Audio

Tape Playback Equalization

THE AUTHORITATIVE MAGAZINE ABOUT H • MAY 1980 $1.25
F 06030

BUILD A HEADPHONE CROSSFEED CIRCUIT

LEACH'S DOUBLE-BARRELED AMP-- PART II

DIGITAL TECHNIQUES PART II

AND IT'S WHAT GOES INTO HPM SPEAKERS THAT MAKES THEM SOUND GREAT ON EVERY PART OF THE MUSIC.

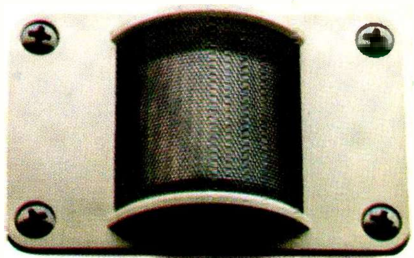
Most speaker companies try to impress you by describing the "wonderful" sound that comes out of their speakers.

At Pioneer, we think the most believable way to describe how good HPM speakers are is to tell you what went into them.

THE HPM SUPERTWEETER: SPEAKER TECHNOLOGY RISES TO NEW HIGHS.

In many speakers, you'll find that the upper end of the audio spectrum is reproduced by an ordinary tweeter.

In HPM speakers, you'll find that the high frequencies are reproduced by a unique *super*tweeter.



The High Polymer Molecular Supertweeter.
So incredible, we named a whole line of speakers after it.

It works by using a single piece of High Polymer Molecular film, (hence the name HPM) that converts electrical impulses into sound waves without a magnet, voice coil, cone, or dome.

And because the HPM supertweeter doesn't need any of these mechanical parts, it can reproduce highs with an accuracy and definition that surpasses even the finest conventional tweeter.

As an added advantage, the HPM film is curved for maximum sound dispersion. So unlike other speakers, you don't have to plant yourself in front of an HPM speaker to enjoy all the sound it can produce.

MID-RANGE THAT ISN'T MUDDLED.

For years, speaker manufacturers have labored over mid-range driver cones that are light enough to give you quick response, yet rigid enough not to distort.

Pioneer solved this problem by creating special cones that handle more power, and combine lower mass with greater rigidity. So our HPM drivers provide you with cleaner, and crisper mid-range. Which means you'll hear music, and not distortion.

WOOFERS THAT TOP EVERY OTHER BOTTOM.

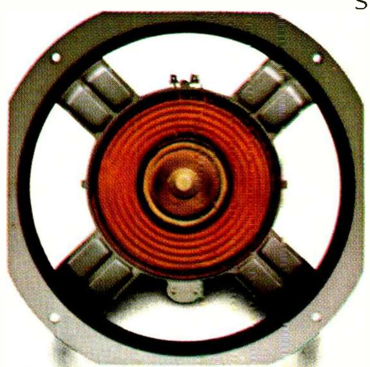
Conventional woofers are still made with the same materials that were being used in 1945.

Every woofer in the HPM series, however, is made with a special carbon fiber blend that's allowed us to decrease the weight of the cone, yet increase the strength needed for clarity. So you'll hear the deepest notes exactly the way the musician recorded them.

And because every HPM woofer also has an oversized magnet and long throw voice coil, they can handle more power without distorting.

OTHER FEATURES YOU RARELY HEAR OF.

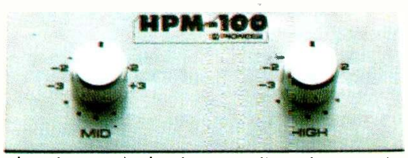
Every HPM speaker has cast aluminum frames, instead of the usual flimsy stamped out metal kind. So that even when you push our speakers to their limit, you only hear the music and never the frames. In fact, our competitors were so impressed, they started making what look like die cast frames, but aren't.



You'll never hear a sound out of these die cast aluminum speaker frames.

HPM speaker cabinets are made of specially compressed board that has better acoustic properties than ordinary wood.

Their speakers have level controls that let you adjust the sound of the music to your living room.



Level controls that let you adjust the sound to your listening area.

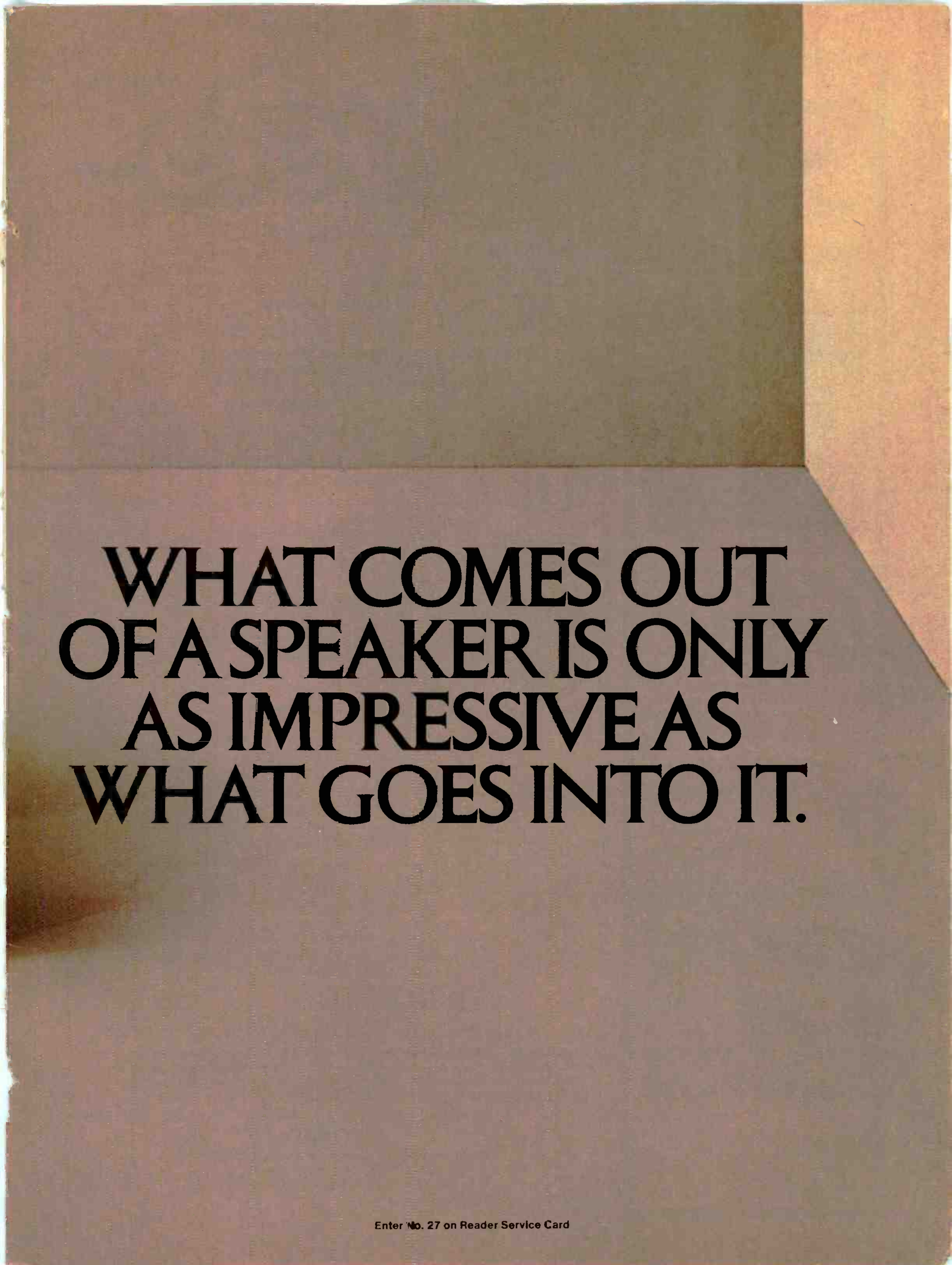
And these features are not just found in our most expensive HPM speaker, but in *every* speaker in the HPM series.

All of which begins to explain why, unlike speakers that sound great on only part of the music, HPM speakers sound great on all of it.

At this point, we suggest you take your favorite record into any Pioneer Dealer and audition a pair of HPM speakers in person.

If you think what went into them sounds impressive, wait till you hear what comes out of them.

PIONEER®
We bring it back alive.


WHAT COMES OUT
OF A SPEAKER IS ONLY
AS IMPRESSIVE AS
WHAT GOES INTO IT.
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May 1980 **Audio** Vol. 64, No. 5

"Successor to RADIO, Est. 1917"

Feature Articles

Equipment Profiles

Record Reviews

Audio in General

About the Cover: Headphones are becoming increasingly versatile, particularly in lightweight configurations such as Sony's 13½-oz. Soundabout modeled by Carter Wilson. Better stereo imaging with headphones can be achieved using a crossfeed circuit detailed in the Repka and Berkowitz article on page 32. Photo by Chris Callis, © 1980 Chris Callis.

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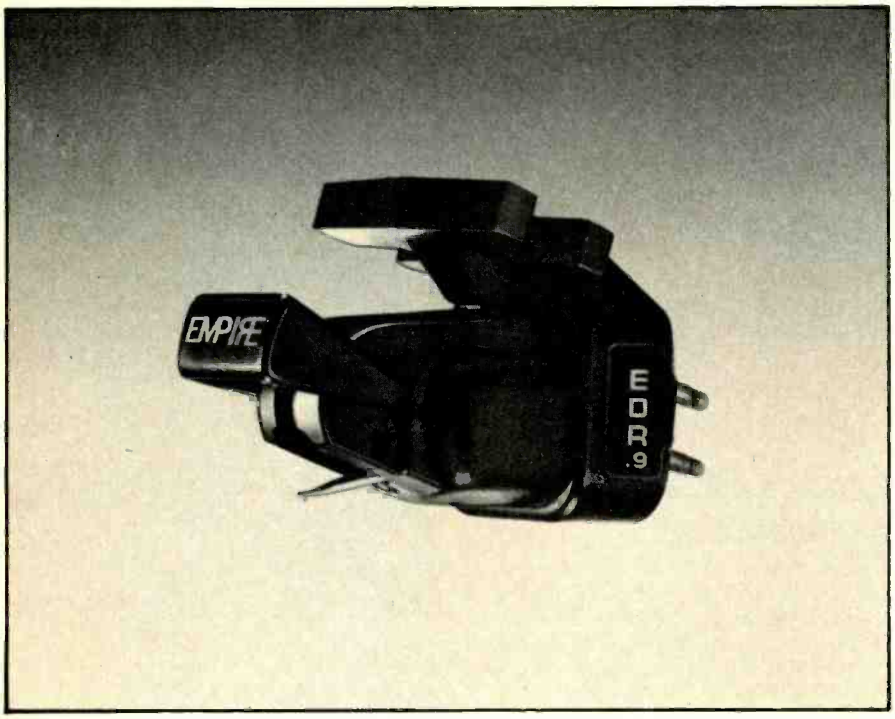
Empire's EDR.9
The Phono Cartridge Designed for Today's Audiophile Recordings



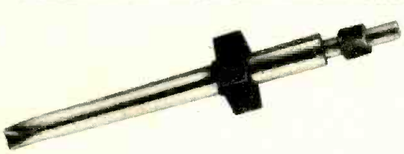
Direct-to-Disc and digital recording have added a fantastic new dimension to the listening experience. Greater dynamic range, detail, stereo imaging, lower distortion and increased signal-to-noise ratio are just a few of the phrases used to describe the advantages of these new technologies.

In order to capture all the benefits of these recordings, you should have a phono cartridge specifically designed to reproduce every bit of information with utmost precision and clarity and the least amount of record wear.

The Empire EDR.9 is that cartridge. Although just recently introduced, it is already being hailed as a breakthrough by audiophiles, not only in the U.S., but in such foreign markets as Japan, Germany, England, France, Switzerland and Sweden.

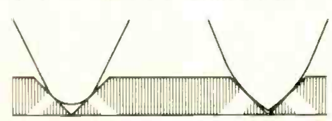
What makes the EDR.9 different?

1. __________



Within the cantilever tube, we added a mechanical equalizer. It serves two purposes: (1) to cancel the natural resonance of the cantilever tube, and (2) to improve the overall transient response of the cartridge. The end result is a stylus assembly that has a mechanically flat frequency response. The frequency response extends from the 20Hz to 35Hz with a deviation of no more than ± 1.75 dB. No other magnetic cartridge has that kind of performance. We call this stylus assembly an "Inertially Damped Tuned Stylus," the refinement of which took over 6 years.

2. __________



Contact area of ordinary Elliptical Diamond.

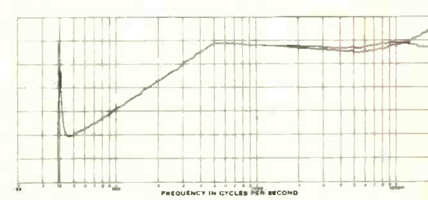
Large contact area of LAC Diamond.

In order to reproduce a groove containing extreme high frequency musical overtones, the stylus tip must have small enough dimensions to fit within the high frequency portion of the groove. Yet, the smaller the stylus tip, the greater the pressure applied to the record surface and the more severe the record wear. In the EDR.9, we have responded to these conflicting requirements by developing a stylus that has the proper dimensions from side-to-side, a much smaller dimension from front-to-back, and a very large, low pressure degree of contact between stylus and groove top-to-bottom. The net result of this large contact area, which engineers call a "footprint," is that the stylus of the EDR.9 can track musical signals to the limits of audibility and beyond, yet has the lowest record wear of any cartridge presently available. The stylus shape of the EDR.9 is called L.A.C. for "Large Area of Contact."

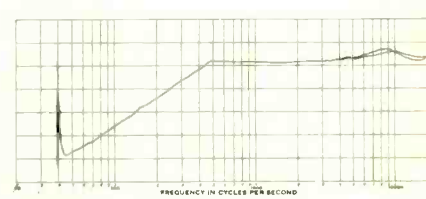
3. __________

Conventional cartridges exhibit radical changes in their frequency response when connected to different preamplifiers. This is because the load conditions — the amounts of capacitance and resistance provided by the preamp — vary tremendously from one preamp to another, and from turntable to turntable. Consequently, most phono cartridges, even expensive ones, have their frequency response determined essentially by chance, depending on the system they are connected to.

But the electrical elements of the EDR.9 have been designed to remain unaffected by any normal variations in load capacitance or resistance. Thus, the EDR.9 maintains its smooth frequency response and accurate transient-reproduction ability in any music system, irrespective of loading conditions.



A conventional cartridge's frequency response changes when connected to different preamps.



EDR.9 is not affected by changes in loading conditions.

4. __________

Then, as a final test of performance, we listen to every EDR.9 to make certain it sounds as good as it tests. At $200, the EDR.9 is expensive, but then again, so are your records.

For more detailed information and test reports, write to:

Empire Scientific Corp.
Garden City, NY 11530

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MEMOREX HIGH BIAS TEST NO. 5.

WHICH HIGH BIAS TAPE STANDS UP TO A GENRAD REAL-TIME ANALYZER?

The GenRad 1995 Real-Time Analyzer is among today's state-of-the-art devices for accurately measuring and displaying audio signals. That's why we used it to show that MEMOREX HIGH BIAS is today's state-of-the-art high bias cassette tape.

When tested at standard recording levels against other high bias tapes, none had a flatter frequency response than MEMOREX HIGH BIAS.

And, the signal/noise ratio of MEMOREX HIGH BIAS proved to be unsurpassed at the critical high end.

Proof you can't buy a high bias cassette that gives you truer reproduction. And isn't that what you buy a high bias tape for?

Is it live, or is it

MEMOREX®

The GenRad 1995 Integrating Real-Time Analyzer measured signals from a Nakamichi 582 cassette deck. Input signal source was "pink noise" at OdB (200 nanowebers—standard record level). If you'd like a copy of the test results please send a self-addressed, stamped business-size envelope to the address below. Ask for the GenRad Test.

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For unbeatable performance in a normal bias tape, look for Memorex with MRX₃ Oxide, in the black package.

Memorex Audio Development Center, P.O. Box 988, Santa Clara, CA 95052, U.S.A.

Audioclinic

Joseph Giovanelli

Use of Record Changers

Q. My friend thinks that using her changer in its automatic mode will result in damage to her records, but I think that the label and outer edge of records are built up to prevent contact with the grooves of other records in the stack. —Name withheld

A. Because so many consumers were using record changers, the recording industry recognized the need to protect records from surface scratches when one disc fell on the one below. Therefore, the thickness between the recorded groove surfaces was reduced, leaving the center label area, as well as the outer edge, built up to prevent accidental contact between the upper groove surface of the lower disc and the lower groove surface of the upper disc. These thicker areas helped produce strong, rigid discs, but overall this meant that the records were made thinner than formerly. In addition, the air cushioning which takes place when the new records descend helps to eliminate damage. Some of the audiophile disc makers feel, however, that the thinner records are too prone to warp, though this problem has a variety of sources, e.g. too short a cooling cycle during pressing.

Older changers tracked so heavily that stylus and record wear were a problem, but tripping mechanisms have been so much improved that tracking forces of a gram or so are common, rivaling those forces obtainable on manual turntables. This means that record wear from this source will be kept low.

Multiple Speakers With Low-Power Amplifiers

Q. I have a 10-watt amplifier with 4, 8, 16, and 600 ohm output taps. I wish to feed not more than one watt (background music) to five to ten speakers in as economical a manner as possible.

How do I connect 10 speakers, each equipped with a line-to-voicecoil matching transformer? How should I connect 10 speakers with 8-ohm impedance not equipped with line transformers? — Name withheld.

A. The problem of how to connect ten speakers to a single amplifier is not difficult to solve, provided that the leads used to supply power to the speakers are short or are of heavy gauge. In your case, where 10 speakers are to be used, they can be connected in groups of five each. The impedance will be a bit low but not low enough to cause trouble.

Assuming you have 8-ohm speakers, connect four of them in parallel and then connect the next four in parallel. Each group of four speakers has an impedance of two ohms. Connect the two groups in series. You then have a total impedance of four ohms, and this is just about what is needed. The combination of speakers is connected between the four-ohm tap of your amplifier and ground.

In the case of loudspeakers equipped with line-to-voicecoil matching transformers, these transformers should take the form of those used for 70-volt line operation. It just so happens that with a 10-watt amplifier, running "flat out," the 600-ohm winding will produce 70 volts. Each speaker can be adjusted so that one watt will be fed to it merely by connecting it to the appropriate tap on the transformer. For best results, follow instructions which may be supplied with the transformer so that you will know to use the best combination of primary and/or secondary taps.

Gold-Plated Switch Contacts

Q. Are gold-plated switch contacts more effective than the conventional kind? — Mike O'Leary, Waiwaialua, Hawaii

A. Gold-plated switch contacts do not oxidize as do contacts made from some other materials and therefore switches which employ gold-plated contacts are very reliable. This reliability is especially important in low-level signal applications in which a minute amount of oxidation can mean high electrical resistance and hence improper operation of their associated circuits. (High-quality electronic keyboard musical instruments use such contacts.) It is not necessary to use switches of this kind in such applications as 117-V power circuits; oxidation is seldom a problem here.

If you have a problem or question about audio, write to Mr. Joseph Giovanelli at AUDIO Magazine, 1515 Broadway, New York, N.Y. 10036. All letters are answered. Please enclose a stamped, self-addressed envelope.

Technics

From the grandest opera to the Grand Ole Opry. A lot of FM stations play a lot of different music yet still have one thing in common: The need for uncommonly accurate turntables. That's why so many FM stations use Technics direct drive turntables.

That professionals use Technics direct drive turntables is really not surprising. What is, is that now you can get professional performance in Technics quartz-synthesizer MK2 Series: The SL-1800 manual, the SL-1700 semi-automatic and the SL-1600 fully automatic.

Wow & Flutter	Rumble	Speed Accuracy	Start-up Time
0.025% WRMS	−78 DIN B	±0.002%	1/4 rotation

As you can see, they all have impressive performance. But with Technics MK2 Series, you also get impressive advances in electronics. Like a quartz-synthesizer pitch control. As you vary the pitch it's instantaneously displayed by 13 LED's in exact 1% increments. That makes life easy.

So does the SL-1600 MK2's infrared disc-size sensor. Just place a disc on the platter, press the start button and immediately an infrared ray activates the micro-computer. Then the Technics precision gimbal-suspension tonearm automatically sets down in the lead-in groove.

And for double protection against acoustic feedback, Technics precision aluminum diecast base has a double-isolated suspension system. One damps out vibration from the base, the other from the tonearm and platter.

The MK2 Series. You don't have to be a radio station to afford performance good enough for a radio station.

Your next turntable should be as accurate as the ones many radio stations use.

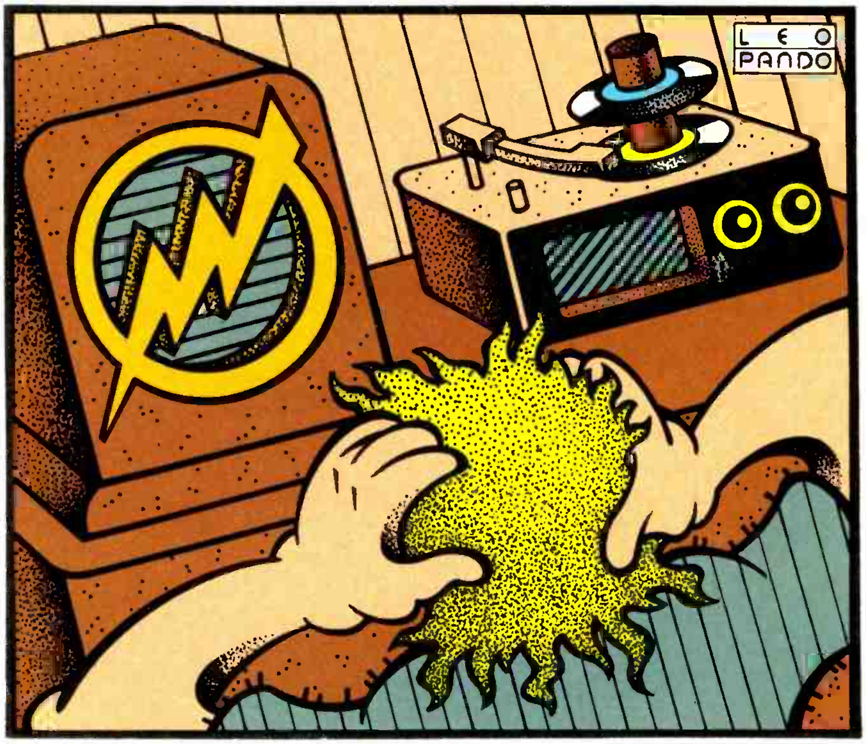
Enter No. 42 on Reader Service Card

Audio etc.

Edward Tatnall Canby

Herewith another segment in my running audiobio (see *Audio*, Jan., 1980), otherwise known as "How I Fell Into Audio," recast and power-amped out of two short pieces I wrote for this mag back in the 1950s.

I left you in the middle of my two pick-up playback of a 78-rpm record, one pick-up acoustic, the other electric, using the two primitive phono portables I then had on hand as a college student. It was a kid's stunt, no more, but as always it seemed to presage much that has happened since in more professional audio terms. Vast (and unexpected) synthetic reverb, thanks to delay between the two needles in the same groove. Distributed frequency bands (not unlike the later Bell Labs two-band experiment) — scratchy, tinny highs from one machine, muddy, tubby bass from the other, for the combined "wide" range. Wider, anyhow. Accidental surround sound, too — out of one loudspeaker and one set of acoustic doors, both aimed randomly in different directions.



I was always the outrageous experimenter via whatever came my way, and always unofficially. Once when my mother was away I got into her kitchen — aged nine, maybe — and concocted a monumental dish that included absolutely everything from Old Dutch Cleanser to raw eggs, heaping tablespoons of flour, soap flakes, oatmeal, vinegar, Jello, and on down the line — I couldn't stop. Like a fine engineer, I was driven by some compulsion towards perfection. I am still the same, though my scope is now more limited. Make do (and more than do) with what you have at hand. That's always been my motto.

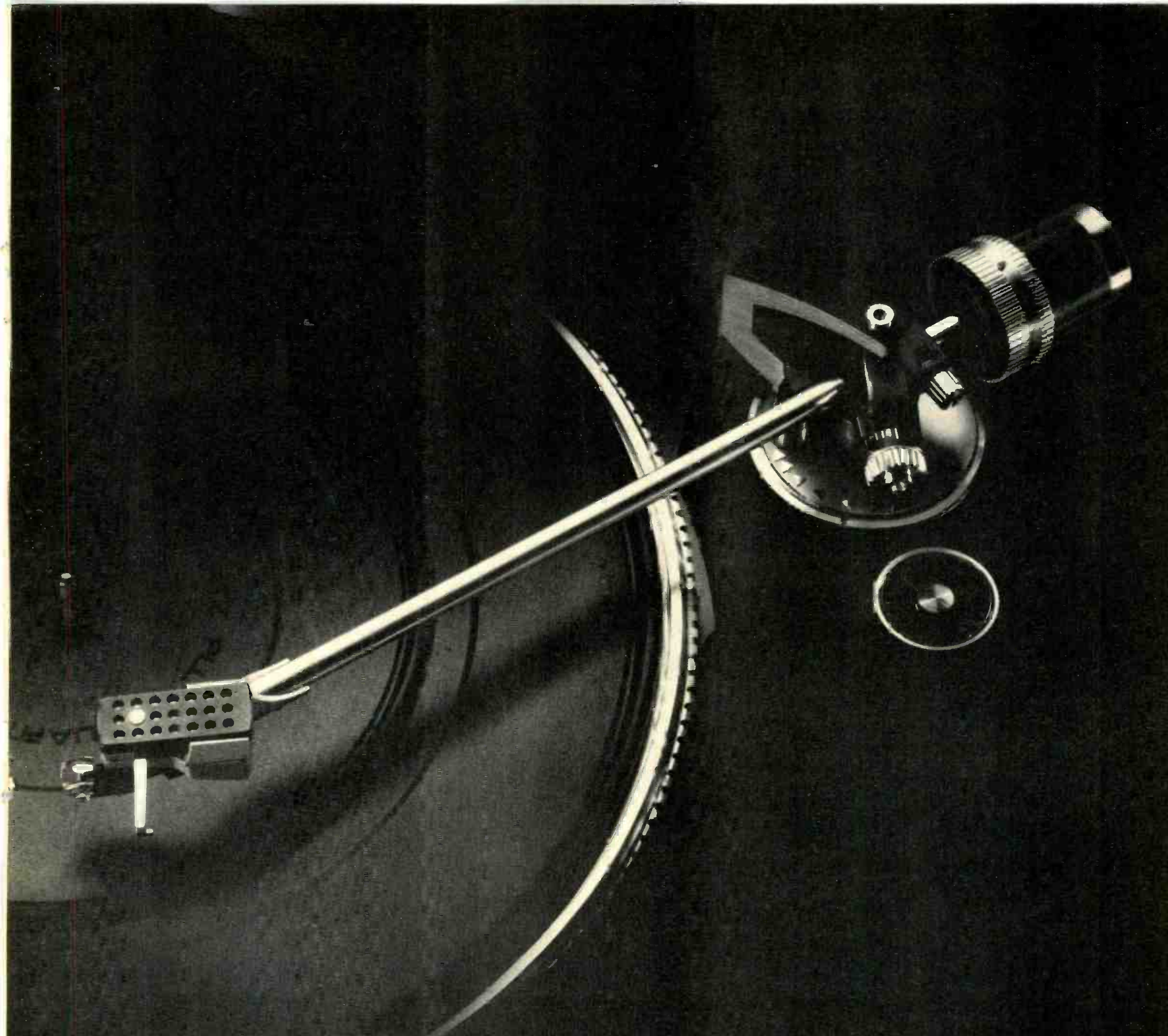
After a somewhat dismal year at the Great University, I moved on to another Great University which was pleased to have me if I didn't mind being a freshman all over again. No love wasted between universities in those days. So it was once again as a freshman that I roomed with an ultra-sophisticated young school friend who thought we really ought to have a big phonograph for respectable playing of our now-combined record collection. The thought of still another suitcase portable made me wince, and so we went right out and splurged our dollars on a second-hand but genuine console electric radio-phonograph (doubtless junked by some earlier freshmen). It was an extraordinary machine, that one, a stand-up job but still crafted out of the old *Art Nouveau* Victrola style, all curves and curlicues. It had a curious bulbous protuberance down below where the loudspeaker was hidden and, at the top, a hefty handle in a long, sidewise slot. To tune the radio you shoved this big handle back and forth in the fat slot. It always reminded me of a tongue stuck out between hideous grinning lips, and the bulbous thing down below was certainly a pot-belly to match. It did have a certain dignity, I'll admit. Some readers may remember the breed.

Getting a Handle on Handel

This machine looked so good in our college room that we went out and bought some new records for it. Nothing small for us! The entire set of 12 Handel *Concerti Grossi* Op. 6, under Ansermet, an early 78 classic. And—phew—Beethoven's huge *Missa Solemnis* in an album that must have weighed 20 pounds. I told you we were highbrow. Too highbrow. About halfway through the *Missa Solemnis*, four-minute sides *ad infinitum*, we looked at each other and agreed to a cease-fire. Next day the album went back to the store.

But we liked the Handel, the best of easy Baroque (as we now call it), in spite of some really dreadful sounds from the records. They seemed to be defective. Some very heavy bass, and that bass was almost unlistenable, all broken up and buzzy and blasty and generally distorted — nothing to do but grit the teeth and play on. Better at least *some* Handel than none. As so often in the early classical days, I got to know Handel, the composer, through this set of records, just as I was introduced to the fascinations of erotica via a borrowed "Lady Chatterley's Lover" in a dog-eared imported (unexpurgated) edition. I went on, far and wide, from these points. Both of them.

Now this Handel turned out to be significant. I understand today why the bass was so prominent. The records were undoubtedly cut with a low-turnover bass roll-off (this was



The 731Q is the finest turntable Dual has ever made.

There is always a special attitude at Dual about the turntable that is to represent the most advanced thinking and accomplishments of Dual's designers and engineers.

The materials, the care in manufacturing, assembly and quality control must exemplify all that has made Dual precision and reliability so highly regarded throughout the world.

And in every measure of performance, this model must set the standard by which other fine turntables are judged. Even more, it must make a significant contribution to the art of record playback.

This year, the quartz PLL direct drive 731Q, with its ultra-low-mass (ULM) tonearm and cartridge system, expresses our attitude perfectly.

If your other components and your record collection warrant consideration of such a turntable, we invite you to visit your franchised Dual dealer. And if you have a record that is warped to marginal playability, but too valuable to discard, bring it with you.

That's all you will need to share our attitude and sense of pride about the Dual 731Q.

For the complete ULM story, please write directly to United Audio, 120 So. Columbus Ave., Dept. Q, Mt. Vernon, New York 10553.

Dual

long before RIAA and standardized recording curves), and consequently they played back with too much bass on an American machine. U.S. discs generally used a higher turnover point to begin the bass de-emphasis that is still necessary today in all commercial discs. Of course, I knew nothing of such things at that time.

But that didn't account for the bad recording — it merely made it sound worse. We were resigned. We played Handel and we winced at the blats and the squawks. But along in the spring we decided we deserved an even fancier phonograph, now that we had bought still more new records. So we traded in the machine with the potbelly and the grinning lips for a newer one, the first of the modern-type console designs and no longer *Art Nouveau*-Victrola. It had flat, simple cabinetry, uncarved and uncurved, and the conventional green-lighted radio dial with sliding pointer that soon became standard. Millions like it were to follow and we see their descendents today.

To our astonishment, the Handel records suddenly repaired themselves! Miraculously, they were undistorted and like new. We played and played, hardly believing our ears. They were OK! Smooth, even bass, not broken up. The problem had not been in the records but *in the machine that played them.* How could we have missed?

A very elementary lesson in hi-fi, you will admit. But even today we still make the same mistake a thousand times. *Don't blame the wrong element in your system.* It's all too easy, as professionals know even more than amateurs. Don't I remember, for instance, the widespread and very vocal skepticism over the new LP around 1949 — we were swamped with complaints that the new discs were impossible to track, the grooves were too small, the system much too fragile. Back to the 78! But as most (not all) of us now know, the problem was *not* in miniaturization, not in the LP record groove, but in the tracking equipment — the working combination of stylus, cartridge, arm and table.

At my second university I was subject to a lot more music teaching via recordings, which were to that period what the electronic music studio is today, very much the "in" thing for a good Music Department. Previously, most professors had just banged out all the music — chorus, symphony, what have you — on the piano. Or, very rarely, had it actually played by live performers. *(That* was decidedly a good thing.) As you see, I was being subjected to audio sound, relentlessly. I practically bathed in it. But what those professors could do to recorded sound, over and beyond the equipment, was a hi-fi education in itself. They had not the smallest idea as to how to use records, how to play recorded music to show it to its own best advantage.

Paine-ful Sound

Most of our music classrooms (in a building unfortunately called Paine Hall) had a low stage up front, with blackboards, piano, etc., from which the professor did his talking and where the piano or the occasional live music was played. When the new electric phonographs came along, and the first actual recordings of the music being taught, the machines were as a matter of course plonked down right at the front of this stage, aiming straight out into our ears. Where else? Why not? That's where any live music would come from. The phonograph, after all, just another musical instrument — of sorts. Canned music.

So hour after hour, month after month, we were blasted straight in the face from that single point source, the one small, highly beamed loudspeaker inside the machine. I will say nothing about the exquisite technique the profs used to locate, say, the second theme of the Beethoven *Eroica* symphony, halfway through a record side. Such squawks and screeches you never heard, with the volume all the way up. (Of course they hated the machines and blamed them, instead of themselves.) We lived with that, as well as a modicum of actual, uninterrupted music. Some people just never learn.

But what bothered me much more was the disastrous effect of aiming a speaker straight into a listener's face at close range. This was the mono era — there was no distributed source, no stereo spread; all the sound came from that one point source (and not even a tweeter), and it was far from undistorted sound to begin with. I didn't know anything, but I suffered. I just felt that, somehow, *something* must be wrong. There had to be a better way. But what? I would not have been able to tell you. I did not know. The profs didn't care — for in their minds this was the way recorded music always sounded. So you grit your teeth and play — and call it canned music.

Nevertheless, I had not forgotten the magical sound of that Orthophonic Victrola playing Bach-Stokowski in the wide, stone spaces of our school chapel, as described in my first installment. The germ of a new thought concerning playback acoustics was in my mind. I began to realize dimly (as the professors did not) that a phonograph

was not a literal substitute for a live performance but, maybe, had its own laws, its own different requirements, its own values for musical sound. It dawned on me that these people, my professors, were really murdering good music, good *recording*, and all with the very best of intentions.

That summer I attended a musical Summer School, not for professionals but a sort of inspirational musical live-in (as it would have been called in the Sixties) to experience what we were already calling "great music." And even to sing and to play it, more or less. Never mind the mistakes; the spirit was what counted. I ate it up — just marvelous. How could I know about the mistakes when all the music was new to me? We didn't have 30,000 LP records to learn from, and the local symphony wasn't that accessible, nor that adventurous.

Gym-Class Mass

We tried to sing the Bach B Minor Mass, with piano accompaniment, but it was no Mass, rather, a mess. We plowed straight through and Bach would have turned over 50 times. Chaos! But fun, even so. Then, one very warm day, we heard we were to be treated to a lecture on the Bach Mass by, of all people, one of my own college music professors. He was going to be really up-to-date. He would illustrate his words by a recording of a real, professional performance. (There was, indeed, a single complete recording of the Mass at this time and for years afterwards). Now, at last, we would get to hear what it really sounded like. Terrific.

So the granddaddy of all console Victrolas was wheeled into the big school gym where we met and, you guessed it, placed straight up front, dead center, at the very edge of the raised stage at one end of the gym. Might have known! Exactly as in the professor's own small classroom. But now, however, there was a big, big space and an audience of some hundreds. So the professor did the obvious. Wouldn't you? He turned the volume up to the very top, stepped back, and let fire.

I shall never suffer a more hideous "concert" than that one. It was agony. I was sitting right in the beam, near the front (eager-beaver me), and I got it right in the face. There was no escaping that lethal blast. Half the audience was figuratively mowed down in the first moments. KY-RIE ELEISON! A vast howl like a thousand buzz saws. Excruciating. So *this* was electrical reproduction?? So this was Bach?? It was just awful, and it was a turning point in my life, too.

LUX *DUO-BETA*

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C-5000A Duo-Beta
Stereo Control
DC Preamplifier

M-4000A Duo-Beta
Power Amplifier
180 watts per channel, minimum RMS, both channels driven into 8 ohms from 20-20,000Hz with no more than 0.008% Total Harmonic Distortion.

The best way to use negative feedback is to design an amplifier that doesn't need any. Manufacturers who start with the idea of feedback wind up with less design. And more correction.

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Lux starts by designing the best DC amplifier possible. So you get exceptional bandwidth and reduced distortion. Then we add not one, but two negative feedback loops. We call it Duo-Beta™ Another first from the people where first is a way of life.

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Lux uses one negative feedback loop of about half the usual amount. Goodbye TIM. **Listen to the brilliance of highs and mid frequencies.**

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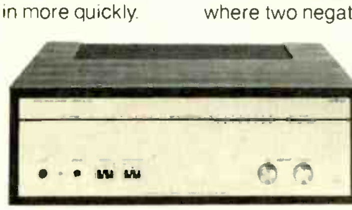
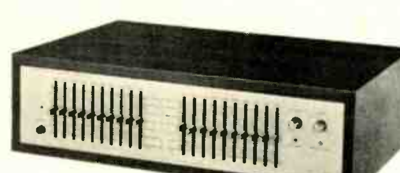
That's Lux-like. Design the best. Then make it better. A case where two negatives become positive.

C-120A Duo-Beta
Stereo Control DC Preamplifier



M-120A Duo-Beta DC Power Amplifier
120 watts per channel, minimum RMS, both channels driven into 8 ohms from 20-20,000Hz with no more than 0.008% Total Harmonic Distortion.



G-120A
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I decided right there that playing recorded music was NOT like playing music live, and that was that. It had to be *different*. You cannot use loudspeakers like machine guns. Or — heaven knows — like musical instruments. This was all something very new that came in with the process of electrical recording. We were experiencing new phenomena at both ends of the audio chain, now that the microphone could take on large, big sounds in big places. Recording got ahead first because it was within the pro area, but playback lagged behind. Too many amateurs, too many professors. Keep in mind that in the long acoustic era of recording, these problems — and opportunities — did not exist. Acoustic records were made at close range and totally dead. They played back scratchily and not loudly. Room acoustics simply did not matter, just as there were no recording-hall acoustics — none to speak of, anyhow. (A few faint background sounds once in a while. Very rarely, an infinitesimal bit of room sense, a space in which the music was occurring.)

So we had the one mono source of reproduced music and we had new, big-sounding records that did indeed occur *in a space*—a space that was in the recording. (Not as much as now, but it was there.) Some of us, even myself as a college kid, began to realize that we had to give that space a better chance. We had to disguise, for the ear if not the eye, the fact that it all came from one, single point. We began to find that some of our listening places did this for us, not badly at all—you might say automatically. Most people then would have credited the machine, or the record, or both. Wrong again! But, one way or another, music did sound good in some of our rooms, and mine—largely by accident—was one. I used to have whole evenings playing records for college friends. I found myself, as usual, experimenting, trying this and that—if only, sometimes, to fit in a few extra chairs and make room; you had to move the phonograph to a new location. I was learning, without thinking too much about it. But after that catastrophonic Bach lecture I began to be a lot more definite.

I went home to Connecticut that same summer and immediately began to have evenings of record-playing at our local swimming club boat house for a lot more people. In effect, these were informal record "concerts." There was a big, rough-hewn upstairs room where the ladies served tea on Saturday afternoons, all unpainted wood with an irregular pitched roof and lots of internal rafters—and one whole side opening widely out onto a deck or balcony over the water. Perfect! Lots of reflection, highly randomized, very few plane surfaces in parallel, and that open side to kill any standing waves. All this, of course, I am saying after the fact. I guess I had an instinct for the right place; I knew nothing about standing waves and random reflections.

I gave a whole series of phonograph evenings there, and you may be sure that I *never* seated any member of my audience directly in front of the phonograph—never that again! Not before the stereo age. I aimed my sonic beam off into a corner, diagonally, or set up the machine to one side so it played along the edge of the audience and into various reflecting surfaces that would disguise the source. In the dark, you could not tell where the machine was at all. That was the idea! Distributed source. And what a difference. Even a lousy old 78 phonograph could sound marvelous in this fashion.

Ah—moonlight! No room to describe that famous evening; enough to say that I acquired a second audience, out in motionless canoes over a half mile of absolutely still lake, listening to my phonograph from far, far away. Now that was the kind of magic I was after. And still am.

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You've heard it so often...just as the music reaches its peak, the phono cartridge simply gives up. But not Precept. Bring on your thundering climax...whether it's the heaviest rock music or the full majesty of a symphony orchestra. Precept cartridges reproduce it all with clarity, definition, and full dynamic range. Or challenge Precept with the softest, most subtle solo. The sound will delight you with its honesty and accuracy.

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Tape guide

Herman Burstein

Jack of All Ohms?

Q. My tape machine has a headphone jack to monitor recordings, and a small earphone of the type used with transistor radios is supplied for this purpose. I have found that when I plug a good-quality headphone, rated at 8 ohms, into this jack, I get excellent sound quality. However, the instruction manual of my tape machine states that a load impedance of 10,000 ohms is required at the monitor jack. Could I hurt my machine using 8-ohm headphones?—Tom Nicholson, Las Vegas, Nev.

A. I am surprised that you get sound of good quality when plugging a low-impedance headphone into a source requiring a load impedance of 10,000 ohms. Usually one would expect a very low sound level and distorted sound, with possible loss of high or low frequencies. Apparently the source impedance is much lower than 10,000 ohms, making such a connection feasible. It is unlikely that you are doing any harm to the headphones or to the tape machine as the result of the mismatch. If the sound is acceptable to you, I think you can continue on. If you do desire to obtain a proper match, you would have to convert to high-impedance headphones or employ a transformer which converts from high to low impedance.

S/N Improvement With Dolby N-R

Q. By using a Dolby noise-reduction unit, how much can I expect to improve signal-to-noise ratio? — Don Summers, APO San Francisco, Cal.

A. A Dolby B noise-reduction system can reduce apparent noise by as much as 6 to 10 db.

S/N Defined

Q. I would like to know what the signal-to-noise ratio of a tape deck actually is.—C. Odgers, Mackenzie, B.C., Canada

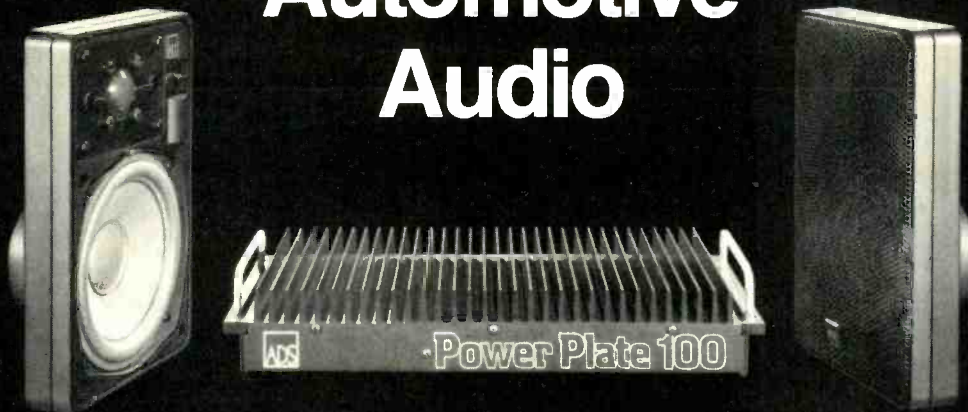
A. Signal-to-noise ratio refers to the ratio between the audio signal processed by a tape system and the noise generated by the tape system. The measure is most usually based on a signal between 400 and 1,000 Hz that is recorded at a level which results in 3 percent total harmonic distortion (or 3 percent third harmonic distortion, which is the chief component of the total) on the tape. If 1 percent harmonic distortion is used as the reference level, this means that the signal is recorded at a lower level, so that the output signal is correspondingly less; then the rated S/N tends to be about 6 to 8 db lower.

Let us assume that a 400-Hz signal is recorded at a level resulting in 3 percent distortion, and that the playback signal has a level of one volt. Let us also assume that the tape is again put through the recording process but without a signal input, that all gain controls are at the same setting as before, and that the output voltage is again measured. Now the output voltage consists solely of the noise generated by the tape system—by the record electronics, playback electronics, and tape. The S/N is the ratio between the first and second voltages, namely between the output of 1 volt (audio signal) and the noise-output voltage. (*Very* strictly speaking, the 1-volt output also includes noise, but the effect of this on the S/N ratio is very trivial, so that we may generally forget about the matter.) If the noise-output voltage is 0.001 volt, then the S/N is 1/0.001, or 1,000 to 1. S/N is ordinarily expressed in decibels (dB). A ratio of 1,000:1 between two voltages, if you consult a dB conversion table, is 60 dB.

Often the noise measurement is weighted to allow for the fact that our hearing sensitivity decreases at lower frequencies. The noise output is put through a filter which reduces the lower frequencies, tending to result in a lower noise measurement. Accordingly, the rated S/N goes up.

If you have a problem or question on tape recording, write to Mr. Herman Burstein at AUDIO, 1515 Broadway, New York, N.Y. 10036. All letters are answered. Please enclose a stamped, self-addressed envelope.

The New Face of Automotive Audio



In 1975 ADS revolutionized mobile high-fidelity with the world's first studio-quality bi-amplified minispeaker, the 2001. It spawned an entirely new industry virtually overnight.

Today, ADS continues to pave the way with the Power Plate 100 amplifier and the ADS 300i speaker system. Together they deliver a level of performance *never before attainable* in a permanently installed car stereo system.

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Supremely compact, easy to install, powerful, musical and durable, the system is an unexcelled value at $299.50 for the Power Plate 100 amplifier and $117.50 each for the 300i speakers.**

You can see *and* hear the ultimate automotive high-fidelity system at your ADS dealer today. But we warn you. You may never be able to live with ordinary car stereo again.

For more information, please write ADS, Dept. AU14, or call 1-800-824-7888 (California 1-800-852-7777) toll free and ask for Operator 483.

*at 4 ohms, 20-20,000 Hz with less than 0.08% THD
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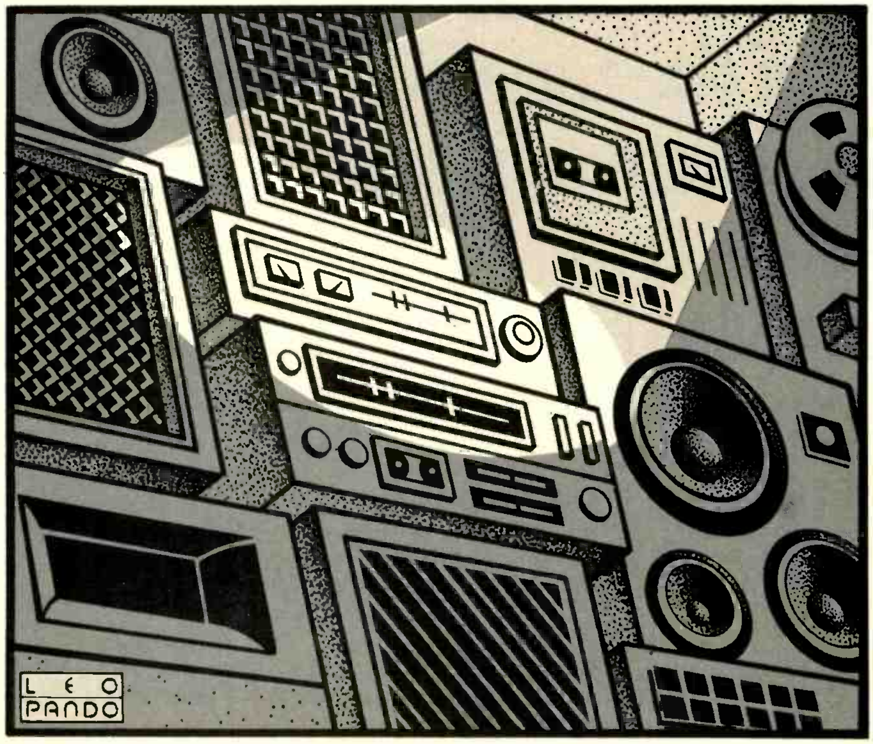
Behind the scenes

Bert Whyte

At the Winter CES there was a considerable amount of comment that many manufacturers were not showing anything really new and were perhaps holding back on their new models and innovative products until the Summer CES in June. While there undoubtedly was some justification for these attitudes, an excursion through the audio exhibits at the Convention Center, and a thorough tour of the Jockey Club (headquarters for the high-end manufacturers), enabled one to ferret out a number of interesting new audiophile products. So herewith the concluding section of the WCES report.



If "hope springs eternal in the human breast," nowhere is this better exemplified than with the manufacturers of exotic audio electronics who exhibit at the Jockey Club at the WCES, or at the Pick Congress Hotel at the SCES. These brave folks always seem to be willing to confront the electronic establishment with new and better mousetraps in the form of new preamplifiers, amplifiers, etc. Many fall by the wayside after a brief moment of glory in the pages of the audiophile press, usually victims of undercapitalization, bad management, or both. But there is no denying that if the products are really worthwhile and the financial and marketing pitfalls can be avoided, a star can be born.

One of the most musical sounds I heard at the Jockey Club was produced by the system demonstrated by Spectral Audio Associates of Sunnyvale, California. Intended ultimately as a complete integrated system, their System One consists of a pair of Quad electrostatic speakers driven by the Spectral CPU-One digital control hybrid FET amplifier. This unit uses FET hybrids and operates in Class A at 75 watts per channel/FTC. Slew rate is claimed to be in excess of a rather incredible 1,000 V/μS, with a power bandwidth extending from d.c. to 10 MHz! A microprocessor constantly monitors all operating parameters and instantly disconnects the load if any anomalies are encountered. Above 7 kHz, a pair of Spectral MS7 direct-drive ribbon tweeters is employed and extends frequency response beyond 30 kHz. The tweeters are powered by their own Class-A 30 watt/channel MOS-FET amplifier. From 80 Hz down, a pair of proprietary distributed bass subwoofers, each powered by its integral Class-AB 200 watt/channel amplifier, is used. This tri-amplified set-up is controlled by the Spectral MS-One preamp, which is actually the only unit now in production; the other products will be coming on stream by the fall of this year.

The MS-One is a slimline unit of modular construction. A dual mono preamp design, it shares only a specially shielded volume control; all ground circuits and shields are completely separate. Each amplifying stage is isolated with its own power regulator, and there are a total of 12 individual regulation circuits. All p.c. boards are said to be of aerospace quality, with all switchware gold over silver contacts. The MS-One has an extremely large bandwidth (3 Hz to 3 MHz), is very fast (slew rate 250 V/μS), produces minimum feedback, and has very high gain circuits to allow the use of moving-coil phono cartridges without step-up devices. The price of the Spectral MS-One preamplifier is $1,595.00. The companion MS-100 a.c. sequencer automates the a.c. control of system components. For use with multi-amplifier systems, it has eight a.c. outlets and employs two separate a.c. delay circuits to turn on system components in a controlled sequence. Delay status is monitored by advancement of front panel LEDs, and this $400 unit indicates incorrect line voltage and also includes filters to minimize power surges and r.f. interference.

Obviously, the Spectral firm has embarked on an ambitious program. Their System One offered exceptionally wide-range, clean, smooth and well-detailed reproduction, with good depth and excellent stereo imaging. The use of tri-amplification permitted a much higher SPL output than would normally be associated with the type of speaker components involved.

Switching On To Switching Amps

Sony had a very large and impressive display of new receivers, cassette decks, and other components, but the focal point for audiophiles was their TA-N88B pulse-width modulation stereo amplifier. This is Sony's successful

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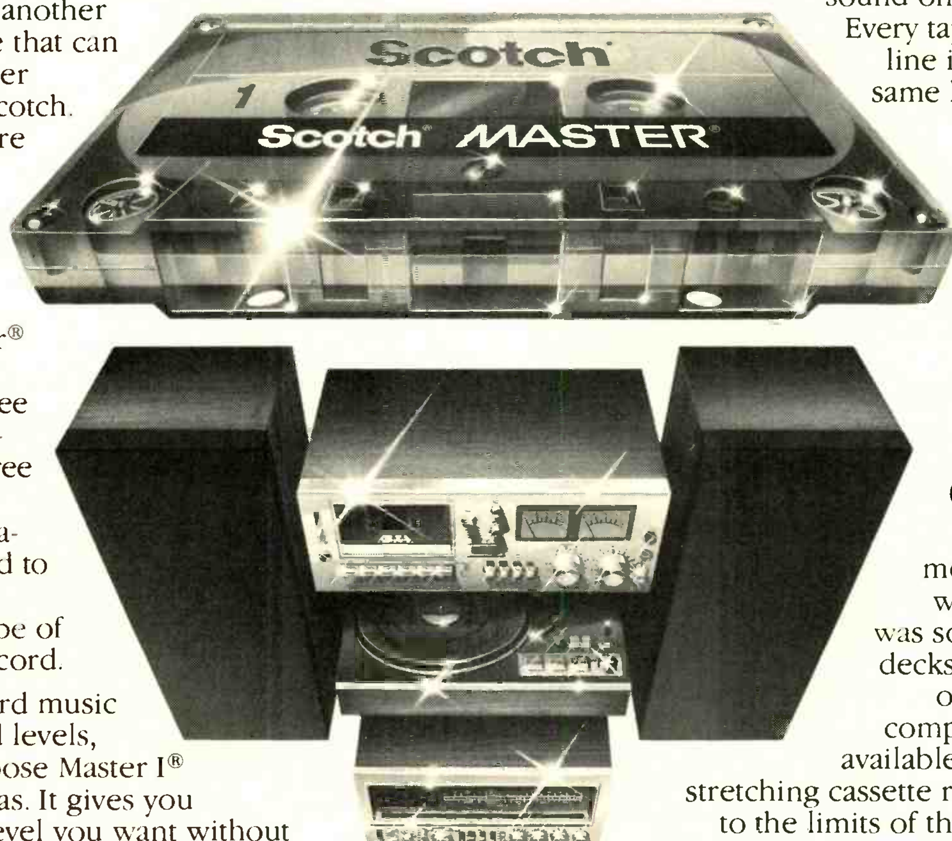

Master III® (FeCr) will give you outstanding clarity for any recording, plus a high-end brilliance that delivers truly remarkable sound on your car stereo. Every tape in the Scotch line is made with the same kind of care and precision that went into your other components, to give you all the performance your system can deliver.

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embodiment of the Class-D switching amplifier, which a number of companies have tried to produce. In a Class-D amp, the transistors act as switches and are either fully on (zero resistance) or fully off (infinite resistance). The conversion of varying amplitude input signals to constant-amplitude pulse widths requires the audio signals to be sampled by an ultra-high frequency, in this case 500 kHz. Complex circuitry ultimately produces 500-kHz pulses such that at each sampled instant, the width of the pulses are directly proportional to the amplitude of the audio signals. The varying width pulses are amplified, and then a passive low-pass filter demodulates the pulse-width output back into the original audio signals. Sony found that conventional transistors did not function well at the 500-kHz frequency needed for pulse-width modulation amplification, so they utilized their special Vertical Field Effect Transistors (V-FETs) for the purpose. The Sony V-FET has a high slew rate, very fast rise and fall time, and is considered quite stable and reliable. In contrast to typical Class AB or B amplifiers, with average efficiencies on the order of 30 percent, this Sony Class-D amp has an efficiency approaching better than 90 percent. In a relatively small (18⅞ in. W x 3⅛ in. H x 14⅛ in. D) package that weighs 24 pounds and without massive heat sinks or cooling fans, there is 160 watts/channel FTC with less than 0.5 percent THD. One of the big advantages of this design, according to Sony, is its soft clipping characteristics when pushed beyond its rated power output. In fact, the company claims the N88B can be pushed up to 250 watts/channel without significant increase in distortion. This is in marked contrast to the rapid and steep increase in THD of conventional transistor amplifiers, which exhibit hard clipping when driven beyond their rated output.

Some years ago when Infinity was working on Class-D switching amplifier design, one of the guiding lights on the project was John Ulrich. One of the founders of Infinity, he now has formed his own company, Spectron Electronics, Inc. in Chatsworth, California. Evidently John decided that further research into switching amplifier design was worthwhile, and now here he was at the Jockey Club proudly displaying a Class-D switching amplifier. In the Spectron configuration, two 250-watt mono amps are mounted on a single 3½-inch thick rack-mountable package weighing 18 pounds. Power supply is a pulse-width regulated switching type operating on either 115 or 220 V at either 50 or 60 Hz. The unit is furnished with an LED bar graph to display output levels. At 18 pounds there obviously are no large heat sinks involved, but a small fan is provided for horizontal cooling so the amplifiers may be stacked in rack mounting. Price of the Spectron Class D amplifier is expected to be around $1,500.

Towers of Power

For some time now, a company named VMPS Audio Products has been advertising in the classified advertising section of *Audio*. They manufacture columnar-type loudspeakers, utilizing multiple driver units and making some fairly outrageous claims for performance, and all at quite modest prices. Lo and behold, in my journeys through the corridors of the Jockey Club, I found a demonstration room for this company, which turns out to be a division of Itone Audio of El Cerrito, California. I must confess that I was preconditioned to this type of loudspeaker, having heard many examples, mostly of foreign manufacture. For the most part, they were sonic abominations, usually characterized by incredibly boomy exaggerated bass, midrange peakiness, shrill and searing high frequencies, no depth, no imaging, and every sonic coloration you can imagine. When I walked into the room, my heart sank because there was this huge black column standing 83 inches high, covered with assorted sized speakers from top to bottom. Determined to hear this "thing," I gritted my teeth, activated my auditory protective filters, and asked the young fellow in charge for a demonstration. Well!!! It is rare that anything in audio surprises me after all these years, but I was literally flabbergasted by hearing some of the best sound at the Show! Partly my shock was the totally unexpected reaction to hearing such excellent sound from what previous experiences had led me to expect would be the worst. It didn't take long to find out that the enthusiastic young man in the room was company president and designer of the speakers, Brian Cheney. He is a veteran audiophile and a devotee of the minimum phase-response theories of *Audio's* Dick Heyser. VMPS Audio manufactures four speaker systems, the Mini-Tower 2, Tower-2, Super Tower, and Super Tower-2, the system to which I had been listening. All are of the minimum phase-response configuration and are sold either fully assembled or in kit form at considerable savings.

Because of space limitations, I'll concentrate on the top of the line, the Super Tower-2. There are a total of 16 drivers in each of these speakers. One 15-inch driver is bottom-firing and slot loaded; another 15-inch driver is front-firing. This is the subwoofer section. Then come two 12-inch low-bass drivers with staggered resonances and compliances. Next is a 12-inch mid-bass coupler. Midrange is handled by four 5-inch butyl surround drivers with staggered resonances. Five 1-inch soft dome tweeters are in a vertical line source array, and two piezo-horn supertweeters are at the top of the line source. The speakers are sold in mirror image pairs, and either full range or bi-amp operation is possible without external crossover. Bi-amping is recommended for the Super Tower-2, and Brian Cheney was demonstrating them in this mode using Bedini Class A, 100 watt/channel and 25 watt/channel amplifiers.

Doesn't sound like much power? Well, the efficiency of the Super Tower-2 is 103 dB at one watt/one meter. If you would like to feed in the maximum 500 watts, you will get a chest-squeezing 132-dB output! If you want bass, the -3 dB point of low-frequency cut-off is 17 Hz. Cheney is very proud of the fact that he can quote distortion figures for the Super Tower-2 at less than 0.25 percent THD, 22 Hz to 30 kHz, with one-watt input. He played a variety of music, all of which was very smooth and clean, highly detailed with tight, rock-solid bass fundamentals, minimal coloration, and in spite of the multiple drivers, no sense of disparate sound sources. Imaging, in fact, was quite good. Then Brian played the Telarc *1812 Overture*, and not only were the cannon reproduced with gut-thumping power, but you heard the real low-frequency fundamental with no doubling.

I am certain that this speaker is one of the few that will have no difficulties handling the dynamic range of true digital recordings when they finally arrive on the audio scene. You can buy the kit version of the Super Tower-2 for $799. The cabinet is fully assembled, and Brian states that about five hours of work installing the drivers is about average. For those who don't dig kits, the speaker costs $1,299 in black and $1,499 in rosewood. Prices quoted are for each speaker. Warning: The Super Tower-2 is a BIG speaker and shipping weight is 300 pounds. The moral of this tale is obvious — even if the speaker looks a bit weird, take time to have a listen.

Cartridge and Arm Wrestling

There are those who will tell you that the analog disc and the phono-

FOR $275;* DBX TECHNOLOGY BRINGS YOUR HOME RECORDING SO CLOSE TO DIGITAL, IT'S ABSURD.

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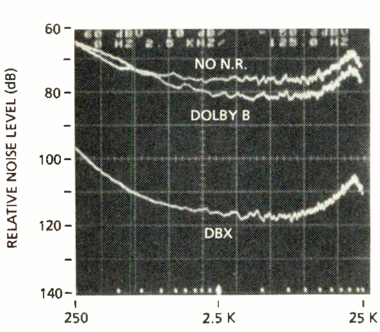
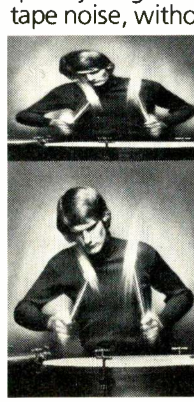
As for noise reduction, nothing on the market comes close to the Model 224.



Dolby reduces noise by only 10dB at best, and only in the high frequency range. dbx virtually eliminates tape hiss, reducing it by more than 30dB across the entire frequency range. (Unretouched laboratory photograph. Data from "The Importance of Dynamic Range," Audio Magazine, January, 1980. For a copy of the article, write dbx.)

The Dolby®** system you've been putting up with certainly doesn't. It only reduces tape noise by 10dB at the most, and only in the high frequency range.

Compare that with the dbx Model 224, which reduces tape noise by more than 30dB across the whole frequency range. It virtually eliminates tape noise, without adding any audible distortion or changing the tonal character of the sound.



The result is a difference you can easily hear. In fact, you'll be able to record quiet music passages that would be lost in tape noise with any other system.

Conventional tape recorders limit dynamic range. With the dbx Model 224, you can get the dynamic range approaching that of a live performance.

DYNAMIC RANGE APPROACHING DIGITAL.

The Model 224 also gives you something else you've never heard before from a tape recorder: full dynamic range.

Dynamic range is the difference in volume between the loudest and quietest passages in a piece of music. It's just as important to the realism of music reproduction as flat frequency response, or accurate spatial perspective.

And although live performances – and digital master tapes – go up to 90dB of dynamic range, even the best home recordings have been limited to only about 50dB. So no matter how good your recorder is, you've been missing at least one third of your music's dynamic range.

Well, the Model 224 gives you the capability to record an unprecedented 85dB on open reel and 80dB on cassette.

So for the first time, you can make live recordings that capture virtually all the dynamic range of the original music.

In addition, the Model 224 is the only system that lets you tape fine audiophile records without losing *any* of their dynamic range.

And you can use the extra head room provided by the 224 to dramatically extend frequency response and minimize distortion during recording.

As if all that weren't enough, you can use the 224 to play dbx Discs, the Full Dynamic Range Recordings that deliver up to 90dB of music dynamics with negligible surface noise. Because the 224 includes the decoding system that makes your present stereo compatible with these phenomenal new discs.

HEAR IT TODAY.

The sound of digital recording really is here. Dynamic range approaching a live performance. Music heard against a background of virtual silence. And a purity of sound that's never been possible before in home tape recording.

Visit your authorized dbx retailer today for a demonstration of the dbx Model 224.

We think you'll agree with us. For $275, you'd be crazy to pass it up.

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*Manufacturer's U.S. suggested retail price: actual price set by dealers; rackmount kit available at additional cost.
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graph cartridge and arm are in the twilight of their long history, that there is little technological progress that can be made or is worth bothering about before this music reproduction system sinks into oblivion. It has been said many times before. But when stereo tape threatened their existence, we learned how to put two channels of sound in the grooves. The quadraphonic sound era started with tape, but even with that, we figured out how to put four channels of sound in the groove. This time, maybe digital audio will indeed knock the tough old analog disc out of the ring. Perhaps it is inevitable, but there are some pretty sharp marketing people who think the ultimate demise is still a long way off and that further refinements can be made in the existing technology.

For all his genial exterior, Dave Fletcher of Sumiko, importer of the Supex moving-coil cartridges and other assorted phono gear, is a very savvy and canny guy. He's figuring that his segment of the high-end phono market is still very much interested in upgrading the quality of its phono reproduction, hence his marketing hand-made Koetsu moving-coil cartridges, at $1,000 each. Similarly, he is introducing what will be known as The Arm, a high-technology design using super-precision bearings expected to sell for a cool $1,100! You don't think audiophiles will pay these prices? With inflation whittling the dollar's value down to 48¢, it's possible.

In the same rarefied area, Dynavector has recently introduced what they call their DV-Karat and DV-Karat Diamond moving-coil cartridges. There is much new technology here, including the fact that the *cantilever* on the DV-Karat is made from solid synthetic ruby, while the DV-Karat Diamond, rather incredibly, has a *solid diamond* cantilever. Moreover, the cantilevers are very short, only 2.5 mm rather than the usual 6 or 7 mm. I had the pleasure of meeting Dr. Tominari, President of Dynavector and inventor of these cartridges. He was Prof. of Mechanical Engineering at Tokyo University, speaks fluent English, and we had some interesting discussions about these radical cartridges. In order to mount the diamond stylus in the cantilever, a special new type of laser "drilled" the very tiny hole. The cantilevers themselves are specially ground and polished from blocks of ruby, sapphire, or diamond. The coils are very tiny and wound with silver wire, while the magnet is of the new samarium cobalt rare-earth type. Unlike most moving-coil cartridges, these have relatively high compliance and are meant to be used in low-mass arms. Tracking force is also low, 1.5 grams optimum. Dr. Tominari pointed out that because the cantilever is so short and Karat Diamond is composed of the hardest material known, wave propagation is very fast.

I have been using the diamond cantilever cartridge recently, mounted in the Technics EPA-500 arm. The total weight of the Diamond Karat is but 5.3 grams and, mounted in this Technics arm tube specifically designed for the compliance range up to 15 x 10^{-6} cm/dyn (which just happens to correspond with the cartridge compliance), arm/cartridge resonance interaction is minimal. As you might expect, tracking is superb. The sound is exemplary in every aspect and is the best I have heard from a moving-coil cartridge. The greatest point of superiority, most probably due to the short diamond cantilever and the fast wave propagation pointed out by Dr. Tominari, is the blazing fast transient response. Playing a direct-to-disc recording like the M & K release of Ed Graham's **Hot Stix** is a revelation. With cartridges like this and other ongoing developments, there is bound to be life in the old discs yet!

ADCOM INTRODUCES BALANCED POWER

AT A PRICE THAT WON'T UNBALANCE YOUR BUDGET.

At Adcom, we firmly believe that the primary justification for introducing a new piece of equipment is superior performance. And, if we can do it at a modest cost, so much the better.

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No amplifier we know of offers such exceptional performance at such an affordable price, only $400.* Indeed, despite the wealth of sophisticated equipment available today, we know of no amplifier *at any price* that is significantly better.

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But high power was not the only or even the most important design consideration. Special attention was paid to reducing transient intermodulation distortion (TIM) and slew induced distortion (SID). Since it has been demonstrated that these two forms of distortion are largely responsible for the coarse or grainy quality known as "transistor sound," a characteristic common to many amplifiers that otherwise measure out well.

In large part, the outstanding performance of the GFA-1 is directly attributable to a singular design innovation, Adcom's "Balanced Bridge™" output configuration.

Unlike conventional amplifier circuits which drive only one terminal of the loudspeaker and fix the other terminal at ground, the Balanced Bridge drives both sides of the loudspeaker 180 degrees out of phase. Consequently, power supply voltages are reduced and the output devices are operated very conservatively. More important, this configuration results in a perfectly balanced design that is fully complementary and symmetrical from input to output.

The same meticulous attention to detail lavished on the design of the output section of the GFA-1 is equally evident in the design of the power supply.

Instead of the massive and comparatively inefficient power transformers found in conventional amplifiers, the Adcom GFA-1 employs a specially wound toroidal transformer for better power regulation and greater efficiency. Moreover, the toroidal transformer which is smaller and weighs less affords greater magnetic field concentration and minimizes stray field effects for lower hum and noise.

To insure continuous safe operation at high power levels, the Adcom GFA-1 has a built-in fan that silently directs a continuous stream of cool air over the output transistors. And in the unlikely event the output devices should overheat, a thermal sensor automatically cuts off power to prevent damage.

In sum, the Adcom GFA-1 represents a unique achievement in amplifier design. A near perfect balance of power and inaudible distortion. A serendipitous balance of performance and price.

For additional information on the benefits of Balanced Power, both audible and financial, as well as the name of your nearest dealer write to Adcom, 9 Jules Lane, New Brunswick, N.J. 08901.

ADCOM™ GFA-1 POWER AMPLIFIER

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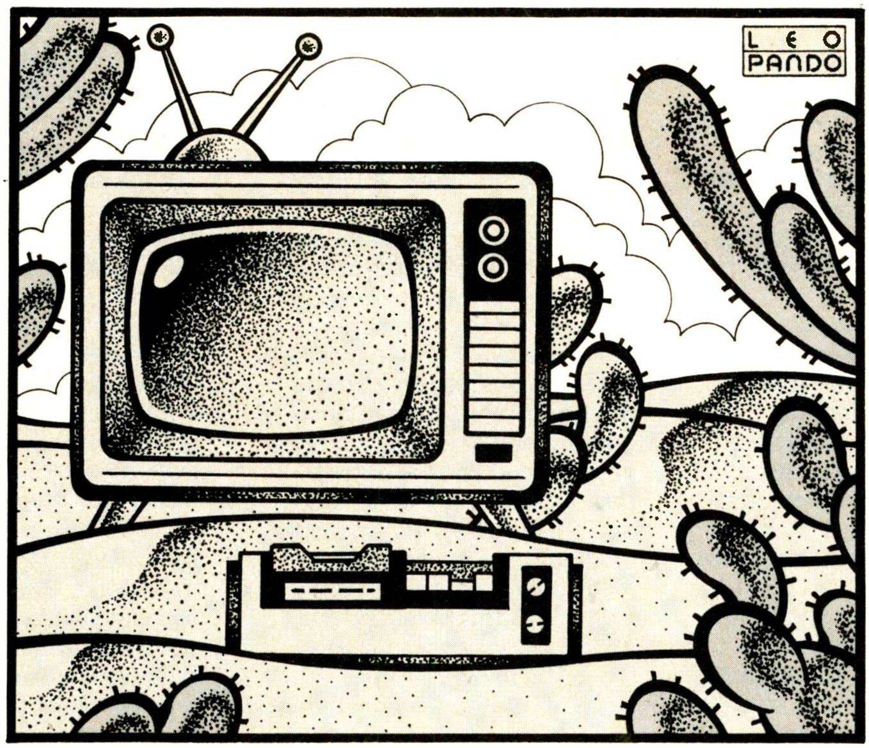
Video Scenes

Bert Whyte

At the Winter CES in Las Vegas, the world of video didn't enter the 1980s with a whimper instead of a bang, but neither did it really stir up much of a commotion. Among dealers and reps there was much moaning and gnashing of teeth because "The VCR market was soft in 1979 and didn't meet sales expectations," "Profit margins in VCR sales have been badly eroded," and above all, "The public is resisting the VCR because the prices are still too high." While the naysayers have some valid points, the old "cool hands" are aware that video is an evolving market and that those who are making the most noise are "fast buck" artists who fail to see the tremendous potential of all aspects of the video market.



While there were some interesting new products and developments at the CES, the biggest news came after it ended. As I am sure you are aware, the video disc has been considered the bright hope of the future, a glamor product that is the key to a vastly profitable new market. Needless to say, everyone wants to get into the act, which is why we have a profusion of video-disc systems, virtually all of which are incompatible.

After the abortive Teldec effort in Europe, the Magnavox/Philips laser/optical video disc managed to get on the American market (albeit in just three cities) in 1979. RCA, which has made a number of announcements about the imminence of their video-disc system, swears they are committed to the introduction of their stylus/groove capacitance-type SelectaVision video disc early in 1981. They have poured some $130 million into its development, with special production equipment for the player and the disc, designated factories, etc. Unlike the Magnavox introduction to a few selected test markets, the RCA plan calls for nationwide distribution.

Video-Disc Sweepstakes

The really stunning news is that at this early stage of development, CBS and Zenith have entered into agreements with RCA to become licensees for RCA's SelectaVision video discs. Traditionally, these corporate monoliths have always been worlds apart on technological developments. Who can forget the 33⅓-rpm versus 45-rpm record-speed war in the early '50s? Having RCA and CBS involved in a joint venture is roughly akin to Yassir Arafat and Menachem Begin becoming lodge brothers. There is no doubt that with RCA and CBS behind SelectaVision, it will be a formidable contender as a standard for video discs. But wait. Although SelectaVision is said to afford a high-quality color picture, in its present embodiment it is a relatively simple system. Unlike some of its competition, it does not offer such features as slow motion, still frame, and other special effects. Most importantly, SelectaVision presently does not afford stereophonic sound. While it is true that American television has monophonic sound, one of the ongoing attractions of some of the video-disc systems is their capability of stereo sound with the video playback, as well as music recordings with true digital stereo playback. To get SelectaVision on the market for the target price of under $500.00, the basic monophonic unit is probably necessary and adequate, but stereophonic sound capabilities must surely be a future consideration.

Another new development may have a bearing on the ultimate capabilities of the SelectaVision video disc. Matsushita, OEM supplier of VCR units to RCA, has decided to put its VISC stylus/groove video disc system on the back burner, so to speak, and concentrate instead on the company-owned JVC grooveless/capacitance video-disc system. The JVC VHD (video high density) video disc permits slow motion, still frame, and many other effects, plus digital stereo sound with video playback. The bonus here is the JVC AHD (audio high density) discs, which afford digital stereo sound playback of music recordings with the addition of a PCM adaptor costing under $500.00. It certainly is not inconceivable that, since the SelectaVision and JVC video discs are both of the capacitance type, these similar technologies might merge. The result could be a compatible video disc which may well be considered as a basis for standardization.

Meanwhile, Magnavox is having its problems. For one thing, the price has increased to $775 for their player and up to $24 each for the video discs. This has raised some speculation that these

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...Magnavox has gained an ...sely powerful ally — none ...ther than IBM. MCA, the big entertainment conglomerate (Universal Pictures, etc.) was in partnership with Magnavox on the Magnavision system and, with their extensive backlog of feature films and TV productions, were to make the bulk of the Magnavision discs. IBM acquired 50 percent of the MCA interest in MCA/Magnavox, and then IBM and MCA formed a new company, Discovision Associates. This new company bought half interest in Universal Pioneer Corp., whose function is to build Magnavision playback machines.

All this big-business wheeling and dealing aside, with the huge financial and engineering research resources of IBM and their expertise in high-density data storage and retrieval in several varieties of discs, it is likely that they can resolve the problems with the Magnavision discs and the laser playback units. Obviously, with giant IBM in their corner, you can't count Magnavision out of the video-disc sweepstakes.

VCRs at CES

As to what was new in video at the CES, it was mainly a matter of new longer playing, programmable VCRs from both the VHS and Beta camps. It is now obvious that VCR users are sensitive to the high (and rising) costs of blank video cassettes. Thus, maximum playing time is more important to many, even if it is accompanied by a loss in picture resolution. The longer playing times, plus the special features of slow motion, freeze frame, etc., make stringent demands on the video tape, especially the thinner formulations. Maxell has introduced Epitaxial HG (high grade) cassettes for VHS machines that afford six-hour playback (tape speed is ⅓ original VHS speed). TDK has followed suit with Super Avilyn HG, and you can be sure other blank-tape manufacturers will soon have similar products.

New six-hour, programmable VHS VCRs were offered by RCA (OEM from Matsushita), Panasonic, JVC, Quasar, Hitachi, and others. In the Beta camp there is the new Sony SL-5600, capable of all three Beta playback speeds so cassettes from the earliest and subsequent Betamax units will be playable on this model. It is a $1,350 VCR with 14-day programming and "Betascan," the scanning system enabling multispeed program search with recognizable pictures. Longer playing (5½ hours) Beta VCRs were also shown by Toshiba (V5425) with forward- and reverse-search modes, and Zenith, also with speed-search facilities. Typical of the VHS long-playing units was the JVC HR-6700, which has two video heads for two-hour playback and two video heads for six-hour playback. Their double-speed-search system allows picture recognition without "monkey chatter" effects on the audio track.

Toshiba did indeed produce its LVR (longitudinal video recorder), Model L-10A with mechanical tuner at about $500.00, and a fancier, more expensive Model L-10S with electronic tuner and remote control. Toshiba insists these are production models and will be available before the summer. The simpler LVR mechanisms (with implied higher reliability) and lower prices are undoubtedly attractive, but some observers feel that the present limit of two-hour playback time can be a significant drawback. Toshiba obviously beat BASF to market with its LVR, but BASF's California plant for manufacturing their LVR machine is now under construction.

Sanyo made some VCR history by offering the first commercially available digital music cassette — Ry Cooder's **Bop 'Till You Drop.** This Warner Bros. production was recorded with their 32-channel 3M digital recorder, and the Sanyo cassette was duped from the digital master. The format is Beta, the cassette costs $25, but you must acquire Sanyo's Plus 10 PCM adaptor at $3,995 for playback. Sanyo emphasizes the Plus 10 PCM unit is a *production* model, available in March of 1980, and it can be used with either Beta or VHS VCRs. You have to admire Sanyo's enterprise, but until we get VCR units with integral PCM on LSI chips, the market for digital cassettes will most likely be minuscule.

Toshiba, which introduced the first programmable TV console, has developed a remote-control 19-inch CA-975 TV set capable of programming up to six programs per day, 24 hours in advance. RCA and Gold Star have similar units, and others are sure to appear.

Heavenly Television

All aspects of the video scene are progressing at a pace that is bringing yesterday's "far-out" ideas to commercial reality much sooner than anyone could have imagined. Speaking of "far out," the really mind-boggling idea of home reception of earth satellite signals is gaining in interest mainly because it is now possible to achieve this at costs that are considered commercially viable. To receive the signals of Comsat, Satcom, Westar and other communications satellites parked in orbit above the U.S. and Canada, you need an 8- to 10-foot parabolic dish antenna, low-noise signal-boosting amplifier and special receiver.

Such equipment is available from a number of American firms, at about $10,000 and up; a good installation would average $15,000 to $18,000. However, a company called Telecommunication, Inc. has teamed up with an equipment manufacturer, Scientific Atlanta, and, purportedly, for an installation fee of $3,000 and a monthly rental of $150, they'll set you up to receive satellite signals. With this service you have an incredible variety of programming to choose from: Nine or so pay-movie channels, special news service and sports channels, religious channels, educational channels and, in addition, FM "super stations" like WFMT in Chicago. There are perhaps over a million households out in the "boonies" which cannot receive normal TV or FM signals. Remember, both TV and FM transmissions are horizon-limited systems; even with transmissions from the top of the 1400-foot Empire State Building in New York City, about 40 miles is about the limit of acceptable reception.

But even forgetting the benefit of earth satellite receivers in isolated locations, think of the fabulous programs one could enjoy. Imagine a live concert of the London Philharmonic Orchestra in Royal Festival Hall, with the excellent BBC microphone pick-up techniques. The transmission is beamed to the British/European satellite, most likely picked up by the big dish at the Goldstone tracking station in Maine, relayed to a Satcom or some other U.S. satellite, and thence down to your backyard dish antenna. Real live symphonic music, received with superb wide frequency-response quality. What a glorious prospect! The same applies, of course, to TV reception of live opera, ballet, drama, etc. With something so desirable and exciting as earth satellite reception, costs are sure to keep declining, and I'm going to be watching this development very closely.

Tape guide

Herman Burstein

Which Is the Real Tape Playback Curve?

In *Audio* magazine, tape playback equalization at 7½ ips has been pictured in the manner of Fig. 1, with pronounced bass boost. Elsewhere it has sometimes been presented in the manner of Fig. 2, which shows quite the opposite — bass cut and treble boost. The uninitiated reader may well wonder which is correct.

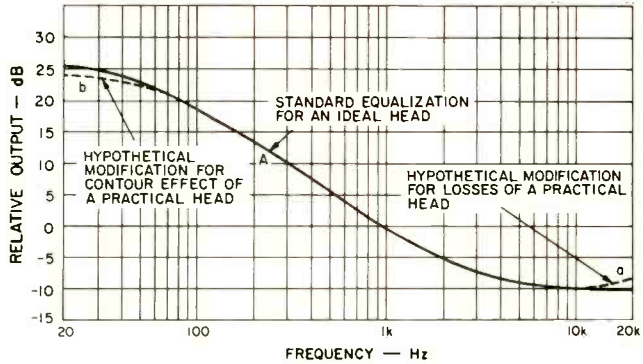
They are both correct but approach the subject from different viewpoints. Before going on, it should be noted that the following explanation applies in principle not only to playback equalization for 7½ ips, but also to equalization for other tape speeds and for various cassette tape formulations.

Conventionally we think of equalization as a change in frequency response performed by an electronic circuit. For example, an FM tuner provides treble cut in order to compensate for the treble boost applied by the broadcast station; this strategy helps reduce noise. A preamplifier provides both bass boost and treble cut when a magnetic pickup is employed to play a phono disc; this compensates for the bass cut and treble boost employed in disc recording to minimize distortion at low frequencies and noise at high frequencies.

Turning to tape, we find that in the complete absence of equalization, record-playback response would take the shape of an inverted U: A combination of severe bass loss and severe treble loss. Bass loss is due to the intrinsic nature of a magnetic playback head, which responds to the rate of change of the signal, so that output varies with frequency. Given a flat signal (constant flux in its core), the head produces an output signal that changes at the rate of six dB per octave as frequency changes. The change in output with frequency may be viewed as either bass loss or treble rise. Here we refer to it as bass loss.

Further, owing to the contour effect—where the playback head as a whole and not only its gap responds to the recorded signal—a practical head may produce somewhat greater output than an ideal head in the low bass region. Thus, Curve A in Fig. 1 might be modified slightly, as shown by Curve b. All in all, however, the playback equalization called for in order to achieve flat response is quite close to

Fig. 1—Standard tape playback equalization at 7½ ips for an ideal magnetic playback head.



that of Curve A in Fig. 1.

In 1965, to emphasize the fact that playback equalization must reflect the irregularities of a practical head, and to get away from the notion that a playback head must inevitably have a six-dB-per-octave characteristic, the NAB (National Association of Broadcasters) decided to present standard playback equalization in a different manner, that of Curve B in Fig. 2. This practice was also adopted by the RIAA (Recording Industry Assoc. of America).

Figure 2 considers the playback head, as well as the playback electronics, part of the playback equalization system. Given a flat signal (constant flux in the core of the head), it indicates that the playback head and the amplifier electronics should *in combination* produce the output of Curve B in Fig. 2—treble boost and bass cut.

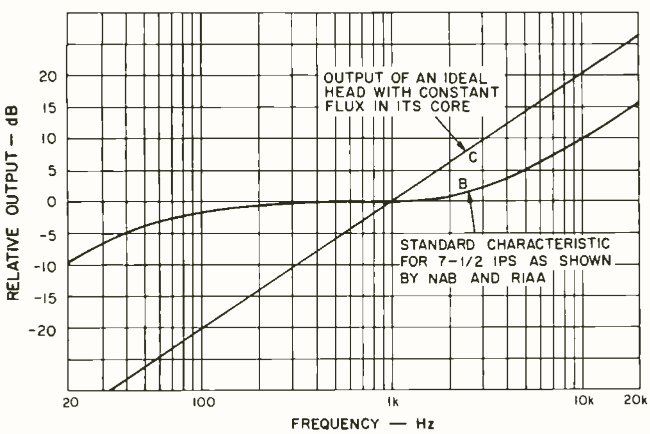
But the output of a magnetic playback head tends to rise six dB per octave with frequency, as shown by Curve C in Fig. 2. Therefore, the difference between Curves B and C must be the equalization supplied by the playback electronics. Specifically, the *difference* between Curves B and C in Fig. 2 is equal to Curve A in Fig. 1.

One way to see this is to plot the difference between Curves B and C on audio graph paper. A second method is to turn Fig. 2 about 34 degrees clockwise until the six-dB-per-octave line (Curve C) is horizontal. In reference to this line, it may easily be seen that equalization supplied by the playback electronics consists of bass boost.

Another way of describing Curve B is that it shows the electronic equalization that would be required if the output of the playback head were flat instead of rising six dB per octave. A Hall-effect head, which has long been in the offing, would have flat output. But up to the time of this writing, playback heads have universally had a six-dB-per-octave characteristic. Therefore, if you measured the playback equalization of a 7½-ips tape deck, you would obtain something quite close to Curve A in Fig. 1.

Similarly, at other tape speeds and for the various cassette tape formulations, you would find that playback equalization supplied by the deck's electronics consists primarily of bass boost.

Fig. 2—Standard reproducing characteristic: Reproducing amplifier output for constant flux in the core of an ideal reproducing head.



BUILD A HEADPHONE CROSSFEED CIRCUIT

Charles Repka & Paul Berkowitz

The late Dr. Benjamin Bauer, a man of many talents, made innumerable contributions to a broad spectrum of areas in the audio field. One of his major interests was psychoacoustics, as evidenced by his work in the development of the SQ matrix and his earlier work in the area of binaural hearing.

In the early 1960s, it was observed that in listening to stereo recordings via headphones, an exaggerated stereo effect is heard as compared to the sound of the same recording via loudspeakers. Research by Dr. Bauer and others revealed the main cause of this effect is the lack of the acoustic crossfeed between the left and right ears that occurs naturally when listening to either live music or recordings through loudspeakers. Another factor is the absence of the natural loss of audible separation at low frequencies because of ear spacing. The use of headphones, acoustically isolating the left ear from the right, removes the crossfeed, exaggerates the low-frequency separation, and produces the unnatural spatial effect.

With this knowledge, Dr. Bauer proceeded to design several circuits which electrically simulated the acoustic crossfeed. Figure 1 shows the circuit devised to drive low-impedance phones, while Fig. 2 shows the version for high-impedance phones, Fig. 3 shows the frequency response and separation produced by either of these circuits. Note that the response below 200 Hz is essentially mono. For a short while, these circuits were produced commercially and incorporated into the Jensen Model CC-1 headphone control center, although this unit has not been available for some time.

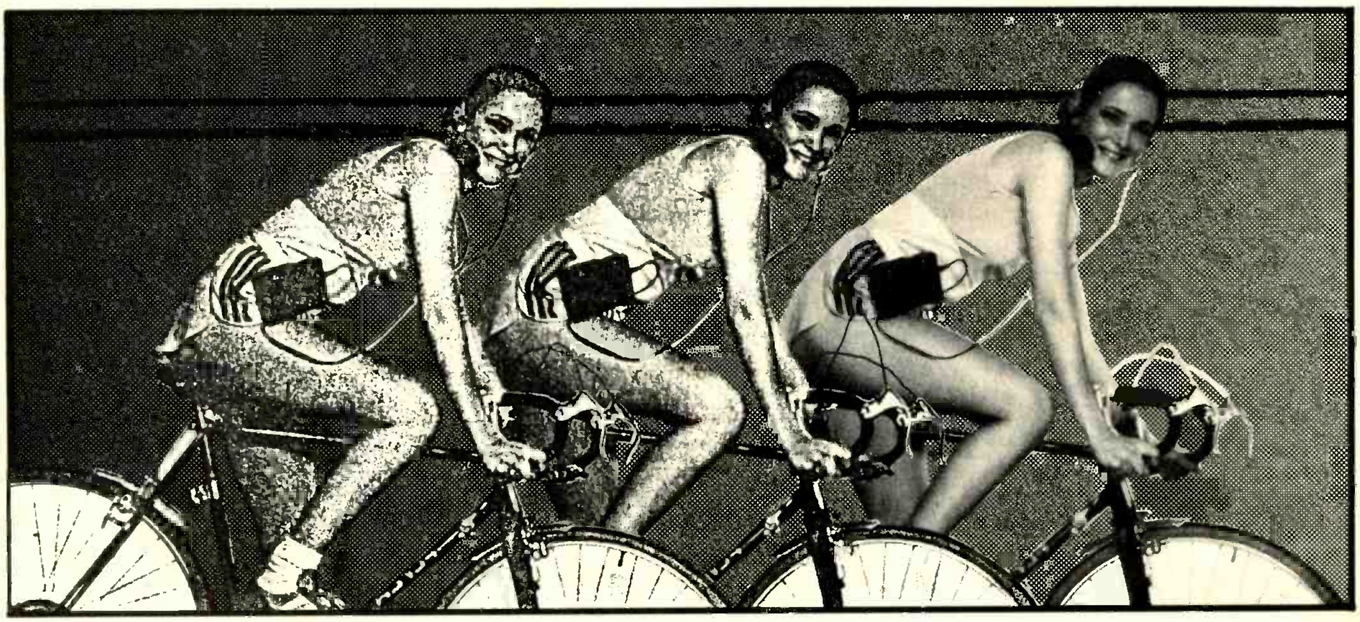
Not too long ago, we became involved in a project to produce a series of recordings designed specifically for headphone listening. Since the cost of making several dozen new recordings using binaural techniques was prohibitively expensive, we decided to investigate the possibility of using the Bauer circuit to convert existing conventional stereo recordings into binaural recordings by passing the signal from the master tapes through the Bauer circuit and then re-recording the modified signal.

We first tried using the Jensen control center circuitry, but this approach proved impractical because of impedance mismatches that caused large signal losses. The Jensen unit had been designed for connection to the output of a power amplifier and to reduce the output signal to the milliwatt level required by a typical pair of headphones.

We then decided to design an active filter equivalent of the passive networks designed by Benjamin Bauer. After consultations with Dr. Bauer, who was very generous with his advice, and some help from a circuit-analysis computer at Columbia University, Paul Berkowitz came up with the circuit shown in Fig. 4.

This circuit is easy to build and does not require any special parts or critical layout. We built our version using a scrap piece of vector board and buss wire and used 741 and 301 ICs because that's what happened to be handy at the time. Actually, any decent linear IC can be used for all stages.

The blend control, R20, was added as an afterthought. Originally, we merely had a switch that allowed us to insert the circuit into the signal path but decided it would be useful to have some means of adding the circuit gradually into the



signal as well as controlling the amount of blend. The 10-kilohm pot does this quite nicely.

Although the binaural record project never got off the ground, we were left with this handy little circuit. It does not have to be used with a tape recorder but instead can be used with any preamp. The circuit can also be monitored either on the preamplifier's own headphone output or, if more power is needed, via the power amp.

The Bauer circuit, in either active or passive form, is very effective in eliminating the unnatural "ping-pong" stereo that occurs when conventional recordings are heard through headphones. This new active circuit, however, provides the added flexibility of variable separation.

Reference

1. Bauer, Benjamin B., "Stereophonic Earphones and Binaural Loudspeakers," *Jour. of the Audio Engineering Society*, Vol. 9, No. 2, 1961.

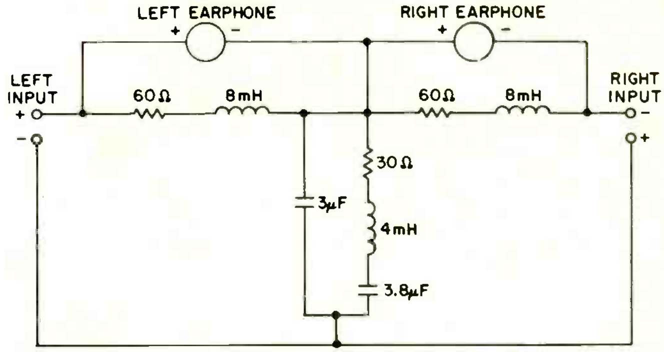


Fig. 2 — Original passive circuit for high-impedance headphones designed by Bauer.

Fig. 1 — Original passive circuit for low-impedance headphones designed by Benjamin B. Bauer.

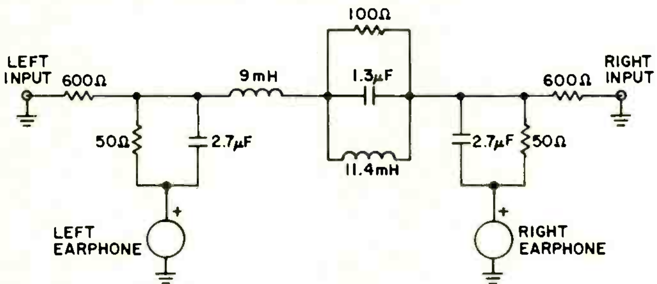


Fig. 3 — Performance of circuits in Figs. 1 and 2.

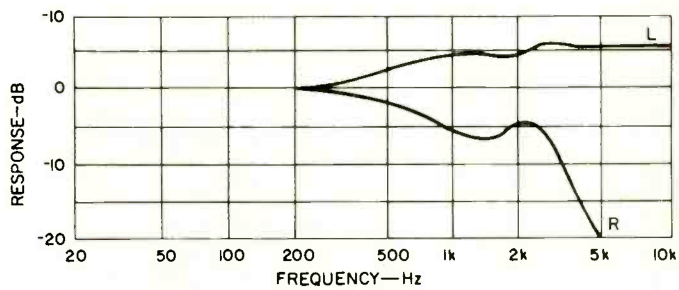
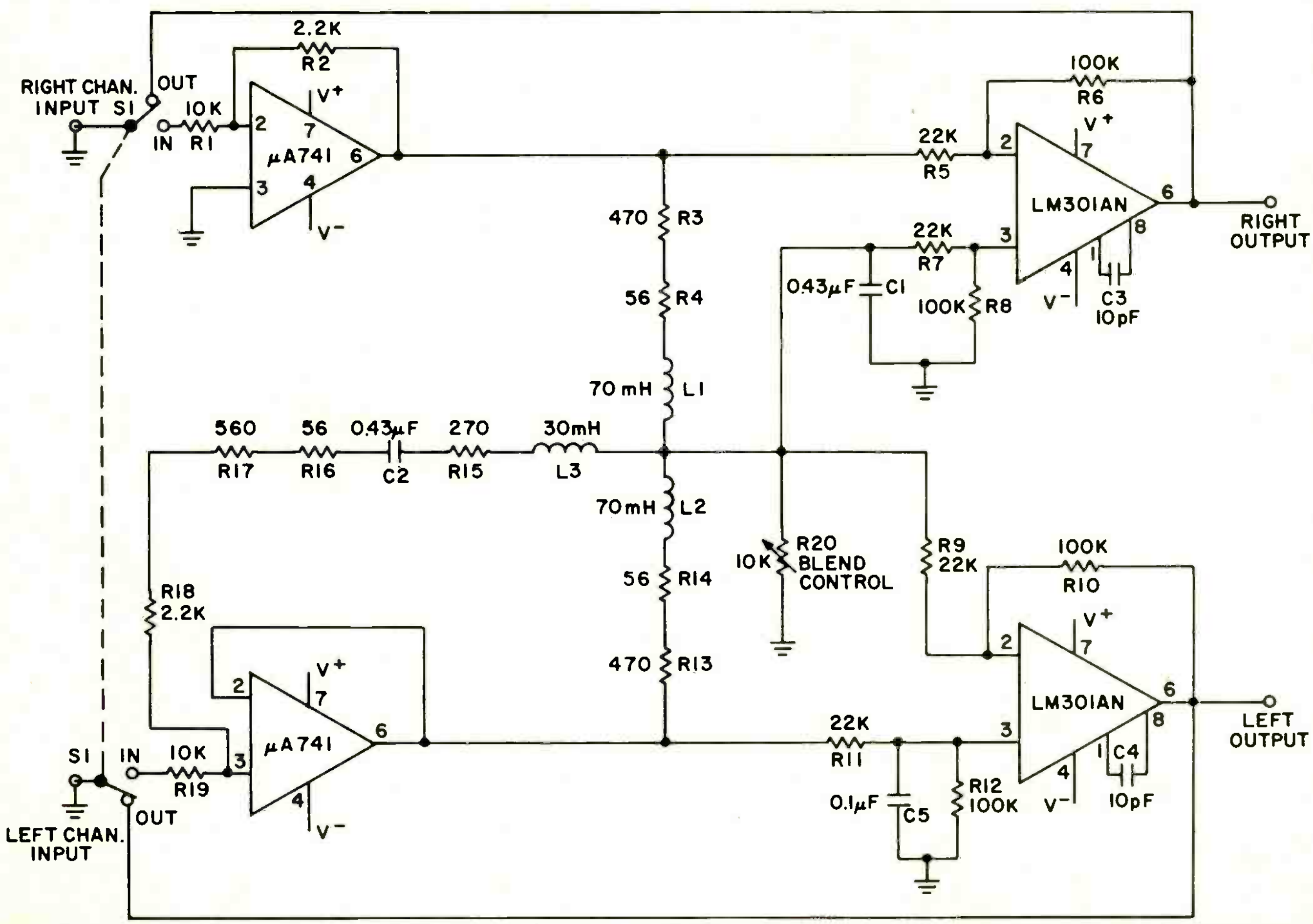


Fig. 4 — Active-filter Bauer circuit.



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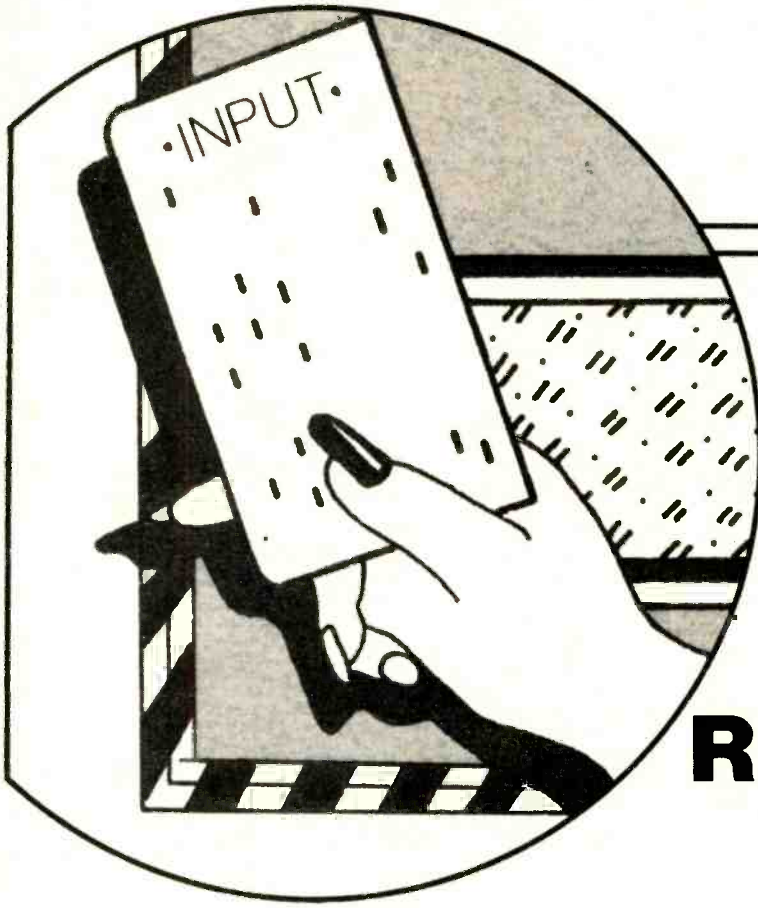


Digital Techniques In Sound Reproduction

Daniel Minoli*

Signal Processing

The advances in acoustic signal processing techniques we describe below have been brought about by the needs of the telecommunications industry to provide (relatively) noise-free telephony over ultra-long distance (intercontinental) calls and to achieve better throughput from existing facilities.

Before we proceed further into signal processing aspects, which is the key subject of this article, we want to point out that computers (which, as discussed in Part I, speak only digital language) also must communicate to distant locations via telephone lines. To do this, and here is the amusing point, computers still in large part must convert this digital stream into an analog stream — the telephone does not transmit square waves very far. A device to do this coding at one end and decoding at the other is called modem and operates (in its simplest form) by coding a 0 with a single sine wave tone at 2025 hertz and a 1 with a sine wave of 2225 hertz. In the telephone audio band, this is all that is required to achieve communication.

How, then, can a wave be converted to and from digital form so the advantages of digital processing can be realized? Broadly speaking, there are two approaches to the conversion problem. Waveform digitization methods take samples of the waveform and represent the sampled waveform amplitudes by digital, binary-coded values. At the other end, the digital signals are converted back to analog form in an attempt to reconstruct the original speech waveform. As the name implies, these coders essentially strive for facsimile reproduction of the signal waveform. In principle, they are designed to be signal-independent, hence they can code equally well a variety of signals — speech, music, tones, wideband data. In contrast, vocoder methods make no attempt to preserve the original speech waveform. Instead, the input signal is analyzed in terms of standardized features, each of which can be transmitted in digitally coded form. At the other end, these features are reassembled and an output signal is synthesized [3.]

The vocoder approach is finding excellent applications to the transmission of speech, particularly where extremely low bandwidth (20 Hz to 1000 Hz or approximately 50 to 2400 bits per second) is needed and for secure, encrypted applications. These devices are still very expensive ($12,000-$15,000 and up), and the underlying techniques cannot be used in a general musical context unless (1) one either knows exactly the instrument playing and this must be in a solo application since the vocoder is tailored after the acoustic entity it is trying to synthesize, or (2) one uses a vocoder to get a synthetic voice — say synthetic operatic voices (do not confuse this with any of the existing musical synthesizers; to my knowledge, no one has yet tried what we advocate here).

Before we continue, let's look at a graphic example which

***International Telephone and Telegraph**
Domestic Transmission Systems, Inc.
New York, N.Y.

Illustration: Wayne Bressler

makes the distinction between the two methods unequivocal. Think of waveform coding techniques, such as pulse code modulation (PCM), as cooking a delectable cake in Paris, then using an SST to carry the cake to New York, in a well-heated oven, for delivery to a fancy restaurant. Think of vocoder techniques as getting in touch with a renowned cook in Paris, writing down his receipe on a piece of paper, mailing the receipe to the New York restaurant we are considering, and baking the cake in New York. The benefits/drawbacks of each method are clear. The first is clumsy and requires a lot of space and special handling, but you get the original, authentic product. The second method is elegant, concise, and quick, but you get a replica (not always 100 percent faithful) of the product.

Interestingly, a software/hardware trade-off between the two approaches exists. Assume we were thinking of coding human voice, so that the vocoder could be used; suppose also we needed to put 20 hours of speech on some software disc. If we use vocoders, the recording/reproducing hardware would be expensive, but the software would be cheap since you could put the entire 20 hours on a single disc (by assumption). If we use PCM, the recording/reproducing hardware is inexpensive (we only basically need A/D, D/A devices as described below), but the software would be expensive since you now need 20 discs to store the same information. This type of trade-off consideration is done everyday in the telecommunications industry: If the call has to go across town, use PCM; if it has to go to Europe, vocoder techniques may be more cost effective.

A digital audio system can be viewed as containing six distinct sections — input analog, analog-to-digital conversion, digital processing, digital storage, digital-to-analog conversion, and output analog. By comparison an analog/digital/analog system is composed as follows, input analog, A/D conversion, digital processing, D/A conversion, analog storage, analog output. Although the two conversion subsections can be designed using any number of waveform coding techniques, they can all be analyzed as information transformations between the analog and digital domains. This provides a unifying structure for examining conversion without regard to implementation.

The analog world (or domain) is characterized by variables that can take any value within a specified range; for example the temperature can be 65, 65.21, 65.211723 degrees F., etc.; an electrical current can be 0.5, 0.55, 0.5592662, 0.5592663 V. (However, if we add the concept of analog noise, then the resolution cannot be any better than the noise value. If, for example, the noise magnitude was on the order of 0.001 V, we might elect to say that the last two voltages could be considered as having originated from the same "true" value and that the difference can be attributed to noise; the additive noise limits the analog resolution in that the ability to distinguish two voltages is impaired by noise.) We can say that *infinitely* many values can be assured by the analog variable.

We have already seen that in the digital domain we can only represent a *finite* set of values: The size of this set, and the preciseness (significance) of the digital quantity is a function of the code we have elected to use. With two bits we can represent four numbers; these can be: 00=0, 01=1, 10= 2, 11= 3; or 0.0 = 0, 0.1 = 0.5, 1.0 = 1, 1.1 = 1.5; or .00 = 0, .01 = 0.25, .10 = 0.50, and .11 = 0.75. If we need more resolution or range, we need more bits.

In order for each digital word to represent a signal that originated in the analog domain, each word is assigned to a region of the analog signal range. This requires that the analog domain be divided (quantized) into the same number of regions as there are digital words. Consider an analog signal ranging between 0 and +1 V which is to be mapped on to a 4-bit word. This requires that the one-volt range be divided into 16 regions, as illustrated in Fig. 11. Since we made each of the quantization regions the same size, in this example the levels are spaced at intervals of 0.0625 V. Any voltage between 0.975 and 1.0000 V would be assigned a unique word such as 1111. (The spacing need not be uniform; this is referred to as "companding" or compression/expansion, which is logarithmic PCM). Since all other voltages in this interval are represented by the same word, we can say that the quantization process creates an error, called quantization error. Clearly, adding another bit to the digital word would allow twice as many levels to be specified, and the quantization error would be cut in half.

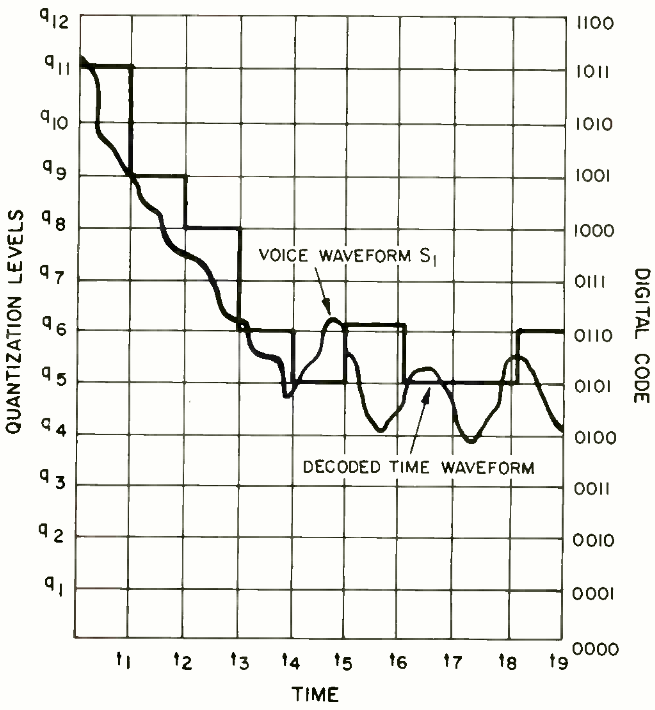
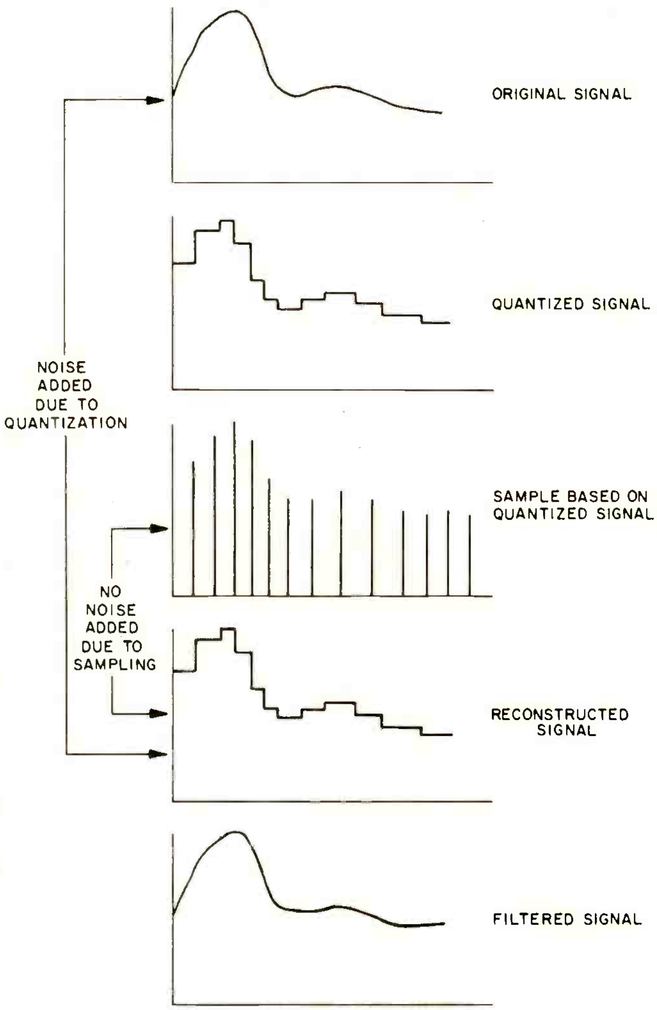


Fig. 11 — Pulse code modulation (PCM).

Increasing the number of bits can reduce this error significantly, but there must always be an error since there are a discrete number of exact analog voltages represented by the digital words but an infinite number of analog voltages [4]. Another way of seeing this form of encoding is as follows: We move along the curve and at every point or, at least, a large number of points, we measure and write down the height of the curve from the X axis, but we must remember four things: (1) Our yardstick does not allow us to measure, say, 7.32172, but only 7.321 (quantization error); (2) The marks on our yardstick are a function of the number of codes we have available (word length); (3) We can't measure *every* point and must settle for a subset (sampling), and (4) Since

Fig. 12 — Conversion steps.



our numbers must be used by a computer, they must be written in digital (101101 V) rather than decimal (45 V) form.

Discrete Time Sampling

The previous discussion considered the mapping of a single analog voltage into a single digital word. However, the audio signal is time varying, requiring us to partition the continuous time variable into a discrete series of time points. At each of the time points, referred to as sampling times, the analog voltage is converted into a digital word. Thus, a sequence of digital words is generated at the same rate as the sampling [4].

The concepts of discrete time and quantized amplitude are not the same. Quantization describes the process of collapsing a group of voltages into a single value, whereas discrete sampling means that only specific values of the time variable are being considered. All changes in the analog signal between discrete sampling times are ignored. Fortunately, if the analog signal is band limited relative to the sampling rate (Nyquist rate), the information in the sampled analog values is identical to that contained in the complete unsampled analog signal. Even though the sampling process ignores all signal changes between samples, no information is lost. Therefore, sampling done the right way preserves all information, while quantization always discards information [4].

How, then, does one sample the signal the right way to retain all the information and thereby reconstruct the original quantized signal? It can be shown mathematically that if the signal has a spectrum which is band limited to one maximum top frequency, that is to say, there is absolutely no energy above this frequency (and by definition none below the lower limit), then the number of samples per second must be equal to $2f_{max}$. This is called the Nyquist rate. Restating this, we can say that with a typical 50-kHz sampling frequency, there must be no energy in the original wave above 25 kHz.

The only way that the analog signal can be band limited is by the use of a very sharp low-pass filter before the sampling process. It is therefore the low-pass filtering which destroys information (bandwidth reduction) rather than the sampling process. This is preferable since the low-pass filter merely removes higher frequency components above the Nyquist frequency, whereas the sampling process would generate new frequencies. The only sources of degradation are the low-pass filtering and the quantization process at the input. It is not the digitization process which creates the degradation: A *band limited time-sampled* quantized analog signal has the identical information as the sequence of digital words (see Fig. 12) [4].

Complete Conversion System

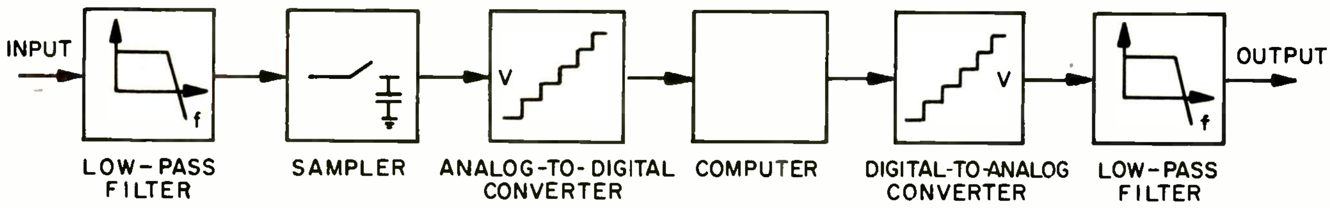
A complete digitized audio system is shown in Fig. 13. The incoming analog signal is low-passed with a very sharp filter to restrict the bandwidth as discussed above. This signal is then sampled, and each sample is held to allow the analog-to-digital (A/D) converter time to convert the information into a digital word. Once in the digital domain, the digital processor can perform any number of functions such as delay, transmission, storage, filtering, compression, or reverberation. At the output, the reverse process takes place: A sequence of digital words is converted to a discrete series of analog voltages by the digital-to-analog (D/A) converter. An output low-pass filter smoothes the discrete analog samples back to a smooth waveform [4].

A/D and D/A converters are inexpensive devices. A D/A converter in a home digital system could cost at most $100; for telephone-grade service, such a device can be purchased for as little as $10.

Signal-to-Quantization Error Ratio

One of the important measures of quality for a digital conversion system is the ratio of the maximum signal to the quantization error. This ratio is a function of the number of bits in the conversion. For a signal quantized with an n-bit word system, the signal-to-noise ratio is $\sqrt{1.5} \times 2^n$ which be-

Fig. 13 — End-to-end digital system.



comes the following, in decibels, 6.02n + 1.76. Each bit contributes six decibels to the system performance.

Some other technical considerations must be given to fully describe the amount of final distortion we would hear in a totally digital system; [4] is the best work yet on this subject. Out of scientific fairness we have talked at length about the distortion produced by the system; we should, however, emphasize the enormous improvements achievable by digital techniques over conventional or even direct-to-disc techniques.

Let us look at some performance specs for analog-digital-analog discs.

Telarc/Soundstream

Frequency Response: D.c. to 21 kHz.
THD: Less than 0.004 percent; at peak level, less than 0.03 percent.
S/N: 90 dB.
Dynamic Range: 90 dB.
Sampling Rate: 50,000/S, 16-bit linear PCM.
Wow and Flutter: Unmeasurable.

Denon

Frequency Response: D.c. to 19 kHz, ±0.2 dB.
THD: Less than 0.1 percent.
Interchannel Crosstalk: -80 dB.
Dynamic Range: 89 dB.
Sampling Rate: 47,250/S, 14-bit linear PCM.
Wow and Flutter: Unmeasurable.

Philips 4½-in. Digital Disc (Announced)

Stereo Program: One hour.
Interchannel Crosstalk: -80 dB.
S/N: 85 dB.
Sampling Rate: Unknown, but greater than 40,000/S, 14-bit PCM.

To quote from Edward Tatnall Canby in his *Audio* September, 1979, "Audio ETC" column:

> . . .The specs for the [Philips] Compact Disc are not quite up to top professional standards — that is, digital standards. Philips is thinking consumer. Most professional digital tape now uses a 16-bit coding, for the ultimate in "headroom." Philips has made a mild cut back, from 16-bit to 14-bit coding. This allows for a system usable in the very lowest, cheapest popular equipment on a mass basis. But is it a serious compromise from the audio viewpoint?
>
> Well, not exactly. Merely from the astronomical to the semi-astronomical. As we are aware, the digital system does not "read" noise of the all-too-familiar analog sort, on either disc or tape. To be sure, S/N in the Compact Disc system is not quite up to professional digital tape. Instead of an incredible 90 dB down for the noise level, it is reduced to a mere *85 dB*.
>
> Please note that the very best an LP can do, in theory, is around 60 dB signal to noise, and we'll say nothing about the average disc. And look at the S/N specs for your hi-fi circuitry, where the noise is purely electronic. This little disc matches the fanciest. Its available dynamic range, to match, is also 85 dB — check that against cassette and LP.
>
> Stereo separation? Because the two stereo channels are read out in separate digital "words" the separation is, well, not quite infinite. The finest stereo cartridges edge up towards a 40-dB channel separation and anything in the mid-30s is very OK for the better models. The Compact Disc figure: *80 dB*.
>
> Need I say more about audio quality? It is sensational, and that is that. And yet still, in the end, this disc is potentially inexpensive enough to go into the cheapest of popular miniplayers. It has that potential, like its cassette sibling.

Those of us lucky enough to own a good system (analog-digital-analog discs do indeed tax your system to an unprecedented level, as a note in one of Telarc's records cautions) must say that such recordings sound spectacular. Low-frequency notes come through uncompromised. This response of d.c. to 20 kHz, ±0 dB, is nothing miraculous in digital recordings; it can best be understood if we think of the spectrum of a signal, namely a graph in the amplitude-frequency domain, depicting the power of each frequency component. In the coding process, low frequencies are as any other frequency; if a 20-Hz note has one watt of power, the coding algorithm so notes that information (effectively); for PCM it is not any different than observing that a 1-kHz note has one watt of power.

It should be remembered that at 50,000 samples per second and 16 bits per sample, one second of music needs 800,000 bits of information (0.8×10^6 bytes/S); 20 minutes of program require 120 million bytes (1 byte = 8 bits), the size of a typical disk pack attached to a medium-sized minicomputer system. This is a rather large amount of data even by today's standards and why, as we have indicated, we must use the principles of the video disc (another bit-waster), which provides the required bandwidth (it, in fact, can give you about 12×10^6 bits/S of storage).

While some end-to-end digital systems already exist or are about to be announced, their introduction will be marked by lack of standardization. For the next two to five years it is safe to assume that A-D-A (analog-digital-analog) processed discs will be the avenue via which most audiophiles will come in contact with digital material (let us hope that the price will come down, too).

Figure 14 illustrates the Denon system. Here the benefits of digital can be harvested by perhaps 90 percent in the sense that during the recording process the music is converted from analog to digital; this implies that all editing and copying (of which there will be many such operations) can be done as many times as needed, without adding any distortion whatsoever. Editing of digital streams is done by transferring the coded information into a computer where all edits are made electronically. The newly arranged information is then transferred back to tape where the information is stored digitally (saturated/nonsaturated), rather than in analog fashion. Let us consider the principle of electronic editing in some detail.

Editing Systems

An editor is a computer program which operates on the data residing in the computer's work space. To do this, the editor makes available to the user a set of commands that can be employed in achieving the objective. Some fundamental commands of all editors are:

Read F1:	Bring into the work space file (data) named F1.
Merge F2:	Bring into the work space file (data) named F2, and merge it to the tail of whatever is already in the work space.
Find X:	Find the line containing the symbol X and stay there.
Replace/X/Y/:	Replace (on the line you are at) X with Y.
Delete n1, n2:	Delete the lines from n1 to n2.
Save F3:	Save whatever is in the work space into a file F3.

You can do quite a bit with these few commands; we illustrate a "splice." Assume that during one session, a performance was recorded by placing each sample (1/50,000 of a second) in each line of a file called "Performance 1" as follows:

Line 1	312
Line 2	715
Line 3	020
Line 4	358
Line 5	971
Line 6	210
Line 7	713
Line 8	358
	Other data not shown
Line 100,000	382

I.e., , we stored two seconds of music (100,000 samples); the line numbers do not actually appear in the file (they are assumed or available on request); the numbers represent, as it should be clear by now, the height of the sound wave at time 1/50,000, 2/50,000, etc. (They should really be written in binary code, but we use decimal notation for clarity.)

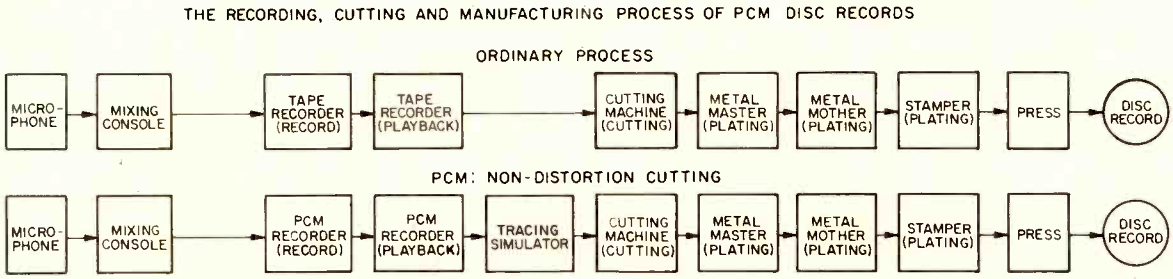
Assume that a second performance of the same musical piece was saved in a file called "Performance 2" as follows:

Line 1	135
Line 2	318
Line 3	721
Line 4	421
Line 5	539
Line 6	781
Line 7	132
Line 8	158
	Other data not shown
Line 100,000	662

Finally, assume that we would like to keep the first 6/50,000 of a second from Performance 1 and the rest from Performance 2. The commands are:

Read Performance 1.
Merge Performance 2.
Delete 7, 100,006.
Save Mastertape.

Fig. 14 — The Denon system.



Electrical Performance and Features

1) Wide dynamic range (more than 89 dB in practical use).
2) Low distortion factor (less than 0.1 percent at operating level).
3) No wow and flutter (not measurable).
4) No interchannel crosstalk (less than -80 dB).
5) Flat frequency characteristic over a wide range (D.c. to 19 kHz, ±0.2 dB; d.c. to 20 kHz, +0.2, -1.0 dB or less).
6) No modulation distortion.
7) Multi-channel recording and playback (2, 4, and 8 channels).
8) Capable of half-speed reproduction, i.e., capable of increasing cutting capacity sharply (characteristic at half-speed playback; d.c. to 10 kHz, ±0.5 dB or less).
9) Equipped with an advanced head (2 channel, direct recording, for variable pitch, which makes cutting as efficient as in the case of conventional records).
10) Capable of editing and splicing.
11) Little loss in duplication.
12) No ghost, can be stored for a long time.

Outline

1) Configuration — PCM converter, 4-head low-band VTR, audio and waveform monitor.
2) Specifications
   a) Modulation — Pulse code modulation, 14-bit sign and magnitude binary code.
   b) Transmission clock frequency — 7.1825 MHz.
   c) Transmission waveform — Standard TV signal (except vertical synchronizing signal).
   d) Audio sampling frequency — 47.25 kHz.
   e) Number of audio channels — 2, 4, 8, selectable.
   f) Advanced signal recording method — Direct recording.
   g) Number of advanced signal channels — 2.
   h) Magnetic tape recorder used — 4-head low-band VTR.
   i) Tape speed — 38 cm/S.
   j) Head-tape relative speed — 40 m/S.
   k) Acceptable tape — two-inch video tape.

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The Onkyo CP-1030F utilizes a uniquely designed low mass, straight-line carbon fiber tonearm and headshell. Its construction assures purer sound even with warped records.

Infrared sensors replace the usual mechanical devices that detect the end of record play ... returning the tonearm more silently to the OFF or REPEAT position. Manual cueing is also smoother and more precise ... with far less lateral drift during stylus descent.

A Quartz-locked DC direct-drive motor ... with an LED illuminated strobe ... assures rotational speed accuracy. And a separate motor controls automatic tonearm movement functions.

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And there is your tape splice. What we did was to bring the first performance in and add on the second performance to get:

Line 1	312	Line 100,001	135
Line 2	715	100,002	318
Line 3	020	100,003	721
Line 4	358	100,004	421
Line 5	971	100,005	539
Line 6	210	100,006	781
Line 7	713	100,007	132
Line 8	358	100,008	158
	•		•
	•		•
	•		•
Line 100,000	382	Line 200,000	662

Next, by deleting (that is deleting electronically or erasing that part of the memory, or asking the computer to forget something) from Lines 7 to 100,006 we obtain:

Line 1	312	Line 7	132
Line 2	715	Line 8	158
Line 3	020		•
Line 4	358		•
Line 5	971		•
Line 6	210	Line 100,000	662

The editor resequences the line numbers to obtain a contiguous set of data. Finally, we save the new product into a file called "Mastertape."

As you may be aware, special equipment is needed by the recording companies to carry out the mixing process; this is indeed the area where the first big steps forward in the introduction of digital audio equipment have occurred. At the 1978 Convention of the Audio Engineering Society, for example, many manufacturers introduced editing mastering systems and other equipment. Sony introduced the PCM-1600, a 16-bit two-channel PCM processor to be used with video cassette recorders; with the PCM-1600 a studio can record a stereo master or submaster with 90-dB range and less than 0.05 percent distortion. Wow and flutter are immeasurable, being functions not of the mechanics of tape transport but of a quartz sampling rate clock. An all-digital mixer, a digital reverberator unit, a multi-channel digital recorder, and precise A/D-D/A converters were also presented. Other manufacturers (notably 3M) displayed a similar range of equipment [7]. For a current view of what is available at the consumer level, consult [1].

Digital techniques can not only be used to produce excellent recordings, but also to allow the revitalization and restoration of old recordings, by a process developed by Thomas Stockham to filter out some type of noise which plagues such recordings [8].

Elementary Signal Processing Devices

Digital delay units now widely available are in effect elementary signal processing devices; we call them simple since no complex operations (as Fast Fourier transforms, spectrum evaluation, digital filtering) are performed; a digital noise suppression device would, on the other hand, be considered a full-fledged signal processing system. Below, we briefly describe the operation principle of two well-known delay units: The Advent 500 and Audio Pulse Model 2 (based on [9]).

The circuitry of the Advent Model 500 SoundSpace control uses eight random access memories (RAMs) with 4,096 bits each. Incoming audio signals pass through a variable gain buffer amplifier and are then filtered into low- and high-pass segments. The low-frequency signals are sampled every 62.5 μS; this corresponds to 16,000 samples per second or a bandwidth of 8 kHz. Each sample is converted into a 10-bit representation using a floating-point technique that provides up to 80 dB of dynamic range.

Conversion from analog to digital representation takes place in two separate steps. The sample is first sized in 10-dB steps, thereby determining the value of the two floating point bits. The remainder of the sample is then compared to a linear ramp, and eight bits of continuous digitization are derived. The combined 10-bit representation is stored in a random access memory and will be recalled when needed by the 10-MHz, quartz-crystal clock-controlled logic. At the appropriate time, each sample is retrieved from memory and reconverted into the analog equivalent by an operation which is the reciprocal of the digitalization system.

Table II — Vocoder types, based strictly on [5].

Relative Complexity†		Coder
1	ADM:	Adaptive delta modulator
1	ADPCM:	Adaptive differential PCM
5	SUB-BAND:	Sub-band coder (with CCD filters)
5	P-P ADPCM	Pitch-Predictive ADPCM
50	APC:	Adaptive predictive coder
50	ATC:	Adaptive transform coder
50	ΦV:	Phase vocoder
50	VEV:	Voice-excited vocoder
100	LPC:	Linear-predictive coefficient (Vocoder)
100	CV:	Channel vocoder
200	ORTHOG:	LPC vocoder with orthogonalized coefficients
500	FORMANT:	Formant vocoder
1,000	ARTICULATORY:	Vocal-tract synthesizer; synthesis from printed English text.

† Essentially a relative count of logic gates. These numbers are very approximate, and depend upon circuit architecture. By way of comparison, Log PCM falls in the range of 1 to 5.

The delay value, selected by altering the "size" control on the front panel, determines the primary time delay (in milliseconds) for the longest "early reflection." This provides an index for apparent "room size." A single large memory holds discrete information from both left and right channels, each sample having a distinct address. Delayed information is purposely mixed, contoured, and multiply delayed in controlled proportions. Each output channel contains delayed information from its corresponding input plus blended signals from prior times and spatial origins. In effect, each output channel becomes a "time series" corresponding to the sound field of a specific sound space.

The Audio Pulse Model Two time delay unit also includes audio signals in the digital domain, but rather than using PCM, it uses Delta Modulation. Instead of generating coded groups of pulses at regular intervals to represent the amplitude of the audio signals at every moment, Delta Modulation uses a waveform detector to digitally encode the moment-to-moment changes in the audio signal waveform. This system requires a smaller digital memory and lowers the cost of the circuitry required to do the job.

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Coding of Speech

Extensive progress has been made over the past 5 to 15 years in digital speech coding. As we have indicated, PCM techniques could be used here (and in fact they are), but PCM is the Cadillac of the coding schemes. First of all, typical telephone lines have a frequency response between 300 Hz and 3 kHz (who knows if it is flat?); hence 64,000 bits per second (8,000 samples at 8 bits per sample) would be sufficient here. However, since we are dealing with a well-defined acoustical mechanism (namely, the human vocal system) we can say that the field is specialized, and many vocoder-like (voice synthesis) techniques can be exploited. Table II, based directly on [5] lists and ranks the various schemes; also see Fig. 15.

The highest quality is achieved by log PCM (at 56,000 bits/S) and ADPCM (at 32,000 bits/S), both telephone quality, followed by log PCM (at 36,000 bits/S), APC (at 7,200 bits/S), at the communication or speaker identification level, followed by LPC (at 2,400 bits/S) and formant vocoder (at 500 bits/S) which produce synthetic quality speech. Very extensive research is taking place in this area; [5] lists over 100 technical articles and several textbooks.

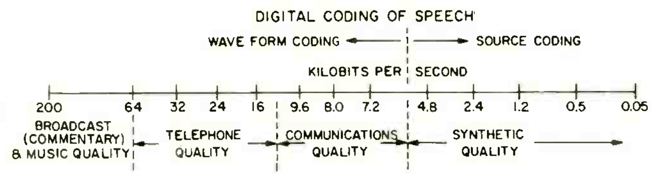


Fig. 15 — Spectrum of quality

The goal of a vocoder is to preserve the perceptually significant properties of the waveform with the intention of synthesizing a signal at the receiver that sounds very much like the original. By analyzing the input waveform, or its short-term spectra, most vocoders compute parameters that describe a simplified model of the speech-production mechanism. Basically, vocoder models assume that speech sounds fall into two distinct classes: Voiced and unvoiced. Voiced sounds occur when the vocal chords vibrate and are characterized by the pitch or rate of vocal chord vibration as well as by the resonant structure of the vocal tract formed from the throat, mouth, and nasal cavities. In unvoiced speech, the vocal chords do not vibrate. Instead, air turbulence, resulting from either the passage of air through a narrow constriction formed by the articulators or the sudden release of air by the lips or tongue, creates acoustic noise that excites the vocal tract. As in voiced speech, the articulators create resonance conditions that concentrate the unvoiced acoustic energy into particular areas of the frequency-power spectrum. Unlike the voiced case, where energy occurs as discrete frequency components, spectral energy during unvoiced speech is continuous with frequency [3].

In general, the analyzer section of a vocoder determines the resonant structure of the vocal tract, estimates the pitch, and decides whether the speech segment is voiced or unvoiced. The synthesizer section uses these speech features to reconstruct a new time waveform that sounds much like the input. Various vocoders differ in their methods for extracting speech features as well as in their methods for reconstructing speech using these features [3].

The conceptually simplest vocoder is the channel vocoder. A basic channel vocoder analyzer is shown in Fig. 16. A sequence of bandpass filters is used to divide the voice signal into frequency channels. The signal components in each of the frequency channels are first rectified, usually by a square-law circuit. Then they are either integrated or low-pass filtered, or both, to yield a continuous estimate of the speech power-spectrum amplitude in each channel. Independently of the spectral analysis, a pitch extractor determines the vocal pitch and a voicing detector determines whether the input represents a voiced or unvoiced speech sound [3].

As shown in Fig. 16, the channel vocoder synthesizer reconstructs the speech signal using estimates of the power spectrum together with pitch and voicing information. During voiced segments, a pulse generator outputs short pulses at the pitch rate, and these pulses excite a bank of filters similar to those shown in Fig. 7. Each filter output is then adjusted in an attempt to make its energy equal to that measured for the corresponding channel at the analyzer. For unvoiced sounds, a Gaussian noise source excites the filter bank [3].

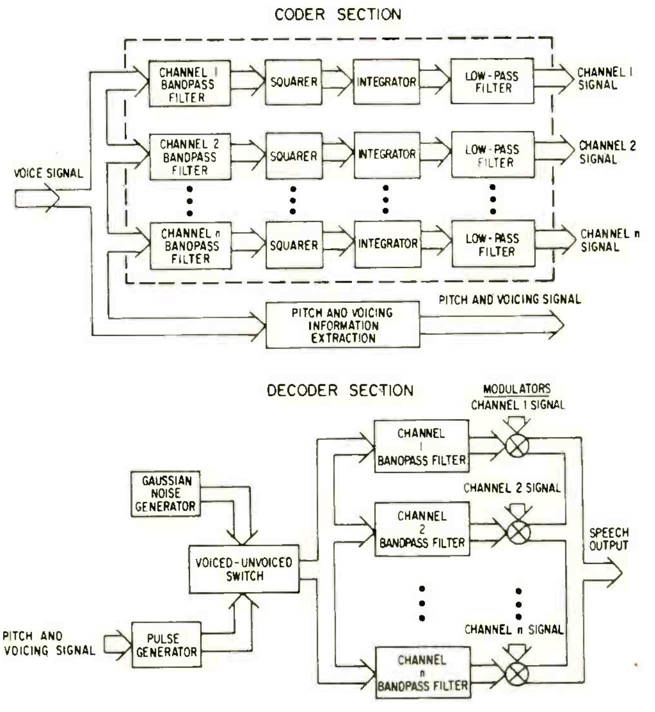
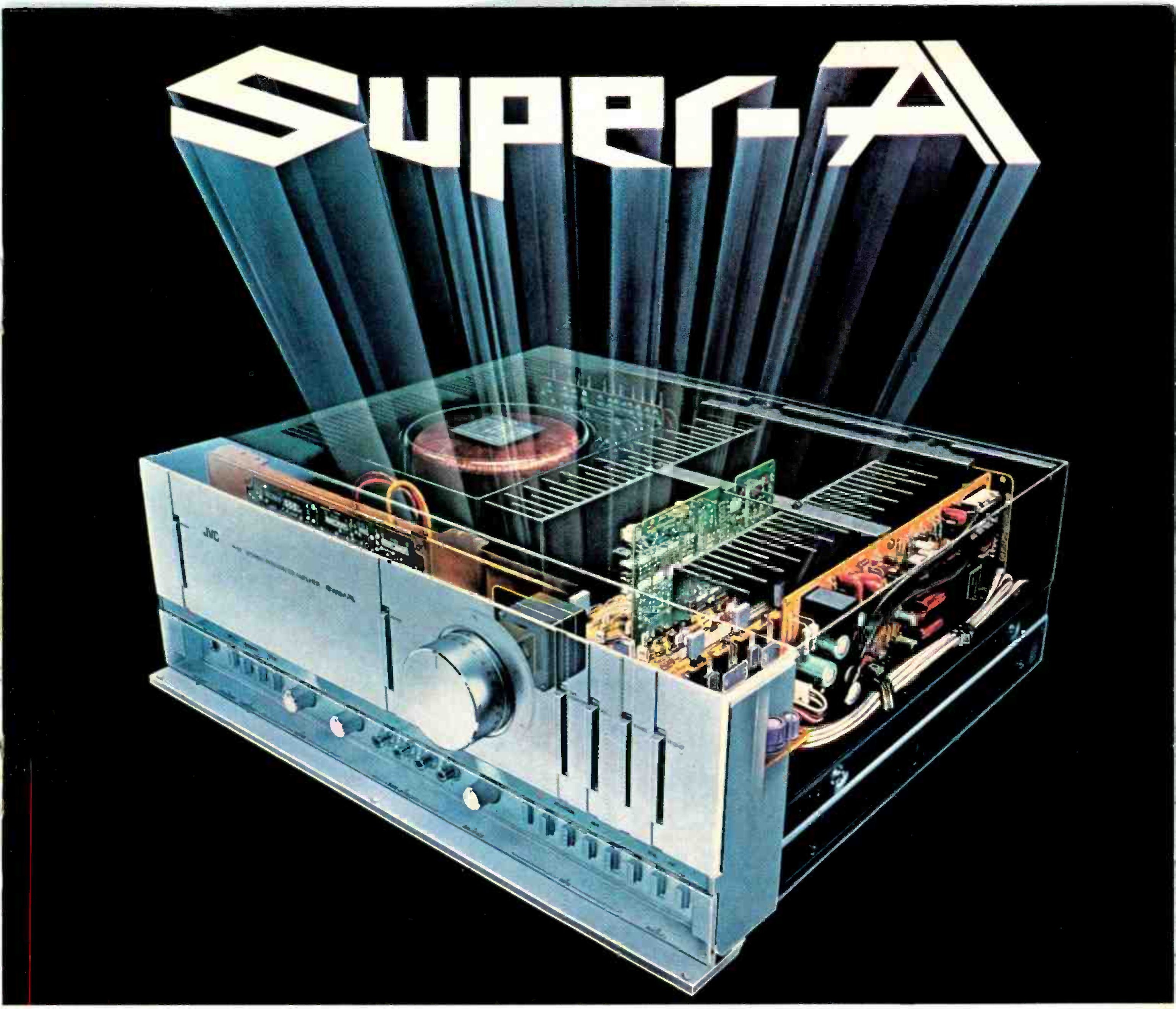


Fig. 16 — Channel vocoder.

Summary

In this series of articles, we have examined the principles of digital encoding, a technology which promises to have a major impact on high fidelity in the near future. The theory was developed in the '60s for telecommunications applications, and in the early '70s the first digitally mastered recording was offered commercially. At the current time a range of digitally mastered recordings is on the market; 1980 promises to be the year during which the first fully digital recording and turntable will be available to consumers. After several years of activity in the area of standardization, we should see compact, inexpensive, reliable, and compatible digital discs of the highest fidelity.

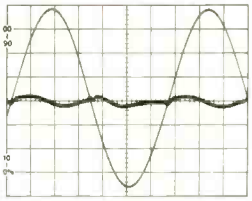


The clarity of Class A sound and the high efficiency of Class A/B power.

JVC engineers, among the most innovative in the world, have achieved a technological breakthrough. Now the clean, clear, less distorted sound of Class A amplification is available with the high efficiency of Class A/B type amplification. That means no excessive heavy power supplies, and minimal heat build-up.

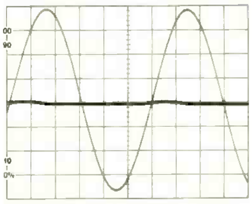
Traditionally, the Class A/B amplifier has been predominant, simply because it is three times more efficient than the Class A type. However, the Class A/B amplifier achieves that efficiency by permitting its power output transistors to switch on and off, leading to switching and crossover distortion, and producing substantially reduced high fidelity performance. On the other hand, engineers knew that while Class A amps had the advantage of cleaner, less distorted output than Class A/B, they produce enormous amounts of heat and require extremely heavy power supplies.

Innovative engineering by JVC solved those problems, by introducing The Super A Amp. A classic, no compromise amp. THD is as low as 0.005% and linearity is higher than with conventional Class A/B power amps. And at the same time the efficiency of the Super A amp is equal to that of Class A/B amps, even with high power output. The transient response, slew rate and rise time are all greatly improved. And there is no TIM (Transient Intermodulation), or crossover distortion.



Conventional Class-A/B AMP

The jagged line at center of the graph indicates the amp is generating switching and crossover distortion as its output transistors switch on and off. These are displeasing types of distortion, because they contain many odd and high-order harmonics.



JVC's Extraordinary Super-A Amp

The center line in the above graph represents waveform distortion, which is at a minimum. This indicates that the amp is generating very little distortion, containing very few odd-order harmonics, resulting in smooth reproduction and velvety sound.

A-X9 Integrated Amplifier.

100 W RMS/Chan. thru 8 ohms 20-20 kHz less than 0.005% THD: MC & MM phono sections dual tape & phono inputs. Speaker outputs. Not shown: A-X5 Integrated amplifier 70 RMS/chan. thru 8 ohms 20-20 kHz less than 0.005% THD: MC & MM phono sections dual tape & phono inputs. Speaker outputs.

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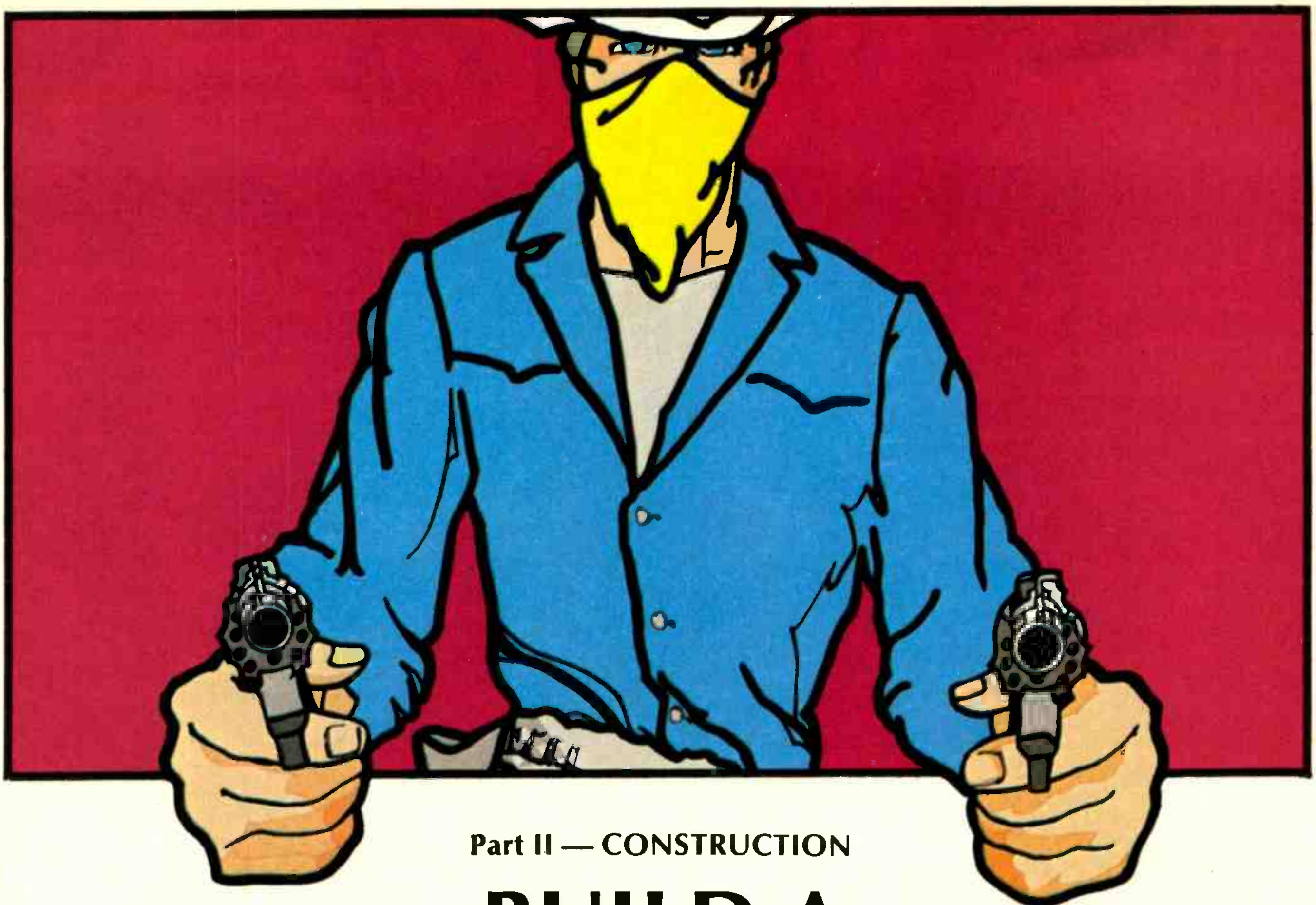

Part II — CONSTRUCTION

BUILD A DOUBLE BARRELED AMPLIFIER

W. Marshall Leach, Jr.*

This is an advanced construction project not recommended for those without experience in building home electronics projects. Power electronics must be respected, for it is unforgiving of even the smallest errors that could lead to the loss of expensive transistors. To minimize the chances of errors, test each part before assembly. Measure resistors with an ohmmeter to double-check the color code — otherwise, orange could be mistaken for red, blue for grey, etc. Check capacitors with an impedance bridge or capacitance meter, otherwise a dipped silver mica capacitor labeled 430 may be incorrectly thought to be 430 pF when the last digit is the multiplier and the capacitor is only 43 pF. The label codes vary with manufacturer, and 430 can be either 43 pF or 430 pF, depending on the code. When electrolytic capacitors are installed, their polarity should be double-checked. If incorrect, the capacitor will become a short circuit when power is applied.

Diodes and transistors should also be checked with an ohmmeter. Diodes should measure a high resistance with one polarity of the test leads and a low resistance with the other polarity. Because the resistance of the human body can affect these readings, the metal probes on the test leads should not be touched when making the measurements. Transistors are more complicated to test, for they require six resistance measurements. A low resistance should be measured with one polarity of the leads and a high resistance with the other polarity from base to emitter and from base to collector. A high resistance should be measured with both polarities from collector to emitter. Most transistors that have failed in a circuit will measure a short circuit on this last test. Neglecting to perform these simple tests at the start of construction can cause a lot of grief when the amplifier is first powered.

The construction details described here are broken into

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Georgia Institute of Technology,
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Atlanta, Georgia 30332

Illustration: Barbara D'Aprile

Sansui is breaking up a very successful relationship. The TU-717 has a new mate: The AU-719.

Sansui has just introduced an exciting new integrated amplifier, the AU-719. It represents the very latest developments in audio and electronics technology. It is so good, in fact, that it has replaced its rave-reviewed, best-selling predecessor as the partner of the TU-717 tuner.

The TU-717's performance has been extravagantly praised by professional critics and knowledgeable consumers alike. With advanced features like switchable IF bandwidth and specs like 81dB signal-to-noise ratio and 0.06% THD, it's only natural.

We expect the tuner's new mate to receive a tremendous reception and set industry amplifier standards for a long time to come. Here's why.

INTRODUCING DD/DC

What particularly distinguishes the new AU-719 amp is Sansui's patent-pending DD/DC (Diamond Differential/DC) circuitry that provides the extremely high drive current needed to reduce THD by adding large amounts of negative feedback without compromising slew rate or adding TIM.

Slew rate refers to an amplifier's ability to respond to rapidly changing musical signals. The slew rate of the AU-719 is an astounding 170V/μ Sec.

MAGNIFICENT MUSIC

Many modern amplifiers have extremely low total harmonic distortion specs. And that's important. But THD is measured with steady test signals and is not really representative of an amp's ability to deal with music. Sansui alone, with it's DD/DC technology, is able to provide both low THD and lowest TIM simultaneously. Instead of the harsh metallic sound you sometimes get on a conventional amp when the musical signals are complex, with the AU-719 you hear only magnificent music.

THD is less than 0.015% at full rated power of 90w/channel, min. RMS, both channels into 8 ohms from 10 - 20,000 Hz. Overall frequency response is awesome: DC - 400,000 Hz, +0, −3dB. Hum and noise are a super-silent −100dB on aux and −88dB on phono. The phono equalizer, which adheres to the standard RIAA curve within ±0.2dB from 20 - 20,000 Hz, also uses our unique DD/DC circuit for record reproduction that's second-to-none.

CONTROL YOURSELF

The unit is equipped with a full complement of versatile controls and connections to create the system and sound that's right for you, including two phono and two tape inputs, defeatable tone controls with switchable center frequencies, deck-to-deck tape dubbing and a very convenient 20 dB muting switch.

Audition the new AU-719 and matching TU-717 at your authorized Sansui dealer. We think it will be the start of a very successful relationship.

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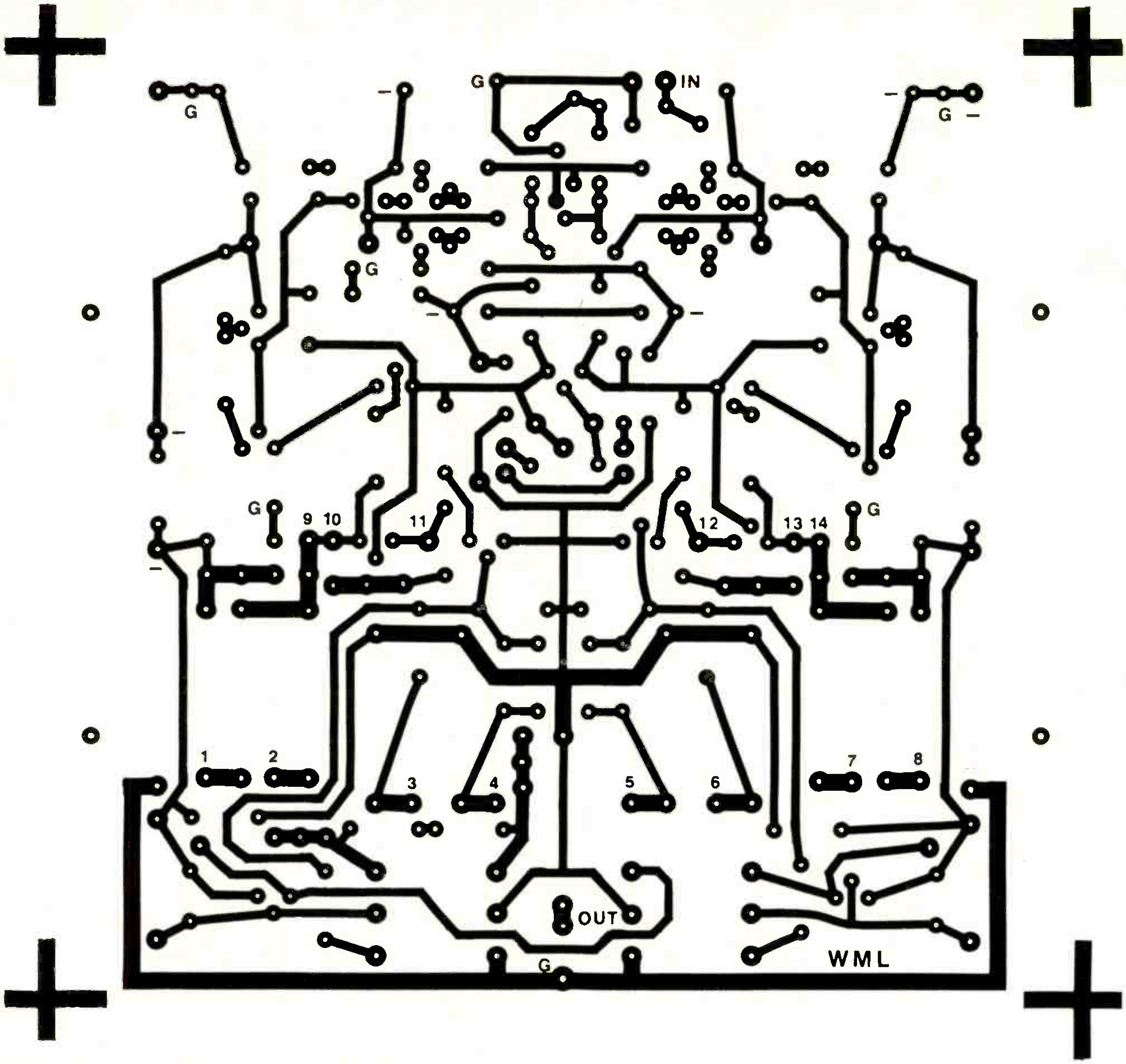


Fig. 12A.—Recommended circuit-board foil pattern for the copper foil or circuit side.

two parts. In this section, the circuit board and heat sink assembly are discussed. In the following section, the chassis wiring details are presented. Before construction is begun, all parts should be assembled so that the layouts can be modified to accommodate any parts having different dimensions from those used by the author. The recommended printed circuit board is a double-clad board, one side of which is used as a ground plane for the circuit. Ground plane construction is standard practice in r.f. circuits, and it is highly recommended for this amplifier. The front and back circuit-board foil patterns are shown in Fig. 12; parts locations are shown in Fig. 13.

Circuit-Board and Heat-Sink Assembly

For optimum results, match the differential amplifier transistors for equal current gains at a collector-to-emitter voltage of 40 V. This will ensure freedom from d.c. offset problems at the loudspeaker output terminal caused by unequal base currents in the input-stage transistors. A simple test circuit can be constructed to match these transistors, as shown in Fig. 14. Optimally, Q1 through Q4 should have equal or nearly equal current gains. Should it be difficult to find a match for all four transistors, it is sufficient to match Q1 to Q3 and Q2 to Q4. A third combination is to match Q1 to Q2 and Q3 to Q4, but this is less desirable.

The first step is to solder six of the seven ground connections on the board; ground connections are marked with a G in Fig. 12A. The one which is not soldered at this point is the one nearest the loudspeaker output connection. To solder these connections, insert a ¼-inch length of No. 22 solid wire through each hole and bend it down against the copper on each side of the board. On the ground plane side, it is best to bend these wires away from any adjacent component locations, especially those near capacitors C27 and C28. The connections can now be soldered. Sufficient heat must be used on the ground plane side to get a good solder joint — a good joint is one for which the solder has flowed smoothly onto the circuit board, and it appears shiny. Only a controlled heat soldering iron such as the Weller Soldering Station should be used to solder to the circuit boards. A 700-degree soldering

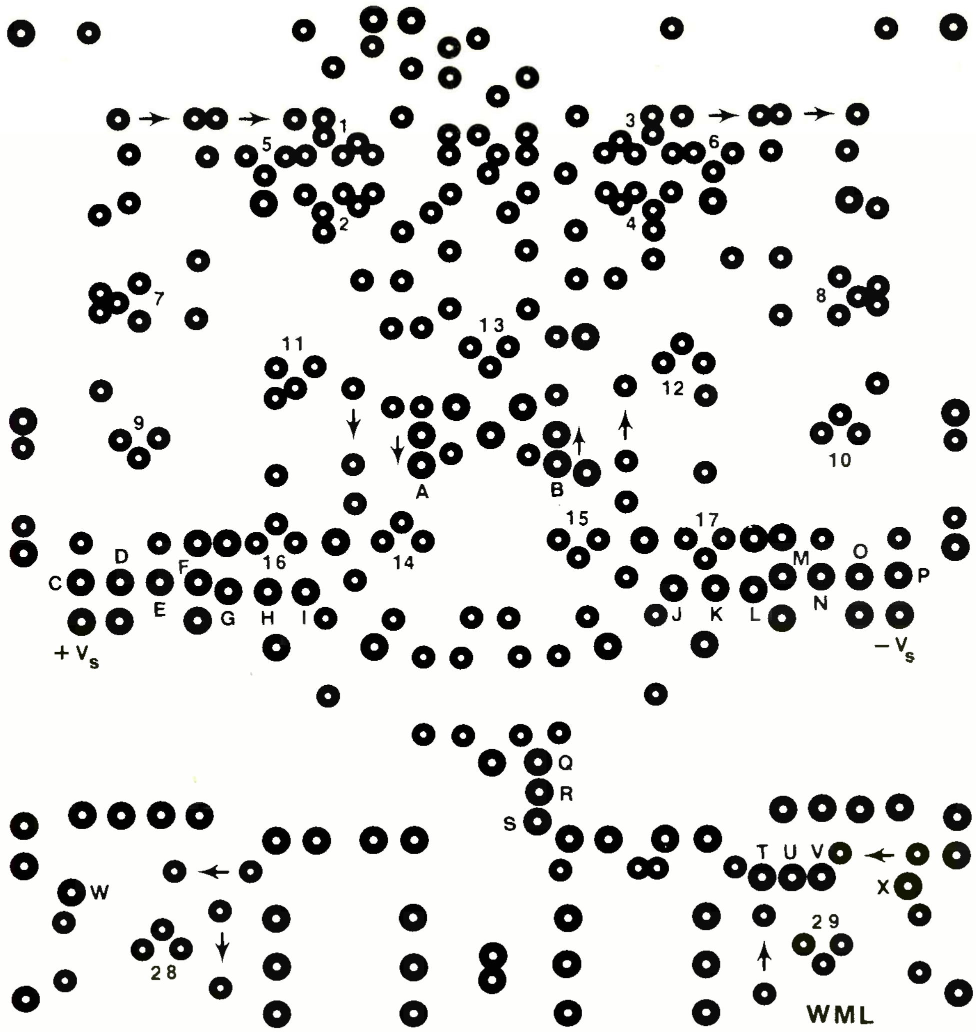


Fig. 12B.—Recommended circuit-board foil pattern for the ground-plane or component side.

tip is recommended, and the Weller PTM7 tip is an excellent choice. Only a high-quality solder such as Ersin SN62 multi-core No. 22 solder should be used. If difficulty is experienced in making the solder flow, use a pencil eraser to clean the area to be soldered and dip the tip of the solder into zinc chloride soldering paste before applying heat.

The next step is to mount and solder all ¼-watt resistors, with the exception of R1, R58 and R59, to the board. All of these should be bent on a resistor bender for a 0.4-inch hole spacing, except for resistors R4, R39 and R40. These should be bent to 0.5 inch for R4 and 1.4 inch for R39 and R40. A 0.5-inch length of insulation should be inserted over each lead of the latter two resistors before bending them. When inserting the resistors into the board, extra care should be taken to prevent peeling off a metal burr from the solder-plated resistor leads which could short to the ground plane. If this happens, the burr should be removed with a small blade screwdriver. Also, do not press the resistors down too hard against the ground plane, for their insulated coating could be broken and a short circuit could result.

With the exception of D3 through D6, the diodes should be installed next. They should be bent for a hole spacing of 0.4 inch and their proper direction is indicated by an arrow in Fig. 12B. The diodes should be installed such that the arrow points toward the banded end or cathode. All other resistors and capacitors should now be inserted. Each one-watt resistor should be bent for a 0.7-inch hole spacing. Pay particular attention to the polarity of the electrolytic capacitors. The negative terminals for these should be inserted into the holes labeled with a minus sign in Fig. 12B.

Next install all transistors which mount on the circuit board. The location of these transistors is labeled in Fig. 12A with the transistor number. Transistors Q1 through Q8 and Q13 through Q15 should be installed with their flat ends oriented as shown in Fig. 13. It is not necessary to bend the leads of these nine transistors to conform to the circuit-board hole spacings; simply spring the leads apart slightly and insert them until the transistors are about 5/16 inch off the board. All TO-5 case, i.e. metal can, transistors that mount on the board should be installed so that they are about this same

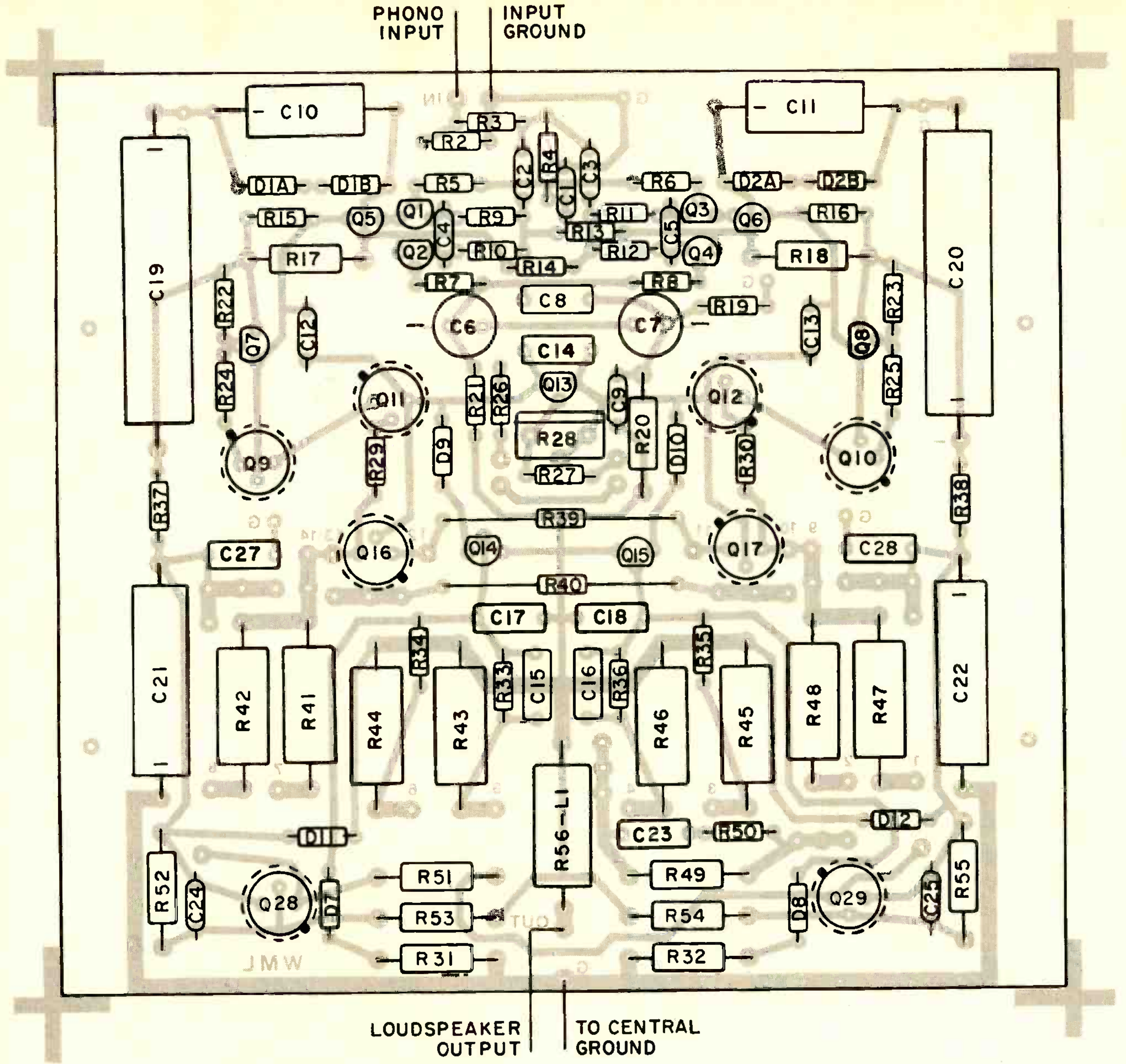


Fig. 13 — Parts layout for the recommended foil pattern.

height above the board. All require clip-on heat sinks which should be installed on the transistors *before* they are soldered to the circuit boards to prevent bending the transistor leads. It is not necessary to use any heat sink compound on these transistors.

The driver heat sinks can now be mounted to the circuit board as shown in Fig. 15. They are fabricated from 3/32-inch sheet aluminum, and the recommended dimensions are 5½ x 2⅛ inches. Mount them on the side of the circuit board opposite the ground plane with No. 4-40 x ⅜ inch screws with an inside star lockwasher under each nut. Insulate the driver heat sinks from the circuit board ground plane by installing a No. 4 fiber shoulder washer in each of the four mounting holes on the circuit board. The driver transistors can now be installed as shown in Fig. 15. A mica insulating wafer should be placed between each transistor and the heat sinks, and both sides of the mica wafers should be lightly coated with thermal compound. Use only molded plastic transistor sockets to install the drivers, and before connecting them to the circuit board, check with an ohmmeter for a possible collector short circuit to the heat sink or a short from a heat sink to the circuit board ground plane. If there are none, the driver leads can be connected and soldered as shown in Fig. 15; the connection codes are provided in Table I.

The final step in the circuit-board assembly is to solder the input coaxial cable, resistor R58, and the power supply, loudspeaker output, and power-supply ground leads to the board. With the exception of R58, these are all inserted from the side opposite the component side. Connect and solder appropriate lengths of color-coded No. 16 stranded wire to the plus and minus power-supply connections and to the loudspeaker output connection. To the ground connection nearest the loudspeaker output, insert one lead of resistor R58 over which 0.5-inch of insulation has been installed and one end of a length of No. 22 stranded wire. Solder these on *both sides* of the circuit board. Finally, connect and solder an appropriate length of miniature coaxial cable to the signal input and signal ground connections on the circuit board. This completes the circuit-board assembly.

Preparation of the main heat sinks is the next step. If they

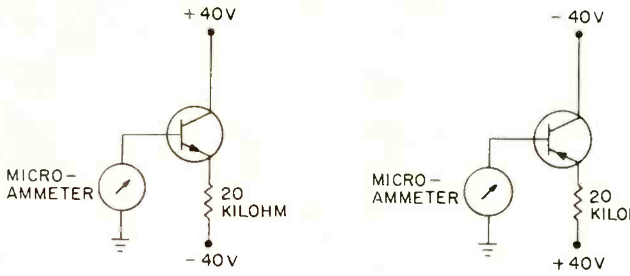


Fig. 14 — Test circuits for matching transistors Q1 through Q4. Select transistors for equal or nearly equal base currents. (A) Test circuit for matching NPN transistors Q1 and Q2; (B) test circuit for matching PNP transistors Q3 and Q4.

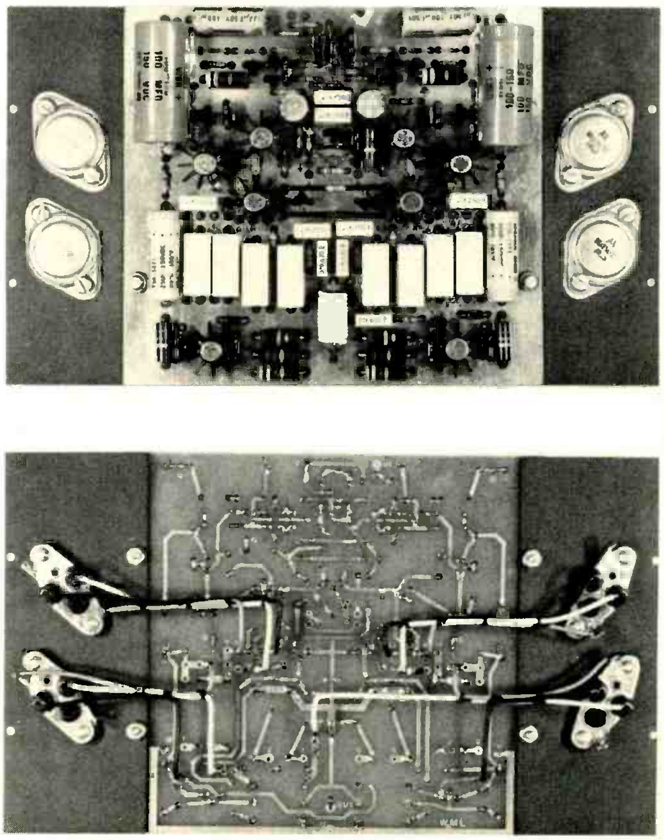
are not predrilled, each must be drilled for four TO-3 transistors. To mark the holes, arrange four mica insulating wafers in each heat sink channel in the position of the transistors and use a pencil to mark the position of the four holes on each wafer. After tapping the marked positions with a sharp pointed punch, drill all holes with a ¼-inch bit on a drill press. *Do not use a hand drill.* The holes must mate the transistors properly if short circuits to the heat sinks are to be avoided. In addition, each hole must be deburred to avoid a short circuit that could be caused by a punctured mica wafer. After the output transistor holes are drilled, the heat sinks can be drilled for the bias regulator diodes. Two of these diodes mount in holes drilled in the center of each heat sink. Drill the holes about ⅜ inch apart with a diameter that permits the diodes to fit snugly without binding. Finally, the holes for mounting the circuit boards to the heat sinks and any holes necessary for mounting the heat sinks to the chassis must be drilled. The circuit-board mounting holes should be marked and drilled for No. 4 screws (No. 33 drill bit) in the heat-sink outer flanges to mate with the holes on the outer edges of the driver transistor heat sinks. These should be marked carefully to ensure proper fit of the circuit-board assembly on the heat sinks. The method of mounting the heat sinks to the chassis may vary; I used bolts through the existing U-shaped cut-outs in the outer heat-sink flanges to attach aluminum brackets designed to hold the heat sinks ½ inch off the chassis bottom.

The output transistors can now be installed on the heat sinks. Use only high-quality molded plastic sockets. Because the heat sinks are so thick, it may be difficult to get a good connection between the socket pins and the base and emitter transistor leads. To solve this problem, I removed the pins from the transistor sockets and soldered them directly to the ends of the transistor leads. Care must be taken in positioning the pins on the transistor leads so that they will properly mate with the socket when installed on the heat sinks. Although this increases the difficulty of replacing an output transistor in the event of a failure, it does ensure good electrical connections for the high-current output transistor leads. The three wires to be soldered to the output transistor sockets should be color-coded No. 20 stranded wire about eight inches long. Next, install the transistors and sockets on the heat sinks. Each transistor should be insulated from the heat sink with a mica wafer that has been liberally coated on both sides with thermal compound. Transistors Q20, Q21, Q24, and Q25 mount on the heat sink that is to be closest to drivers Q18 and Q30, while Q22, Q23, Q26, and Q27 mount on the heat sink that will be closest to drivers Q19 and Q31. Use an ohmmeter to verify that no transistor lead is shorted to the heat sinks.

The diode bias assemblies are now installed into each heat sink and should be prepared as shown in Fig. 16. It is best to first solder the wire that is used to connect each diode to the circuit board, and these wires should be color-coded No. 22 stranded wire about eight inches in length. Before soldering, tie-wrap the joints with a single strand from No. 22 stranded wire to form a tight mechanical connection. After installation into the heat sinks, insulate the solder joints with heat-shrink tubing, preferably shrunk with a heat gun. Take extreme care to avoid cracking any of the bias diodes during installation into the heat sinks. If a crack occurs, the diode will become an open circuit and the amplifier can be seriously damaged. Thus the diodes should not be forced into their mounting holes nor should there be tension on their leads. It is not necessary to use heat-sink compound on the diodes; if necessary, a drop of instant bonding glue on each may be used to bond them to the heat sinks.

Before attaching the circuit board to the heat sink, it is best to pretest it with a lab power supply. This can be done with dual 50-V supplies, preferably with a current-limit circuit. On the rear of the circuit board, temporarily tack-solder four 100-ohm 1/4-watt resistors, one from the emitter of Q30 to the collector of Q18, one from the emitter of Q31 to the collector

Fig. 15 — Photographs of each side of an assembled circuit board.



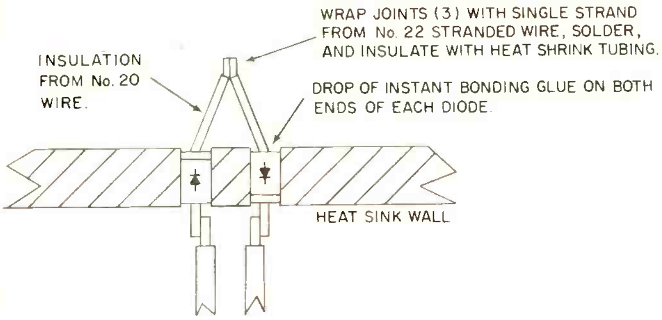


Fig. 16 — Recommended mounting of bias diodes in each heat sink.

of Q19, one from the emitter of Q18 to the junction of resistors R43 through R46, and one from the emitter of Q19 to this same junction. Solder a short-circuit jumper wire across C14. With clip leads, connect the negative output of one power supply to the circuit-board ground wire and the positive output to the circuit-board positive power-supply input. Connect the positive output of the other power supply to the circuit-board ground wire and the negative output to the circuit-board negative power-supply input. With the power supplies set to current limit at 100 mA, the voltages can be slowly turned up. If current limiting does not occur or if the current drawn does not exceed about 50 mA, turn the power supplies off, use clip leads to connect the output of a signal generator to the signal-input cable, and connect an oscilloscope probe to the loudspeaker output wire. The oscilloscope ground should be connected to the circuit-board ground wire. With a sine wave of 1 V rms at 1 kHz applied to the input, slowly turn up the power supply voltages. A clipped sine wave that looks like a square wave should appear on the oscilloscope before reaching plus and minus 10 V. At 50 V, the sine wave will appear unclipped with an amplitude of about 60 V peak-to-peak. Turn the power-supply voltages down and connect a 10-kHz square wave source to the circuit-board input. With power supplied to the board, the output signal should look like the waveform of Fig. 8. If it does not, check the values of R3, R4, C1, C2, and C3.

If the previous tests are negative, the circuit board should be inspected thoroughly. Check for solder bridges; cold solder joints; shorted components to the ground plane; backward electrolytic capacitors, transistors, and diodes; incorrect component values; unsoldered ground connections, etc. Correct all errors at this point — before the output transistors are connected. If components must be removed from the circuit board, desolder them with a desoldering braid (such as Solder Wick) and with as little heat as possible to prevent lifting the copper foil from the circuit board. When the circuit is operational, remove the jumper wire and four resistors from the rear of the board. The solder flux must now be removed from the boards with a soft-bristle brush and a good solvent (such as Stripper brand) spray-on circuit-board cleaner. When cleaned, each solder joint will be shiny; dull joints may be cold solder joints so make sure they are touched up.

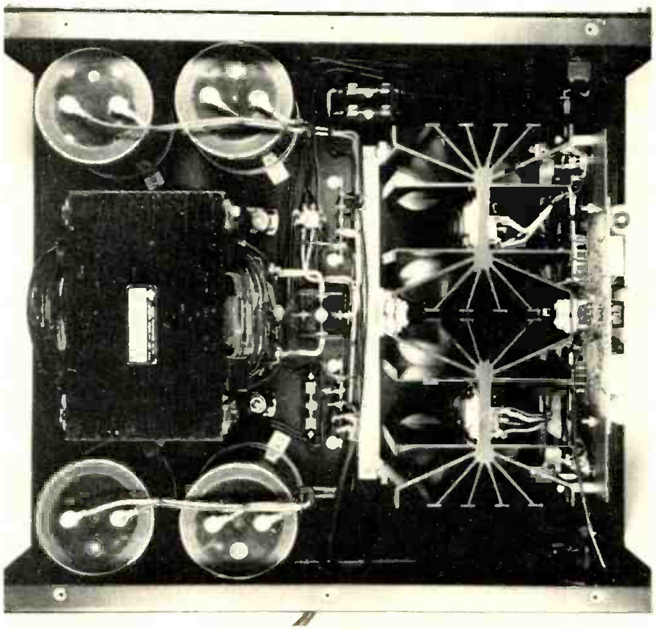
The circuit board is now ready to be mounted to the heat sinks. The wires from the power transistors and bias diodes should first be cut to length and soldered to the circuit board. These are connected from the circuit side of the board, i.e. the side opposite the components. To do this, lay the board in front of the heat-sink assembly with the ground plane side down and the loudspeaker output connection nearest the heat sinks. Cut the wires from the heat sinks just long enough so that after they are soldered to the board there will be no tension on them with the board in this position. If this is done properly, you will not have to desolder any wires from the board should it need servicing. However, to minimize undesirable coupling effects, the connecting wires should be no longer than necessary.

The proper connections of the wires from the heat sinks to the circuit board are given by the codes in Table I. After soldering these wires to the circuit board, use cable ties to separately tie the wires from each transistor and bias diode assembly into neat bundles. Carefully inspect the ground plane side of the board for any soldered wires that may protrude out too far and cause a short circuit. No wire should protrude through the board by more than 1/32 inch. When all wires are connected, double-check the wiring for errors. The bias diodes especially should be checked for correct connection to the board, for backward diodes can damage the output transistors when the amplifier is first powered. The circuit board can now be attached to the heat sinks. This is done with four No. 4-40 x ¾-inch threaded aluminum spacers and eight No. 4-40 x ⅜-inch screws with an inside star lockwasher under each. Neatly route the cabling between the heat sinks and circuit board after the circuit board is installed. This completes the circuit-board and heat-sink assembly.

Wiring of the Chassis

The amplifier can be built on any chassis, provided the general layout and wiring used by the author are followed. The chassis shown was bent from 16-gauge steel by a sheet-

Fig. 17 — Interior view of the amplifier chassis showing chassis wiring.



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But suppose you want to record on location. At a rock concert, say, or a performance of your church choir or glee club. Sony has mikes that, combined with your tape recorder, practically make up a portable studio.

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metal shop. Its dimensions are 17 inches W x 15 inches D x 6¾ inches H. A 7-inch x 19-inch steel panel is bolted to the front, and a perforated steel cover is placed over the chassis to make it mechanically rigid. The cover is screwed into No. 6-32 nutserts installed in the chassis outer flanges. An interior view of the chassis component placement and wiring is shown in Fig. 17. An aluminum chassis can be used, but it is difficult to paint and may not be strong enough to support the 38-pound transformer.

Before painting the chassis, punch and drill all holes, smooth sharp edges with a file, and remove all corrosion with a wire brush, sandpaper, and steel wool. For proper ventilation, vent the area beneath the heat sinks by punching eight 1⅜-inch circular holes under the heat-sink assembly with a chassis punch. After the chassis is completed, thoroughly wash it with a spray-and-wipe all-purpose cleaner to remove oil traces. Next, prime and paint the chassis (I used Rust-Oleum 960 spray primer and Rust-Oleum 7278 satin black spray paint). For best results, apply the paint in light duster coats and allow 30 to 60 seconds for the gloss to disappear between each spray. This will produce a professional-looking textured finish without runs. After one coat is built up, wait at least 48 hours before applying a second. This is important if the finish is to harden properly and not wrinkle.

The signal input jack must be insulated from the chassis, and a phono jack which mounts in a circular hole with a single nut from the back is recommended for this. It can be insulated from the chassis with a flat washer on one side and a shoulder washer on the other. The recommended loudspeaker output connector is a double five-way binding post. If two single five-way binding posts are used, drill the chassis for the standard ¾-inch spacing between them.

Before placing the circuit-board and heat-sink assembly into the chassis, install the power supply and associated a.c. chassis wiring. The power supply is wired as shown in Fig. 2. A single central chassis ground point is used, to which all high-current leads are connected. This central ground point should be a No. 10 machine screw on which are nine No. 10 soldering lugs separated by No. 10 flat washers. A No. 10 inside star lockwasher is installed under the bottom washer to ensure that the ground point makes good connection with the chassis ground through the paint. Firmly tighten the screw so that these lockwashers engage properly. The green a.c. safety ground from the power cord, the filter capacitor grounds, and the two transformer center taps are then connected to the ground point. The circuit board ground wire and the loudspeaker output ground terminal are also connected to this point after the circuit-board and heat-sink assembly has been installed. The latter connection should be made with a length of No. 16 stranded wire. It is important to carefully solder all the high-current leads in the power supply. Also, the the central ground point must make good electrical connection to the chassis. Before mounting the transformer, clean all paint and corrosion from its terminals, coat them lightly with zinc chloride soldering paste, and install a ¼-inch screw-size grommet into each hole in the transformer mounting brackets. The transformer is installed with four ¼-20 x ¾-inch bolts with two No. 10 flat washers between each grommet and the chassis — one washer between each grommet and nut, and one washer under the head of each bolt. Solder separate lengths of No. 16 stranded wire from the two secondary terminals labeled 57½ V to the central ground point. Next, solder separate lengths of No. 16 stranded wire from the two terminals labeled 0 V to one a.c. input on the bridge rectifier. Similarly, solder No. 16 wire from the terminals labeled 115 V to the other a.c. input on the bridge rectifier. Solder capacitor C29 directly across the two a.c. inputs on the rectifier. Wire the d.c. outputs from the bridge rectifier to a terminal strip from which separate lengths of No. 16 stranded wire are connected to each filter capacitor and to the d.c. power-supply fuse clips. The three wires on the a.c. power cord must be connected properly to minimize shock hazard. First, coat each lead with zinc chloride soldering paste and solder the leads to separate terminals on a terminal strip. Solder a length of No. 18 stranded wire from the terminal with the green or safety ground wire to the central ground point. Next, solder a length of No. 16 stranded wire from the white or neutral wire to the 0-V transformer primary tap. The black or "hot" power-cord wire should be connected with lengths of No. 16 stranded wire through the a.c. fuse clip and the a.c. power switch to the 115-V transformer primary tap. The pilot light is connected in parallel with the transformer primary.

After the power supply has been wired, the heat-sink and circuit-board assembly can be mounted on the chassis and connected to the power-supply fuse clips, the central ground point, and the loudspeaker output terminal. The No. 16 and 22 stranded wires for these connections should already have been soldered to the circuit board. Before soldering leads to the loudspeaker output terminals, install the series combination of resistor R57 and capacitor C26 directly across the ter-

Table I — Codes for external connections to the circuit board.

Circuit Board Label	Connected To
1	Emitter Q26
2	Emitter Q27
3	Emitter Q22
4	Emitter Q23
5	Emitter Q20
6	Emitter Q21
7	Emitter Q24
8	Emitter Q25
9	Collector Q22
10	Collector Q19
11	Base Q19
12	Base Q18
13	Collector Q18
14	Collector Q20
A	D3-D4
B	D5-D6
C	Collector Q24
D	Collector Q25
E	Collector Q30
F	Collector Q21
G	Base Q20
H	Base Q21
I	Emitter Q18
J	Emitter Q19
K	Base Q22
L	Base Q23
M	Collector Q23
N	Collector Q31
O	Collector Q26
P	Collector Q27
Q	Emitter Q30
R	Base Q24
S	Base Q25
T	Base Q26
U	Base Q27
V	Emitter Q31
W	Base Q30
X	Base Q31

Numbers are etched on the copper foil side of the circuit board and letters on the ground plane side.

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minals and connect one end of resistor R59 to the loudspeaker ground terminal. Solder the other end of this resistor to a nearby grounding solder lug. The loudspeaker output wire from the circuit board and the speaker ground wire from the central ground point can now be connected and all connections soldered. Next, solder the free end of resistor R58 to a grounding solder lug that connects to the chassis ground near the circuit board ground (to which this resistor connects). The final step is to connect the input leads to the phono input jack. Solder resistor R1 between the insulated phono jack ground and a nearby grounding solder lug.

Proper grounding is a must if ground loop problems are to be avoided. To minimize these problems, separate chassis and signal grounds were used. The circuit-board ground plane was insulated from the driver transistor heat sinks so that there is only one direct connection between the circuit-board ground and the central ground point—through the wire soldered to the ground connection nearest the loudspeaker output connection on the circuit board. There are three small value resistors that complete the grounding — R1, R58, and R59. Resistor R1 solders between the insulated ground terminal on the phono input jack to a solder lug connected to the chassis ground adjacent to the jack. Resistor R59 solders between the loudspeaker output ground terminal and a solder lug connected to the chassis ground adjacent to the loudspeaker output terminal. Resistor R58 solders between the circuit-board ground closest to the loudspeaker output connection to a nearby grounding solder lug. Although complicated, this grounding procedure follows the practices recommended in [16] and should ensure freedom from oscillations and hum that can be caused by mutual coupling in the ground system.

These steps complete the amplifier assembly.

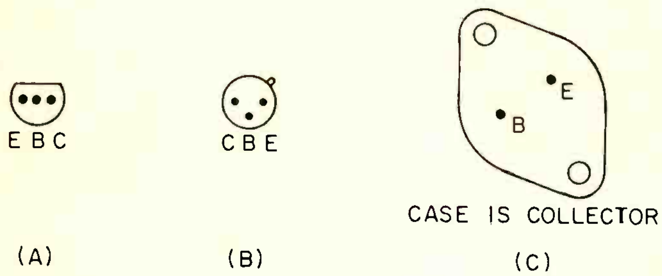

Fig. 18 — Transistor pin connections. Views are from the pin side of each transistor. (A) Small signal plastic case transistors; (B) TO-5 metal case transistors, and (C) TO-3 metal case transistors.

Turn-On Procedure

Before attempting to apply power to the amplifier, it is strongly recommended that the entire unit be checked for errors. If everything appears to be correct, the initial tests can be performed. First, install the a.c. power fuse; do not install the d.c. power fuses to the circuit board at this point. Plug the a.c. power cord into a Variac autotransformer, turn the amplifier on, and slowly increase the a.c. voltage until a d.c. voltage of about 5 V is measured with a voltmeter across the d.c. outputs of the bridge rectifier. The polarity of the voltages on each filter capacitor should now be checked with the voltmeter before increasing the voltage further. If the voltage polarity is incorrect on any capacitor, it will short-circuit if the voltage is increased. If all filter capacitors are polarized correctly, the a.c. voltage can be increased to 120 V. Do not increase the Variac above that value. The positive and negative d.c. power supplies should read within one or two volts of 85 V. The a.c. power can now be removed. Before further tests, discharge the filter capacitors with care, since approximately 110 joules of energy will be stored in them. It is best to do this by connecting two leads to a 16-ohm dummy speaker-load box and then touching the leads across the terminals of each capacitor for several seconds. If a dummy load box is not available, a 3.9-kilohm, 2-watt resistor can be used although the discharge will take several minutes. Do not hold a resistor by its body across the capacitor terminals to discharge them, for the resistor can become hot enough to burn the fingers.

In the next test, d.c. power is applied to the circuit board. Before proceeding, adjust potentiometer R28 for maximum resistance, i.e. 5 kilohms. This should be verified with an ohmmeter, for otherwise the power transistors could be damaged in the next test. Install a 10-ohm, 2-watt resistor with clip leads across each d.c. fuse clip to prevent the release of excessive current into the circuit if there is an error. If everything is normal, the current through the resistors in the next test will be less than 50 mA and the voltage drop across them negligible. Apply a 1-kHz sine-wave signal of amplitude 1 V rms to the amplifier input. With an oscilloscope, check the signal at the phono input jack to ensure there are no short circuits in the input cable from the jack to the circuit board. If there are no shorts, connect the oscilloscope to the loudspeaker output terminals. With the a.c. power switch on, slowly increase the a.c. voltage with the Variac until the output signal is observed. The signal will initially appear as a clipped sine wave that looks like a square wave. If no problems are encountered, the a.c. voltage can be slowly increased to 120 V. The amplitude of the sine wave output signal should be about 60 V peak-to-peak. The input signal should now be removed and the d.c. output voltage from the amplifier measured. This should be less than 100 mV, although a slightly higher value is acceptable. The magnitude of the d.c. offset depends on the matching of the transistors in the differential amplifiers, i.e. Q1 through Q4.

If the preceding tests are successful, the bias potentiometer R28 can be adjusted next. Remove the a.c. power and discharge the power-supply capacitors. Install a fuse in the negative power-supply fuse clip and a d.c. milliammeter across the positive power-supply fuse clip. With no input signal and no load connected to the loudspeaker output terminals, slowly turn the Variac up until the a.c. input voltage is 120 V. Adjust R28 until the milliammeter reads 250 mA. This will bias the amplifier so that it operates Class-A for a peak power level of 2 W or less with an 8-ohm load, thus eliminating all traces of crossover distortion. Let the amplifier idle for at least 30 minutes while readjusting R28 for 250 mA every few minutes. When the current stabilizes to this value, the heat sinks will be warm to the touch.

The amplifier is now ready to be used. Turn it off and let the power supply discharge. When the milliammeter reading drops to zero, remove it from the fuse clip and install the positive power-supply fuse. The amplifier will have no turn-on thump if it is switched on after the power supply has completely discharged. This takes several minutes after each turn-off. To prevent turn-on thumps from the preamplifier from reaching the loudspeaker, *always turn the preamplifier on for several seconds before turning on the power amplifier, and always turn the power amplifier off and wait until the sound stops before turning off the preamplifier.* This procedure should always be used with d.c.-coupled amplifiers to prevent d.c. transients generated in the preamplifier from reaching the loudspeakers.

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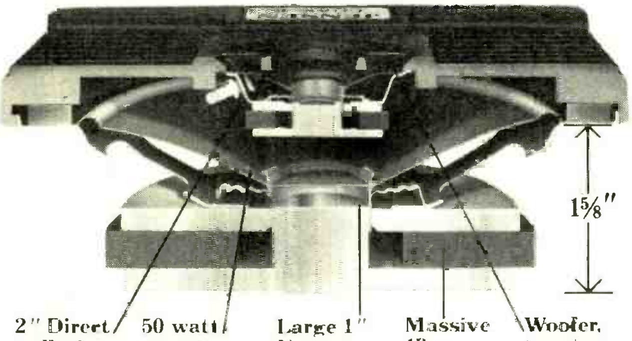

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Concluding Comments

The basic circuit topology of the amplifier was originally conceived in 1975. With the enormous tasks of completing the circuit design details, translating them into a finished amplifier, and describing its construction for this article accomplished, the task of building a second amplifier to complete a stereo system will begin.

The original intent was to build a single stereo amplifier rather than two mono units. However, I recognized that most audiophiles who build the amplifier would probably prefer the two channels with separate power supplies. Thus, weight and size limitations dictated a separate chassis for each channel. A single chassis and power supply can be used if desired, although a special grounding procedure must be observed to prevent hum caused by ground loop problems. The two phono input jacks should be installed adjacent to each other. Connect their insulated grounds together and use a single resistor R1 from this connection to a nearby grounding solder lug. Omit the No. 22 ground wire that connects from the circuit-board ground of one channel back to the central ground. This circuit board will then be grounded back through the phono input cable grounds, the circuit-board ground plane of the other channel, and the No. 22 wire which connects that channel to the central ground point. Resistors R58 and R59 should be installed on both channels as described previously.

The problem of obtaining parts is not a trivial one. The transistors and diodes cannot be bought from consumer electronics stores or those that supply TV repair shops; they can only be ordered through industrial electronics suppliers. *Under no conditions should substitute transistors or diodes be used*, for the amplifier is frequency-compensated only for the types and manufacturers specified in the parts list. Many parts, such as heat sinks and filter capacitors, can be obtained from money-saving mail-order electronics surplus companies. There are also many mail-order firms that sell high-quality non-surplus items such as carbon film resistors, small electrolytic capacitors, small signal transistors, zener diodes, chassis hardware, etc. at bargain prices. The addresses of these companies can be found in the back pages of many consumer electronics magazines. (A list of sources for parts will be sent with all circuit board orders from the supplier listed in the accompanying parts list.)

The power transformer is the single most expensive item in the amplifier. If two surplus 230- to 115-V transformers can be found, their primaries can be connected in parallel and secondaries in series to form a 115- to 115-V transformer. If the transformers are not connected properly, the series secondaries will be out of phase and the voltages will cancel. Therefore, an a.c. voltmeter should be used to verify that the secondaries are phased properly. The current rating of the 115-V windings should be no less than 10 A. The specified transformer has a current rating of 12 A with its two 6-A secondaries connected in parallel for a 115 to 115-V rating. One measure of transformer quality is the weight. The specified one weighs 38 pounds, which should be comparable to the total weight of any substitute transformers. Under no conditions should more than 85 V be used on the amplifier power supply. With substitute transformers, it is sometimes possible to remove several turns from the secondary to reduce the output voltage in case it is too high. If the line voltage runs higher than 120 V a.c. with the specified transformer, the 125-V primary tap should be used. If a 230-W amplifier is sufficient, the use of the 125-V tap is highly recommended. This will ensure protection of the amplifier in case the a.c. line voltage increases due to poor regulation by the power company. With a line voltage of 120 V a.c., the power supply voltages will be plus and minus 80 V.

Removal of the Bessel input filter to increase the amplifier bandwidth beyond 40 kHz is not recommended, for the frequency compensation will be affected. Capacitor C1 in this filter affects the high-frequency bandwidth of the input stage for signals applied to the feedback input. Its removal may cause oscillations. Also, because the amplifier slew rate is so high, the filter protects the amplifier and its loudspeaker load from accidental or unintentional ultrasonic input signals. Some advertisements have misled audiophiles to believe that very wide bandwidths are required for negligible phase distortion. Thus, some builders may be tempted to remove the filter to extend the amplifier bandwidth to 500 kHz. Do not do this, for the circuit still has a bandwidth of 500 kHz with the filter. The filter simply prevents signals with a frequency higher than 40 kHz from entering the circuit. The phase response of the Bessel filter has been carefully researched [3]. The filter phase response is such that it introduces a constant time delay in the audio band of 5.4 μS. This delay is equivalent to the listener moving 1/16 inch back from the loudspeaker. Further, it is minuscule compared to the time delay between an original recording session and any playback of the recording. As a point of interest, the nice phase characteristics of a Bessel low-pass filter are not shared by a Bessel high-pass filter. Thus, unfortunately, the low-frequency phase response of loudspeakers cannot be successfully linearized with the Bessel alignment.

As stated previously, removal of the limiter circuit is not recommended. Its threshold is high enough so that it would not be triggered by normal loudspeaker loads. Also, the limiter cricuit will not respond to fast transients so that it will not limit the slew rate of the amplifier with normal loads. Without the limiter, an accidental short circuit on the loudspeaker output can severely damage the amplifier, and I have heard from several builders of the low TIM amplifier [4], [5] who related their unfortunate experiences. In one case, the builder lost his amplifier when he sat on the bed; investigation showed that the loudspeaker wire ran under the carpet and beneath the bedpost.

Finally, there are some precautions which should be observed in testing the amplifier. Never attempt to apply continuous large-amplitude high-frequency sine waves or square waves to the input. Not only could the output transistors be damaged, but resistor R57 will surely be fried. This resistor must be noninductive, and thus a carbon composition resistor is specified. The highest wattage standard carbon-composition resistor is 2 W. If the amplifier is tested at 20 kHz with a full power sine wave, it will dissipate 3 W. With a square wave, it would be about double this figure. If the builder anticipates that the amplifier will be subject to continuous sine or square wave tests that could fry R57, it is recommended that four 39-ohm 2-W resistors be connected in parallel to form this resistor, which will increase its power rating to 8 W. During any tests, occasionally touch these resistors to check that they are not so hot that they could be damaged. With normal audio signals, R57 is safe at 2 W. If R57 is unknowingly fried during a test, the stability of the amplifier with reactive loads could be affected. This means that it may oscillate with reactive loads and possibly damage the output transistors.

For those readers who wish to ask questions or make comments about this construction article, I ask that you please not use the telephone. I must politely refuse all calls made to my office at Georgia Tech that pertain to this type of project. Instead, mail letters to me and enclose a self-addressed stamped envelope for return; I will make every effort to answer them. I sincerely hope that the ideas I have expressed in this article will spark the imagination of readers, and I wish the best of luck to those who build the amplifier. The best advice I can offer is to take your time! It has taken me four years to build my amplifier, and I estimate that anyone who

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takes less than four months to acquire the parts and build it will do a sloppy job. Happy listening!

Addendum

Although not indicated on the circuit diagram, parts list, or parts layout, the protection circuit should be modified by the addition of two diodes and two resistors. The diodes should be type 1N4934. The resistors should be 680-ohm ¼ W 5 percent. Solder one diode and one resistor in parallel across the leads of capacitor C17 and the other diode and resistor in parallel across the leads of capacitor C18. The banded end or cathode of the diode which connects in parallel with C17 should be the end that connects back to the center lead or base of transistor Q14. The unbanded end or anode of the diode which connects in parallel with C18 should be the end that connects back to the center lead or base of transistor Q15. If the diodes are installed backward, the operation of the protection circuit will be seriously affected.

Parts List

All resistors are ¼-W 5 percent carbon film unless otherwise specified. Manufacturer codes for active devices: M—Motorola, R—RCA, I—ITT, N—National Semiconductor. *Do not substitute transistor or diode types or manufacturers.*

R1—4.7 ohm.
R2—43 kilohm.
R3, R4—6.2 kilohm.
R5 through R12 and R29, R30—270 ohm.
R13, R14—10 kilohm.
R15, R16—1.2 kilohm.
R17, R18—4.3 kilohm, 1 W.
R19, R40—240 ohm.
R20, R52, R53, R54, R55—5.6 kilohm, 1 W.
R21—56 kilohm.
R22, R23—20 ohm.
R24, R25—330 ohm.
R26, R27—1 kilohm.
R28—5 kilohm trimpot (CTS X201R).
R31, R32—3.9 kilohm, 1 W.
R33, R34, R35, R36—360 ohm.
R37, R38—100 ohm.
R39—470 ohm.
R41 through R48—0.22 ohm, 5 W.
R49, R51—15 kilohm, 1 W.
R50—39 ohm.
R56—10 ohm, 2 W.
R57—10 ohm, 2 W or four 39-ohm, 2 W resistors in parallel (see text).
R58—3.3 ohm.
R59—1 ohm, ½ W.
C1—430 pF silver mica (Arco DM15-431J).
C2, C3, C24, C25—270 pF silver mica (Arco DM15-271J).
C4, C5—15 pF silver mica (Arco DM15-150J).
C6, C7—330 μF, 10-V radial electrolytic (Panasonic 330/10R).
C8, C14, C17, C18, C26, C27, C28—0.1 μF, 100- or 250-V metallized polyester (Plessey Minibox 0.1/100 or 0.1/250, C or D box).
C9—15 pF silver mica (Arco DM15-150J).
C10, C11—100 μF, 50-V axial electrolytic (Panasonic 100/50A).
C12, C13—10 pF silver mica (Arco DM15-100J).
C15, C16, C23—0.01 μF, 400- or 630-V metallized polyester (Plessey Minibox 0.01/400 or 0.01/630, B or C box).
C19, C20—100 μF, 100-V axial electrolytic (Mallory TC10101B).
C21, C22—25 μF, 100-V axial electrolytic (Mallory TC10250C).
C29—0.1 μF, 250-V metallized polyester (Panasonic 104K).
C30—0.01 μF, 630-V metallized polyester (Plessey Minibox 0.01/630, C box).
C31, C32, C33, C34—8,600 μF, 100-V electrolytic (Mallory CG832U100G1).
L1—10 turns No. 22 solid insulated wire wound tightly around R56 and soldered to the resistor leads.
D1, D2 — Two 1N5250B 20-V zener diodes in series for each.
D3, D4, D5, D6 — 1N4001, 1N4002, 1N4003, or 1N4004.
D7, D8, D9, D10— 1N4934 (M) fast recovery rectifier.
D11, D12 — 1N4935 (M) fast recovery rectifier.
Rect 1 — MDA3504 (M) 400-V, 35-A bridge rectifier.
Q1, Q2, Q5, Q8, Q13, Q14 — MPS8099 (M) or 2N5210 (M, I, or N).
Q3, Q4, Q6, Q7, Q15 — MPS8599 (M) or 2N5087 (M, I, or N).
Q9, Q11, Q17, Q29 — MM5415 (M) or 2N5415 (R).
Q10, Q12, Q16, Q28 — 2N3439 (M or R).
Q18, Q30 — MJ15001 (M).
Q19, Q31 — MJ15002 (M).
Q20, Q21, Q24, Q25 — MJ15003 (M).
Q22, Q23, Q26, Q27 — MJ15004 (M).
T1 — Signal transformer 230-6, 115V C.T., 12A (Signal Transformer, 500 Bayview Ave., Inwood, N.Y. 11696).
F1, F2 — 8-A 3AG fast blow fuse (Littlefuse 312008).
F3 — 6.25-A, 3AG slow blow fuse (Littlefuse 3136.25).
S1 — 15-A 125 VAC two-pole single-throw circuit breaker (Airpax T21-2-15.0A-01031) with both poles wired in parallel, punch chassis for ½-in. hole.
One neon pilot lamp (Drake 6063-001-634), drill chassis for ⅜-in. hole.
One etched, plated, and drilled ground plane circuit board (see text).
Two heat sinks to mount on circuit boards for Q18, Q19, Q30, Q31 (see text).
One three-conductor UL-type SJ No. 16 a.c. line cord (Alpha 618) and line cord strain relief (Heyco SR-6P3-4), punch chassis for ⅝-in. hole.
One phono chassis jack (Switchcraft 3505F) insulated from chassis with ⅜-in. I.D. nylon shoulder washer on one side and flat nylon washer on other, punch chassis for ½-in. hole.
One double five-way binding post (Superior Electric DF30-2-BRC) for loudspeaker output terminals.
Three 3AG fuse mounting holders (Littlefuse 357001).
Four 4-40 x ¾ in. x ¼ in. O.D. aluminum threaded round spacers (Waldom 60477) for mounting circuit board to heat sinks.
Twelve TO-3 transistor sockets, molded types preferable.
Twelve TO-3 mica insulating wafers.
Eight TO-5 transistor finned heat-sink coolers (Wakefield 205CB).
Two Wakefield 441K transistor heat-sink coolers drilled for Q20 through Q27 and D3 through D6 (see text).
Misc. — Suitable heavy-duty steel chassis with cover; mounting brackets for circuit board and heat-sink assembly; silicone heat-sink compound; shielded phono cable; No. 16, 18, 20, and 22 stranded hook-up wire; No. 22 solid hook-up wire; five heavy duty ½-in. hard plastic feet; No. 6 and No. 10 soldering lugs; chassis hardware; rubber grommets for mounting transformer; etc.

An etched, drilled, and reflow solder-plated circuit board plus two mating heat sinks punched for the four driver transistors are available for $16 from Custom Components, P.O. Box 33193, Decatur, Ga. 30033. Shipping and handling charges for orders inside the continental USA are $1.00 plus five percent of the total price of each order. Georgia residents must add four-percent sales tax.

After equipping the world's most advanced sound studios, Studer Revox is ready for your living room.

Recording studios and radio stations that pride themselves on the quality of their master tapes and broadcast signals specify Studer Revox audio equipment.

If you take the same kind of pride in the quality of the music reproduction in your home, you'll specify Studer Revox, as well. Like the new B780, the first receiver good enough to be a Revox.

A sophisticated microprocessor and quartz-crystal reference oscillator provide the B780 with a digital synthesis FM tuning system so accurate that the only way to equal it manually would require a laboratory distortion analyzer. The microprocessor memory also lets you "program" the frequencies (and even the optimal antenna rotator settings!) of up to 18 stations, for instant pushbutton recall. A digital frequency readout tells you exactly where you are, and a signal strength meter calibrated directly in dBf tells you just how much signal your antenna is supplying.

And if stations in your area utilize Dolby FM processing, a simple plug-in circuit board is available.

LED digital indicators independently show which of the five stereo inputs is being fed to your recorder(s) and which to your speaker system(s). Separate bass, treble, and presence controls (plus defeat switch), along with separately switchable high- and low-cut filters, ensure proper tonal balance between nearly any music source and your living-room/loudspeaker acoustic environment. And the power amp features individual-stage, local feedback design for lowest TIM (transient intermodulation distortion) and a sophisticated SOAR protection circuit that safeguards both the amplifier and your speakers.

Of course, professional-oriented designs cost more than "home consumer" equipment. You can feel it in the controls and you'll hear it, not only now, but years from now. With Studer Revox, professional design is a matter of pride, and if you share that pride in sonic quality, you'll visit your Revox dealer.

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The Franklin Mint Record Society presents
the ultimate private library of recorded music

The 100 Greatest Recordings of all time

A unique collection of the greatest performances ever recorded, selected by an international panel of music authorities and presented on 100 records of superb proof quality.

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These are the supreme masterpieces of man's musical genius, performed by the most outstanding artists of the century. Together, they form a record library unprecedented—and unsurpassed—in the entire history of music. *The 100 Greatest Recordings of All Time.*

The greatest music—and the greatest performances

An international panel of renowned music authorities was appointed to participate in the selection of these great recordings. This distinguished panel considered countless recordings of each of the greatest works of music—a momentous task.

For instance, members of the panel reviewed 24 recordings of Beethoven's 7th Symphony and chose the *one* recording they considered superior to all others: Toscanini with the New York Philharmonic.

From 30 great recordings of Tchaikovsky's Nutcracker Suite, the panel selected the *one* greatest performance: Arthur Fiedler and the Boston Pops.

Similarly, the recordings of other great symphonies, concertos, sonatas, rhapsodies, ballet and vocal music were reviewed and the most outstanding performance in each instance recommended.

The creation of this definitive collection has been made possible through the cooperation of leading record companies both here and abroad. And now, *The 100 Greatest Recordings of All Time* is being issued by The Franklin Mint Record Society.

Among the works chosen for this collection are immortal masterpieces by Beethoven, Brahms, Mozart, Tchaikovsky, Schubert, Rachmaninoff, Debussy, Verdi—performed by such superb artists as Vladimir Horowitz, Jascha Heifetz, Enrico Caruso, Van Cliburn, Isaac Stern, Artur Rubinstein, Leontyne Price—with the world's great orchestras under the direction of Toscanini, Ormandy, Bernstein, Stokowski, von Karajan, among others.

In every sense, the ultimate private library of recorded music—to be cherished for a lifetime, and presented as a legacy to later generations.

Superb proof-quality records

Each record is exceptional for its clarity and tonal quality—capturing the beauty of today's finest performances *and* of the historic performances of the past. Indeed, the recordings of legendary greats such as Caruso and Ponselle have been remarkably *improved* by electronically removing imperfections in the earlier recordings.

A superior vinyl material, containing its own anti-static element, is used in the production of these records. This special material, and the process by which the pressing is made, results in a record that is more rigid, durable and resistant to dust. A record that has true fidelity, clearer sound quality and a long life.

To further assure their quality, the records are pressed in a special "clean room" similar to the facility in which The Franklin Mint produces its flawless proof-quality coins. In this atmosphere-controlled clean room, the most meticulous attention is paid to the pressing of the records. And the records are carefully inspected to make certain that the full quality of each original recording is faithfully preserved.

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To house these magnificent proof-quality records, special library cases are provided for all 100 records in the complete collection. Each library case holds two long-playing 12" records and is sturdily hardbound and attractively designed. Displayed in a bookshelf, breakfront or cabinet, these handsome library cases will be an impressive addition to any home.

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Thus, you will enrich your understanding of great music—and you will introduce your entire family to a world of pleasure and cultural satisfaction.

Created solely for subscribers to this series

The 100 Greatest Recordings of All Time are produced *exclusively* for those who enter subscriptions to this series. The collection may be acquired *only* from The Franklin Mint Record Society. It will not be sold in any record stores.

To begin building your private library of the world's greatest performances on *proof-quality* records, mail your application by May 31, 1980.

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Equipment profiles

Crown Model FM-1 Stereo FM Tuner

Manufacturer's Specifications
Mono Usable Sensitivity: 10.8 dBf (1.9 μV).
50-db Quieting Sensitivity: Mono, 14 dBf (2.75 μV); stereo, 36.1 dBf (35 μV).
S/N at 65 dBf: Mono, 70 dB; stereo, 65 dB.
THD at 1 kHz: Mono, 0.1 percent; stereo, 0.09 percent.
Capture Ratio: 2.0 dB.
Alternate Channel Selectivity: 75 dB.
Stereo Separation: 45 dB at 1 kHz, 35 dB at 10 kHz.

General Specifications
Weight: 15½ lbs. (7 kg).
Price: $995.00.

Crown International of Elkhart, Indiana, long renowned for their high-quality amplifier and preamplifier products, has finally come up with an FM tuner designed to match and complement their other high-end audio products. The Model FM-1 looks distinctively different from any other tuner we have ever seen. As you might expect, in these days of digital readout audio equipment, the conventional flywheel and dialstring have been replaced by a quartz-crystal referenced LSI digital controller. In deference to the traditionalists who insist upon seeing where they are on the FM dial, an analog frequency reference band, composed of a series of LED indicators, is located to the right of the purely digital frequency readout. These LEDs, 20 in all, simply flash to indicate the nearest MHz to which the unit is tuned.

Additional LED displays to the left of the frequency readout area are used to indicate multipath reception and signal strength. Unlike the usual mechanical signal-strength meter found on many tuners and receivers, the LEDs of the signal-strength indicator display on the Crown FM-1 have been calibrated to provide meaningful indications of signal strength. Specifically, on the sample tuner we tested, illumination of successive LEDs occurred at the following levels of input signal at the antenna terminals: 31 dBf, 35 dBf, 40 dBf, 45 dBf, 51 dBf, 55 dBf, 62 dBf, 75 dBf, and 85 dBf. The multipath-indicating LEDs show the amount of multipath interference being received, so that a minimum or no indication on this bank of LEDs is to be sought when orienting any FM antenna connected to the FM-1.

Five push buttons at the lower left of the front panel handle power turn-on, selection of 25- or 75-μS de-emphasis, FM muting, stereo/mono selection, and high-blend filtering. The action of this last button is somewhat unexpected since what we feel to be the normal position, where the filter is defeated, is the depressed position. We usually assume the "out" position to be the normal one.

All of the remaining functions of the FM-1 are controlled by touch-button surfaces along the lower edge of the panel, which is gently sloped upward for easy finger access. A *Program* button and five preset touch switches are used to store five favorite station frequencies in the tuner's "memory." To program the unit, one simply tunes to the desired frequency, touches the program button and then touches one of the five numbered buttons. To recall the frequency memorized, it is then simply necessary to touch the appropriate numbered button. A pair of arrow-marked segments of the switching area are used to tune the FM-1. By repeatedly touching and releasing one of these segments, the tuner will tune in 200-kHz increments. By pressing and holding either the *Up* or

Down button, continuous scanning of the entire FM band takes place, enabling you to reach a desired frequency more quickly.

Tapping the *Scan* segment switch causes the tuner to scan the FM band until it finds a signal it can lock onto. Once locked in, the unit will allow you to sample the program material being broadcast for approximately seven seconds. If you hear something you like, you simply touch the *Scan* segment again. Otherwise, the FM-1 will scan to the next usable signal and repeat the process until you give it a command to stop scanning.

By touching the *Search* segment switch, the FM-1 will search up or down the FM band until it comes across a signal whose strength is great enough to overcome the mute threshold level. When the FM-1 locks onto a signal in the search mode, it will remain tuned to that signal until another command has been entered. Finally, the *Stereo Search* switch segment initiates the same sort of band searching as does the *Search* button, except that the search operation will only stop when stereo signals of adequate strength are encountered. Interestingly, if you push the *Mono/Stereo* switch so that it is in the mono mode and then touch the *Stereo Search* segment, the tuner will continue to search, endlessly, until you cancel the command, since it cannot intercept a stereo signal under those conditions.

If the a.c. current goes off or if the unit is unplugged, and then normal supply of power goes on again, the digital readout will display the frequency of (and the tuner will be tuned to) the signal last listened to before the power interruption.

There are two sets of output jacks on the rear panel of the FM-1. Both deliver the same signal, but the signals available at the "variable" jacks are controllable in level by means of potentiometers from around 160 μV to 0.9 V. Another control on the rear panel is used for adjusting mute threshold level, while additional rear panel jacks permit connection to an oscilloscope for visual display of multipath.

Six double-varactor diodes are used in the front end of the FM-1, instead of the conventional mechanically tuned variable capacitor. A combination of three linear-phase ceramic filters, followed by a single SAW filter, are used in the FM i.f. section of the tuner. The memory system of the tuner uses an electronically alterable ROM which insures memory retention of selected frequencies even after the power is turned off.

In addition to using the FM-1 as it comes, adaptor hardware consisting of "mounting ears" and the required bolts are supplied for mounting the unit in a standard 19-in. rack. Alternatively, Crown has available an optional hardwood cabinet into which the FM-1 can be installed.

Laboratory Measurements

Usable sensitivity in mono measured 10.7 dBf (1.9 μV) as claimed. Stereo switching threshold was set a bit higher than we would like to see, which limited stereo usable sensitivity to 31.6 dBf (21 μV). Fifty-dB quieting sensitivity measured 14.7 dBf (3.0 μV) in mono and a very satisfactory 34.7 dBf (30 μV) in stereo. Best signal-to-noise in mono and stereo, for 65 dBf input signal strength, measured 76 dB and 71 dB respectively. Clearly, the advantages gained through varactor tun-

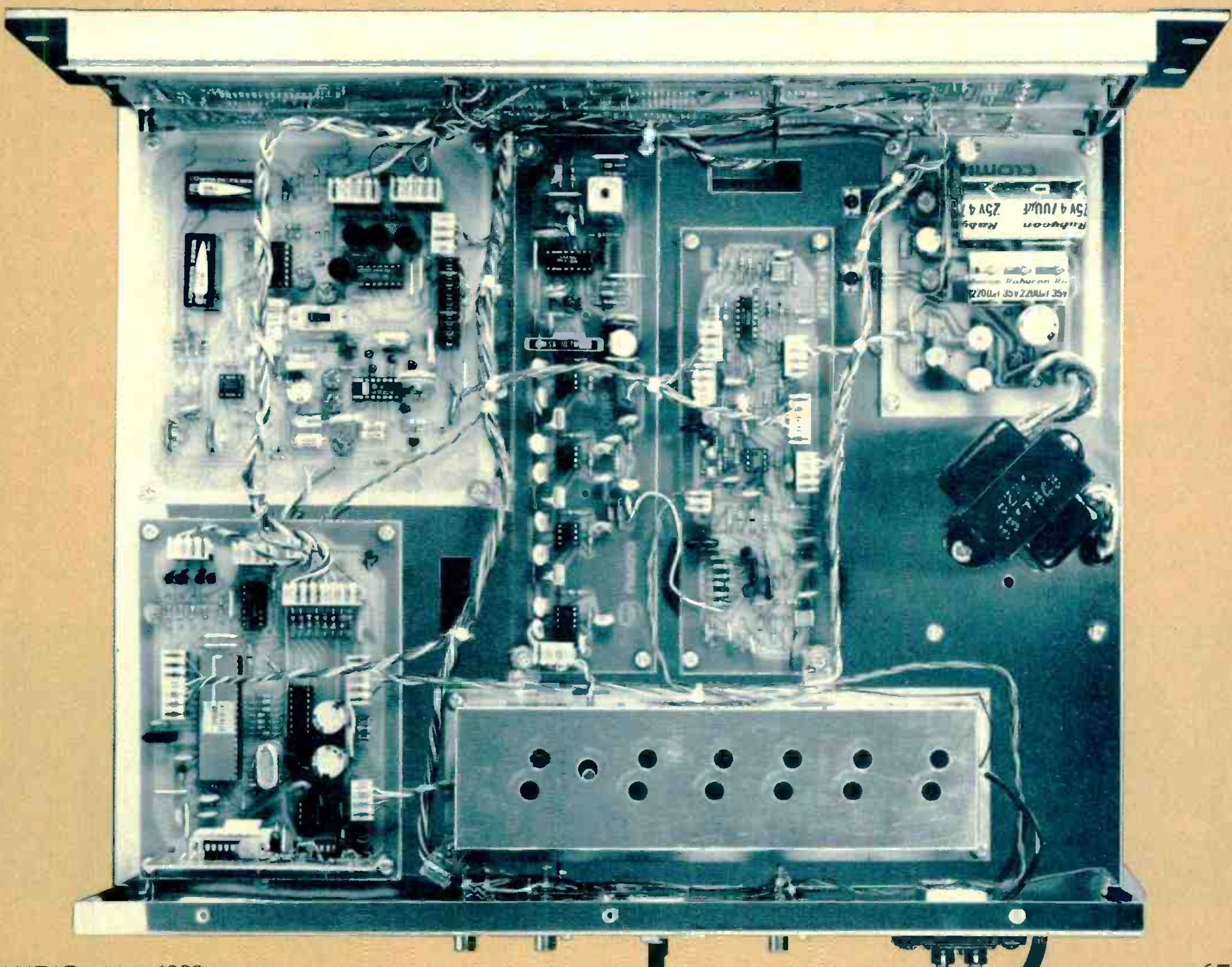
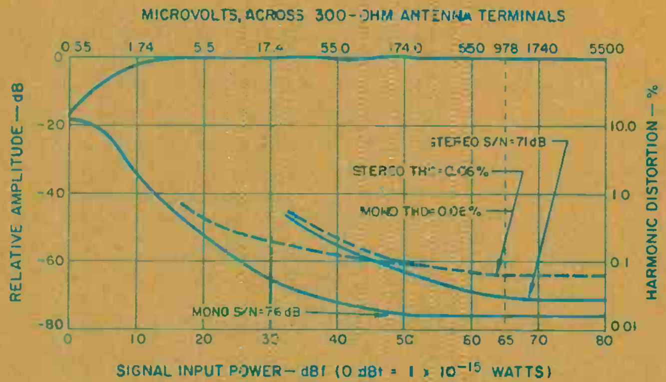


Fig. 1—Mono and Stereo quieting and distortion charateristics.



ing (programmability, frequency synthesis, etc.) are still offset, in part, by signal-to-noise considerations, though the figures obtained for the FM-1 are adequate in most listening situations.

The quieting and distortion characteristics of the FM-1 are shown in the graphs of Fig. 1. Harmonic distortion for mono, with a 1-kHz modulating signal, reached a low of 0.06 percent; the same low level of distortion was obtained in stereo.

At the other standard test frequencies, distortion in mono remained quite low, with readings of 0.1 percent at 100 Hz and 0.15 percent at 6 kHz. In stereo, THD measured 0.25 percent at 100 Hz and 0.33 percent at 6 kHz. Capture ratio, at 65 dBf, measured 1.8 dB, a bit better than the 2.0 specification. Alternate channel selectivity measured 83 dB, an excellent value for a tuner which is not equipped with variable i.f. bandwidth facilities, while spurious response rejection measured 76 dB.

Frequency response in both the stereo and mono modes was extremely flat, as can be seen from the upper trace of Fig. 2. Deviation from flat response was no greater than ±0.5 dB from 30 Hz all the way to the 15-kHz extreme. The lower curve of Fig. 2 represents stereo separation (each vertical division in the display is 10 dB of amplitude), and it is interesting to note that there was very little loss of separation at the frequency extremes compared with separation at 1 kHz. Specifically, we measured 50 dB of separation at 100 Hz and 1 kHz, and 45 dB at 10 kHz. Excellent performance!

Figure 3 illustrates what happens when the stereo filter is activated. The designers of the FM-1 have chosen to introduce an extreme amount of blend to reduce weak-signal stereo noise and distortion; so much so that when this feature is used, there is very little separation remaining above 2 kHz or so.

Figure 4 illustrates the nature of the crosstalk observed in the unmodulated channel output of the tuner when a 5-kHz signal is used to modulate the opposite channel to a level of 100 percent. The spectrum analyzer was swept linearly this time (5 kHz per horizontal division) and vertical amplitude is still 10 dB per division. The tall spike at left represents the desired output from the modulated channel-output terminal. The shorter spike, contained within the tall one, is the actual 5-kHz crosstalk observed in the opposite channel, while the additional spikes to the right represent distortion components in the crosstalk signal, 19-kHz pilot-carrier component and, at the right of the display, minute amounts of 38-kHz and other subcarrier harmonic components.

Use and Listening Tests

The Crown FM-1 is certainly an easy tuner to use, and one which assures minimum-distortion tuning and complete freedom from drift. Externally, it offers a degree of elegance which is totally consistent with that offered by other Crown audio products. As for sound quality and reception capability, the FM-1 will in most every case be limited by the quality and strength of the signal from the FM station, rather than its own abilities. There is sufficient range of mute threshold control to take care of virtually all listening situations, though as we mentioned earlier, we would have preferred a lower stereo threshold switching point in view of the fast quieting characteristics of the tuner.

Evaluating the FM-1 simply in terms of dollars per dB or µV will not tell the whole story of this tuner. While it will certainly perform with most every unit on the market today, the host of convenience and tuning accuracy features must also be taken into account. If one is going to go beyond good basic performance and desires a tuner with such niceties as digital readout, signal locking, memory recall of stations even after power failures, touch selection of station search, etc., then the near-$1,000 price tag of this American-made tuner will be seen to be much more reasonable. It's a matter of paying your money and taking your choice, and whoever said features and quality came cheap. *Leonard Feldman*

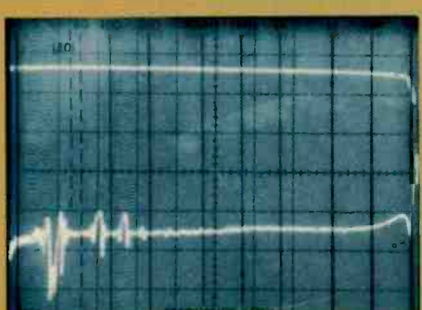


Fig. 2—Frequency response and stereo separation.

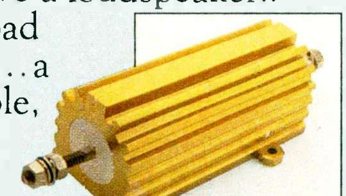
Fig. 3—Separation vs. frequency with the blend filter on.

Fig. 4—Crosstalk components for 5-kHz modulating signal.

At last, an amplifier that listens to loudspeakers.

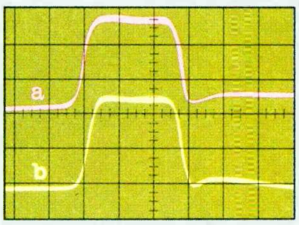
You buy an amplifier to drive loudspeakers. If you're like most people, you rely heavily on distortion "specs" to make a buying decision. SAE found that today's specs don't tell you everything. How could they when the tests for these specs don't even require an amplifier to drive a loudspeaker!!

They use a load resistor instead... a static, predictable, unchanging representation of the dynamic, unpredictable, ever-changing loudspeaker. As a result, specs can't tell you how well an amplifier is going to handle your loudspeakers. SAE has researched this problem and developed a test which actually measures the amplifier while it drives a loudspeaker.



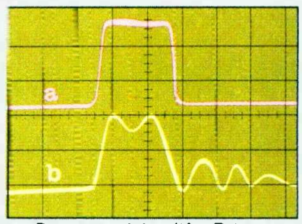
The predictable Load Resistor

Chart I shows the response of our all new 250 watt/channel* 2401 Dual High Resolution Power Amplifier under conventional tests and under SAE's new "real world" tests. As you can see, this amplifier performs much the same whether connected to a load resistor or a loudspeaker. It really *listens* to your speaker's needs.



SAE 2401 Driving:
a) a load resistor b) a loudspeaker

Chart II shows how a conventional amplifier attempts to handle the same situation.



Conventional Amplifier Driving:
a) a load resistor b) a loudspeaker

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*at 0.025% THD into 8 Ohms from 20Hz to 20kHz per FTC standards.

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Enter No. 31 on Reader Service Card

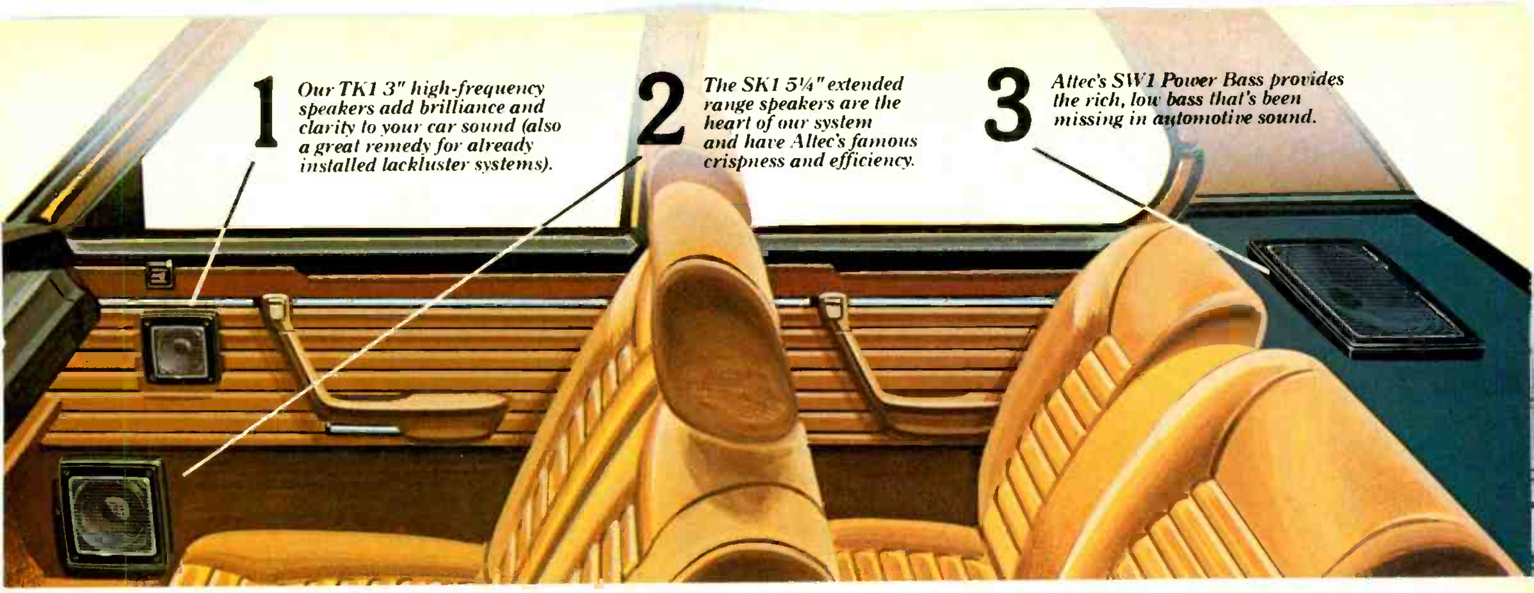
Dual CS 731Q Automatic Single-Play Turntable

Manufacturer's Specifications
Type: Two speed.
Motor Type: Quartz-reference, phase-locked loop, direct drive.
Wow and Flutter: ±0.015 percent W rms.
Rumble: -78 dB (DIN 45-539).
Speed Control: ±5.5 percent.
Optional Cartridge: Ortofon ULM 60E.
Separation: 30 to 35 dB.
Stylus: Bi-Rad.
Output: 0.7 mV/cm/S at 1 kHz.
Tracking Force: 0.5 to 1.25 grams.
Dimensions: 16½ in. (41.25 cm) W x 14½ in. (36.25 cm) D x 5¼ in. (13.125 cm) H.
Price: $559.95; $699.95 with cartridge.

The CS 731Q is Dual's new top model turntable and, while it bears a certain family resemblance to older units like the 721, there are some important differences. The arm and cartridge together have an exceptionally low mass of 8 grams. The tube is smaller in diameter, and though the counterweight looks familiar, a closer examination shows that it has a calibrated ring. You might have thought that this sets the stylus force, but it doesn't — there is a separate dial for this function located near the arm pivots. The ring tunes a mechanical filter to reduce the arm-cartridge resonance, and the result is a smaller "double-hump" resonance familiar to speaker engineers. The object is to improve trackability with warped records and reduce distortion. The arm itself is 8¾ inches long, terminating in a low-mass headshell on which there is an Ortofon ULM 60E cartridge. ULM — as you have probably guessed — means "Ultra Low Mass," and the cartridge weighs only 2.5 grams, including the mounting bracket and hardware! It is one of the series of three magnetic cartridges designed by Ortofon to Dual spec with a tip mass of only 0.35 milligrams. For those who prefer a conventional (high mass) cartridge, a spare headshell is also supplied.

An anti-skating dial is positioned near the arm base and just in front of it is a manual/repeat switch and a cue lever. A green strobe light is near the platter, while over on the left-hand side is the two-position speed switch. The rest of the controls are mounted on the angled front panel where they are accessible when the dust cover is closed. Two pitch controls are on the left, together with a switch for unlocking the quartz-controlled PLL circuit. Speed deviation is displayed on a horizontal array of LEDs: When the speed is locked, a green LED lights up at 0; variations from +5 to -5 percent are indicated by red LEDs. On the right-hand side of the front panel are three push buttons for *Stop*, *Start*, and *Lift* (yes, the cue lift control is duplicated). Additionally, the cue control descent speed is adjustable by means of a ring at the arm base.

The servo-controlled motor does not rotate at 400 or 1800 rpm but turns at the actual platter speed—the center spindle is the top of the motor shaft. An integral generator provides the correction pulses for the quartz control circuit which, by the way, still operates when the speed is changed from the pre-set standard. Dual also stresses the fact that the strobe light is connected to the PLL circuit, not to the power supply.



INCREDIBLE CAR SOUND IN THREE EASY STEPS. AND ONE HARD ONE.

4 *Suggested retail price.*

Let's break all rules and get to the hard one first. Number four: $350 for a complete car stereo speaker system. Gulp. But considering what you paid for the stereo in your dash, if you don't have good speakers, all that money is simply wasted.

Before we get to number one, a word about our whole Voice of the Highway™ system (the AL1). It's extremely modular. So much so, you can buy any part of it and enhance what you've got now. Of course, it's best to get it all and listen to car stereo as it's supposed to sound. A system designed exclusively for the road, but engineered to rival the one in your living room.

Now to number one, a pair of TK1 3″ high frequency drivers that deliver the highest highs you've heard in car stereo. It's a dimension other speaker systems just don't have.

Just as essential, number two, our SK1 5¼″ speakers. Designed for extended range and for fitting in where nothing else will. The sound? It's what made Altec famous: clean, clear and tight.

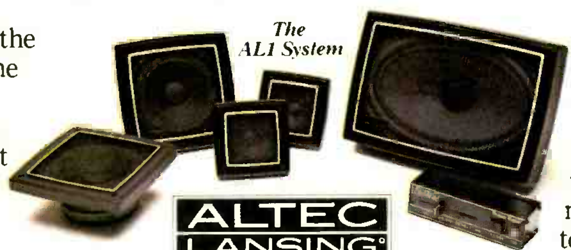
Number three is a unique requirement: the SW1 Power Bass. A self-powered subwoofer that fills out the entire system, improves its dynamic range and reduces distortion. Its unique die-cast structure contains a 40-watt amplifier, electronic crossover, balanced inputs and an active equalizer. And the results are dramatic. (Or you can add the Power Base to your existing speakers for $219.95 and still get great sound.)

Now back to number four, our $350 item. If you want true car stereo, super efficiency and clear performance (not just so much noise on the road), you have to give our Voice of the Highway™ a listen. We believe it's the only speaker truly designed for the car. (And when it's installed by an authorized dealer, we'll guarantee it for as long as you own the car).

In addition to our AL1 system, we also have an incredible set of 6″x 9″ Duplex speakers. They're ideal for all cars with severe space limitations, because they easily mount into a door. They also can be used with the AL1 system or are available themselves at $159.95 per pair.

LISTEN. FREE GAS.

Just to get you to listen, we'll pay for your gas money. Take this ad to your car stereo dealer, listen to the speakers, and we'll send you $2 for gas money, whether you buy or not. That's how confident we are you'll like our Voice of the Highway.™ So when it comes down to the four steps, all of them are really easy to take. One at a time, or all at once. Including the last one. It won't be so hard, once you really listen. Hear Altec's Voice of the Highway™ today and end up driving a real bargain. For the name of your local dealer, call toll-free (800) 528-6050, Ext. 731; in Arizona (800) 352-0458.



ALTEC LANSING Voice of the Highway™

1515 South Manchester Avenue, Anaheim, California 92803

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The platter is dynamically balanced and there are deep-cut strobe markings around the edge, while the complete assembly—motor, motor board, and arm—is mounted on springs attached to the base. This is covered in a black vinyl material that makes a nice contrast to the elegant, anodized front panel.

Laboratory and Use Tests

The first exercise was to check the position of the counterbalance tuning ring, which is quite simple as there is a chart printed in the instruction manual. Next, the resonance was measured and the two points came out at 8 and 12 Hz with a rise of about 3 dB. Tracking error was less than 0.5 degrees per inch, and calibration of the tracking force dial was within 5 percent above 0.75 gram. Both lateral and vertical bearing friction was too low to measure accurately (the specifications quote 7 milligrams). Wow and flutter measured 0.035 percent, using the DIN 45-507 standard, and rumble was a low -63 dB (ARLL weighting). The speed control gave a variation of ±6 percent. So good marks for performance here.

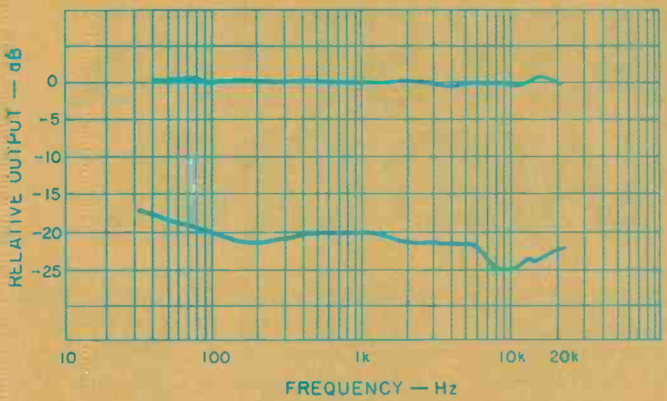

Fig. 1 — Frequency response and separation.

Figure 1 shows the frequency response of the ULM 60E cartridge, and I was interested to see that maximum separation is at the higher frequencies instead of the usual 200 Hz to 5 kHz band. The square wave response (Fig. 2) showed a single moderate overshoot followed by a smooth, well-damped response typical of a wide-range cartridge having a low Q resonance outside the audio range. The optimum tracking force was a hair over 1 gram with the anti-skating dial set to a similar figure. All bands of the big drum section on the Shure —ERA III test record were negotiated with ease, while there was just a trace of "sandpaper" on band 5 of the sibilance group. Maximum tracking velocity was 27 cm/S (10.8 kHz pulsed) and 24 cm/S at mid-frequencies (400 + 4 kHz). IM distortion for 1 kHz and 1.5 kHz (4:1) reached 2 percent at 20 cm/S. Again, good marks.

Dual recommends a total load capacity of 400 pF, and this was used for the measurements. Switching to 200 pF — a more common value — caused a slight dip in the midrange followed by a 2-dB rise at 18 kHz.

Fig. 2 — Square wave response, Ortofon ULM 60E cartridge.

Tested with a variety of records, the sound quality was as neutral as most top-flight cartridges and the tracking ability was better than average. As mentioned earlier, a spare headshell is supplied so you can use a different cartridge — but don't forget the capacitive load requirements. (The capacity of the cables is just under 200 pF.)

At the end of a record, the arm swings back very quickly, total cycling time is less than five seconds in the *Repeat* mode. The cue lift device was almost totally free from backlash, and the descent time could be varied from two to about four seconds. As far as acoustic feedback is concerned, the 731Q is better than most all current models, and you can knock the base quite hard before mistracking occurs. But don't be tempted to reduce tracking force much below 1 gram: Although the cartridge will happily play many records at half a gram, as with any tonearm, a stylus that is swinging about can cause as much damage as one with too much pressure! *George W. Tillett*

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Evaluation Records

The following test records were used for the listening evaluation of the Dual CS 731Q turntable with the Ortofon ULM 60E cartridge: Shure TTR-103, TTR-9, TTR-10, and TTR-15; CBS STR-100, STR-110, BTR-150, and STR-120; and Denon XG-7001. Additional records included:

Stereo

Hammond Castle Pipe Organ (Vol. 1), D. Marshall — Decibel DB 1000.

Direct to Disc

Sonic Fireworks (Vol. 1), Morris, Atlanta Brass Ensemble — Crystal Clear Records CCS-7010.

Sonic Fireworks (Vol. 2), Morris, Atlanta Brass Ensemble — Crystal Clear Records CCS-7011.

Swing Sessions, Kitamura — RCA RDCE-10.

Percussion in Colors, Yoshihara — RCA RDCE-9.

The Great Organ of the Methuen Memorial Hall, Murray — Telarc DD-2.

Digital

Tchaikovsky: *Symphony No. 4*, Maazel, Cleveland Orchestra — Telarc 10047.

Malcolm Frager Plays Chopin — Telarc DG-10040.

Holst: *Suites 1 and 2*, Handel: *Music for the Royal Fireworks*, Fennell, Cleveland Symphonic Winds — Telarc 5038.

Encoded dbx

Copland: *Billy the Kid*, Johanos, Dallas Symphony — Turnabout-dbx SS-3007.

Mark Levinson Presents — dbx RTS-1.

Dbx encoded discs are available through audiophile dealers or from dbx, 71 Chapel St., Newton, Mass. 02195.

Decibel Records' address is Box 631, Lexington, Mass. 02173.

Denon Records are distributed by American Audioport, Inc., 1407 N. Providence Rd., Columbia, Mo. 65201.

*"The Realistic® STA-2200 is a highly advanced stereo receiver which sounds every bit as good as its specifications and our measurements suggest . . . an impressive value for the money."**

Computerized All-Digital Tuner

Breakthrough is a word Realistic seldom uses, but nothing else describes the STA-2200. And the critics agree. The heart of the tuner is the quartz-locked, microprocessor circuitry that ends mechanical tuning problems.

Radio Electronics magazine puts it this way: *"On the whole, the receiver embodies a great many design features, most of them concerned with the ease of use and convenience of accurate tuning."*† Bright fluorescent digits display each station's frequency with absolute accuracy, and computer-type tuning automatically scans up or down the FM and AM bands. You can store any six FM and any six AM stations in the microprocessor for instant touch-button recall.

Radio Electronics also says: *"The STA-2200 is a joy to use."*† For example, you can command the receiver to sample each station in the memory, then touch-select the one you want. There's also Dolby® FM Noise Reduction, LED signal level indicators, and the display doubles as a quartz clock.

Stereo Review summed up the STA-2200's tuner by saying it *"worked to perfection."** And Radio Electronics said *". . . because of its clever design and pleasing layout, we have assigned a VERY GOOD R.E.A.L. rating to the STA-2200."*†

Advanced MOSFET Amplifier

The STA-2200 uses a new breed of power transistors called MOSFETs. Their ultrahigh-speed operation brings you stunningly accurate sound reproduction through superior linearity, superior slew rate and inaudible TIM.

Radio Electronics says *"The unit seems quite conservatively rated in terms of power output, as well as rated distortion, delivering a clean 72 watts per channel at mid-frequencies and just under 70 watts per channel at the 20 Hz and 20 kHz frequency extremes for its rated total harmonic distortion of 0.02%."*† You can monitor the output with the 10-step, dual range output LED power indicators.

Stereo Review reports *"There are no signs of skimping in any area of its design or construction."** The amplifier features go on and on. We've included 11-step bass and treble controls with turnovers for controlling ranges below 150 Hz and above 6 kHz, tone defeat, monitor and dubbing controls, Hi-MPX filter. And more!

Says Stereo Review: *"With the STA-2200, Radio Shack has made it perfectly clear that the technical sophistication responsible for the overwhelming success of the TRS-80™ computer system has been applied very effectively to their high fidelity products."**

We couldn't have said it better. Thanks, guys!

Radio Shack®

The Nationwide Supermarket of Sound

*Quoted by permission from Hirsch-Houck Test Labs Report, Feb., 1980, Stereo Review. (Copyright Ziff Davis Publishing, all rights reserved)
†R.E.A.L. Sound Audio Lab Report by Len Feldman, Jan., 1980, Radio-Electronics. Gernsback Publications Inc., all rights reserved.
The STA-2200 is 599.95, at participating stores and dealers, price may vary. Dolby® is a trademark of Dolby Laboratories.

RG Dynamics Model RG D-3 Stereo Preamplifier

Manufacturer's Specifications
Phono Preamplifier Section
Input Impedance: 47 kilohms.
Input Capacitance: Selectable at 30, 130, or 360 pF.
Gain: 35 dB.
RIAA Accuracy: ±0.1 dB from 30 Hz to 15 kHz.
Input Level: 2 mV.
Channel Separation: 65 dB at 1 kHz.
THD at 2.0-V Output: At 20 Hz, 0.05 percent; at 1 kHz, 0.01 percent; at 20 kHz, 0.015 percent.
Input Stage Acceptance Level, 1 kHz (See Text): 1200 mV rms.
Input Stage Acceptance Level, RIAA Pre-emphasized 500-Hz Square Wave and 1-μS Rise Time: 3700 mV p-p.
Input Sine Wave Overload Level: 140 mV at 1 kHz.
S/N (New IHF): 72 dB.
Maximum Output Level: 7 V rms at 1 kHz and 20 kHz.

Line Amplifier Section
Rated Output: 2.0 V rms.
Gain: 20 dB.
Frequency Response: 20 Hz to 20 kHz, ±0.05 dB; 0.5 Hz to 80 kHz, ±3.0 dB.
S/N: 87 dB, "A" weighted.
THD, 20 Hz to 20 kHz: 0.012 percent maximum.
IM Distortion: 0.012 percent maximum.
Maximum Output Level: 9 V rms.
Treble Control Range: +9 to -12 dB at 15 kHz.
Bass Control Range: ±12 dB at 20 Hz.
Subsonic Filter: -3 dB at 18 Hz, -20 dB at 5 Hz.

General Specifications
Power Requirements: 120 V, 50/60 Hz, 9 W.
Dimensions: Rack panel version, 19 in. (475 mm) W x 3½ in. (87.5 mm) H x 12 in. (300 mm) D; silver panel version, 18 in. (450 mm) W.
Weight: 13 lbs. (5.91 kg).
Price: $595.00.

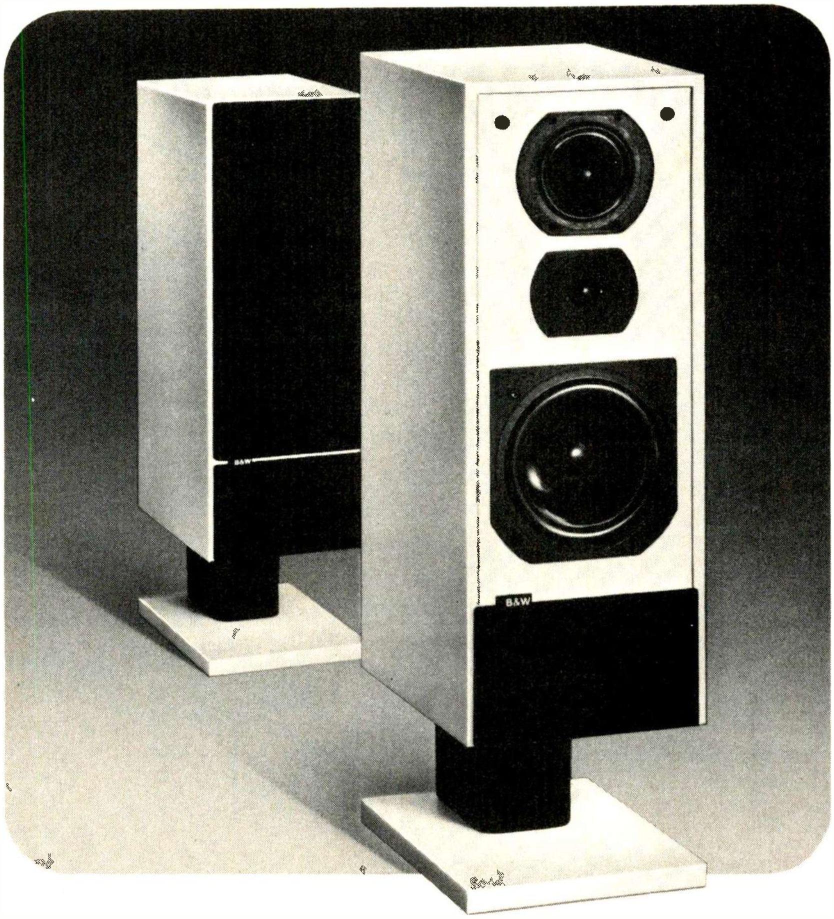
My first encounter with Robert Grodinsky, President of RG Dynamics, Inc., was when he developed a rather unusual dynamic expander which he sold to Pioneer. I sensed then that Grodinsky's future lay not in designing and selling designs to other companies, but in producing and selling them himself. It wasn't long after that Mr. Grodinsky formed his own company which manufactured a dynamic range expander whose performance surpassed, by far, that of the earlier model which had been designed on behalf of Pioneer.

Now RG Dynamics, still very much under the engineering direction of Bob Grodinsky, has come up with a new preamplifier that incorporates his ideas concerning phono preamplifier overload problems and their elimination, as well as his research into time-related distortion and its elimination. More about these concepts shortly.

The preamplifier in question is called the RG Dimension 3, or D-3 for short. Its front panel controls are intelligently laid out and their number suggests that the unit is mid-way between the so-called straight-wire-with-gain approach and the no-holds-barred philosophy of preamplifier-control unit design. The selector switch at the left has *Phono 2, Phono 1, Tuner*, and *AUX* positions. Note that even this arrangement has been carefully thought out, in that the two most often used program sources, *Phono 1* and *Tuner*, are assigned to adjacent switch positions on the selector, avoiding the need to switch through unused positions in most cases. Illuminated LEDs indicate which program source is in use, including a pair of LEDs associated with the four nearby rectangular push buttons that control two tape monitoring and two-way dubbing functions. A mode switch, with settings for mono, stereo, reverse, left-only or right-only comes next, followed by bass and treble tone controls, the balance control and a large master volume control. The three push buttons to the right of the volume control are for activating a subsonic filter, bypassing tone controls, and applying power to the unit. Actually, calling the last button a power switch is a bit of a misnomer. The circuitry of the RG D-3 remains on continuously so long as its line cord is plugged into a power receptacle. RG Dynamics elected this approach to maintain circuit stability and to reduce noise. Power consumption is less than six watts when the "power" switch is off.

Flanking the line fuseholder on the rear panel of the D-3 are a total of five a.c. convenience outlets, two unswitched and three switched. Clearly delineated jack clusters which follow include a double pair of main outputs, in-and-out jacks for any sort of external add-on processor (expander, noise reduction unit, etc.) with an associated slide switch that provides access to this "loop" or bypasses it with jumper

THE B&W DM2/II. A CLASSIC IN EVOLUTION.



Despite the almost daily claims of revolutionary breakthroughs, loudspeaker design is basically an evolutionary process. A systematic, step by step exploration of new ideas, materials and measurement techniques.

Consider the new B&W DM2/II, for example. When its predecessor, the original DM2, was introduced several years ago, it was widely acclaimed as a classic of impeccable design and outstanding performance.

In pursuit of excellence.

Since that time, however, B&W's unparalleled research and development program has yielded new and fascinating insights into virtually every aspect of speaker design and performance.

From these uniquely innovative studies has emerged a completely new design of surpassing accuracy, the B&W DM2/II.

Each driver of the DM2/II has been designed for exceptionally smooth response over its entire operating range. The crossover is a computer calculated nineteen element network employing true third order Butterworth filters that result in significantly lower intermodulation distortion and exceptional phase and amplitude characteristics. Indeed, the DM2/II comes very close to attaining that most illusive of all speaker qualities, an apparently seamless transition from driver to driver.

Listening. The final proof.

Listening to the B&W DM2/II is, quite simply, a revelation. It produces completely natural, uncolored sound of extraordinary clarity and depth. Moreover, its modest size and elegant appearance permit advantageous placement in almost any listening area.

As with all B&W loudspeakers, each DM2/II is individually tested and shipped with its own proof of performance chart recording.

However, the ultimate proof of performance is in the listening. Your B&W dealer invites you to audition this classic contribution to the evolution of speaker technology and decide for yourself.

For additional information write:
Anglo-American Audio Co., Inc.,
P.O. Box 653, Buffalo, N.Y. 14240.
In Canada: Remcron Electronics Ltd.

B&W Loudspeakers. The next step up.

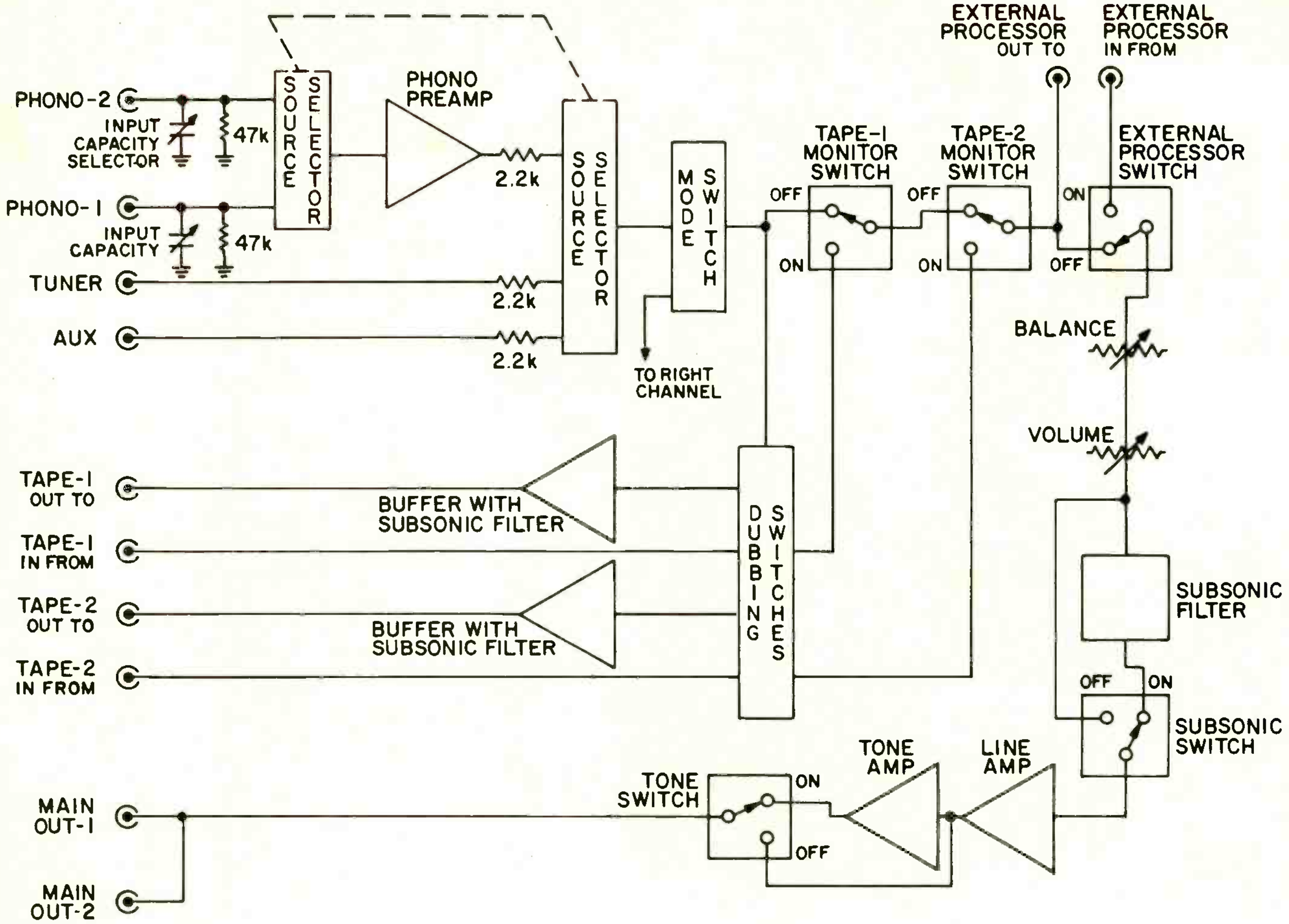


Fig. 1—Left-channel circuitry of the RG D-3; right- channel circuitry is identical except where noted.

action, Tape-1 and Tape-2 in-and-out jacks, and the AUX, Tuner, Phono-1 and Phono-2 input jacks. Below each pair of phono jacks is a three-position slide switch enabling the user to load the phono cartridge with either 30, 130, or 360 pF of parallel capacitance (over and above the capacitance that will normally be contributed by the phono cartridge audio cables). In the well-written owner's manual supplied with the RG D-3, there is a list of 28 turntable manufacturers, 15 makers of separate tonearms, and 19 manufacturers of popular phono cartridges, along with recommended capacitance values for the cartridges and known wiring capacitances for the tonearms or complete turntable systems.

A block diagram of the RG D-3 is shown in Fig. 1. According to the company, the unit's circuitry is a new topology (for which patents are pending); the design goal was to handle the most difficult peak signals of wideband phono cartridges without introducing peak distortion or TIM. One of the techniques used in the design is passive high-frequency de-emphasis between the two stages of wideband linear amplification. The manufacturer indicated that this minimizes any peak handling problems in the second preamp stage and in all subsequent stages. Although sine wave overload quoted for the preamp is fairly typical (140 mV at 1 kHz), peak overload claimed is up to 30 dB better than with typical preamp circuits.

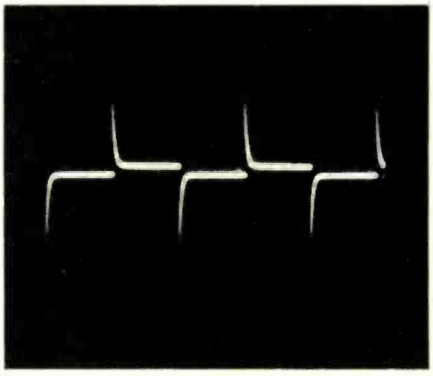
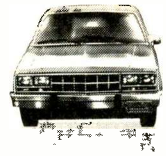


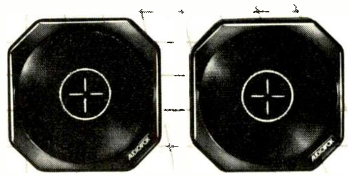
Fig. 2—Test signal used by RG Dynamics is an RIAA-compensated 500-Hz square wave.

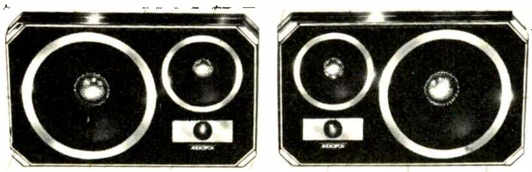


For less than $400 Audiovox can put the sound of home stereo in your car.

With four power-coordinated components that will "charge" your car with 30 watts per channel.

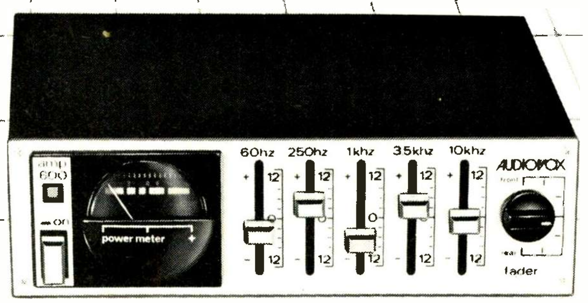
The COSC-5A. The incredibly slim (just 1¼" deep) coaxial speaker system that fits practically anywhere, in imported and domestic cars! Shallow 1¼" design – special shallow depth provides easy installation in all door panels unable to accept bulkier coaxial speakers. 5" Woofer–Air-suspension design to allow free cone response. Produces deep Bass at extremely high input power levels. Special 1" heat-proof voice coil allows sustained operation at high power without voice coil distortion. 1" Tweeter–with TDK Summarium cobalt magnet, usually found only in costly home speaker systems. Provides unmatched high-frequency response combined with a wide-dispersion capability.

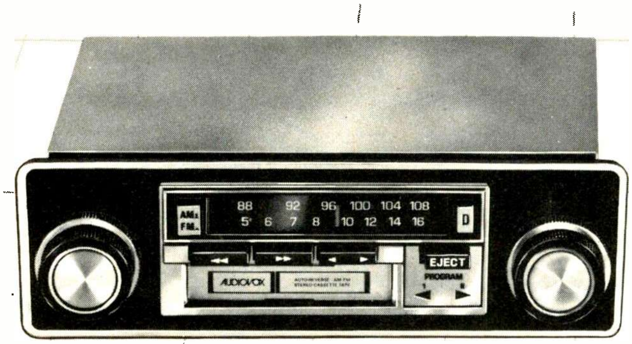




The Tryvox 30. A 3-way stereo speaker system built around 5¼" woofer, 2¼" mid-range and 1" horn tweeter speakers mounted on ⅝" particle board like quality home hi-fi speakers to give better baffling and solid bass response.
The Woofer–giant 20 ounce magnet combined with flex-edge air-suspension and a high temperature 1" voice coil for rich bass at maximum power.
The Mid-Range – A powerful ferrite magnet drives this incredibly responsive mid-range featuring a mylar dome and extra heavy cone for crisp audio.
The Tweeter – A full dispersion, wide angle short horn tweeter that captures all the highs and delivers them to you as brilliantly as the original recording.

The AMP-600B. To make the sound fit the internal size and shape of your car with 30 watts per channel to boot. An impressive way to turn ordinary stereo into true hi-fidelity Super Power. It produces unbelievable power . . . up to a maximum of 60 watts RMS stereo output . . . with slide bar control of the entire audio reproduction range. You control the response from Bass through Treble, a total of five ranges, customizing the audio to your enjoyment and to the size and shape of your car.





The ID-625. Just about everything you'd find in an in-home tuner/cassette deck plus auto-reverse. The Tuner: A super sensitive AM/FM/MPX radio with a local/distant switch for optimum FM reception; great FM stereo separation plus automatic frequency control. The Cassette Player: Featuring auto-reverse and tape direction indicator light, 4 speaker outputs and 4-way sound balancing controls.

For further information, write to: Robert Harris, Technical Director, Dept. 11L, Audiovox, 150 Marcus Blvd., Hauppauge, New York 11787

Audiovox autosound systems are designed and developed by the audio research laboratories of Shintom Co., Ltd., Yokohama, Japan.

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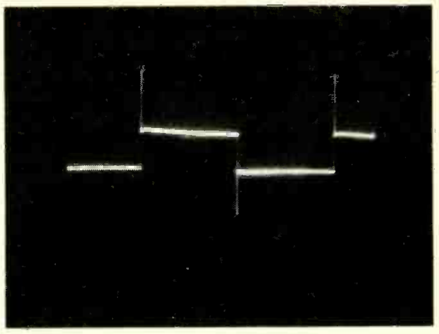
Fig. 3—Fed with test signal of Fig. 2, conventional preamp exhibits overshoot spikes at output.



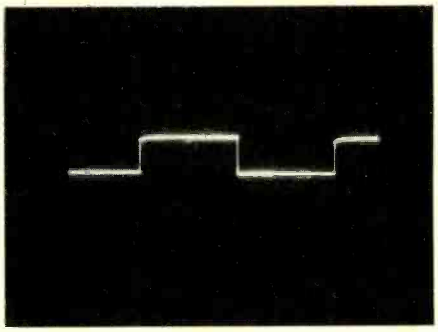
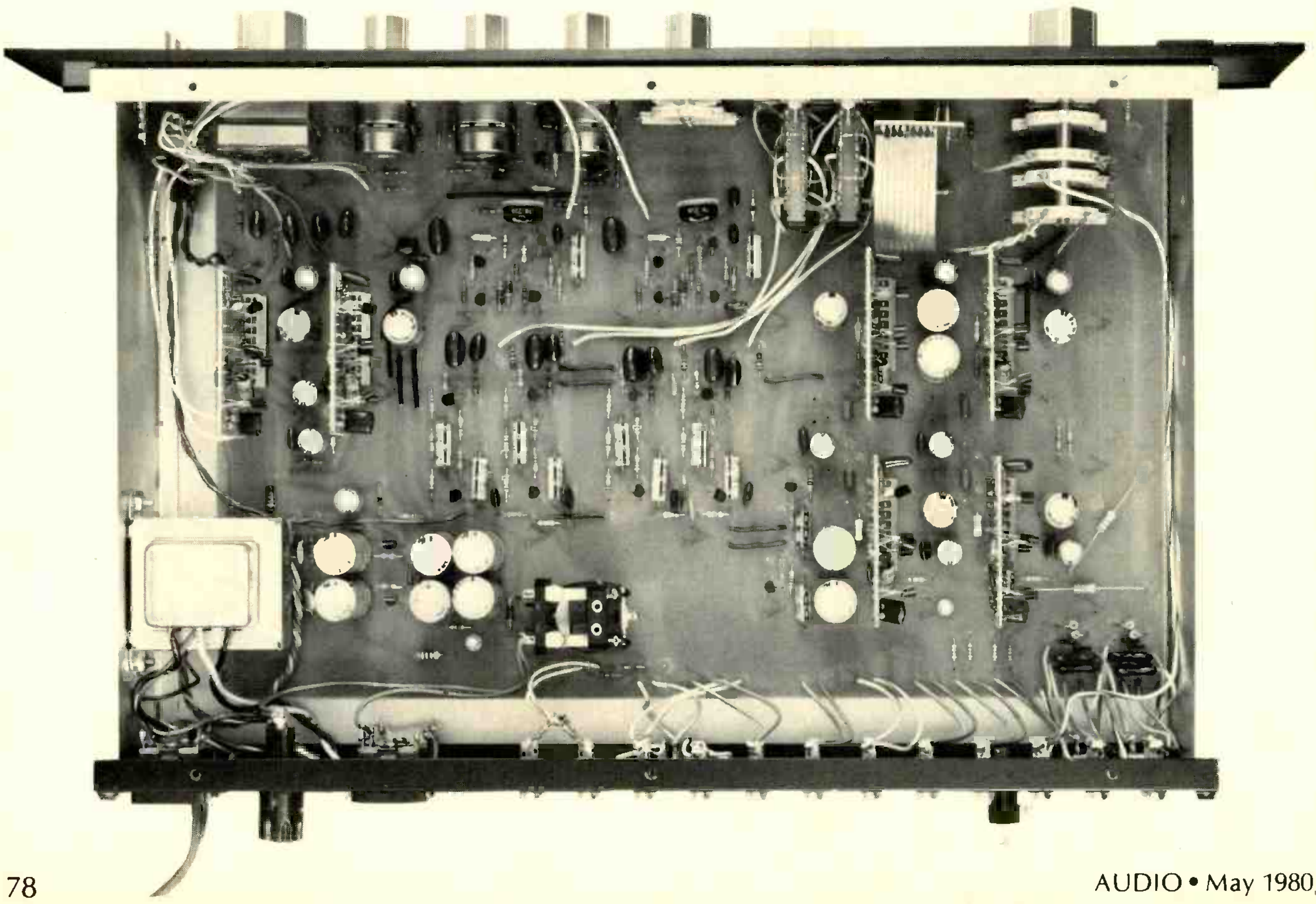


Fig. 4—Phono preamp of D-3 unit exhibits no overshoot spikes when test signal of Fig. 2 is applied.

Measurements

In the course of developing this circuitry, RG Dynamics came up with a special test signal which we have duplicated and shown in Fig. 2. This test signal is nothing more than a 500-Hz square wave, RIAA pre-emphasized, and band limited to 60 kHz, for the -3 dB roll-off point. Rise time is approximately 1 μS. With no overload or time-domain problems, a phono preamplifier having RIAA playback equalization should be able to reproduce this signal at its output as a near perfect square wave. In our tests, we adjusted the amplitude of the signal for slightly more than 3.5 V peak-to-peak. Feeding this signal to what we had regarded as our standard lab reference phono preamplifier, we were shocked to discover an output which contained very large overshoot spikes, as shown in Fig. 3. Feeding the same signal through the RG Dynamics D-3 preamp, we obtained an output signal as shown in Fig. 4, with no evidence of any overshoot.

Measuring conventional THD of the phono-preamp section proved to be a bit difficult, since 'scope observations clearly showed that we were reading more noise than THD on our meter-reading distortion analyzer. For the record, the reading was just under 0.01 percent at 1 kHz. By employing the combination of the Sound Technology 1700 distortion analyzer and our Tektronix spectrum analyzer, however, we were able to read actual distortion components which were in fact much lower. As can be seen in Fig. 5, a reference 1-kHz signal is positioned at mid-screen. Using the distortion-output terminal of the Sound Technology instrument, we were able to change the sensitivity of the readings on the spectrum analyzer by 70 dB so that while the two distortion



MONSTER CABLE

Hear the difference at discriminating audio specialists, including:

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Shimek & Co. Anchorage
Team Stores, All locations

ARIZONA
Arizona HiFi, Phoenix

CALIFORNIA
Audible Difference, Palo Alto
Audio Excellence, San Francisco
California Audio Systems, Visalia
Catania Sound, San Rafael
Century Stereo, San Jose
Cherry Stereo, Palo Alto
db Audio, Berkeley
Dimensions In Stereo, Torrance
Dow Sound, San Diego
Federated Group, All locations
Havens and Hardesty, Huntington Beach
House of Music, San Francisco
Hunter Electronics, Napa
Jonas Miller, Beverly Hills
Mateo HiFi, San Mateo
Monterey Stereo, Monterey
Natural Sound, San Francisco
Pacific Stereo, All locations
Paradyme Electronics, Davis
Quement Electronics, San Jose
S & T Sales, San Francisco
Serra Stereo, Colma
Shoreline Stereo, Mill Valley
Sound Company, San Diego
Sounding Board, Berkeley
South Lake Stereo, S. Lake Tahoe
Stereo Store, San Francisco
Sun Stereo, All locations
Turntables Unlmited, Sacramento
Warehouse Sound, All locations
Water Street Stereo, Santa Cruz
Whittier Music, Whittier
World of Sound, Mill Valley

COLORADO
Gramaphone Shop, Denver
The Stereo Place, Ltd., Denver
Team Stores, All locations

CONNECTICUT
Northeast Audio, All locations
Stereo Lab, New London
Take 5 Audio, New Haven

FLORIDA
Audio by Caruso, Miami
Duty Free Shops, Miami
Sound Advice, Miami
Sound Shack, W. Palm Beach
Stereo Factory, Ft. Meyers

GEORGIA
Pacific Stereo, All locations
Stereo Shop, Martinez

HAWAII
Audio Center, Honolulu
Lakeside Audio Video, Honolulu
Sounds by Thom, Honolulu

IDAHO
Sound Wave, Pocatello
Stereo Shop, Boise

ILLINOIS
Audio Creations Ltd., Downer's Grove
C.S.H. Inc., Kankakee
Pacific Stereo, All locations
Schaak Electronics, All locations
Team Stores, All locations

INDIANA
EH Tepe Co. Inc., Mishawaka
Grahams, Indianapolis
Risley Electronics, Evansville
Ted Fink Audio, Evansville

IOWA
Audio Odyssey, Davenport
Stereo Shop, Cedar Rapids
Team Stores, All locations

KANSAS
Team Stores, All locations

LOUISIANA
Kadair's, Baton Rouge
Wilson Audio, New Orleans

MAINE
HiFi Exchange, Augusta

MARYLAND
Discerning Ear, Baltimore
Paragon of Sound, Bethesda

MASSACHUSETTS
Audio Forum, Watertown
Natural Sound, Framingham

MICHIGAN
Schaak Electronics, All locations
Stereo Shoppe, East Lansing
Team Stores, All locations

MINNESOTA
Audio Perfection, Bloomington
Audio Store, Mankato
Schaak Electronics, All locations
Sound Environment, Edina
Sound World, Rochester
Team Stores, All locations

MISSOURI
Pacific Stereo, All locations
Sound Enterprises, Kansas City
Team Stores, All locations

MONTANA
Rocky Mountain Hi Fi, Great Falls
Team Stores, All locations

NEBRASKA
Sound Environment, All locations
Team Stores, All locations

NEVADA
Tin Ear, Reno

NEW JERSEY
Audio Guild, Englewood
Contemporary Sound Assoc., Upper Montclair
Pro Audo Consultants, Florham Park
Sam Goody's, All locations
Woodbridge Stereo, Woodbridge

NEW MEXICO
Transamerican Audio, Albuquerque

NEW YORK
Audio Breakthroughs, Manhasset
Audio Exchange, Garden Ctr.
Clark Music, Syracuse
Designation, Ltd., Hicksville
Eardrum, Nanuet
Gordon Electronics, Syracuse
Harmoney House II, New York City
Harvey Sound, New York City
Leonard Radio, New York City
Lyric HiFi, New York City
Sam Goody's, All locations
Sound Odyssey, Wappingers Falls
Sound by Singer, New York City
Stereo Emporium, Buffalo
Stereo Plus, Kenmore
Transcendental Audio Ltd., Amherst

NORTH CAROLINA
Stereo Sound, Chapel Hill
Taylor House, Denver

NORTH DAKOTA
Schaak Electronics, All locations
Team Stores, All locations

OHIO
Audio Connection, Huron
Audio Warehouse, All locations
Audio World, Rock Springs
B & B Appliance W, Middleberg
Custom Stereo Electronics, Columbus
Stereo Lab, Columbus

OKLAHOMA
Seigels Sound, Bartlesville
Sound Chamber, Ardmore
Team Stores, All locations
Thomson Sound, Tulsa

OREGON
Chelsea Audio, Beaverton
Andersch Home Fumishings, Klamath Falls
Riverside Sound, Medford
Team Stores, All locations

PENNSYLVANIA
Chestnut Hill Audio, Philadelphia
Electronics Place, York
Hi Fidelity House, Broomhall
Opus One, Pittsburgh
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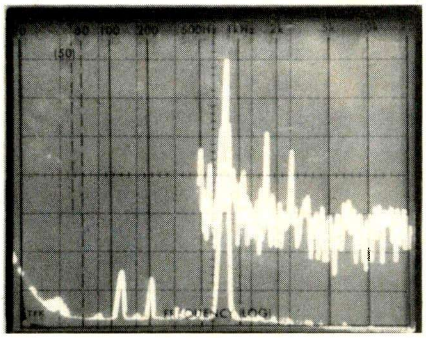
Fig. 5—Dual-sweep spectrum analyzer display showing the most significant harmonic distortion component as 90 dB below the fundamental 1-kHz reference signal.



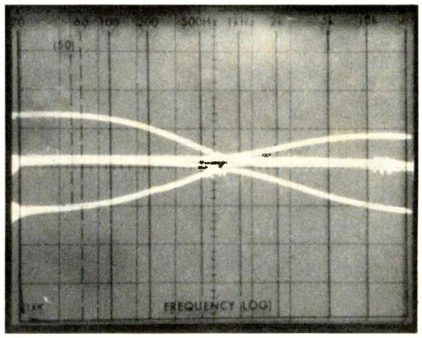


Fig. 6—Range of tone controls in the RG Dynamics D-3 preamp.

components observed during the second sweep of the analyzer appear to be 20 and 25 dB lower than the reference signal, they are, in fact, 90 and 95 dB lower. (Each vertical division of the display is worth 10 dB, to which must be added the 70-dB difference in sensitivity between the reference and distortion sweeps of the analyzer). The actual total harmonic distortion, then, consisting primarily of third-order and fifth-order harmonic components, works out to an infinitesimally low 0.00363 percent!

THD measurements taken via the high-level (line) inputs of the preamp, for a rated output of 2.0 V, were 0.0065 percent at 1 kHz, 0.0083 percent at 20 Hz, and 0.012 percent at 20 kHz. SMPTE-IM distortion measured 0.0075 percent. Phono input sensitivity, referred to 0.5-V output and with the master volume control fully open, measured 1.1 mV, while for the high-level inputs it was 64 mV for 0.5-V output. Sine wave phono overload measured 145 mV, or just a bit better than the 140 mV claimed. RIAA equalization was so accurate that we cannot assign a plus-and-minus tolerance to this response characteristic. As for the high-level input, frequency response was flat to within 1 dB from 4.5 Hz to 105 kHz, and within 3 dB from 0.5 Hz to 200 kHz. Signal-to-noise ratio for either set of phono inputs was 75 dB, "A" weighted, referred to 5-mV input and 0.5-V output. For the high-level inputs, the S/N ratio measured 81.5 dB, again referred to 0.5-V output with 0.5-V input. At minimum volume settings, the hum and noise was 87 dB below the 0.5-V output level reference.

Tone control range for the bass and treble controls is depicted in the spectrum analyzer sweep of Fig. 6. Treble boost action is relatively moderate (+9 dB at 15 kHz, as claimed), while bass boost and cut are shelved at approximately ±12 dB from 50 Hz downward to 20 Hz, the lower end point of the spectrum analyzer display. The subsonic filter action began just below the 20 Hz lower audio limit and provided around 20 dB of attenuation in the critical warp-rumble region of 5 Hz.

Listening and Use Tests

I have had two opportunities to listen extensively to the RG Dynamics Model D-3 preamplifier. The first of these was under controlled conditions specified by Grodinsky himself, when he put on a demonstration of the unit for various members of the audio press at the offices of his New York sales representatives. At that time, we compared the sound quality of the D-3 against a fairly popular competitive unit, using a variety of recorded material selected by Grodinsky. As you might expect, the RG Dynamics unit was a clear winner, both in terms of its large signal handling capability and in absolute musical reproduction terms. With standard recorded fare, the differences in clarity were rather subtle but were nevertheless evident. Grodinsky stresses the importance of actually manually connecting and disconnecting audio component cables when making such comparison tests, pointing out that, in his opinion at least, switches inserted at such low-level signal points can make meaningful comparisons difficult.

Duly impressed, I repeated the comparsion tests in my own controlled environment, expecting the differences to be less obvious—if apparent at all. Much to my surprise, the superiority of the D-3 over what I had regarded as my reference phono preamp in the lab was just as obvious with my own selected recordings, most of which were direct-to-disc or digitally mastered. Overall sound was simply cleaner, particularly at the high end where so often we tend to accuse cartridges of being the offenders instead of the mismatch between the cartridge and the preamp.

Grodinsky has joined the mainstream of componentry (his earlier products having been strictly sound processing or add-on devices) with an auspicious and well thought-out preamplifier whose record reproduction capabilities and refinements seem to justify its rather expensive price tag.

Leonard Feldman

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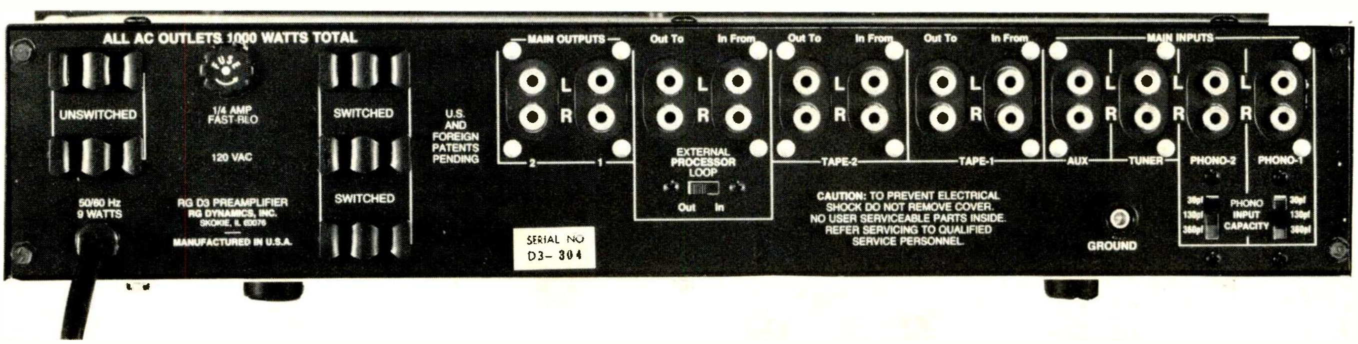

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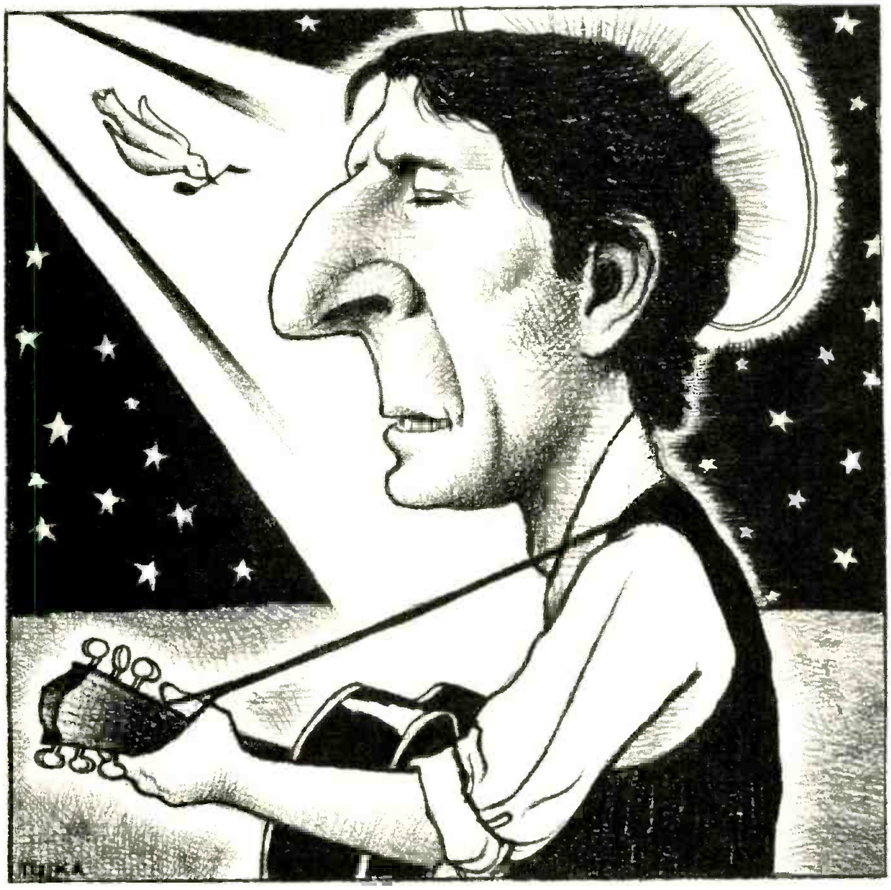
Michael Tearson

Jon Tiven



Recent Songs: Leonard Cohen
Columbia JC 36264, stereo, $7.98.

Leonard Cohen is a poet of the first magnitude. At his best he writes songs that possess a timeless, deep, rich beauty. At his worst he is simply embarrassing.

Recent Songs comes about three years after **Songs from a Ladies Man** which was a misguided, star-crossed, desperate sounding collaboration with Phil Spector. **Ladies Man** remains one of the very worst albums of the '70s, bad enough to drive nearly anyone into hiding.

With the new album Leonard returns to a more natural musical setting, one very much like his classic first album, **Songs of Leonard Cohen,** which included the likes of *Suzanne* and *Sisters of Mercy*. The best of the new songs have a similar haunted feeling.

Several elements dominate the album: The wonderful combination of John Bilezikjian's oud with Raffi Hakopian's violin, and the harmony voicings of Jennifer Warnes. The opener, *The Guests,* is a prime example. It is a mystical, gothic song, hypnotic. Jennifer's choral-backing vocal with its multi-tracked arrangement is an intricate, delicate, shimmering tapestry. Meanwhile the oud and violin follow Cohen's voice and the melody like Dwight Frye, as Fritz, follows behind Colin Clive in the movie original of "Dr. Frankenstein," elegant toadies. In its way the song is as subtly powerful as *Suzanne*.

For several other songs Cohen employs members of the Texas band Passenger. Here his songs take a constrasting texture, a cocktail feel for *Humbled in Love* and the *Smokey Life,* which features stunning Warnes/Cohen duet vocals. On *Our Lady of Solitude* he gets a Band-like feel which is underlined by Garth Hudson's cameo appearance. For two other tracks Cohen uses a rough-hewn mariachi band, the sprawling *Ballad of the Absent Mare* and *Un Canadien Errant,*

Illustration: Rick Tulka

which last dates from the mid-19th century and relates the feelings of the losers of a rebellion forced into unhappy exile.

To record the album, Cohen went to A&M Studios and Henry Lewy, the studio and engineer of nearly all of Joni Mitchell's recorded work. Lewy has a keen and perceptive sensitivity which is central to **Recent Songs'** artistic success, with its disparate textures, brooding airs and the gruff voice of the poet.

Recent Songs is one of the very best collections Leonard Cohen has put on record. It is at least as good as any since his second album, **Songs from a Room,** and a worthy companion to **Songs of.** He is the romantic outsider, the man on the fringe missing nothing behind the mask of grey eyes and shadow. *M.T.*

Sound: B Performance: A-

Too Old to Change: Jerry Jeff Walker
Elektra 6E-239, stereo, $7.98.

I remember when Jerry Jeff Walker started touring with Dave Bromberg as his shadow guitarist, even before that magnificent first album, the one with *Mr. Bojangles* on it. He was a gas. He'd alternate the tender and the tough. A hard-drinking, hard-living cuss, but lots of fun. Over the years there have been many more albums, some sublime, some absolutely forgettable, especially those over the last few years since **Viva Terlingua.**

Marvelously, **Too Old to Change** is Jerry Jeff's best album in ages. True, he still hasn't written any new tunes himself in years, but when you can assemble them as well as this collection and draw out performances as involved and emotional as these, who needs to write?

Each song has a very personal Jerry Jeff vocal. He may not always be on the note, but the passion never lets up. His go at Rodney Crowell's recently oft-recorded *I Ain't Living Long Like This* has the fury and attack of a Thompson submachine gun. The Susanna Clark song *I'll Be Your San Antone Rose* is lots of fun behind the unlikely vocal duo of J.J. Walker and Carole King. *Hands on the Wheel* you'll remember from Willie Nelson's **Red Headed Stranger.** Paul Siebel, a criminally under-recognized and under-appreciated genius, is the source of *Then Came the Children*, a song of transcending tenderness. Even the done-to-death *Me and Bobby McGee* sounds so fresh you wonder why no one thought to do it like this before. And that's only half the tunes.

The playing is living-room loose, and the players obviously had a great time recording. The album is refreshingly free of slickness. It's a raw-nerves album you would expect to collapse under the chaos that can plague Jerry Jeff's work. But it doesn't.

Clearly the man has remained faithful to his musical vision. Stay loose, Jerry Jeff, wherever you are. Awful good to hear you sounding so happy. *M.T.*

Sound: B– Performance: A

X-Static: Hall & Oates
RCA AFL1-3494, stereo, $8.98.

It's very difficult to listen to this album because the lyrics are so cloying and horrendous they make you want to ditch it when you're barely into side one: "Number One, you're number one with me/Blast from the past say why don't you call me anymore," for instance. The songs aren't as bad as the lyrics make them out to be, but no matter how well they're sung — Daryl Hall has the voice Todd Rundgren strives toward — no one could sing those words convincingly. The playing is of a high calibre, at times even exceptional, but the only time you can really get past their choice of words is when you can't tell what they're singing, like on the standout track *Intravino,* which is very similar to the Hall/Fripp collaboration *You Burn Me Up I'm a Cigarette*. The latest Hall & Oates album sounds like they went into the studio without any songs and wrote some lyrics on the spot. If that's not the case, and they actually spent a great deal of time working on these tunes, then I *really* feel sorry for them. *J.T.*

Sound: B+ Performance: D+

Madness

One Step Beyond: Madness
Sire SRK 6085, stereo, $7.98.
The Specials
Chrysalis CHR 1265, stereo, $7.98.

There's a crop of pseudo-reggae/ska bands starting up in England, the prime exponents of this movement being these two. Personally, I find these groups far less interesting than any of the originals, and the pose they choose to strike is often quite offensive and has attracted a singularly reactionary audience. In fact, I'm disappointed in Elvis Costello for lending his name to projects this mundane. *J.T.*

Sound: D — Performance: D

Pretenders
Sire SRK 6083, stereo, $7.98.

Despite the stock punk attire they've chosen to wear for their album cover, The Pretenders are not just another atonal group of screamers and strummers. It's refreshing to find a new group with a solid musical base and an interesting approach in conveying their lyrical and instrumental resources. The Pretenders are a lot "softer" than might be expected of the current British New Wave fave. Their producer, Chris Thomas, seems to be aiming for a pop sound and has lead singer, songwriter, and band frontwoman Chrissie Hynde styled more like Sandy Shaw than Patti Smith, both of whom she can effectively emulate. For instance, the vocal on *Stop Your Sobbing* is rich and sensual and fairly singerly, but when Chrissie talks her tougher numbers the delivery is an off-putting mumbled rant which does a disservice to the consistently tight instrumental track behind her.

The album's best tunes are those with a relaxed feel that show off Chrissie's melodious vocal potential. *Up the Neck* has some nice guitar picking and a pleasant vocal that displays the singer's phrasing expertise. Ms. Pretender knows her way around a rock delivery and pumps the emotional implication of her lyrics for all they're worth. *Kid* sounds like a Nick Lowe song ('though he actually produced only *Stop Your Sobbing*) in which Chrissie's voice wavers like a disciple of Phoebe Snow, and the pretty dirge *Lovers of Today* is animated by her sexily sliding to and from the designated pitch. The highlight of this LP is the slightly funky *Brass in Pocket*, wherein Chrissie gets soulful and delivers the melody in a Candy Staton-like fashion.

About half of this album is strong material, a considerable achievement for a band's first effort at laminating their repertoire. Repeated listening reveals the range of tones Chrissie's capable of—in respect to the vocals this is a highly arranged album despite its simple compositions. Now if the group could just be convinced that pop isn't square, their second record might boast 12 gems with no "progressive" (i.e. fragmented/overartful/primal scream) filler. *Sally Tiven*

Sound: A- — Performance: A-

Please Stand By . . .: 1994
A & M SP-4769, stereo, $7.98.
The Motels
Capitol ST-11996, stereo, $7.98.

The difference between 1994 and The Motels is the difference between the '70s and the '80s. Each group is built around a female lead voice — 1994 has Karen Lawrence, and The Motels have Martha Davis. Each lady is heavily involved in developing the band's material, but there the musical similarities end.

1994 is a straightforward rock band as direct as Heart. They play a solid monochrome of a beat. Their songs are what a friend called standard love stuff. Good as they are, they seem somehow anachronistic, rooted in the '70s with Foreigner and Bad Company.

The Motels are something totally else. They are artier, less direct, and much more concerned with such trifles as texture and atmosphere. That their material, nearly all written by Ms. Davis, is not so mundane is clear from titles like *Atomic Cafe, Closets & Bullets* and *Porn Reggae*. Musically they have a fresh-sounding attack like a newer, younger Roxy Music, yet more direct. Not surprisingly, The Motels have found initial acceptance has come more quickly from Europe than America.

Something is happening to the thrust and sound and politics of rock and roll. As it expanded in the '70s to corporate size and the record companies learned how to better expose (market) their artists, a breed of manageable and predictable superstars emerged with often mechanical sounds. The so-called New Wave had one essential point to make, and that was that any four kids *could* form a band and make up some songs. Lots got this far and then made homemade records for cheap without watering down some personal and idiosyncratic ideas and forms. Playing live in the studio is a major key, bypassing a lot of technology (in the form of dubbing, for instance) in the name of getting down the essential spontaneous performance. With this came fresh views in songwriting, less boy/girl standard love stuff and other often cinematic concepts.

The difference between the '70s and the '80s. That's why I play The Motels so much at home lately and 1994 so little. *M.T.*

1994

Sound: B	Performance: C

Motels

Sound: B	Performance: A-

The Beat
Columbia JC 36195, stereo, $7.98.
S.O.S.: The Yachts
Radar/Polydor PD 1 6220, stereo, $7.98.
Puttin' On the Dog: The Hounds
Columbia JC 36098, stereo, $7.98.
Present Tense: Shoes
Elektra 6E-244, stereo, $7.98.
The Sound of Sunbathing: The Sinceros
Columbia JC 36134, stereo, $7.98.

Recent successes of The Knack, Joe Jackson, and other so-called "power pop" bands have motivated every record exec with his eye on the bottom line to sign up whatever local one-syllable rock band happens to play his neighborhood. Thus a plethora of post-New Wave bands has hit the record racks all at once, most of which sport similar stylistic leanings, both visually and musically. I suppose it's better than everyone hopping on the disco bandwagon and less draining than glitter rock, but it's often hard to hear the musicality through all the style.

I mean, if you take a little bit of The Cars' arrangement and add a tad of Elvis Costello's chord structure, you get The Sinceros. Of if you purge that of all minor chords, add a little Knack and heavy metal, you've got Hounds

Shoes

(who only succeed at their covers). Then give them all punk haircuts and they're The Yachts. Or there's the even Beatlesque school that claims their Sixties roots but sounds more or less like a rekindling of Big Star, calling themselves Shoes or The Beat. Shoes is still very young and sound it—both they and The Beat have nothing to write songs about except girls—and they've still got a ways to go before they stylistically mature beyond their roots, and besides, they haven't learned to use their voices yet. Of the whole bunch, I personally like The Beat the best—although they could stand to inject a little more personality into the tunes, as that's what this genre is all about. Their songs are good and almost memorable, and their Raspberries style works with the singer's voice, sounding like what The Knack are aiming at but miss hitting (excluding *My Sharona*).

But the groups that seem to last in this category are the ones who manage a hit single, even if the entire rest of the record is a genuine turkey. Any one of these could come up with a hit single and therefore extend their life expectancy past a year, but without that, every one of these bandwagon jumpers is thoroughly expendable, mainly because they fail to either define a musical style or even bend the rules. *J.T.*

The Beat	
Sound: B+	Performance: B
The Yachts	
Sound: C-	Performance: B-
The Hounds	
Sound: B	Performance: D-
Shoes	
Sound: B	Performance: B-
The Sinceros	
Sound: B	Performance: D+

John Lissner

John Diliberto

Jazz & blues

Benny Goodman Live at Carnegie Hall
London BP 44182/83, 2 discs, stereo, $19.98.
The Complete Benny Goodman, Vol. III, 1936
RCA AXM2-5532, mono, $9.98.
The Complete Benny Goodman, Vol. IV, 1936-37
RCA AXM2-5537, mono, $9.98.
The Complete Benny Goodman, Vol. V, 1938
RCA AXM2-5557, mono, $9.98.
Benny Goodman & His Orchestra: The King of Swing on the Air
Aircheck 16, mono, $7.98.
Benny Goodman & His Orchestra, The War Years
Jazz Society AA 510, mono, $7.98.
Benny Goodman & His Orchestra
Jazz Society AA 508, mono, $7.98.

The days when Swing was King and Benny wore the crown are long past, and the attempt to recapture them last year at a Carnegie Hall concert this writer attended was, unfortunately, a big disappointment. The London double-set recording, **Live at Carnegie Hall,** at least edits out some of the dullest moments. What's left, for the most part, is a tepid reworking of great Goodman classics. The zest and fire of the original *King Porter Stomp* and *I've Found a New Baby,* for example, are nowhere to found on the performances here. The lusty, forthright blowing of trumpeters Bunny Berigan and Harry James have been replaced by some prosaic efforts by Warren Vache, a merely competent and mostly uninspired neo-swing player who offers us a string of cliche statements. Goodman himself, an unpredictable performer today who can coast pleasantly or move to inspired swing during a number, had an "off" night the evening of the concert, though there are some nice "easy listening" moments here, such as his work on *Send in the Clowns* and *Yesterdays.* The only examples of barnstorming swing found in the collection are Lionel Hampton's exuberant *How High the Moon* and Mary Lou Williams' vigorous, gutsy boogie woogie piano on *Roll Em.*

RCA has now completed five volumes in its Bluebird Complete Benny Goodman Series. Volumes III, IV, and V offer us the quintessential Goodman band of the mid-to-late '30s, and these three releases show us what big band swing was all about — joyous and jubilant, full of melody and briskly syncopated choral statements. The distinctive sound of the classic Goodman orchestra came from its precision sound work; the beat beautifully rehearsed, exquisitely blended saxophones, the choirs of trumpets and trombones that made sharp attacks and quick releases; the total effect was an irresistible, supremely danceable, all 'round rhythmic and musical feast for the jazz buff and layman. Goodman's playing here is youthful and exciting; his skillful maneuvering of the clarinet keys, the brilliant tone and biting attack are dazzlingly showcased here. The three RCA double-sets are blessed with bright arrangements, crisp musicianship, and enthusiastic performances of such numbers as *Loch Lomond, Camel Hop, One O'Clock Jump, Thanks for the Memory, Life Goes to a Party, Roll Em, Sing, Sing, Sing, Sugarfoot Stomp, Minnie the Moocher's Wedding Day, Bugle Call Rag,* and dozens of other inspired swing milestones. Soloists such as Jess Stacy, the pianist with the sharp, staccato touch, and trumpeter Harry James at his fiery best are strongly featured. The subtle interplay of the Goodman Trio and Quartet can be found on such numbers as *Avalon, Liza, Runnin*

Wild, and *Tea for Two*.

By 1940, the Goodman band had revised its personnel considerably. The addition of Charlie Christian's guitar gave it an interesting new voice and an irresistible drive. Aircheck's **The King of Swing on the Air** offers us some fine moments by Christian and some of Johnny Guarnieri's rollicking swing piano. Christian, Guarnieri, and Lionel Hampton are heard to advantage on two fine sextet tracks, *Seven Come Eleven* and *Six Appeal*, and the full band plays with precision and energy on *Let's Dance* and such numbers as *Big John's Special* and *Idaho*. The broadcasts, for the most part, are from the Peacock Court of the Mark Hopkins Hotel in San Francisco. The last two tracks, a sensitive *These Foolish Things*, with a vocal by the 16-year-old Peggy Lee, and a rousing *After You've Gone*, are from a 1942 Fitch Bandwagon Broadcast from Chicago. Aircheck Records has a fine catalog of off-the-air big band swing; their address is P.O. Box 724, Redmond, Wash. 98052.

Jazz Society's **Benny Goodman: The War Years** offers us more fresh and vital '40s swing. Goodman's clarinet is the principal solo voice throughout, and he plays with his customary zest and earthy ebullience on such wartime hits as *Mission to Moscow*, *Mr. Five by Five*, and *Gotta Be This or That*. Outstanding is a splashing, careening big band performance of Fats Waller's *Stealing Apples*. Mildred Bailey offers us a poignant *Down Hearted Blues*, and Peggy Lee is the singer on *Cow Cow Boogie* and *Mr. Five by Five*. The musician's union recording ban was on from 1942-44, so these recordings, mostly V Discs or AFRS (American Forces Radio Service) transcriptions, fill in some gaps for the Goodman collector.

Another album for Goodman collectors is Jazz Society's **Benny Goodman,** a set of broadcast performances from late 1945 and the immediate 1946 postwar period. The Goodman trumpet section by then had been augmented to five pieces and included such powerful players as Bernie Privin, John Best, R. D. McMickle, and Nate Kazebier. The trombones featured two barrelhouse stalwarts — Lou McGarrity and Cutty Cutshall. Some splendid cuts include *I'm Always Chasing Rainbows* with blazing brass and McGarrity's robust and fiery solo on *Oh Baby*. The saxes also blend beautifully and distinctively on *Give Me the Simple Life*, which has a good tenor solo by the young Stan Getz. Jazz Society, a Swedish import label, is carried by such collectors shops as J & R Music World in New York City, Rose's Discount Records in Chicago, and Ray Avery's Rare Records in Glendale, Calif.

John Lissner

Live at Carnegie Hall

Sound: A | Performance: B-

Complete Benny Goodman, Vols. III, IV, and V

Sound: A- | Performance: A+

King of Swing on the Air

Sound: B | Performance: A

The War Years
Benny Goodman & His Orchestra

Sound: B- | Performance: A

Sound Suggestions: George Adams
ECM ECM-1-1141, stereo, $8.98.

George Adams' saxophone had been a featured voice in one of the last ensembles led by Charles Mingus and more recently with the unit of McCoy Tyner. Despite the fact that his blues-drenched horn is unlike any other instrumentalist on the ECM label, his sound has been easily adapted to Manfred Eicher's conception. Eicher surrounds Adams with ECM stalwarts like Richie Beirach on piano, Kenny Wheeler on trumpet, Dave Holland on bass, and Jack DeJohnette on drums. These players have helped hone the sound of creative refinement that characterizes ECM. The group is completed by tenor saxophonist Heinz Sauer, who has been a long-time associate of Albert Mangelsdorf.

Sound Suggestions is an album of carefully constructed tunes with immaculate playing. If it doesn't stretch any boundaries, it also doesn't make any concessions. Adams' playing is as vital as ever. He can blow masculine, romantic ballads as he does on *A Spire* or rip off the careening scalar runs of *Stay Informed*. His accompaniment is always supportive and the other soloists seem to be setting him up. Adams takes the last solo on most of the tunes, and all the others seem to lead up to him. On the Sauer-penned *Stay Informed*, Sauer takes a perfectly shaped solo that gradually builds in intensity. He's followed by a sparse Beirach interlude and then a rising solo by Wheeler that allows Adams to begin, already in overdrive.

If his tone and power weren't enough to set him apart, Adams also tosses in a stompin' blues number replete with growled vocals, *Got Somethin' Good for You*. Adams has harnessed his more extravagant tendencies to make a clear and purposeful statement that could only be enhanced by ECM's clear production values. There is subtle textural interplay between the rhythm section and the horns that is only disturbed on *A Spire* by DeJohnette's overly busy drums. Otherwise, Adams keeps a tight reign on his group to highlight his own tenor saxophone.

John Diliberto

Sound: A- | Performance: B

Globetrotter: Clark Terry
Vanguard VSD 79393, stereo, $7.98.

Trumpeter Clark Terry has always combined wit and taste with a great facility of instrument. On **Globetrotter** he offers fine examples of his spare, pulsing, melodic playing on both trumpet and flugelhorn. His relaxed singing tone and exuberant high spirits on numbers like *Canadian Sunset*, *Satin Doll*, and the title cut make listening to him a constant delight. *Zip Co Ed*, a Terry original, moves at a torrid pace and has several ringing, jubilant choruses by the composer. The alternating sidemen on the several dates that make up this collection — pianists Ronnie Mathews and Walter Bishop, tenor Ernie Wilkins, guitarists George Davis and Roland Prince, and drummer Ed Saph — all cooperate to bring us joyful, swinging, unpretentious jazz. Each player offers strong individuality yet never loses sight of the fact that he is playing as part of a cohesive unit.

John Lissner

Sound: A | Performance: A

Classical reviews

Edward Tatnall Canby

Grant Johannesen in Recital. (Fauré, Schumann, Mozart, Poulenc.) Golden Crest CRS 4201, DIG and DD, stereo (digital and direct-to-disc versions).

It had to come to this — and surely will again: Two releases of the same recorded program of piano music, one done direct to disc, the other in digital (Sony). They are packaged in a single shrink cover — don't know whether you can buy them separately or not. Comparison is obviously the idea and, in any case, the music is excellent, either way, via an experienced high-level pianist, who could undoubtedly play note-perfect for hour after hour if needed! DD is no great problem for him.

The notes, extensive on the backs and identical for both discs, are mildly confusing, though the account of the differences between the two systems is well presented. Both say that there was no editing. Obviously not on the DD record — but there still could have been a number of individual takes of each separate piece in the digital format. However, I noted no particular differences of a musical nature — we can take them as one performance, produced two ways. What *are* the differences, then?

Before I played so much as a note I took out the two discs and looked at them under a light. Wow — very different! The DD version seems to have been cut straight through at a fixed groove pitch and at a somewhat cautious overall level (confirmed in the listening); it is entirely smooth from outside to inside. Whereas the digital version is full of the usual darker and lighter bands, sharply separated, the loud segments look relatively wider than the soft passages, which is what we might expect if a previously made

Illustration: Rick Tulka

tape (digital) were to be cut with the normal adjustments. Oddly, the DD version goes less far towards the center than the digital — again, probably a matter of safety margin for the unknown. In DD we deal with real time.

I suspected I would enjoy the digital more — so, of course, I put all such thoughts aside and played the DD disc straight through for the music. No problem! What I heard was Grant Johannesen playing a haunting work by Fauré and three shorter, more energetic pieces by Schumann. Then on the other side, two sets of variations, nicely juxtaposed, first Mozart and then Francis Poulenc in his very last piano work. Good program, superbly played.

Then I went back and put on the digital disc. Immediately it seemed to be louder and closer, with more presence. This could be no more than a higher cutting level — which can produce the effect of a closer mike placement and more immediate sense of dynamics, curiously. And so it continued. The same music, also highly enjoyable. Cleaner? Could be, especially in the carefully spaced-out loud passages — but I was still more interested in the music itself.

If I had my choice? The digital, of course. It has every advantage for all concerned, from the pianist and the engineers straight through to you and me. The results show. But if we did not have this version, the direct-to-disc alternative would be quite excellent on its own. As a comparison, then, these two are almost anticlimactically true to life, as it exists in the recording world. Thanks, Golden Crest.

P.S. Though the backside notes on both discs say the music was recorded on a Sony machine (digital), this must be an editorial slip. If the DD version *is* DD, then there was no tape! Both were taken down on the new Neumann FET89 mikes, a pair of them, and cut with the Neumann computer lathe on Pyral. Presumably NOT at the same time. Nor even the same place! Questions to Golden Crest, 220 Broadway, Huntington Station, N.Y. 11746.

Mozart: Piano Concertos Nos. 25 in C, K. 503, 27 in B Flat, K. 595. Alicia de Larrocha; London Philharmonic, Solti. **London CS 7109,** stereo, $8.85.

Two of the very late and rich Mozart concertos, the second, K. 595, out of the last year of his life. Two impeccable performances if, shall I say, on the cool side. But gorgeously recorded.

That coolness is perhaps somewhat different in the piano and in the orchestra. These musicians play with the usual and familiar British conscientiousness, careful, accurate, giving full measure and respect — not a sloppy note to be heard. And all that is lacking is a bit more fire from the conductor. As for de Larrocha, she is one of our finest pianists, particularly, of course, in Spanish music and the bigger standard Romantic works. Her Mozart, then, is a bit out of the older generation that was brought up on big Romantic piano — delicately accurate, beautifully phrased and shaped, flowing smoothly and, somehow, on a deliberately small scale of emotional expression. That was the standard approach to Mozart, after all, for a good century and a half.

Curiously, London's recording engineers have helped bring this somewhat underplayed Mozart to life. Their orchestral sound is impressively big and wide but without excess reverb, which would indeed be bad for Mozart. And the piano is perfectly balanced, neither too close (as is common) nor too loud, yet absolutely clear. A lovely sound and a genuine "concerto" effect.

Sound: B+ Recording: A- Surfaces: B-

Folk bag

Tom Bingham

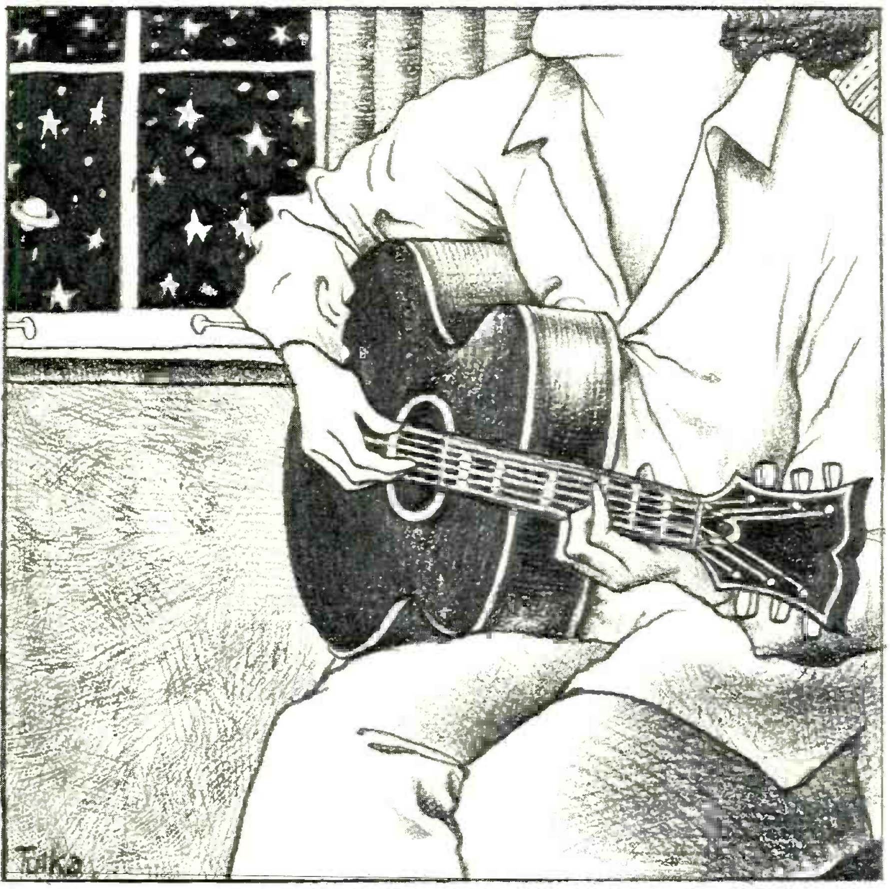


Illustration: Rick Tulka

Fingers, Don't Fail Me Now: Dale Miller
Kicking Mule KM 155, stereo, $7.98

Dale Miller has attracted a wide following through two previous Kicking Mule albums that featured finger-picked guitar renditions of Beatles songs, pop standards, jazz classics, as well as a small assortment of the common rags and blues. This album, however, focuses on Miller's original compositions which, surprisingly enough, reveal him to be an outstanding exponent of the John Fahey folk impressionist school.

Although his gift for complex textures and extended constructive patterns rivals Fahey's own, Miller's bountiful melodic resourcefulness, the light-fingered precision with which he executes involved passages, the warm delicacy, rippling flow, and joyful rhythmic lilt of his playing show little of the introverted abstraction of his early mentor. Even when he builds a full-length composition out of a few repeated and transposed figures (a la Fahey), the results are refreshingly tuneful, elegantly proportioned, rhythmically captivating, and easily accessible; hear *Noe Valley Sunday* and the six-minute *White Water.*

Moreover, several of Miller's pieces draw from the same pool of influences he relied upon for his previous albums. There are echoes of ragtime (*[Do The] Hippie Swing, Twenty Year Old Women and Twelve Year Old Scotch*), East Coast blues (the Earl Butz-inspired *Tight Arrangements, Loose Fingers,* and *a Warm Place to Practice* with second guitar by Bay Area veteran Janet Smith), early jazz guitar (the bridge of *Sherwood Caper*), boogie (the title cut and *Lone Star Boogie*), and Beatles (*Win or Lose in Santa Cruz,* which makes a perhaps subconscious reference to *Eleanor*

Rigby, much as the rag, *The Sophisticate*, seems to quote from Billy J. Kramer's *From a Window*).

The album's lone non-original is a charming rag, *Leisure Man*, written by Mike King. The album's only failure is the sole vocal, the pointless and sophomoric *Star Trek Blues*. Miller makes up for it with an exquisite Fahey-esque miniature, *Butano Lullaby*.

The audience for rag/blues/eclectic fingerpicking doesn't usually intersect with that for the Impressionist guitar composers. But with his facility for creating works for both substance and instant likability in an idiom not noted for its mass appeal, Dale Miller should have little trouble narrowing the gap between these two normally mutually exclusive camps, attracting a lot of new fans along the way. *Tom Bingham*

Sound: A- Performance: A

The Flax In Bloom: Brendan Mulvihill
Green Linnet SIF 1020, stereo, $7.98.

Brendan Mulvihill's father is the Limerick-born fiddler/teacher Martin Mulvihill, who is represented in the Green Linnet catalog by his own album (SIF 1012) plus another (SIF 1009) featuring his young students. Brendan himself appeared on a Green Linnet album by his Washington-based trio, The Irish Tradition.

Despite these unmistakable roots in traditional Irish fiddling, Brendan Mulvihill is young (25), adventurous, and eager to stamp his own personal innovations onto that tradition. Consequently, he has aroused a bit of controversy among some Irish fiddle enthusiasts.

The main bone of contention is a startling new embellishment, invented by Brendan, called a "stutter roll" (analyzed in detail in Mick Moloney's liner notes). This stutter roll breaks into the regular rhythmic movement of a tune far more drastically than a normal roll or triplet does. While it is technically difficult to play, Mulvihill is able to execute it so rapidly that he can recapture the natural flow of the melody without losing track of the beat. It's quite dazzling, to be sure, but whether it enhances the tunes (which is, after all, the primary purpose of using any ornament) or detracts from them is a question listeners will have to decide for themselves.

For examples of how Mulvihill applies this new roll, listen to the hornpipe sets *The Concertina/The Circus* and *The Home Ruler/The Brigade*. On the first tune of each set, he restricts his ornamentation mostly to triplets and standard rolls, but as the second tune unfolds he relies increasingly on the stutter roll. Actually, the less systematically he uses it, the more effective it is, since its unpredictability catches the listener offguard, as the reels *Mullingar Races/Miss Thornton's* illustrate.

The stutter roll aside, Mulvihill is an adroit, highly animated fiddler who drives his tunes ahead with uncommon force and inspiration. His style is entirely his own and cannot be traced to any specific region or mentor (certainly not to his father, as their duet set, *Fermoy Lassies/Bunker Hill*, should suggest). Indeed, his improvisational approach can be most nontraditional at times, as in the reels *The Pigeon on the Gate/Miss Monahan's*. In short, Brendan Mulvihill is a singular personality on the Irish-American musical front and as such will attract as many rabid detractors as rabid fans.

Mick Moloney's guitar accompaniments suffer from a rather "boomy" sound, while there's an odd, huffing distortion on some of the fiddle tracks. (Innisfree, Inc., 70 Turner Hill Road, New Canaan, Conn. 06840.)

Tom Bingham

Sound: C+ Performance: A-

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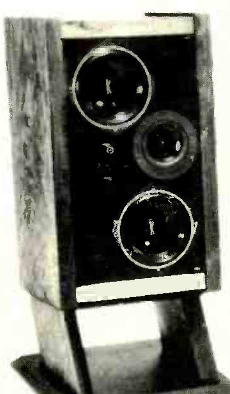

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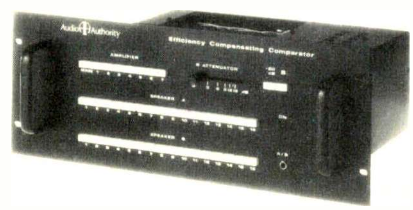

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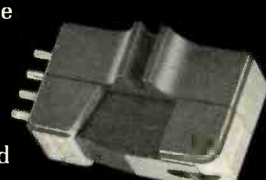

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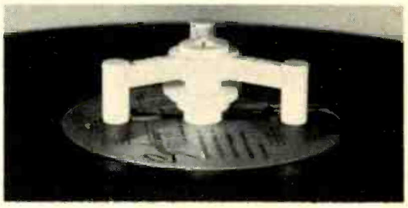

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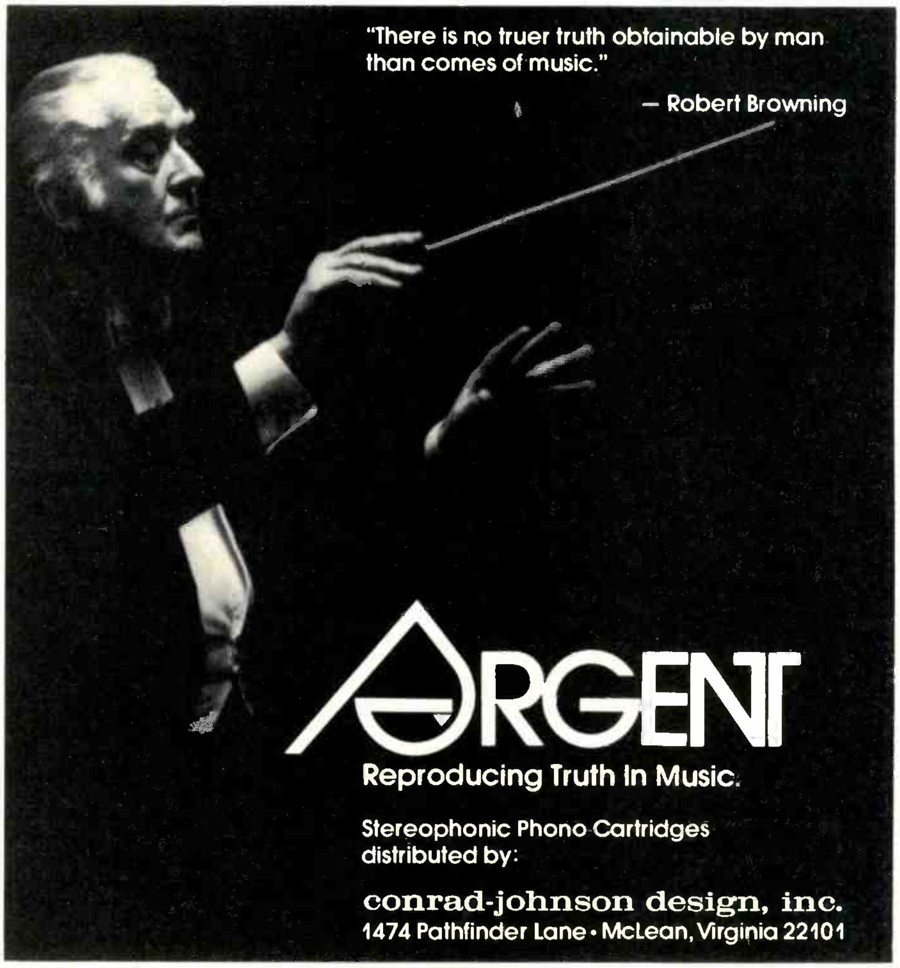

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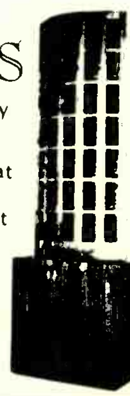

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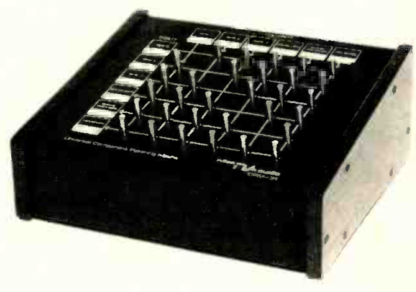

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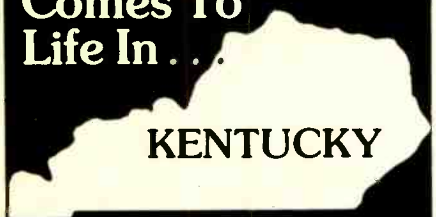

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TDK's answer to the need for a normal bias reference standard.

Optimum Dynamic is the outcome of the same, sophisticated technology which set the high bias reference standard with TDK's SA cassette. Its tape formulation consists of Optima Ferric particles. A needle-shaped, pure iron oxide that has been ultra refined to cover the tape surface evenly and densely. The result is a cassette with a sensitivity and MOL audibly superior to any normal bias cassette available in the market today.

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Supplier to the U.S. Olympic Team

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We believe we've been highly successful in fulfilling the need for a normal bias reference standard. But there's a simple test. Listen to an Optimum Dynamic just once. Compare it to anything else you've been using. From then on, you may want to use it as a reference.

TDK
The machine for your machine

*In the unlikely event that any TDK cassette ever fails to perform due to a defect in materials or workmanship, simply return it to your local dealer or to TDK for a free replacement.

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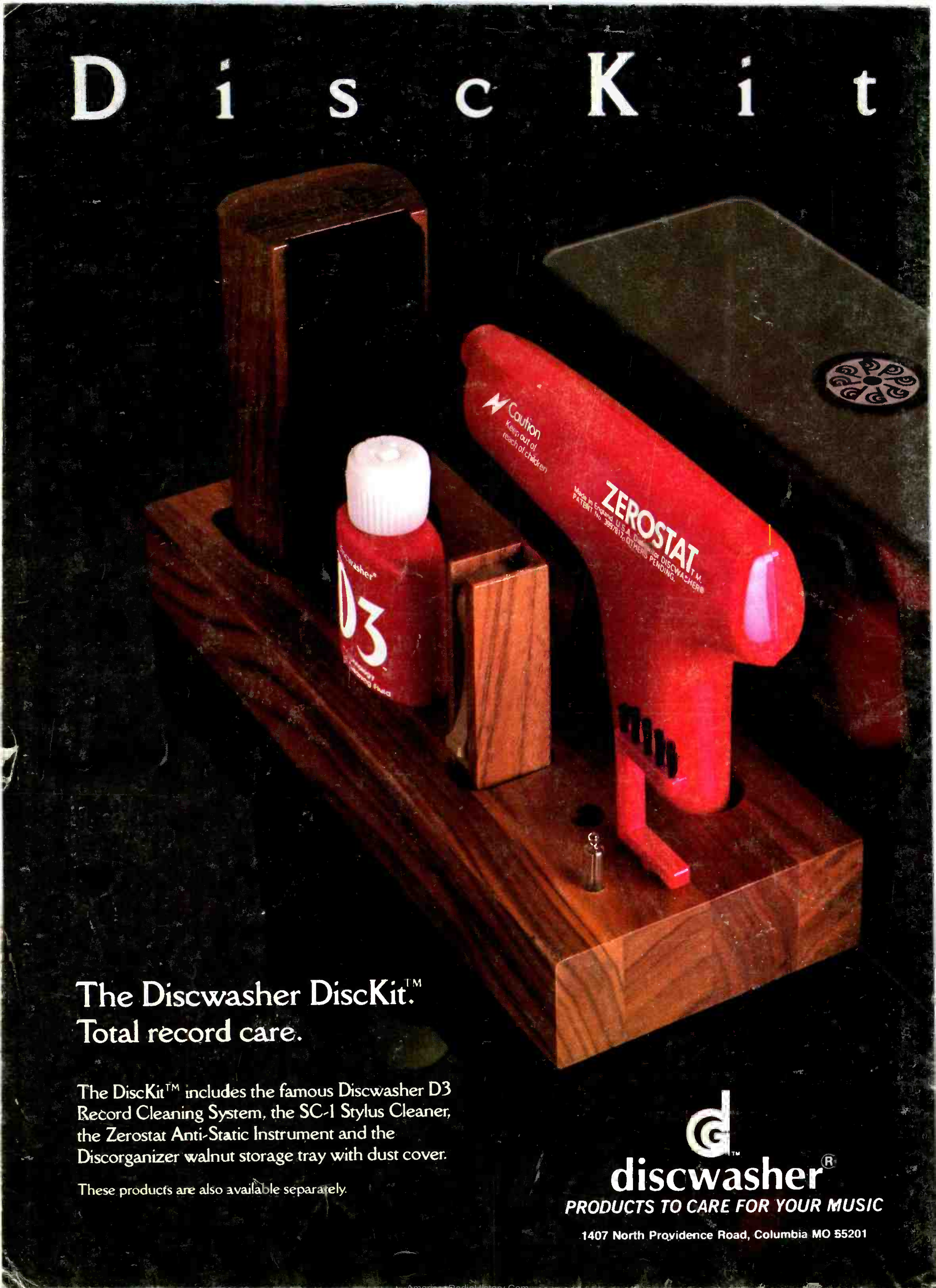
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