 25 microsecond (upper trace) and 75 microsecond de-emphasis characteristics.

nector. The standard AM ferrite bar antenna has been positioned below the antenna input and tape out terminals so that the legends associated with the various output and input jacks remain visible at all times. A separate ground terminal as well as an FM discriminator output jack are also provided on the rear panel.

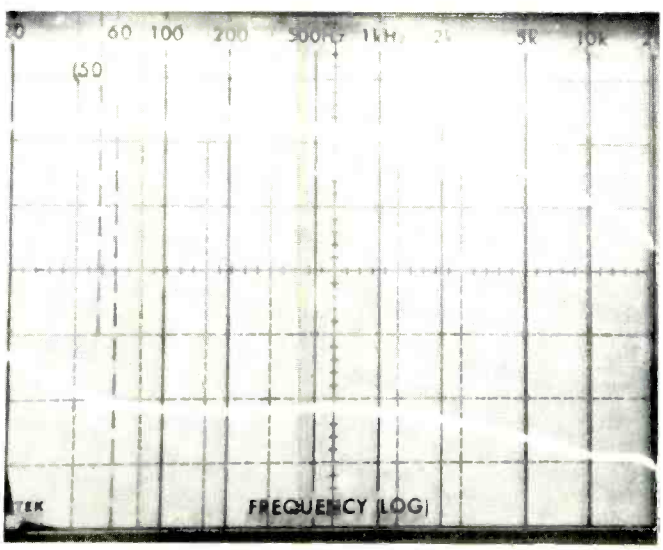
We can remember when Sony used to go to a fair amount of trouble to give a rather complete description of the circuitry used in their products as part of the owner's manual. However, the company has not kept up this practice, and we weren't supplied a schematic diagram with our test sample. Owners can no doubt obtain a complete service manual from the company, but presently we can only reproduce the two sections of the overall receiver block diagram that were provided. These are shown in Figs. 1(a), (b).

FM Tuner Section Measurements

Signal-to-noise ratio and distortion characteristics are plotted as a function of the input signal strength in Fig. 2. (*NOTE:* Our presentation of these curves has been modified to emphasize the new dBf signal strength notations used in the recently adopted IHF/IEEE Tuner Measurement Standards. This makes for a linear graphic layout, both in the horizontal and vertical axes. Equivalent "microvolt" notations, referenced to a 300-ohm antenna impedance, are shown for key dBf values to assist those who have not yet become accustomed to the new dBf values). Usable sensitivity in mono measured 1.7 μV (9.8 dBf), while in stereo it measured 5.0 μV (19.2 dBf). The 50-dB quieting point in mono was achieved with a signal input of 2.5 μV (13.2 dBf), with 42.0 μV (37.3 dBf) being required for the same quieting in stereo. S/N at 65 dBf measured 73 dB for mono and 68 dB for stereo, exactly as claimed. THD in mono and stereo were almost identical, with readings of 0.22 per cent and 0.24 per cent respectively. Selectivity measured 80 dB, while the various rejection capabilities all measured within a dB or two of published claims. Capture ratio measured 1.0 dB exactly. Figure 3 is a spectrum analyzer plot of separation versus frequency. Separation at 1 kHz measured 44 dB. Figure 4 shows the two de-emphasis characteristics of the FM tuner section (upper trace is 25 microsecond response, used in Dolby setting), while in Fig. 5 we have plotted distortion versus frequency for both mono and stereo FM.

Stereo switching threshold measured 4.5 μV (18.3 dBf), a perfectly reasonable value in view of the usable stereo sensitivity figure previously noted. Muting threshold measured exactly 5 μV (19.2 dBf) as claimed. Sub-carrier rejection was 62 dB, somewhat better than claimed. Overall frequency response deviated from flat by no more than 0.5 dB, even at the 15 kHz frequency extreme.

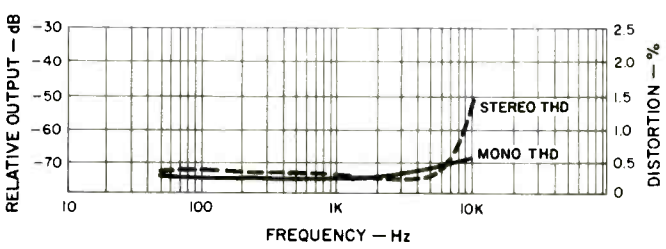
Fig. 3—Stereo FM separation (includes the 75 microsecond de-emphasis).



Amplifier Section Measurements

The power amplifier section of the STR-6800SD delivered 96 watts per channel of continuous power for the rated THD figure of 0.15 per cent (99.0 watts per channel for 0.15 per cent IM distortion), while at all lower power levels, THD and IM were considerably lower, as plotted in Fig. 6. At the

Fig. 5—FM Distortion vs. frequency.



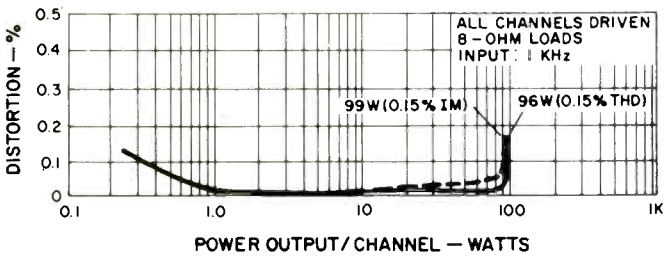


Fig. 6—Harmonic and intermodulation distortion characteristics.

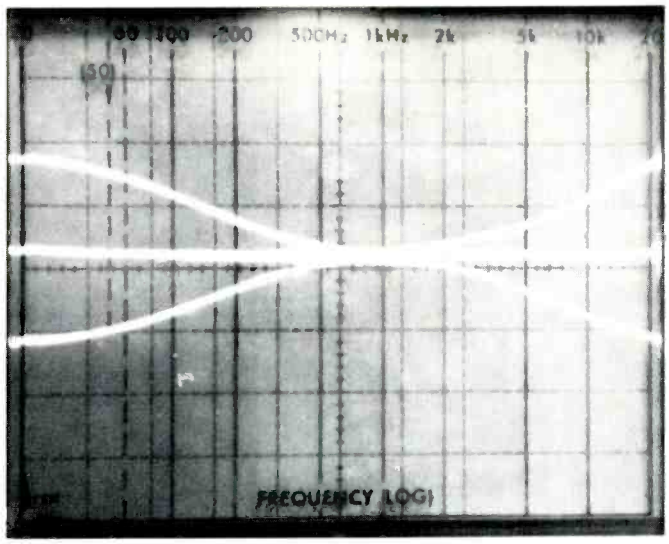


Fig. 8—Bass and treble range with the Sony STR-6800SD.

1-watt output level, THD was 0.018 per cent, while IM measured 0.015 per cent. At rated output (80 watts per channel, 8 ohm loads), THD measured 0.014 per cent for a 1-kHz test signal, while IM measured 0.044 per cent. Full power band (frequency extremes at which 80 watts per channel was obtainable with no more than 0.15 per cent THD) extended from below 10 Hz to 26 kHz. Our particular sample would have met its FTC power test even if the unit has been rated at 92 watts per channel instead of the conservative 80 watts. A plot of distortion versus frequency, taken at the 80-watt per channel level, is shown in Fig. 7.

Phono input sensitivity measured 2.6 millivolts for full power output, while high level input sensitivity was 250 mV, exactly as specified. Phono overload, using a 1-kHz test signal, occurred at an input level of 90 millivolts — a bit on the low side compared to some other high quality receivers we have measured recently, but still adequate for use with most cartridges when they are reproducing heavily modulated disc grooves. Unweighted hum and noise in both phono inputs measured 70 dB, while in the high level positions, hum and noise was a high 92 dB. Overall frequency response in phono was within 0.7 dB of the prescribed RIAA playback curve from 30 Hz to 15 kHz, while in high level service, frequency response was flat to within 1.0 dB from below 10 Hz to 25 kHz (-3 dB at 45 kHz).

Range of bass and treble tone controls is depicted in the spectrum analyzer sweeps of Fig. 8, while the action of the "presence" setting of the acoustic compensator switch is plotted (compared with a flat response reference) in Fig. 9. Note that in Fig. 9, the vertical scale of the 'scope presentation has been magnified so that one vertical division equals 2 dB as opposed to the usual 10 dB per box used in Figs. 8, 10, and 11. Thus, the presence "bump" is approximately 3 dB high at its peak between 1 and 2 kHz. The "low boost" setting of the acoustic compensator switch really duplicates the low end of the loudness control function and is dependent upon the relative master volume control settings. In Fig. 10, we compared the action of the "low boost" setting with that of the more familiar "loudness" setting, in which both low and high frequencies are emphasized at the -30 dB point on the master volume control.

Low and high filter cut responses are plotted, by means of the spectrum analyzer sweeps, in Fig. 11. While cutoff slopes are only 6 dB per octave, Sony has taken care to set the cutoff points sufficiently far away from important mid-range frequencies to make the filters moderately effective in reducing hiss and rumble without interfering too much with musical content.

Use and Listening Tests

Figured purely on a dollars-per-watt basis, the Sony STR-6800SD offers unusually good value for its price. Consider, too, that the built-in Dolby feature alone is worth around $100.00 if purchased as a separate add-on accessory. Considering the extra control features such as those two-position

Fig. 7—Distortion vs. frequency.

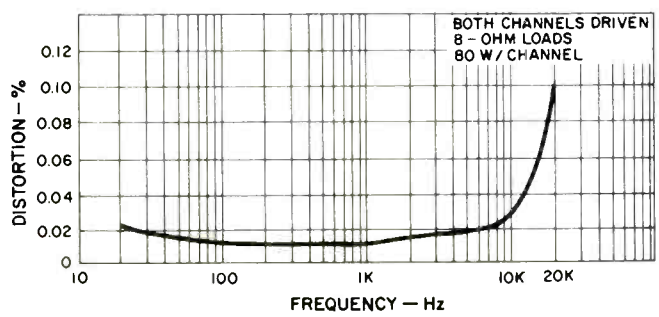
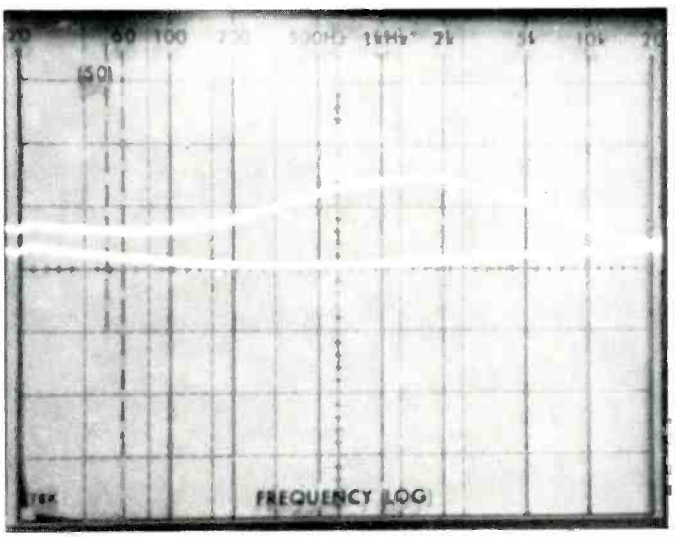


Fig. 9—The "presence" setting response. (*Note:* the vertical scale is altered to 2 dB per division in this graph.)



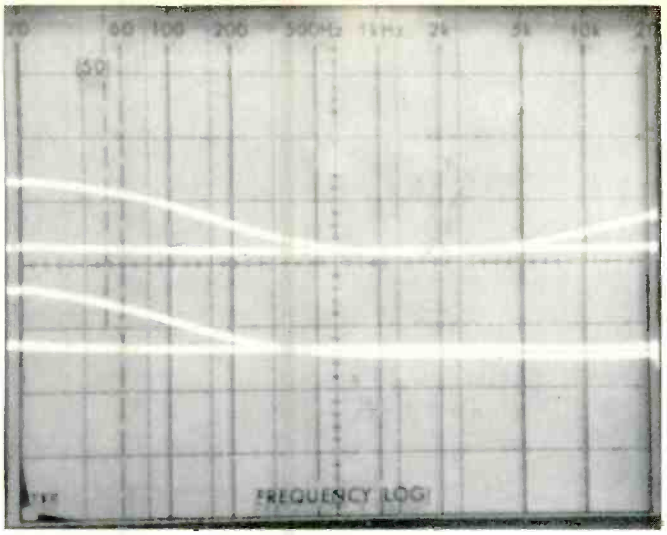


Fig. 10—The "low boost" setting is similar to "loudness" except the treble emphasis is omitted.

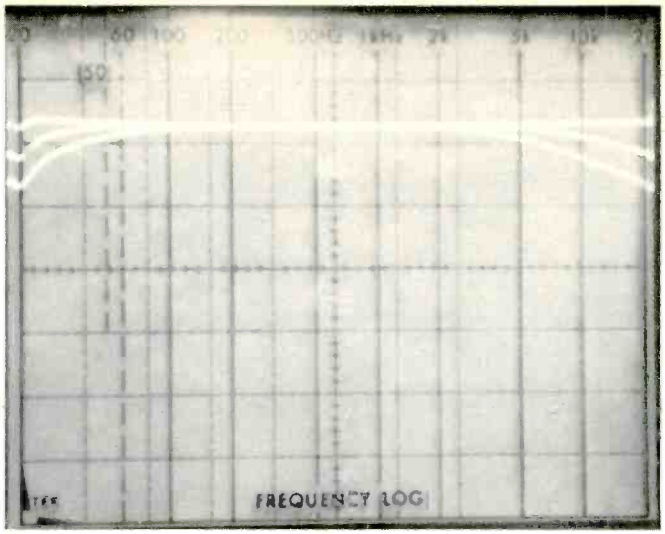


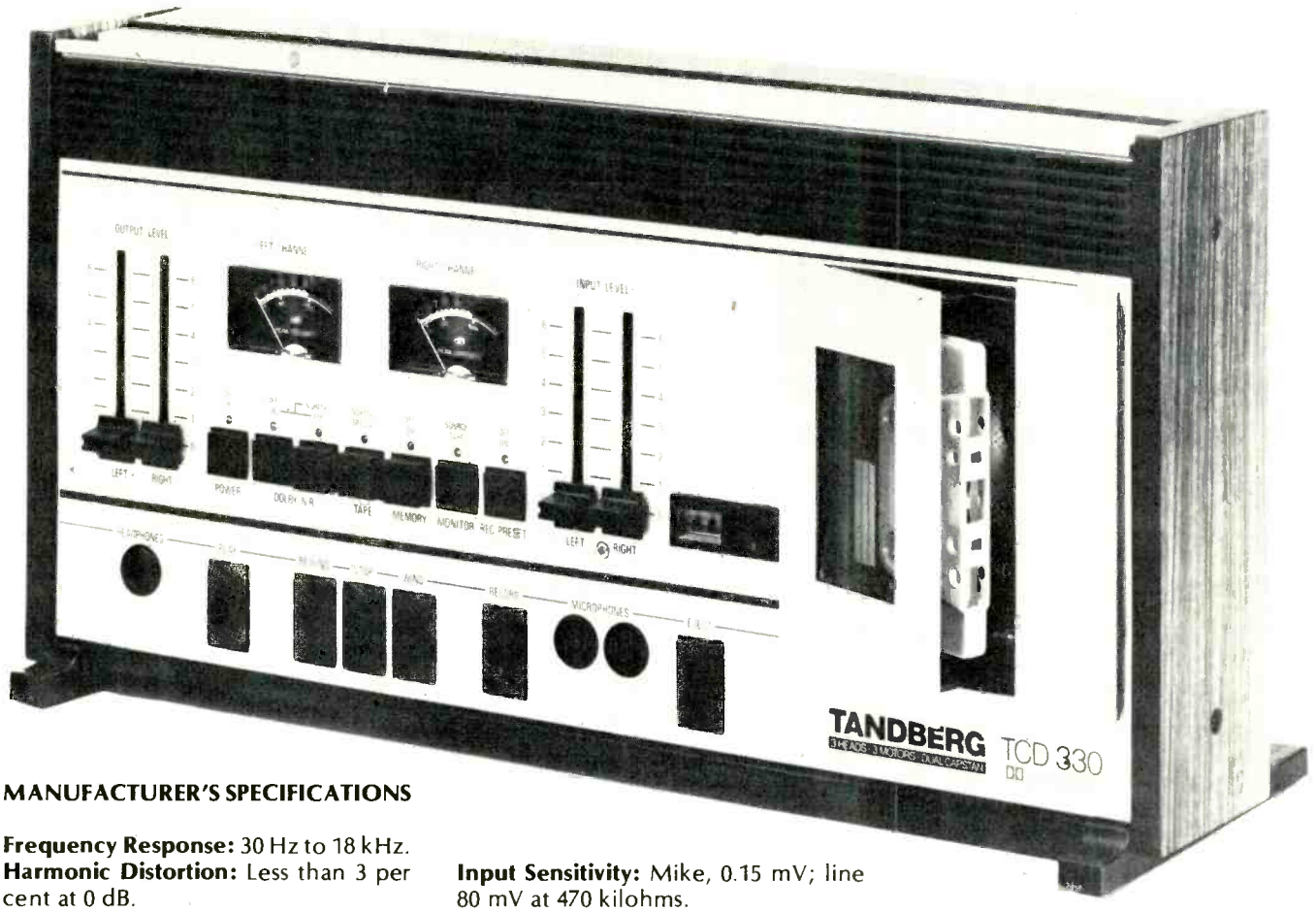
Fig. 11—Low- and high-cut filter responses.

high and low cut filters, the unique acoustic compensator feature, the intelligent control layout, and the conservative, cool-running amplifier circuitry, the receiver's inherent worth increases still further.

In our listening tests, the receiver was connected to a pair of low-efficiency bookshelf-type speakers, to which it provided both solid and ample power. Dial calibration was virtually perfect — no small feat when you consider the precise markings on the expanded dial scale. The alternate use of the signal-strength meter as a multipath indicator is very worthwhile and it worked extremely effectively for us. AM circuitry is a bit on the minimal side and not consistent with the quality of the rest of the receiver — but then this is true of so many high fidelity receivers that it almost need not be mentioned. In using the receiver for recording purposes, we were not bothered in the least by any sub-carrier product beats — so effectively has Sony managed to suppress such output products without sacrificing good FM frequency response in stereo. All in all, it appears that Sony's revamped receiver line involves much more than just a new front panel layout and, in the case of their highest power receiver at least, the company has managed to deliver an outstanding value for a very reasonable price. *Leonard Feldman*

Enter No. 70 on Reader Service Card

Tandberg Model TCD 330 Cassette Deck



MANUFACTURER'S SPECIFICATIONS

Frequency Response: 30 Hz to 18 kHz.
Harmonic Distortion: Less than 3 per cent at 0 dB.
S/N Ratio: 65 dB at 3 per cent THD with Dolby.
Separation: 35 dB.
Crosstalk: 60 dB.
Input Sensitivity: Mike, 0.15 mV; line 80 mV at 470 kilohms.
Output Level: Line, 1.5 V, headphones 5 mW @ 8 ohms.
Wow and Flutter: 0.18 DIN wtd. peak.
Speed Deviation: 0.5 per cent.
Dimensions: 18 ½ in. (47 cm) W x 4 1/8 in. (10.5 cm) H x 9 1/8 in. (23 cm) D.
Weight: 15 ¾ lbs (6.6 kg).
Price: $995.00.

The Tandberg TCD 330 three-head cassette deck provides excellent overall performance with a number of interesting and helpful features. Its appearance is similar to other Tandberg products, with an aluminum front panel, wooden end pieces, and the square push-button switches. The TCD 330 can be operated either horizontally or vertically, on a table or even hung on a wall. Snap-on feet are provided to ensure stability in the vertical on-table position, used for the following description. The output level slide pots are at the left, with the headphone jack below. The two peak-reading meters are scaled from -30 to +5 dB with the Dolby level reference at -2.5 dB. The white and red scale with the blue background and the good illumination combine to make for good meter legibility. Below the two meters is a rather imposing row of large push-button switches, each with its own status light. Starting from the left, the power *On/Off* switch is first, followed by the Dolby button, and then a selector for decoding FM/Dolby broadcasts. The *Normal/Special* tape switch is next, and then the *Memory* On/Off. The *Monitor* switch to the right allows selecting either *Source* or *Tape* (from the unit's playback head) to be fed to the outputs. The meters, however, always show source (or record level) except for record head alignment or when a tape is simply being played. The last button in the row is the *Rec Preset* switch. If the preset is not *On*, a recording cannot be started even if *Record* and *Play* are accidentally pushed at the same time. Once the switch is preset, however, a recording can be started just by pushing *Record*.

Below are the light-touch tape-motion switches with *Rewind*, *Stop*, and *Wind* centered between *Play* on the left and *Record* to the right. Logic control permits switching in any order with the exception that *Record* is only possible from *Stop*, or *Play* if both buttons are held in (*Rec Preset* pressed). At first the layout seemed a little odd, but in use the convenience of it seems very logical. *Play* is near the headphone jack and the output level controls: what else to play the tape for but output? *Record* is handily under the preset switch, and the mike jacks and the input pots are just to the right. Below the counter is the control button for the *Eject* solenoid. On the back of the unit is a manual release for the cassette which can be used when the power is off. The well opens up for cassette insertion from the right. Removing the snap-in cover provides easy access for all cleaning and demagnetization tasks. A window in the cover and a light in the bottom of the well facilitates observation of tape motion. All the way to the right is the access door for the 10 kHz alignment tone switch and the record-head azimuth adjustment. When the test tone is turned on with the deck in *Record*, its playback level appears on the right meter. The record-head adjust knob is turned for a maximum in-

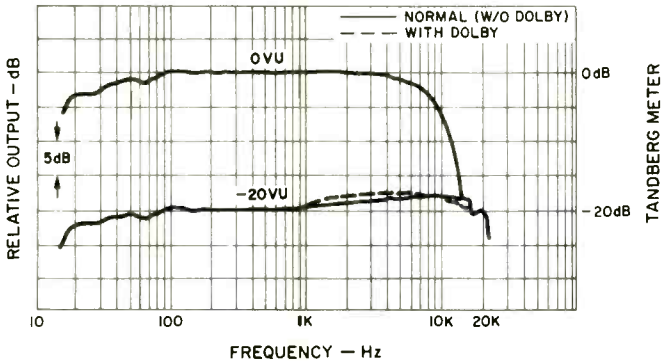


Fig. 1—Frequency response plots with Maxell UDXL tape with the *Normal* tape select.

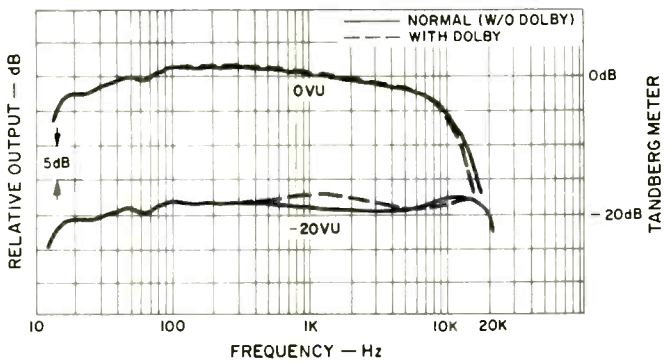


Fig. 2—Frequency response plots with the Maxell UDXL II tape with the tape select on *Special*.

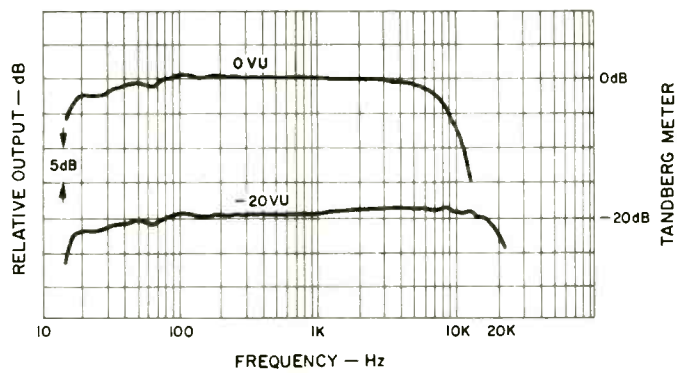


Fig. 3—Frequency response plots with the Ampex 20-20+ with the *Normal* tape select, both with and without Dolby. The Capitol Music tapes are substantially identical with the Ampex.

dication, thereby ensuring alignment with the playback head. Access is also provided for playback head adjustment by qualified personnel using an alignment tape.

On the top are the line in/out connectors, the multiplex filter switch and a remote-control socket. A snap-on cover keeps cabling snug to the unit for an extra-neat appearance. Holes in the back metal cover provide access to adjustments, but there are no labels either there or on the large circuit board revealed with the removal of the cover. Elements of the dual-capstan closed-loop drive system could be examined with this view. There was a good-sized hysteresis-synchronous motor which belt drives the flywheels of the capstans. The two direct-drive d.c. motors are servo controlled with motion sensing and pre-tensioning for fast, smooth tape handling without loops or excessive tension.

Performance

The playback responses of the Tandberg TCD 330 were within 2 dB for both the 70- and 120-microsecond equalizations at all frequencies, except for slightly greater droop at the highest frequencies with the chrome EQ. The record head was aligned for each test cassette using the built-in 10 kHz test tone. After alignment, an external 10 kHz signal was recorded on both channels, and playback was fed to a two-channel scope. The average phase discrepancy was only three degrees, with a maximum error of just eight degrees. This is excellent alignment, and it might be noted that the average phase error at 1 kHz would be 0.3 degrees. Tests with pink noise and the third-octave real-time analyzer showed that good results were obtained with Ampex 20-20+, Capitol Music, Nakamichi EXII, and TDK Audua, as well as with the Maxell UDXL and UDXLII cassettes supplied with the unit. Record/playback responses were run at *Normal* settings with Maxell UDXL, Capitol Music and Ampex 20-20+. The results were almost identical, within 3 dB at meter zero from 19 Hz to 8 kHz. At -20 dB, the responses extended from 17 Hz to over 20 kHz, notably better than the 30 Hz to 18 kHz specification. With the UDXL and *Special*, response at meter zero was from 18 Hz to 7 kHz, and from 17 Hz to 20.4 kHz with the record level 20 dB lower. The results with Dolby were very close for all tapes, with a little boost around 2 kHz at -20 dB for the Maxell tapes. A record/playback response 2.5 dB down at Dolby level, more in accordance with the zero level of other machines, showed a headroom limit of 9 kHz.

Measurements of HD_3 (third harmonic distortion) vs. level with a 1-kHz test tone were made from -15 to +6 dB. The results with Maxell UDXL and UDXLII were very similar. HD_3 was about 1.4 per cent at meter zero, much less than the specified 3 per cent. At Dolby level, HD_3 was 0.8 per cent, and at -15 dB, it was down to 0.06 per cent. Operation with Dolby reduced the distortion figures by 20 to 30 per cent. Data was also obtained on HD_3 vs. frequency from 30 Hz to 7 kHz with Maxell UDXLII at meter zero and 10 dB below that. At the lower record level, the distortion was 1.0 per cent or less from 30 Hz to over 6 kHz.

The signal-to-noise ratio was 52.2 dBA (A-weighted) at meter zero for UDXL tape and 55.3 dBA for the UDXLII tape. With a reference level where $HD_3 = 3$ per cent, the ratio was 55.3 dBA for UDXL and 58 dBA for UDXLII. With Dolby and $HD_3 = 3$ per cent, the figures were 62.9 dBA for UDXL and 65.6 dBA for UDXLII, both excellent results. Separation from one track to the other was 35 dB, exactly as specified. Crosstalk to the adjacent track of opposite play direction and erasure were both at least 75 dB down, excellent performance. Mike input sensitivity was 0.16 mV, better than most decks and substantially to specification. Line input was 77 mV, slightly better than the spec. The multiplex filter notch was

28 dB down at 19 kHz. The playback of 0 dB record was varied with the output pots with a maximum of 1.4 volts, somewhat less than the specified 1.5 volts, but still considerably higher than most decks. Headphone drive into 8 ohms was 880 mV, producing a high and easily controlled volume. The two meters tracked very closely, and the scale markings were without error from -10 to +5 dB. The TCD 330 zero level is higher than most others, actually 2.5 dB above the Dolby reference. The feed to the meters is after record EQ, rather than the more-common before-EQ connection. The response was up 4 dB at 30 Hz, 6 dB at 10 kHz, and about 12 dB at 20 kHz. With the relatively limited headroom of cassette systems, this scheme helps to ensure that high-level sounds at the frequency extremes aren't distorted or self-erased from too high a recording level. Measurements of the meter dynamics showed that the indications were down just 1 dB with a 90 millisecond 1 kHz tone burst. Additional checks proved that the response met the requirements of British Standard 4297 for peak program meters. The slower decay time was judged to be well chosen for operational use.

The lowest measured flutter was 0.02 per cent DIN weighted peak, with an average value of 0.065 per cent. These figures are outstanding for a cassette deck, and much better than the specified 0.18 per cent Wtd peak. Tape play speed was measured to be 0.6 per cent fast, slightly above the specified 0.5 per cent limit. Speed variations with time or with line voltage were negligible. Rewind time was 44 seconds, much faster than many units, and the winding was smooth throughout. The built-in slow-up near the end resulted in a low-stress non-bang stop. Cassettes were inserted with varying amounts of purposely-introduced slack and the pre-tensioning system promptly eliminated any loose loops. With the cassette well cover removed and the deck in play, a small screwdriver was used to stop rotation of one spindle and then the other. The take-up motor's brush-noise sensor detected the condition generating the loose loop, putting the deck into *Stop* before any damage had been done to the tape. When the supply hub was stalled, that motor's sensor caused a switch to *Stop* quite promptly. A small amount of curling was noted on one edge of the tape, but at worst the effect on the recorded music was minor. Such purposely generated problems might not be common, but Tandberg's sophisticated design does provide possible benefits not available in other decks.

In-Use Tests

The deck was easily operated either horizontally or vertically. The horizontal orientation facilitated cassette insertion and removal and was more suitable for on-shelf use, but the in-panel meters were harder to see. The vertical position was used most of the time for better observation and operation during the testing. All controls and switches worked smoothly without any malfunctions during these tests, including a concerted effort to defeat the tape motion controls and their associated logic. The status lights were useful, particularly with the quiet operation of the deck. The peak-reading meters were easy to read and record levels could be set more quickly than would be the case with VU-type meters. Personally I liked the TCD 330 approach for monitoring while recording. Even when switched to *Tape*, the meters continue to show the record level, and the output level pots set headphone and line levels. I've always been a little nervous when I switch to monitor on a typical unit, and then in setting a good listening volume, end up with nothing showing on the meters.

The record head was aligned for all cassettes used in the course of this evaluation with the built-in 10 kHz test tone. As the adjustment is made while monitoring playback, any

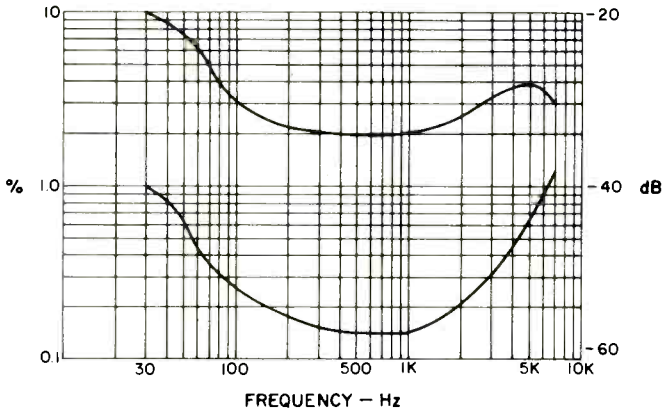


Fig. 4—Third harmonic distortion vs. frequency with the Maxell UDXL II tape and Dolby off with the meter readings at 0 and -10.

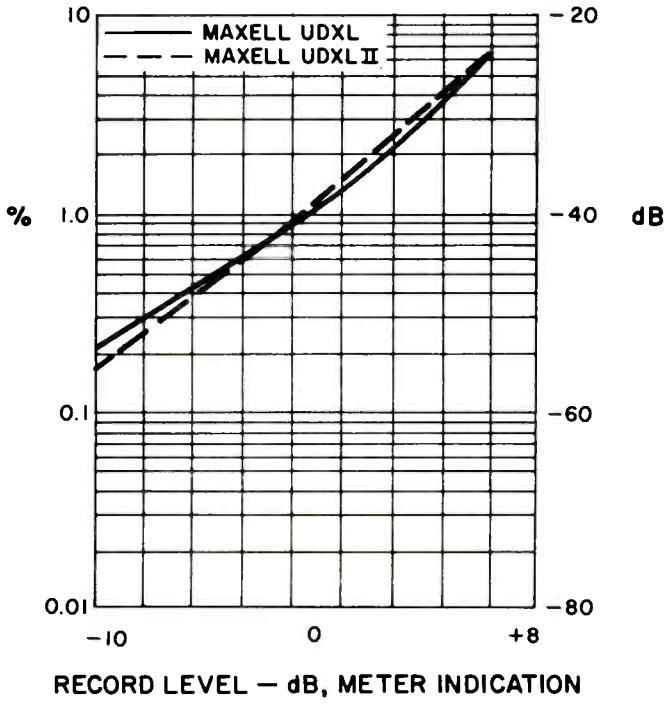


Fig. 5—Third harmonic distortion vs. record level with the Maxell UDXL and UDXL II tapes with the Dolby off (at -15 dB the THD was 0.06 per cent).

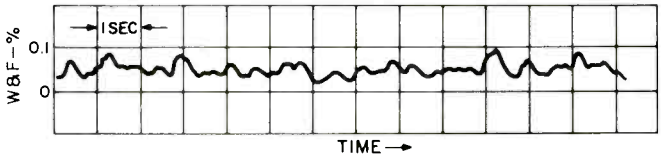


Fig. 6—The weighted peak wow and flutter at tape middle; the wow and flutter at the start and finish are substantially the same.

variations from tape record sensitivity, bias requirements or poor tape/head contact are shown at the same time.

The instruction book is not very detailed and does not include a schematic...but it is well written and includes very good illustrations. There is a limited list of recommended tapes, which is consistent with the lack of information on internal adjustments that might be required for other tape formulations. The listening tests included both FM and discs, switching back and forth from *Source* to *Tape*. This monitor switching generated no detectable clicks. Record on/off transients were substantially at tape noise level. No problem ensued from having the multiplex filter switch out of sight, but for the forgetful it would also be "out of mind." It didn't take long to conclude that playback was "as in" except when levels were set extra high. The good low-frequency response was particularly evident with one rock-band recording. Overall, the premium-priced Tandberg TCD 330 provides excellent performance, particularly in some areas, and a number of interesting and helpful features for the serious audiophile. *Howard A. Roberson*

Enter No. 71 on Reader Service Card

AKG C451E Condenser Microphone System

MANUFACTURER'S SPECIFICATIONS

CK1 Microphone Capsule

Type: Pressure Gradient.
Frequency Range: 20-20,000 Hz.
Directional Characteristic: Frequency-independent cardioid.
Sensitivity at 1000 Hz: 0.95 mV per microbar; 0.95 mV/Pa; -41 dBV/Pa; -38 dBm.
Unweighted Noise Level: 3.6 microvolts eff., -107 dBm.
Weighted Noise Level: 2.2 microvolts eff., -111 dBm, filter CCITT-c/DIN 45-405.
Equivalent Noise Level: 21 dB.
Capsule Capacity: 27 pF.
Weight: 20g; gross weight, 60g.
Temperature Range: -20°C (-4°F) to +60°C (140°F).
Humidity: 99 per cent at 20°C (68°F), 95 per cent at 60°C (140°F).
Dimensions: 18mm diameter x 26.3 mm long.
The above measured with an AKG standard measuring preamplifier with following data: no-load amplification, 0.47; input capacitance, 12 pF; polarization voltage, 62 V.

C451E Preamplifier

Type: FET preamplifier.
Frequency Range: 5-30,000 Hz.
No-load Amplification: 0.47 ±0.5 dB.
Source Impedance (20-20,000 Hz): ≦ 200 ohms.
Supply Voltage: 9 to 52 d.c. Sensitivity is proportionally reduced from 7.5 to 9 V.
Noise Level: see CK1 data.
Current Consumption: ≦ 5.5 mA (DIN 45-596).
Sensitivity to Magnetic Stray Field: At 50 Hz, 5 microvolts/50 milligauss (-138 dBm, 1 milligauss); at 100 Hz, 8 microvolts/50 milligauss; at 1000 Hz, 80 microvolts/50 milligauss.
Load Impedance: ≧500 ohms.
Harmonic Distortion at 1000 Hz (UE= 200 mV): ≦0.5 per cent.
Weight: 74g, Gross Weight, 370g.
Temperature Range: -20°C to +60°C (-4°to 140°F).
Humidity: 99 per cent at 20°C (68°F), 95 per cent at 60°C (140°F).
Dimensions: 18 mm diameter x 120 mm long.
Connector: XLR-3 pin male.
(dBm) values computed for 150 ohm impedance.
Prices: C451E combination, $229.00; complete with CK1 microphone capsule, C451E preamplifier, W3 foam windscreen, and SA15/1 stand adapter.

Optional Accessories

B46E battery supply unit (9V), $75.00; MCH-20 extension cable, XLR plugs, $13.00; H60 elastic suspension, $18.00, and H15 elastic suspension, $37.00.

The AKG CMS Series includes a large "a la carte" selection of studio-quality condenser microphone components. These include microphone capsules, preamps, power supplies, windscreens, "shotgun" pipes, and mountings. From these interchangeable modular parts, the user may assemble microphones varying from a pop-proof cardioid mike for close talking to a "shotgun" type for distant sound pickup.

We tested a cardioid system suitable for many professional or advanced audiophile applications in speech or music pickup. The CK1 capsule is a cardioid type with nominally flat frequency response. The capsule housing is an acoustically open structure enclosing the transducer element, which is similar in size to a stack of three or four nickels. The gold-film coated plastic diaphragm is stretched and cemented to the front of the transducer. The membrane has a rough surface which AKG says is a micro-

embossed pattern which controls tension. Apparently this is similar to the embossed corrugations in a ribbon which serve to increase compliance and stabilize the tuning. The exterior of the transducer is coated with an organic finish which probably keeps out moisture. The rear sound port is a sintered metal disc about ¼-inch in diameter. This disc is made to pass sound and barometric pressure, but retard moisture.

The CK-1 is advertised as stable with temperature and humidity, and we can believe this after examining the transducer. We are not equally well impressed with the electrical contact arrangement, which reminds us of a carbon microphone. The "hot" center contact is via a gold-plated spring which may have a resonance at some audible frequency. This spring also presses the gold-coated diaphragm against the case, forming the ground connection.

The C451E preamplifier is a FET-input discrete component circuit. A balanced low impedance output is provided by a transformer. The C451E "handle" also includes an integral 62-volt power supply for polarizing the capsule. A standard two-wire shielded microphone cable carries audio away from, and brings d.c. power to, the preamp. A so-called "phantom" power circuit is used. The audio signal is balanced to ground, but the d.c. is an unbalanced "common-mode signal." D.C. power, for our test, was obtained from the B46E battery supply. This contains an audio transformer with the primary center tap connected to the positive terminal of the 9-volt battery. The user may be able to provide power from the recorder or mixer and save on the cost of this accessory.

The "phantom" power arrangement is obviously compatible with either dynamic or ribbon microphones. In other words, the "common-mode" d.c. will have no effect if an electrodynamic mike is plugged into the condenser input. However, if you make a wiring error, the ribbon or voice coil could be destroyed. The output of the B46E is a balanced, low impedance line with no d.c. on it.

The application of the other accessories is obvious, but the cable deserves mention. AKG has engineered their own high quality microphone cable with long flex-life conductors and an especially tough plastic jacket. These cables are available in four colors which is a boon to multi-mike setups.

Packaged along with the microphone capsule was a frequency response graph, which showed the CK1 capsule to be +3-6 dB from 40 Hz to 15 kHz. Enclosed with the hardware was a data sheet on the preamp alone and a two-page pictorial showing the CMS line. We received separately a batch of microphone applications information intended for audiophiles and musicians, emphasizing the AKG dynamics, but not describing how the CMS studio condensers might be used in these applications. We were not supplied the usual explicit instructions (connect jack "A" and socket "B") which accompany most domestic microphones. (*Editor's Note:* We understand that AKG has a new owner's manual in progress, but was not able to complete it in time to supply one for the review.)

Laboratory Tests

The impedance curve (Fig. 1) shows that the impedance is not 200 ohms or less from 20 to 20,000 Hz, as specified, though it is within spec from 25 Hz to 8 kHz. We suspect that the transformer in the battery pack may be responsible, but AKG does not specify what effect this transformer may have. The rise at 20,000 Hz is due to the leakage inductance of preamp and battery pack transformers. It had no effect on frequency response when the mike was tested with a broadcast preamp. We recommend a load of not less than 1000 ohms,

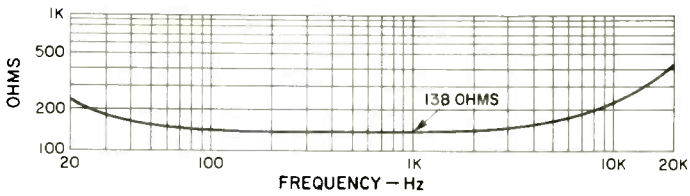


Fig. 1—Impedance of the AKG C-451E microphone.

corresponding to a high-quality 150-ohm "unloaded" input. The rise at 20 Hz is caused by the output coupling condenser in the preamp. This may indicate an undersized capacitor which could cause some loss in low frequency response if load impedance is not high enough.

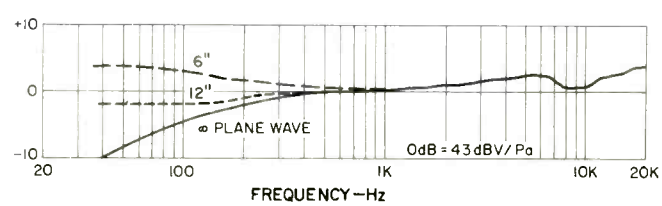
The frequency response (Fig. 2) shows a smooth and slightly rising response. From 500 to 20,000 Hz, the AKG is somewhat flatter and smoother than our RCA BK-5B reference microphone. Above 500 Hz, our curve agrees precisely with the calibration curve supplied with the microphone. Below 500 Hz, it is flat at 12 inches, but with a pronounced rolloff for plane waves or sources greater than 3 feet away. The AKG may be preferred for high fidelity reproduction of treble instruments, voice, or the close miking of bass instruments, but it's my opinion that it will not be as good as the BK-5B ribbon mike for distant miking of symphony orchestras, as mentioned later. The AKG curve shows the response of the *capsule only*, which is down 6 dB at 50 Hz. Apparently, the preamp and battery box account for an additional 2 dB loss at 50 Hz, which might be reduced with alternative powering arrangements. (*Editor's Note:* AKG confirms that statement.)

The low frequency response of the AKG is similar to the V1 (voice) response of the BK-5B. This is an excellent characteristic for distant speech pickup as it suppresses low frequency room noise. The AKG should be good for pickup of stage plays or opera.

The sensitivity of the AKG is more than 10 dB higher than the BK-5B or other electrodynamic microphones. For most applications, we recommend a 10-dB attenuator at the input of the mixer or recorder. AKG sells attenuators for use between capsule and preamp for use with high sound levels, though with normal sound levels these will degrade signal-to-noise ratio. We found the CK1/C451E will not clip on peaks up to 130 dB, so there is little need for the capsule attenuators—unless you are recording jet aircraft. In-line attenuators are available for low impedance microphones from several manufacturers. Take care that an attenuator does not interfere with d.c. powering.

The directional characteristics (Fig. 3) show a cardioid unidirectional pattern that is extremely uniform with frequency. It is superior in this respect to almost any mike we've tested. This means that undesired sounds of all frequencies will be uniformly rejected, and the sound of distant sources in reverberant rooms will be most accurately reproduced.

Fig. 2—Frequency response vs. distance.



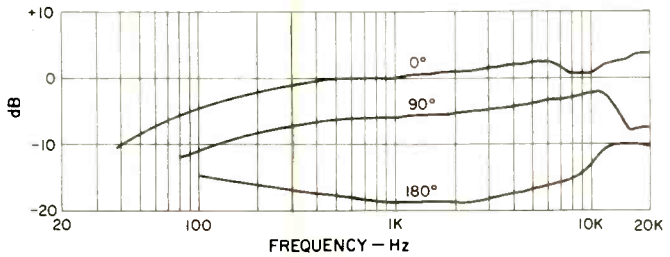


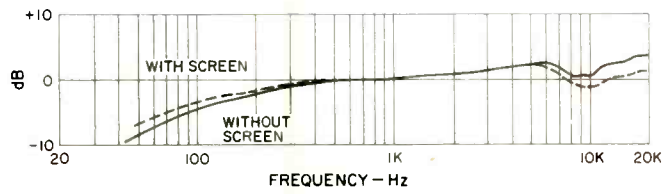
Fig. 3—Frequency response vs. angle.

While tapping the AKG microphone, we noticed a bell-like ringing sound that decayed slowly. We made a one-third-octave band spectrum analysis of the vibration noise of the AKG compared to the BK-5B (Fig. 5). Some of the higher noise of the AKG can be attributed to the higher mass of the condenser diaphragm as compared to the ribbon. The 630-Hz resonance is far more annoying than it seems on the graph, and we suspect it may be related to the contact spring. The 630-Hz resonance could also be related to the acoustical resonance of the preamp case's air space. The vibration sensitivity of the AKG is not significantly reduced by the H60 shockmount. We did not try the H15 mount which looks like a better design. If you have a vibration problem that the H15 doesn't solve, try adding some mass to the microphone.

The H60 shockmount which we tested is a small shockmount, intended for use with a floor or desk stand. It is very compliant in a direction parallel to the microphone axis, but very stiff in the perpendicular direction. The H15 mount is a larger one which could be used on a mike boom or stand, and it will probably have reasonably equal compliance in all directions. As with all low-mass mikes, the AKG is difficult to isolate and a very compliant mount is required.

Another indispensable item is the windscreen, which is supplied as part of the C451E "combo" package. The wind and "pop" sensitivity of the CK1 is very high. The integral capsule grille is formed by one piece of wire mesh which is both too open and too close to the diaphragm to offer much protection. We found that the foam windscreen offers excellent protection, virtually eliminating wind and "pop" noise. It would be a good idea to use this screen for all applications, but what effect does this use have on performance? We tested frequency response for each cardinal direction: 0°, 90°, 180°, both with and without the screen. The effect of the screen was minor, but easily measured with this high quality microphone. Only the 0° response (Fig. 4) is shown, for clarity. Significant but not objectionable changes were noted in the 90° and 180° responses. High frequency response is slightly reduced because the screen acts as a resistance in series with the acoustically capacitive diaphragm. If this were a pressure (omnidirectional) microphone, no change in low frequency response would be observed. The bass response of the AKG is improved because the screen covers the side sound entrances. You may imagine that less sound reaches the rear of the diaphragm, and since it responds to the pressure gradient (difference between front and rear pressure), the net pressure acting on the diaphragm increases. The screen has a net flattening effect on response, and we recommend it be used at all times. AKG offers an attractive metal screen with foam lining that is more durable. The frequency response must suffer a little from acoustic reflections off the metal screen, so the plain foam screen performs best.

Fig. 4—Effect of foam windscreen on the AKG C-451E Microphone.



The phasing test with the EMT Polarity Tester revealed that the red wire of the output cable from the battery box is positive with positive sound pressure. Before you conclude that this fully agrees with EIA standards, read RS-221 paragraph 3.3 again: "...in phase terminal shall be the red (or other than black) conductor, the out-of-phase terminal shall be the black conductor." Since the cable does not contain a black conductor, the AKG system does not conform to standards. We recommend that AKG follow EIA RS-215 which calls for red and black conductors in broadcast microphone cables. (*Editor's Note:* The B-46E power supply is now being supplied, says AKG, complete with a standard XLR-type connector mounted on the output cable. Both the microphone and the power supply are phased [poled] "pin 2 high," i.e. positive acoustic pressure on the microphone's diaphragm will result in a positive voltage on pin 2 with reference to pin 3. This follows IEC standard 268-12 and IEC 268-4.)

We found the MCH-20 extension cables to be of excellent quality. The Swiss-made three-pin connectors are inferior to either the Cannon XLR or Switchcraft A3 type connectors. The strain reliefs are a positive sort, in that they continue to tighten as force is applied. The ones on the set supplies needed additional tightening, as they were a bit loose when received, and the cable could be twisted inside the relief. The female connector did not mate easily with the plug on the microphone. (*Editor's Note:* These connectors were from the initial production run, and several design changes will be implemented in the final product available by the end of this year. AKG says that their original design intent was to provide a connector with a compliant insert which would be compressed during mating to prevent rattling during use.)

Subjective and Listening Tests

We recall from the classic theoretical studies that a condenser microphone with less than approximately 150 volts, polarization could be too noisy. The AKG uses 62 volts, but was quiet enough that we could not measure the noise without replacing the microphone with a capacitor. Subjectively, it seems quiet enough for most applications, but if you intend to use it for extremely low sound levels, we suggest you check the noise level first.

As previously indicated, the preamp has quite a high output capability and did not clip or distort with any sound we could generate, up to about 130 dB.

The very low magnetic hum sensitivity rating was difficult to believe, what with the unshielded transformer in the preamplifier. We found the hum to be less than our BK-5B reference microphone so we believe the specification is correct. The CK1/C451E is extremely impervious to magnetic fields. AKG transformers utilize D-U laminations and two separate coils, which is a hum-bucking design.

The mid range and high frequency sound is extremely clear and transparent, and perhaps just a little cleaner than our BK-5B. The bass response sounds a little thin compared to the BK-5B for sound sources such as a bass viol in an orchestra where just two microphones are used at a great distance. For close miking and most "pop" music, the AKG is

just about the best microphone we've heard. But for classical recordings, the BK-5B or 77-DX ribbon microphones remain our favorites, as the small orchestras we record are always weak on bass.

The quality and durability of the AKG products is excellent. Most parts are abrasive blasted and nickel plated, resulting in a very tough finish. Biomechanics are good, save for the stand adapter. It is very difficult to slide the microphone into the plastic clamp because neither microphone nor clamp have chamfered edges. These remarks apply to the clamps on the SA15/1 and H60. (*Editor's Note:* AKG says they are now changing the adapters to a less rigid material for an easier fit.)

Our conclusions from the tests: As an exdesigner of ribbons, I have to admit a built-in bias against batteries and power supplies and—in fairness—point out that this system would normally be phantom powered in the studio, though again this is another subsystem which at least potentially can break down. Be that as it may, for the devotees of "condenser sound," we can state that the AKG CK1/C451E is one of the best condensers we have tested and certainly not the most expensive. We can enthusiastically recommend the AKG to anyone wanting a condenser microphone. *Jon Sank*

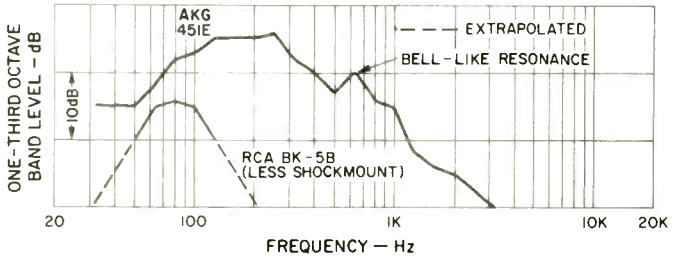


Fig. 5—Analysis of tapping noise (see text for discussion).

Enter No. 72 on Reader Service Card

Pioneer Model 510A Direct-Drive Manual Turntable

MANUFACTURER'S SPECIFICATIONS
Motor: d.c. servo.
Speeds: 33 1/3 and 45 rpm.
Wow & Flutter: 0.03 per cent W rms.
Rumble: 68 dB, DIN B.
Arm Length: 9 ¼ in. (22.1 cm).
Cue Control: Oil damped.
Dimensions: 17 in. (43.2 cm) W x 14 ¼ in. (36.2 cm) D x 6 ¼ in. (15.9 cm) H.
Power Consumption: 5 watts.
Price: $200.00.

Direct-drive turntables are becoming more and more popular with new models appearing on the scene almost every week. Most of them are fairly expensive, but there are several now available, at the $200.00 mark, which thus offer excellent value for the money. One of the best examples of these is the Pioneer 510A which compares favorably with models costing nearly twice as much — and what's more it doesn't *look* cheap! It has the same level of styling and finish

as the more expensive units, and nothing appears to have been skimped on.

The S-shaped arm is made of polished tubular aluminum, and balancing is both vertical and lateral. A weight slides on an extension rod projecting out from the left-hand side of the arm near the pivot, and the adjustment is not critical. The headshell is the low-mass type, and it is locked to the arm by the usual collar. Controls are all located to the right, on a neat satin-finished panel, with the *Off/On* switch at the front of the unit. This switch is unusual as it also controls the cueing. The *Off* position is at the rear and in moving the lever forward to the center position you start the motor, while bringing it forward again to the third position at the front lowers the tonearm onto the record. This takes a little getting used to, but it's all quite logical enough. Behind this dual-purpose switch are two pushbuttons for 33 1/3 and 45 rpm, and behind those are the variable speed adjustments. At the rear alongside the tonearm base is the anti-skating adjustment, which is calibrated from 0 to 4 grams.

At the left front is the strobe lamp, protected by a cover, with the strobe markings on the edge of the platter, which, incidentally, weighs just under 3 3/4 lbs. (1.7 kg). The motor is a d.c. servo type, and all bearings are permanently lubricated. The unit is styled in matte black and silver with a woodgrain vinyl base which stands on four acoustically damped feet. The turntable comes complete with a hinged dustcover, and the accessories include an overhang gauge and a miniature screwdriver.

Measurements

Like all Pioneer turntables, the 510A came with a generous selection of cartridge mounting hardware, and no particular difficulty was experienced in either balancing the arm or obtaining optimum alignment. The cartridge selected for testing was an Empire 2000Z, a top of the line, high compliance model which needs a good tonearm for best performance. The tracking force was set at 1¼ grams with the anti-skating dial turned to 1½ grams for optimum performance, and these were used throughout the tests, although it was found that the 2000Z could track very well at lower forces.

Checking the speed variations first, the 33 1/3 control had a range of +1.6 per cent and -4.5 per cent, while the 45 rpm speed could be varied ±4.5 per cent. Wow and flutter measured 0.05 per cent (DIN), and the rumble was -63 dB using the ARRL weighting. Tonearm resonance with the Empire cartridge was just under 8 Hz with a rise of approximately 3 dB. Both lateral and vertical arm friction was less than 10 mg, and the tracking error was within 0.5 degrees per inch, standard for this type of arm. Both the tracking force and anti-skating dial calibrations were found to be within practical tolerances for accuracy, and the position of the lateral weight was non-critical, as stated by Pioneer.

In-Use Tests

The cue lift device took longer than usual to lower the arm onto the record, but it was very gentle, with insignificant side drift. As mentioned earlier, the combination motor start and cue switch does take a little getting used to, but it really works well. And once the turntable speed has been set, the servo control holds it right on the nose.

All in all, the 510A is a first-class value for the money, and the engineers at Pioneer are to be congratulated for bringing the price down without sacrificing very much in the process.

George W. Tillett

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Optonica Model RT-3535 Cassette Deck

MANUFACTURER'S SPECIFICATIONS

Motors: 1 d.c. servo and 1 d.c. high torque.
Heads: 3, record-replay, erase, and APLD sensing.
Wow & Flutter: 0.04 per cent W rms.
Bias: 3 position switch.
Equalizing: 3 position switch.
Bias Frequency: 84 kHz.
Frequency Response: Normal tape, 30-15 kHz; CrO_2, 30-16 kHz, and FeCr, 30-17 kHz ±3 dB.
S/N Ratio: 58 dB, 64 dB with Dolby.
Output: 580 mV.
Input: Line, 70 mV; mike, 0.2 mV.
Dimensions: 18 3/4 in. (46.6 cm) W x 5 3/4 in. (13.5 cm) H x 14 in. (32.8 cm) D.
Weight: 22.4 lbs (10.2 kg).
Price: $429.95.

Sharp is an old, established Japanese electronics company known mainly in the United States for television, appliances, and medium-priced audio products. Recently, following the example of other manufacturers, they have decided to make equipment for more critical audio enthusiasts, under the name Optonica. The first model is a versatile cassette deck, designated the RT-3535, introduced recently and boasting some unusual features. It looks much like other front-load-

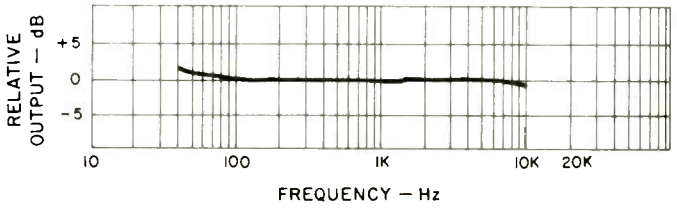


Fig. 1—Frequency response with the 40 Hz to 10 kHz test tape.

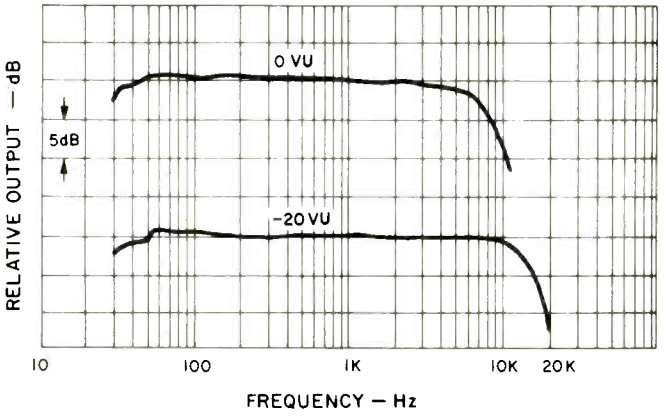


Fig. 2—Record-replay response with the Maxell UDXL tape.

ing decks, with the typical semi-professional type instrument styling, but the big difference is a row of buttons just under the two VU meters. These push-buttons are numbered from one-to-nine with one marked C and a blank one on the left which turns out to be a digital indicator. The function of these buttons is to operate the "auto program locate device" (APLD) which enables a quick selection to be made of any program on the tape. It uses a signal sensing circuit with a separate tape head, and here is how it works: assuming you want to hear the fifth selection on a cassette, all you have to do is press button number 4 and either the *Fast Forward* or *Play* button. The first four selections are automatically skipped and the tape comes to rest at the beginning of number five. At the same time, visual indication is given as the digital readout shows the numbered sections in sequence. Obviously, the user must know what order the various selections are in, but this information can be written on the cassette if it is not there already. How about making new tapes with APLD? There are no problems, provided a space is left between the selections . . . but more on this later.

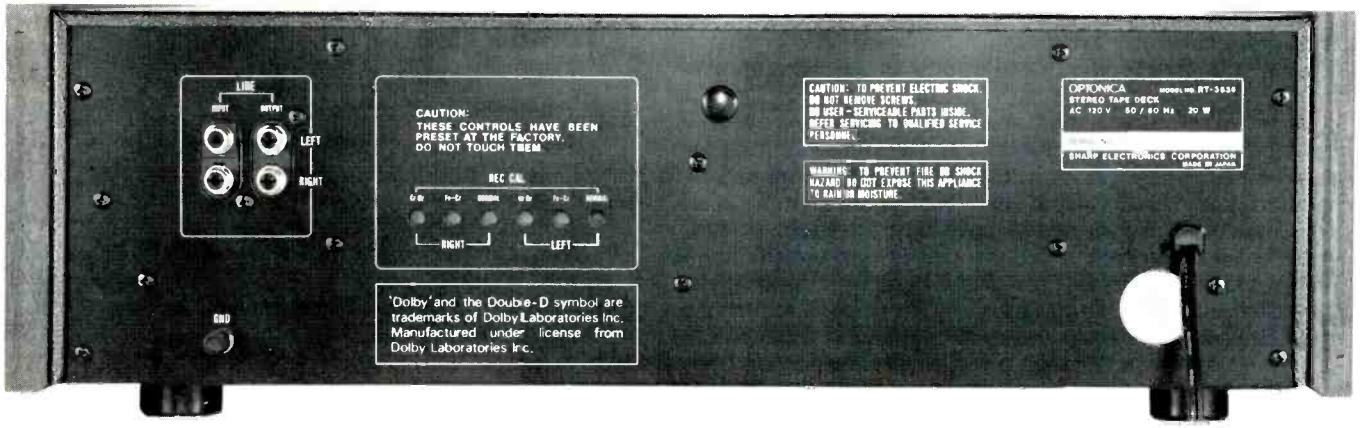
Let's take a look at some of the other features of the 3535 . . . on the left under the cassette compartment is the usual group of tape control keys; including a separate control for eject. To the right is a row of three lever switches, one is for bias with a provision for high, medium, and low; the second lever controls equalizing for CrO_2, FeCr, and Normal, while the third is the Dolby switch, which also has a position for the MPX filter. Above these three levers are the digital counter and three pushbuttons for limiter, mike line input, and auto-selection control. When the auto-selection control button is depressed a red LED indicator just above it lights up. There are two VU meters mounted at an angle for good visibility with a recording indicator light located between them. Underneath are three control knobs for output, and right and left inputs, while on the extreme left to the side of the cassette compartment is the *On/Off* switch, in addition to jack sockets for microphones and headphones . . . which completes the listing of the front panel controls. At the rear are the usual RCA-type input and output sockets, plus a group of six controls for bias and equalizing which have a cautionary note placed above them stating they have been factory set and should not be touched.

Two motors are used, one for fast winding and a d.c. servo type for the capstan drive. Eight ICs are used in the APLD gating and pulse generating circuits. There are a total of 45 transistors with 59 diodes used in the circuitry, plus two SCRs.

As mentioned earlier, the styling conforms to the modern instrument type concept with a satin-finished panel and matching knobs. The two wooden veneered sidepieces make a nice contrast, and the metal top cover has a durable "hammer" finish. Near the front is a small trap door which gives access to the tape heads for cleaning.

Measurements

Figure 1 shows the frequency response from a standard 40 Hz to 10 kHz test tape, while Fig. 2 shows the record-replay response with Maxell UDXL tape. The high frequency 3-dB point was just above 16 kHz, and the low frequency response was well maintained with a minimum of "fringing." I ought to mention that the 0 VU on the meter corresponds to a level of 200 nWb/m which is the Dolby level and 3 dB higher than the standard used by most other machines. So in order to allow for more meaningful comparisons, the 0 dB



reference on the graphs is equal to −3 dB on the meters. Results similar to the Maxell tape were obtained with Fuji FX60, TDK Audua, and Scotch Master tapes. The next tapes tested were the Sony and Advent CrO_2 variety, with the results shown in Fig. 3. The high frequency response was extended slightly to 16.5 kHz and the saturation curve is very similar. Finally a FeCr tape was tested, a Meriton, and it will be seen from Fig. 4 that the high frequency response has been increased significantly with a 3 dB point at nearly 19 kHz.

The next series of measurements were related to distortion at 1 kHz, as shown in Fig. 5. The Maxell and other low noise tapes gave almost identical results, so only one tape is shown for this group. Figure 6 indicates distortion versus frequency the three different kinds of tapes. Signal-to-noise for the Maxell was 60 dB (66 dB), Sony CrO_2 58 (65 dB), and Meriton FeCr 59 (67 dB). The Dolby figures are in parenthesis and the reference is for 3 per cent distortion with A weighting

Line input for 0 VU was 68 mV, and the output was then 700 to 900 mV, depending on the kind of tape used. Microphone input for 0 VU was 220 microvolts, and the decrease in signal/noise was 7 dB. Erase efficiency was over 67 dB. The Dolby system tracked within 1.5 dB, and the MPX filter was 3 dB down at 17 kHz, reaching −20 dB at 19 kHz. The limiter has a very fast action, keeping peaks down to the 0 VU level.

Turning now to the mechanical side, wow and flutter was a very low 0.04 per cent (DIN), exactly as claimed, and speed was right on the nose. Rewind time for a C-60 cassette was 80 seconds.

Listening Tests

Well, as you might expect, the first exercise in the listening tests was to check out the automatic program locate device (APLD). As I could not find a recorded cassette having a number of separate selections, I decided to make one. And so I recorded eight musical selections from my local FM stations. As I mentioned earlier, a space has to be left in between the items, but this was taken care of by a "delayed action" pause key. When this is depressed the tape travels for about four seconds without being recorded and then stops. Having rewound the tape, I pressed button number five so I could hear selection six on the cassette, and then I pressed the fast forward key. The digital indicator showed 5, 4, 3, 2, 1, and—bingo—there was number six! I also made recordings with longer spaces between items, but I couldn't fool the sensor—it worked every time! The button marked C clears any previous instructions from the "memory"—just like a calculator.

The tape control keys need a fair amount of pressure to operate, but they have a very positive feel to them, and it is evident that the whole mechanism is soundly constructed. The rotary controls have an unusually smooth, silky kind of feeling—almost as if they were turning in oil-damped bearings.

In terms of basic performance, the Optonica RT-3535 must be placed in the highest category—all tapes sounded very good except when overdriven. The best sounding tapes seemed to be the CrO_2 and FeCr. Precise adjustments were very easy to make with this unit. The provision for FeCr tapes is a definite plus, as are the biasing and equalizing facilities, but whether the cost of the automatic program locate device (APLD) is justified is a moot point. It is certainly ingenious and well engineered, so I suppose, it could be argued that other decks in the price range offer less for more money.

George W. Tillet

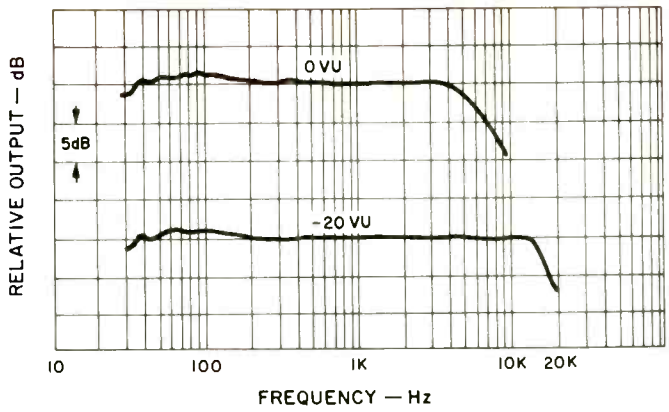


Fig. 3—Record-replay response with the Sony and Advent CrO_2 tapes.

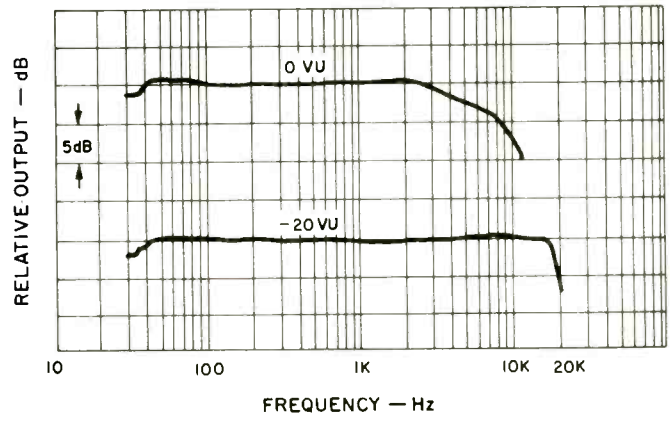


Fig. 4—Record-replay response with Meriton FeCr tape.

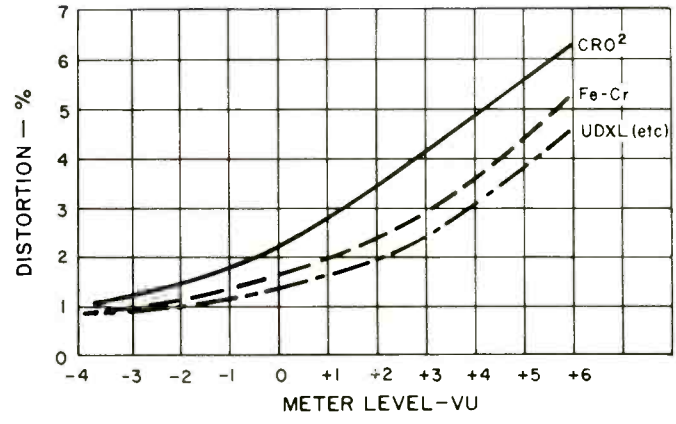


Fig. 5—THD at 1 kHz.

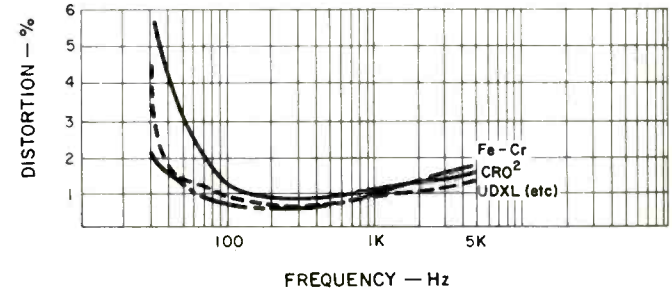


Fig. 6—Distortion vs. frequency.

Folk bag

Tom Bingham

Live At McCabe's: Norman Blake
Takoma D-1052, stereo, $6.98.

If he continues at his present pace, it won't be long before Norman Blake challenges Doc Watson as neo-traditional country music's most-recorded flat-picking guitarist. Even more so than with Doc's, each of Blake's albums is different than the one preceding it, and has its own distinct character.

On **Live At McCabe's**, Blake re-examines several tunes from earlier albums in solo performances. Stripped down to their bare essentials, devoid of studio over-dubbing or splicing possibilities and without Charlie Collins' rhythm guitar for support, Blake's interpretations must rise and fall on his own technique and musicality.

It's a challenge to which he's more than equal. His long, intricate, melodic improvisations are every bit as amazing unaccompanied as they are when he has a rhythmic backing. *Nine Pound Hammer* and *Arkansas Traveler* (which segues into *Caperton Ferry*) are genuine head-turners, as is the medley of *Bully of the Town, Bonaparte's Retreat*, and *Richland Avenue Rag*. It should be noted, though, that a little insecurity can be detected in his touch—especially on the first couple of tracks—as if he were afraid of fluffing his way through the set. Yet, while his lines are not entirely note-perfect and his timing not quite as sharp as in the studio, the percentage of flaws is low enough to keep his flat-picking virtuoso status intact. Even the runs he throws away between some songs are a joy to hear—listen carefully after *Sweet Heaven* and *John Hardy*.

Besides guitar, Blake plays fiddle on two tracks, accompanied by Nancy Blake on cello. The two instruments mesh to produce a sound oddly reminiscent of an old country-church harmonium. While Blake is a competent fiddler, his work on this instrument is most notable for the personality transformation he undergoes in moving from the guitar. Gone are the solos with dazzling runs and good-time licks, which are replaced by long droning phrases, ranging from the melancholy *Border Widow* to the bittersweet *"G" Medley*, which includes *Green Leaf Fancy* and *The Fields of November*.

The recording focuses sharply on the guitar, with the singing on side one sounding off-mike and a bit echoey. The surface crunches badly at the beginning of each side, but clears up after several minutes.

Sound: C+ Performance: B+

Woody Guthrie
Warner BS 2999, mono, $6.98.

Amid the long overdue celebration of Woody Guthrie and the veritable flood of tribute albums, Moses Asch, who founded Folkways Records and recorded these sides between 1940 and 1946, has put together the basic Guthrie album. His selection is exemplary with the likes of *This Land Is Your Land, Pretty Boy Floyd, Hard Traveling, Pastures of Plenty*, and *So Long (It's Been Good to Know You)*. The packaging is handsome, and Asch's notes are informative and provide an enlightening insight into the man's character. Given the recording's age, the sound is quite fine. My one complaint is that there are only 10 selections—under 28 minutes of music—on the album, and when the production costs are near zero, that is damn skimpy. *Michael Tearson*

Presentation: B

The column

Exodus: Bob Marley & The Wailers
Island II PS9498, stereo, $6.98.

From the first you can't help noticing that the richly overtoned bass part and percussion sounds are fully defined and right, and that is the very spine of reggae. Superior sound indicates that **Exodus** is going to be some heady going. And it is, with Marley's best studio work, at least in a long while.

Jamming is due to be a new reggae anthem. It is a celebration. The seven minute *Exodus (Movement of Jah People)* is one of the most insistent and hypnotic performances Marley has ever recorded. The ballad *Waiting in Vain* is one of Marley's most convincing and it's played very confidently. *One Love/People Get Ready* is a charming, witty extrapolation on the Curtis Mayfield classic.

The only change in the Wailers' lineup is a new lead guitarist, Junior Marvin, who is hot. The Ashton "Familyman" Barrett/Carlton Barrett rock-steady rhythm section is reggae's best and abetted by Tyrone Downie's keyboards, Secco on percussion, and the dynamic backing vocals of the I Threes plus Marvin and Marley you have reggae's best band. Add to the pot the recorded sound that Marley has always deserved and lacked, and you have a superior Wailers album.

From that gold cover on through the inner sleeve to the disc itself, **Exodus** is a Bob Marley album of finest Jamaican gold. *M.T.*

Sound: A Performance: A

Ice on Fire: The Mighty Diamonds
Virgin PZ 34454, stereo, $6.98.

There's an air of an unholy alliance about **Ice on Fire,** the second U.S. Mighty Diamonds album. It has been obvious how great an influence the R&B music of New Orleans has had on reggae, so an Allen Toussaint reggae production should be a natural, right?

Not really. Sprinkled among the Diamonds' new originals are some very highly assorted Toussaint covers: *You Are Just a Song, Get Out of My Life, Woman* and, most odd, *Sneakin' Sally Through the Alley* done in the original Lee Dorsey arrangement instead of the more recent Robert Palmer version, plus Frankie Miller's *Little Angel* and Smokey Robinson's classic *The Tracks of My Tears.*

Given the dichotomy of material between political and secular, it is not too big a surprise that Toussaint's production is not one of his more compassionate jobs. As a result, **Ice on Fire** resembles a sampler of many groups rather than a unified effort. Clearly

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the failure of reggae to produce a bonafide hit single in 1976 is responsible for this fusion record which ultimately is not likely to satisfy either the reggae fan or the Toussaint fan. *M.T.*

Sound: C Performance: C

Equal Rights: Peter Tosh
Columbia PC 34670, stereo, $6.98.

The second Peter Tosh is much better than the first, primarily because the muddy, muffled sound of **Legalize It** has been cleared and cleaned up. **Equal Rights** goes all the way to bright.

Tosh's songs are strong. Opening with a remake of his best song with the Wailers, *Get Up Stand Up*, doesn't hurt; it cuts the original with grace and ease. *Stepping Razor* is brilliant.

Tosh recruited some of Jamaica's very best to play on **Equal Rights.** Among them are ex-Wailers' guitarist Al Anderson and keyboardist Earl "Wia" Lindo, the one and only Bunny Wailer for harmonies, and the rock steady rhythm of Robbie Shakespeare and Sly Dunbar.

Equal Rights is an excellent album of reggae, conceived and created with purpose, strength, and poise. *M.T.*

Sound: A– Performance: B+

Stratosfear: Tangerine Dream
Virgin PZ 34427, stereo, $6.98.
Trans-Europe Express: Kraftwerk
Capitol SW 11603, stereo, $7.98.
North Star: Philip Glass
Virgin PZ 34669, stereo, $6.98.

It's good to see avant garde seeping through to the pop market, as they add dimension to the whole musical horizon and also tend to have excellently recorded discs.

Kraftwerk is probably best known in America for their hit single and album **Autobahn.** Their follow-up **Radioactivity** was a rather dour affair, so it's good to see their sense of humor back on **Trans-Europe Express.** The German clowns of the rhythm master are in top form on *Showroom Dummies*, an hilarious send-up of showbiz and the star-syndrome, two years after the hit. *Europe Endless* and the title piece are lovely, full of railroad imagery created through electronic percussion at its most insistent.

Tangerine Dream has just concluded an American tour with the light show Laserium, and the lights easily upstaged the music. T. Dream keeps more than a safe distance from the audience, and their music's stern, dour pose can be alienating. At their best, such as on the **Phaedra** album,

they can be hypnotic yet fascinating. **Stratosfear** is more pretentious and dispensible.

Philip Glass' album has relatively little to do musically with either T. Dream or Kraftwerk. Glass is concerned with small repeated phrases which move through his keyboards, Dickie Landay's woods, and the Swingle-tinged voices of Joan LaBarbara and Gene Rickard. The ideas mingle and slowly turn over one another in intricate rondo style. Some pieces may turn out juvenile, but more are transcendant. Either way **North Star** is a deceptive album, as it is both more complex and more simple than it first appears. It challenges the traditional ideas of song by simply ignoring them. Warning . . . this condition may be contagious. *M.T.*

Kraftwerk:

Sound: A	Performance: A-

Tangerine Dream:

Sound: A–	Performance: C+

Philip Glass:

Sound: B+	Performance: B+

A Bunch of Stiff Records
Stiff SEEZ2, stereo, $6.98.

By now the English punk rock scene is more than just an item in the news but a commercially viable institution, and the labels over there which started as back-of-a-sedan operations (such as Chiswick and Stiff) are emerging as the moneymakers of tomorrow. Bands like The Damned, the Sex Pistols, the Clash, and the Stranglers are more than just concert attractions, but are making the charts as well. And so the labels are beginning to have identities of their own, with one of the most promising, Stiff, releasing a sampler album featuring a few previously available tracks, some special bonus unreleased ditties from non-Stiff (but Stiff-affiliated) artists, and a track or two from artists yet to release anything on their own. All in all, an interesting concept which works well in practice, and surprisingly enough the best features of the album are the new artists Stiff has yet to unleash upon the public at large.

The two artists who make the album are Elvis Costello (who may or may not be Nick Lowe, Stiff's sometimes producer and a recording star in his own right — his *I Love My Label* is amusing here but nowhere near his *Heart of the City* single) and Wreckless Eric. Elvis rests a hysterical Kennedy Assassination lyric upon a backing track which sounds like a 1977 update of the *Hang On Sloopy/Twist and Shout* syndrome, coupled with a vocal delivery not unlike early Van Morrison. To say the very least, he's a phenomenal talent and unlike anything/anyone else currently making records (by the way, this song entitled *Less Than Zero* was released as a single in the UK with minor impact for some reason unbeknownst to this writer) and should provide the Seventies and Eighties with many more records like this one I should hope. Eric, on the other hand, who seems like the punk embodiment of Tommy Boyce & Bobby Hart, has a sense of humor, and a voice made of raw raunch. Other items of interest include two tracks by Graham Parker (a Dylan mockery called *Food* and *Back to Schooldays),* a Chuck Berry cover by Dave Edmunds (distinguished primarily by its phasing), the Chantels' *Maybe* covered by Jill Read (beats the original), and several other items of interest and amusement. All in all, a value for your money.

The productions of Dave Edmunds and Nick Lowe are also featured prominently here, and although they

have been characterized as being slightly throwback due to certain sonic debts to Phil Spector, Norman Petty, and Sam Phillips however . . . this listener finds no faults in their sound. Adjectives like "crude" do apply at times, but at least these discs don't sound like your typical 1970s record. I mean, records nowadays sound like too much plastic and lacquer; Stiff Records remembered to leave the music there, too, and that's a bold move in this dry age. *J.T.*

Sound: A Performance: A-

A Period of Transition: Van Morrison
Warner BS 2987, stereo, $6.98.

A Period of Transition certainly doesn't sound like it took Van Morrison over two years to produce. Indeed, it sounds like it went down rather rapidly once Van and Mac "Dr. John" Rebenneck got to it. What they created is most of all a throwback to Van's **Moondance His Band and Street Choir** sound, a smooth sax-based R&B type of thing. *It Fills You Up, Heavy Connection, Flamingo Fly* and *Joyous Sound* are songs that just play very well and, with the band's gusto, they insinuate themselves into your head. Van's music is easily the most direct it's been in years. *The Eternal Kansas City* is an extended joke that doubles as a tribute to Charlie Parker. What it is is the line "Excuse me, do you know the way to Kansas City?" repeated mantra-funk style.

Van and Mac have achieved the loose, easy bar-band sound they were looking for, casual and fun, yet as precise as it needs to be. If it appears facile at first, a rehash of earlier Van Morrison, give it a chance. If you don't push it so hard, you might find it's a gas. *M.T.*

Sound: B+ Performance: A-

Deceptive Bends: 10CC
Mercury SRM-1-3702, stereo, $7.98.

10CC's sound on record is state of the art, a standard to measure others by. They come across with an incredibly bright, clean sound that is matched by clever, inventive production technique. In addition, appearing after a rift sent founder members Lol Creme and Kevin Godley elsewhere to market a new instrument/device they've invented, **Deceptive Bends** is probably the most direct, accessible album 10CC has made yet.

Remaining members Eric Stewart and Graham Gouldman have played it

faithful to the band's original conception: bent, whacko lyrics wedded to irresistably hooked melodies to tell some slightly sick stories. The left-field hit *The Things We Do for Love* is a good example, but only a sample. That wicked humor is laced through *Good Morning Judge, Marriage Bureau Rendezvous, Modern Man Blues,* and *You've Got a Cold,* plus, of course *Honeymoon with B Troop.*

As usual lifted riffs abound, of which the intro to the Beatles' *Dear Prudence* sandwiched into the middle of the brilliant 11-minute *Feel the Benefit* is only the most obvious.

10CC remains a clever, witty, and most of all calculated affair. **Deceptive Bends** takes some chances, but with the spectacular studio wizardry they employ their chances are sure bets. *M.T.*

Sound: A+ Performance: A

Time Loves a Hero: Little Feat
Warners BS-3015, stereo, $6.98.

With **Time Loves a Hero** the production expertise of Ted Templeman (credits include all the Doobie Brothers output) is added to the unique Little Feat equation. The immediate result is a sound sparkling with a clarity and presence they have not previously had.

From the beginning Lowell George has been the central figure of Little Feat, but now he has consciously withdrawn from that position. Previously the producer as well, George helped write only two songs on **Hero.** The bulk of Feat's material now comes from Bill Payne and Paul Barrère whose work is totally consistent with the melodic quirks and odd lyrical themes that have always distinguished Little Feat from everybody else. For instance, the title song concerns an uncle who splits from his wife for a fishing boat in Puerto Rico. *New Delhi Freight Train* is an old fashioned Western shoot 'em up that takes place in India. *Old Folks Boogie* is about the energizing effects of L-Dopa.

Little Feat's music is well-matched to the words, a cerebral and physical mix few bands can duplicate. The instrumental *Day at the Dog Races* has a wicked bent to it. It opens with a Spanish guitar flourish played on keyboard and treated to alter the sound. It segues into a steaming jam most like Weather Report mixed with gumbo.

Time Loves a Hero may be the huge seller to finally bust Little Feat as wide open as what may be America's very finest rock band deserves. However, don't be surprised if Lowell George finally leaves for good. He's worked the band hard to bring it to the point that it can finally bear his departure without breaking up as his energies have now spread to other interests. Besides endless biscuit days do become a drag. *M.T.*

Sound: A Performance: A

Overnight Angels: Ian Hunter
Columbia PC 34721, stereo, $6.98.

Ian Hunter is no dummy. He may go out on the wrong limb every once in awhile, his writing might have a dry spell, but he's got ages of wisdom in him. He and Mott the Hoople faded into oblivion (commercially speaking) after they toured with rising stars Queen, and so after two stiff albums on his own he's robbed Queen of their producer Roy Thomas Baker and he's hot, ready, and rarin' to take America by storm again — but this time he's got some heavy artillery. Granted his ballads are beginning to sound repetitive and saccharin, but at least he's rocking once more. It's the sound of Mott the Hoople reborn with *Justice of the Peace* and *Wild & Free,* buoyed by Earl (anything Mick

Ronson does I can do better) Slick's guitar. The voices are cleverly used (a la Mott), and Hunter's own pipes sound better than ever. I don't know whether it's because it was recorded in England or what, but Hunter has recovered those things which initially drew his fans to him. I only hope that he will sell a lot of records, and have his confidence built up so that he can *consistently* come up with the songs that count. *J.T.*

Sound: A Performance: B+

Did You Miss. . .?

Release: Henry Gross
Lifesong LS 6002, stereo, $6.98.

Cursed with the most annoying falsetto voice known to modern man, Henry Gross is an artist who persistently annoys, except for the few times when he sounds so anonymous he becomes muzak. The moment he starts to play guitar, he always overplays and the listener is hit by a meaningless barrage of notes rather than a solo with a shred of melodic content. There are plenty of fast guitarists around like Gross who are quick to demonstrate their technique, knowledge of scales, and lack of intonation; but only masters such as Ritchie Blackmore, Jeff Beck, Olly Halsall, Brian May, and a handful of others possess equal command in that supreme musical sense.

As for the sound quality of the record, you'll find Cashman & West burying whatever vocal personality Henry has in their prefabricated walls of sound, but then again you wouldn't want to hear what his voice or the instruments really sound like.

Jon Tiven

Sound: D+ Performance: F+

Nuggets: Various artists
Sire SASH 3716-7, stereo, $7.98.

...if only to call attention to a re-release of an excellent if occasionally flawed collection (which only means that I would have made a few different selections) of psychedelic one-shot hits of the late 60s, a watershed period of pop music. Lenny Kaye, who is now Patti Smith's guitarist, assembled it. The new Sire edition contains all the songs and liner notes of the Elektra original. And a much nicer cover. Plus hints of a **Nuggests, Vol. II** for the future. *M.T.*

Downtown Tonight: Racing Cars
Chrysalis CHR 1099, stereo, $6.98.

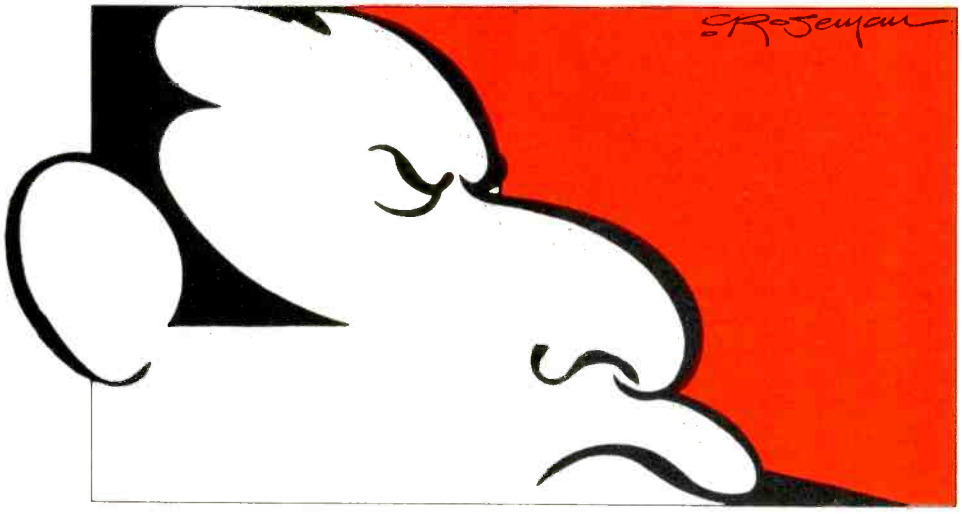
From that cover, I was somewhere between being prepared and anxious to hate Racing Cars, what with that deco dandy print on the front and the sweaty photo on the back. But much to my prejudgment's dismay, Racing Cars delivers the goods.

Cars is a good, nervy young band, with some great songs that stick in your mind. Garith Mortimer—known naturally as Morty—writes and sings 'em. *Ladee-Lo,* complete with an eerie Beatles quote, and *They Shoot Horses, Don't They?* cover the soft and pretty angle. They have an abundance of good rockers, among them *Calling the Tune, Pass the Bottle,* and *Moonshine Fandango.* The band's stylistic inspirations clearly come from the clean, economical music of Free (the antecedant of Bad Company) and The Band whose song *The Shape I'm In* reappears as *Get Out and Get it.*

Combine confidence with chops and material, and you've gotta come up with a winner...like Racing Cars. *M.T.*

Sound: B+ Performance: A –

Jazz & blues



Woody Herman & His Thundering Herd: 40th Anniversary Concert
RCA BGL 2203, stereo, $7.98.

Beginning in the late 40s and through the 50s, the dynamics of American popular culture worked against big bands. While solo singers, Easy Listening, and rock and roll prospered, big bands died like dinosaurs. Out of 600 Swing Era ensembles, only a handful, Woody Herman's among them, survived.

Except for a seven-month break in 1947 and a brief stint with a sextet, Woody Herman has been on the road with a big band for 40 years. For the past three decades, he has successfully bucked trends by adapting to them; and, while yielding to pervading tastes, his bands have retained a fiesty jazz quality that is uniquely Herman's.

RCA's two-record set is a tribute to Herman's tenacity and acute musicianship, as well as to his remarkable record of survival. Taped live on stage last November at Carnegie Hall, it combines the youngsters in his current Thundering Herd with veteran sidemen identified with Woody's bands of the 40s, 50s and early 60s — old pros like Flip Phillips, Zoot Sims, Al Cohn, Stan Getz, Jimmy Guiffre, Pete and Conte Candoli, Nat Pierce, Jake Hanna, Don Lamond, and Chubby Jackson.

It's unfortunate that not all of the exhilaration and power that pinned one's ears back at the 40th anniversary concert comes boiling out of these tracks. RCA's on-the-spot taping suffers from poor balance so that some of the exciting ensembles enjoyed live are muffled, and in one or two instances Herman's soloists sound as if they were playing off stage.

Record One opens with the Herd's pungent theme *Blue Flame*, and moves swiftly into Ralph Burns juggernaut arrangement of *Apple Honey* featuring tenor man Flip Phillips, trumpeter Pete Candoli, guitarist Billy Bauer, bassist Chubby Jackson, and drummer Don Lamond. Phillips' sax is tender and torchy on *Sweet and Lovely*, which is followed by an exuberant *Four Brothers* with its familiar full-throated sax ensemble and dancing choruses by tenors Guiffre, Getz, Cohn, and Sims. *Wrap Your Troubles in Dreams,* in a cheery mid-40's swing arrangement, features singer Mary Ann McCall whose horn-like phrasing reflects the Anita O'Day/Billie Holiday influence. There's a fine performance by Herman veteran Phil Wilson, whose ripe trombone skillfully maneuvers *Bijou's* tricky harmonies and elaborately-wrought cross rhythms. Stan Getz's lazy, soft-edged phrasing on *Early Autumn* is another delight.

Record Two showcases the contemporary Herman book and his current sidemen. *Blues in the Night* is a turbulent, over-long, pretentious jazz/rock reworking of the Harold Arlen/Johnny Mercer tune that can't compare with Herman's simple, melodic version recorded for Decca in 1942. An adaptation of Aaron Copeland's *Fanfare for the Common Man,* with fuzztone, feedback, and all the electronic brio of today's pop, comes off

better and features a searing Coltraneish solo by Herman on soprano sax. Freddy Hubbard's *Crisis* and Joe Beck's *Penny Arcade* are replete with wah-wah guitar riffs, electric piano, and aggressive, high-energy solos by the 63-year-old Herman, trumpeter Dennis Dotson, and tenor Joe Lovano. There's fire-eating excitement on the Herman classic *Caledonia*, which surges relentlessly under drummer Jake Hanna's swaggering push.

Woody Herman's 40th Anniversary Concert is not all that it should be, but it is a praiseworthy attempt to provide an authoritative cross section of this important musician's work in a contemporary collection. Yet one must admit that the Old Woodchopper's *original* recordings have yet to be surpassed. *John Lissner*

Sound: B Performance: A

The Complete Glenn Miller Vol II, 1939
RCA AXM2-5514, mono, $7.98.

This writer has often observed that most jazz critics have a Glenn Miller bias—they tend to judge the Miller Orchestra in terms of its commercial success rather than the actual merits of the music. No doubt about it, Miller's was the most commercially successful of all the swing bands. Between the cloying sentimentality or businessman's bounce of Sammy Kaye and Guy Lombardo and the rugged big band jazz of Basie and Ellington stood the Glenn Miller Orchestra, cutting a broad swath in the late 30s and early 40s, its enormous appeal encompassing all age groups, musical preferences, and dancing tastes.

On **The Complete Glen Miller Vol. II**, RCA's two record set, part of RCA's ambitious project of reissuing every Bluebird and Victor recording cut by the Miller civilian band (English RCA is already up to Volume 13 in a similar reissue program), we catch the Miller ensemble in studio sessions from the spring to the fall of 1939. By June of that year, the Miller band had hit it big, and, as money started to pour in, Miller added instrumentalists and arrangers of considerable jazz talent, such as trumpeter John Best and arranger Jerry Gray who he took from Artie Shaw. These were to be followed by trumpeters Billy May and cornetist-guitarist Bobby Hacket. The Miller band showcased here has lost all of the tentativeness of a green band breaking in one hears on Volume One in the RCA/Bluebird series.

The spirited ensembles such as on *Pagan Love Song, Wham, I Want to Be Happy, Farewell Blues* and *In the Mood* have a rugged, full-bodied attack; the sheer quality of sound and tonal balance must be admired. Miller was not only an ensemble perfectionist, he had the gift of setting off his soloists with maximum attractiveness in the overall musical fabric. *Pagan Love Song* has brief, vigorous 8-bar jazz choruses by tenor men Al Klink and Tex Beneke and a fine muted solo by trumpeter Clyde Hurley. Hurley also has a punching chorus on the rollicking *I Want to Be Happy* (an overlooked fine bit of high-powered Miller swing-jazz that originally appeared on the back of *In the Mood*); both musicians perform splendidly on the swaggering *Farewell Blues*.

Yes, there are plenty of glossy ballads, some sprinkled with Ray Eberle's croony, gigilo sound—*Isle of Golden Dreams, Over the Rainbow, Starlit Hour, Blue Moonlight, Blue Orchids, My Prayer*, and *Blue Rain*, and each is enhanced by that rich, fluent, famous Miller reed sound (clarinet voiced on top of the saxophones and playing the lead line along with the tenor sax). And yes, there are sappy novelties like *The Man with the Mandolin* and *I Want a Hat with Cherries*, but even they swing like blazes. All in all, **The Complete Glenn Miller Vol. II** is richly framed, hearty, swinging dance music, intelligent in its conception, enthusiastic and artistic in its execution. The re-editing and sound transfer job by RCA is outstanding; the quality and sparkle of these 1939 recordings is not to be believed, and this reviewer looks forward to Volume III. Play it again, Glenn. *John Lissner*

Sound: A Performance: A

Blisterstring: The Jimmy Dawkins Band

Delmark DS 641, stereo, $6.98.

Jimmy Dawkins has been highly respected in blues circles since the end of the 60s, though he's never had much luck in the recording studio. His first album (Delmark DS 623) was hard, tough Chicago blues with superb guitar and committed singing, though it suffered from a somewhat disorganized production, Dawkins' 1972 **Transatlantic 770** (Excello EX 8024), overproduced in London by Mike Vernon, was a disappointment; it had fine guitar but *un*committed singing. (Historical note: **770** was the recording debut of British disco favorites, the Olympic Runners!).

Blisterstring, then, is the first fully-realized Jimmy Dawkins album. Gone for the most part are the mandolin-like trills and rapid fills which gave him his former nickname, "Fast Fingers." Replacing them are a mastery of the distortion potentialities of his stereo guitar, a solid sense of musical direction (infusing his solid blues base with the electricity and rhythms of rock), and a willingness to gamble with his material.

Nowhere is this last tendency more apparent than on *Ode To Billie Joe.* Bobbie Gentry would no doubt be hard pressed to recognize her sleepy, dusty Delta melody in Dawkins' hard-charging, riff-rocking instrumental of the Freddie King school. It's on this track, incidentally, that Dawkins most closely resembles the "Fast Fingers" of old. The other instrumental, *Chitlins Con Carne,* is a more contemporary soul-blues, on the order of *The Thrill Is Gone.*

The two best cuts, *Blues With a Feeling* and *Welfare Line,* are slow scorchers with a wailing, moaning guitar. Dawkins' singing is gruffer than before, with a throaty growl which lends a threatening sense of desperation to the doom-laden *Welfare Line.* His guitar commentaries and long solos are constructed from sharp, acute, buzzing lines, consisting of few notes, but with a searing intensity that's heightened by a keen sense of timing and self-control.

On the stomping opener, *Feel So Bad,* Dawkins' guitar is white-hot, soulful and pleading. He plays sparingly on *If You're Ready,* a rather skeletal, yet infectious tune reminiscent of the Staple Singers, built around a dancing Jimmy Johnson riff that's bound to raise your body temperature a few degrees. The one weak spot is Fats Domino's *Blue Monday* (complete with New Orleans piano triplets by Sonny Thompson), which Dawkins turns into a well-meant, but ineffectual tribute to Smiley Lewis.

Rhythm guitarist Jimmy Johnson's wahed accompaniment on *Feel So Bad* and *Ode To Billie Joe* is a bit monotonous, though he's certainly adequate enough elsewhere. Bassist Sylvester Boines and drummer Tyrone Centuray keep things tight and pumping.

Dawkins' distorted leads are beautifully recorded, but his vocals are downplayed on several tracks. A pressing gaffe resulted in fluttering cymbals and tambourine on my review copy; the other instruments were not so sorely affected.

Tom Bingham

Sound: C+ Performance: A−

The Light of Smiles: Gary Wright
Warner BS 2951, stereo, $6.98.

After the breakthrough of **Dream Weaver**, Gary Wright's follow-up, not surprisingly, follows much the same pattern. The album contains no guitar or bass guitar. All non-percussive sounds are produced through a battery of keyboards and synthesizers with rare string parts. The production is a bit more fully colored this time out, the sound quite fine.

Child of Light and *Water Sign* are the most attractive songs on early listenings. Throughout Gary sustains the muscular sense of melody that has always characterized his work from Spooky Tooth on. His intensity does not waver.

The Light of Smiles probably won't expand the circle of Gary's fans, but it probably won't hurt him at all either.

Michael Tearson

Sound: A− Performance: B

Classical reviews

Edward Tatnall Canby

Berlioz: Romeo et Juliette. Hamari, van Dam, Dupouy, N.E. Conservatory Chorus, Boston Symphony, Ozawa. **Deutsche Grammophon 2707 089**, two discs, stereo, $15.96.

One of the finest Berlioz recordings ever released—enough to make you weep. With pride, that such a superbly styled and disciplined and ultra-dynamic performance of French music should come out of Boston, in the U.S. of A. And with the frustration, that such marvelously knowing and perfect recording should have to come out of Boston via Europe. From microphone placement to disc pressing, one must simply admit that here is a technical perfection beyond our usual American standard. Talk about state of the art! Unfortunately, not *our* state of the art, even though without a doubt a good deal of American assistance went into the job. Credit just has to go basically to Deutsche Grammophon, which is definitely not an American record company.

First—the music. The vast, palpitating, sprawling score, a mammoth symphony with voices (various choirs, soloists too), can be a deadly bore if the thing is not done, literally, with all the zealous fire of 1838 Romanticism, along with that utter accuracy of execution which French music must have in almost any period. The performance here—under a Japanese (out of Manchuria) and except for the tenor a wholly non-French cast—is a model that should astonish the French themselves. Hair raising in its Romantic intensity, astonishing in its total accuracy and dedication, without the slightest trace of that incipient roughness that indicates too few rehearsals and all-in-the-day's-work routine recorded performance. This is a mass labor of love, a rare event in these days. The New England Conservatory chorus combines professional power with youthful student zeal, and though their French is hearty-American, their dedication to this music is total. The solos are up to their roles, notably the Belgian bass, van Dam, who sounds more French than a Walloon (French Belgian) which he apparently is not. And it is abundantly clear that Mr. Ozawa has a hold on the august Boston Symphony players which his French predecessors with that orchestra seldom achieved.

Clean recording, with totally silent surfaces, is merely the start. The life-giving element here is the sensitive and intelligent balance in the sound of the large vocal-orchestral forces. What will please audio listeners most, I think, is that the voices—both solo and chorus—are put in their exact rightful places as adjuncts to the orchestra, not blown up via solo and accent microphones but off on the stage and thus aurally unobtrusive. Even the most rabid vocal-hater will find the musical flow acceptable, as between those portions that are all-orchestra (a major part) and those where the voices assist. A rare accomplishment in microphone restraint.

Nexus—Ragtime Concert. Umbrella UMB DD-2 (Lim. ed. available via Audio-Technica dealers.)

This second direct-to-disc offering from Canadian Umbrella is curiously classical. Though in late ragtime style, via an ensemble of xylophones and marimbas, it is performed by virtuoso young players of impressively classical training, out of orchestras such as the

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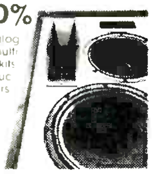

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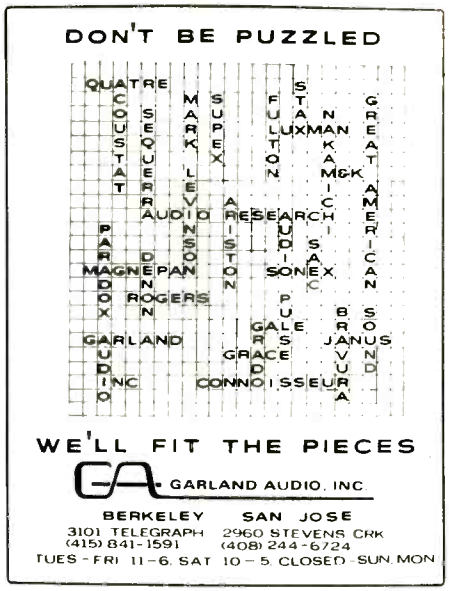

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The Revolutionary

Wow & flutter: .04%.* Signal/noise ratio: 62 dB.**

Introducing the incredible Elcaset system. Developed by Sony to bring you unsurpassed cassette sound.

1. The Elcaset tape is as wide as reel-to-reel tape: ¼".

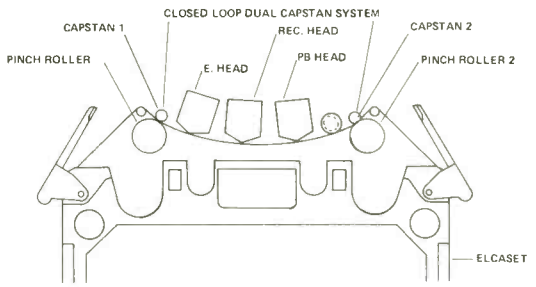
2. Tape moves twice as fast: 3¾ ips. Result: the widest dynamic range, the widest frequency response, the cleanest sound ever offered in a cassette format. Unlike the standard cassette, the Sony Elcaset sound is not compressed, constrained. It's expansive and full. It "breathes." It's true high fidelity.

3. The tape is lifted out from the cassette and guided across the heads by a stabilizing pin in the deck itself—just as in reel-to-reel.

Result: lowest wow and flutter, superior tape/head alignment, even better frequency response. (See diagram).

4. All-new tape formulation with thicker oxide coating and thicker polyester for highest quality sound.

5. Automatic tape formulation adjustment. Small holes encoded on the cassette case "tell" the Elcaset deck what type of tape is being used (SLH, FeCr). The Elcaset then automatically adjusts both bias and EQ for optimum performance.



Tape (Actual Size)

Sony Elcaset System

Frequency response: 25 Hz–22 kHz, ±3 dB.***

An engineering triumph, the Sony EL-7 Stereo Elcaset Deck was designed exclusively for the new Elcaset tape.

1. Closed-loop dual capstan tape drive. One of the most advanced tape drive systems now available, it assures constant tape-to-head contact pressure, low wow and flutter and virtually nonexistent modulation noise.

2. The 3-motor system starts with a **DC servo motor** for utmost reliability. A sophisticated feedback circuit corrects for line voltage fluctuations, and other speed-altering factors. This is the finest tape recorder motor system money can buy. Proof? Wow and flutter of only .04%.

3. Sony's 3-head system offers the most precise tape/head alignment possible. All three heads are made of **ferrite and ferrite**—a super-strong formulation that lasts up to 200 times longer than standard permalloy. Head surfaces are mirror-smooth for friction-free tape travel and optimum tape/head contact. Incredibly close tolerances in the head gap assure widest frequency response.

4. Direct coupling of playback head with the FET first-stage reproduction amplifier significantly reduces distortion, improves signal/noise ratio and frequency response linearity.

Also available: The Sony EL-5 Stereo Elcaset Deck. Includes many of the same high performance features of the Sony EL-7, at a lower price.

Deck

Brought to you by **SUPERSCOPE**

Memory tape counter provides automatic sequential rewind and playback immediately after recording from a specific spot on the tape.

Timer activating capability, in conjunction with an external timer, turns on/off playback or record mode unattended.

Illuminated "feather-touch" solenoid operation. Logic-controlled system allows instantaneous mode change, bypassing stop.

Air-cushion eject slowly, softly opens tape compartment door, thus minimizing wear on eject system.

Dolby Noise Reduction System includes 25 μS de-emphasis circuit for Dolby FM, as well as controls for standard Dolby applications.

*WRMS. **FeCr tape, Dolby**** out. ***FeCr tape. ****TM Dolby Labs. Inc. (Source: Sony Corp.)

What you don't hear is as impressive as what you do.

Up to now the most you could expect from a medium-priced cassette deck was rather medium performance. But now there's the RS-630US. The medium-priced cassette deck with high-priced performance.

We started by going to work on the sounds you don't want to hear with any cassette deck. When we finished, we ended up with virtually inaudible wow and flutter (0.09% WRMS). Negligible distortion. Transistorized switching that reduces signal loss. And a S/N ratio where there's practically no room for noise (−63dB with Dolby* and CrO_2 tape).

That's what you won't hear. What you will hear is a frequency response of 30Hz to 16kHz (CrO_2 tape). That means cymbals, brass and strings will sound crisp, smooth and natural. The reasons: A super alloy tape head formed under intense heat and pressure. As well as high-grade premium transistors.

You can also forget tape hiss. Because we use a two-stage direct-coupled equalizer as well as Dolby.* So that soft musical passages will remain quiet.

The RS-630US also has highly accurate peak-check meters that let you set the recording levels without the fear of overload distortion. So you get highly accurate recordings. With excellent dynamic range.

There are also dual output level controls. A CrO_2 tape selector switch. A lockable pause control. And Auto-Stop at the end of the tape in both record and playback modes.

So if you've been looking for a cassette deck with outstanding performance, audition the RS-630US. It only sounds expensive.

*Dolby is a trademark of Dolby Laboratories, Inc.
Cabinetry is simulated wood.

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