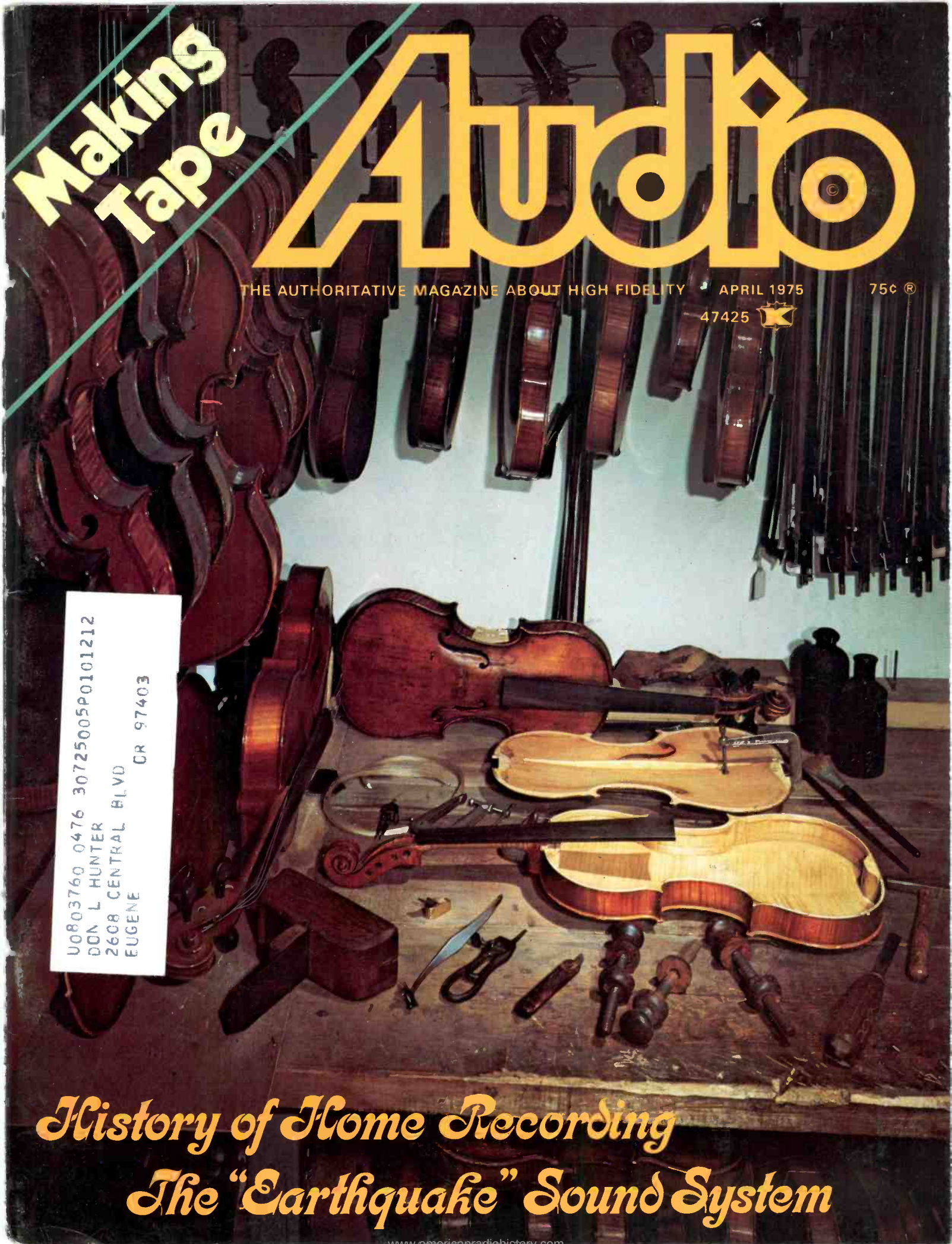
Audio

THE AUTHORITATIVE MAGAZINE ABOUT HIGH FIDELITY • APRIL 1975 • 75¢ ®

47425

Making Tape



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EUGENE OR 97403

History of Home Recording

The "Earthquake" Sound System

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receivers the world

Pioneer believes that any objective comparison of quality/performance/price between our new SX-1010, SX-939 and SX-838 AM-FM stereo receivers and any other fine receivers will overwhelmingly indicate Pioneer's outstanding superiority and value.

Our most powerful ever.

Pioneer uses the most conservative power rating standard: minimum continuous power output per channel, into 8 ohm loads, across the full audio spectrum from 20 Hz to 20,000 Hz.

Despite this conservatism, the SX-1010 far surpasses any unit that has come before it with an unprecedented 100 watts of power per channel, minimum RMS, at no more than 0.1% total harmonic distortion. Closely following are the SX-939 (70 watts RMS per channel, minimum) and the SX-838 (50 watts RMS per channel, minimum), both with no more than 0.3% total harmonic distortion. Dual power supplies driving direct-coupled circuitry maintain consistent high power output with positive stability. A fail-safe circuit protects speakers and circuitry against damage from overloading.

Outstanding specifications for flawless reception

FM reception poses no challenge to the exceptionally advanced circuitry of these fine instruments. Their FM tuner sections are designed with MOS FETs, ceramic filters and phase lock loop circuitry. The result is remarkable sensitivity, selectivity and capture ratio that brings in stations effortlessly, clearly and with maximum channel separation.

	SX-1010	SX-939	SX-838
FM Sensitivity (IHF) (the lower the better)	1.7uV	1.8uV	1.8uV
Selectivity (the higher the better)	90dB	80dB	80dB
Capture Ratio (the lower the better)	1dB	1dB	1dB
Signal/Noise Ratio (the higher the better)	72dB	70dB	70dB

Total versatility plus innovations

Only your listening interests limit the capabilities of these extraordinary receivers. They have terminals for every conceivable accommodation: records, tape, microphones, headsets — plus Dolby and 4-channel multiplex connectors. Completely unique on the SX-1010 and SX-939 is tape-to-tape duplication while listening simultaneously to another program source. The SX-838 innovates with its Recording

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The finest stereo
has ever known.

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There can be only one best.

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3,025 possible tonal compensations with unique twin stepped tone controls (SX-1010, SX-939)

Selector that permits FM recording while listening to records and vice versa. Up to three pairs of speakers may be connected to each model.

INPUTS	SX-1010	SX-939	SX-838
Tape monitor/4-ch. adaptor	3	2	2
Phono	2	2	2
Microphone	2	2	1
Auxiliary	1	1	1
Noise reduction	1	1	1
OUTPUTS			
Speakers	3	3	3
Tape Rec./4-ch. adaptor	3	2	2
Headsets	2	2	1
Noise reduction	1	1	1
4-channel MPX	1	1	1

Master control system capability

Pioneer's engineers have surpassed themselves with a combination of control features never before found in a single receiver. All three units include: pushbutton function selection with illuminated readouts on the ultra wide tuning dial, FM and audio muting, loudness contour, hi/low filters, dual tuning meters and a dial dimmer.

Never before used on a receiver are the twin stepped bass and treble tone controls found on the SX-1010 and SX-939. They offer over 3,000 tonal variations. A tone defeat switch provides flat response instantly throughout the audio spectrum. The SX-838 features switched turnover bass and treble controls for more precise tonal compensation for room acoustics and other program source characteristics.

In their respective price ranges, these are unquestionably the finest values in stereo receivers the world has ever known. Audition their uniqueness at your Pioneer dealer. SX-1010 — $699.95; SX-939 — $599.95, SX-838 — $499.95. Prices include walnut cabinets.

Also new and more moderately priced.

Pioneer's most complete and finest line of receivers ever, presents equally outstanding values starting at $239.95. Shown here are the SX-535 — $299.95, SX-636 — $349.95, SX-737 — $399.95. All with walnut cabinets.

U.S. Pioneer Electronics Corp., 75 Oxford Drive, Moonachie, New Jersey 07074
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PIONEER®
when you want something better


SX-535


SX-636


SX-737

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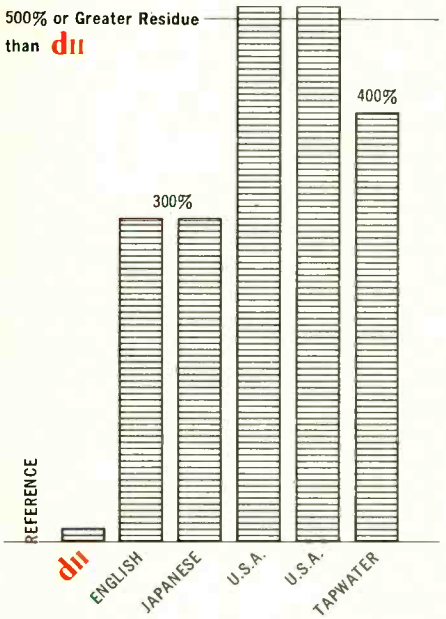
RESIDUE PROOF

Every record cleaner claims to remove dirt. But never mentions what it leaves behind. Recent independent tests show that this omission may be more than just oversight. See for yourself.



Actual dry weight measurements of best selling record cleaners.

The chart is just half our story. Only discwasher's directional pile brush (Pat. Pending) lifts fluid and any residue off the record by capillary action. So things aren't left to air dry.

Discwasher—the superior record cleaner is at Audio Specialists world wide.

Discwasher Inc.
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Audio

April, 1975 *"Succesor to RADIO Est. 1917"* **Vol. 59, No. 4**

Feature Articles

Equipment Profiles

Record Reviews

Audio in General

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For data sheets and a reprint of the article "FTC Power Ratings: An Optimistic View," (Audio Magazine, Feb. 1975) write or call:

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Audioclinic

Joseph Giovanelli

Connecting Several FM and TV Sets to One Antenna

Q. My problem is this. My signal source is a community TV/FM 75-ohm cable. I want to connect a black-and-white TV set, a color TV set, and an FM tuner to this cable. I now have them hooked as follows: The cable terminates in a 75-to-300 ohm adaptor and two-way splitter. The main output of the splitter goes to the black-and-white TV set and the other output of the splitter is connected to the input terminals of another two-way splitter, with one set of output terminals connected to the FM tuner, and the other set to the color TV set. The black-and-white set works very well. The color set, however, is adversely affected by the black-and-white TV set when changing from one channel to the other. This causes snow and even a loss of color on the lower channels when the black-and-white set is switched to higher ones.

Please tell me the proper way to straighten this out. I think I need a 75-to-300-ohm adaptor with three outputs, but I cannot locate one. I also wonder if a signal booster is called for in this situation.—Keith J. Webster, Elko, Nevada

A. Your problem will be best solved by using a transformer to step up the 75-ohm impedance of the cable to the 300 ohms which is required by each of the various pieces of equipment you wish to connect to the cable. Chances are that this transformer will have but one 300 ohm set of terminals. You then must obtain a three-way coupler by which you can interconnect the sets. It would appear that your present signal splitters are not much good or you would not get the interaction between sets. The whole purpose of a signal splitter is to avoid just such problems as those you mentioned.

Obtain the best possible transformer and coupler because you do lose some signal in each of these devices. By the time signals reach the various sets, 4 to 6 dB of signal will be lost. This loss is not too serious if the strength of the signals is high, and where you have good isolation between sets, as is supposed to be accomplished by the splitter.

Plaing Old Mono Tapes

Q. I have several 12-year-old reels of tape recorded from FM using a mono recorder. What type of track arrangement currently available should I use, 4-track stereo or two? What would one sacrifice with each kind, soundwise?—Edward J. Sampson, Jr., Andover, Mass.

A. You will get better results with a half-track (2-track) stereo head when playing mono tapes. The difference will be a 3 dB higher signal-to-noise ratio, because the longer half-track gap will pick up more signal than the quarter-track gap. On the other hand, using a half-track playback head, there is the possibility of poorer treble response owing to imperfect azimuth alignment. The longer the gap, the greater the treble loss for a given degree of azimuth misalignment between the head used in recording and the head used in playback.

Editor's Note: In his February *Audioclinic* column, Mr. Giovanelli stated that "the output impedance of tube . . . preamplifiers is generally so much higher than the input impedance of transistor units that the signal output from the tube unit is inadequate to drive the transistor component." The Audio Research folks ask us to note that their tube preamp has an output impedance low enough to drive all current transistor amps, and ranges from 50 to 600 ohms depending on tone control setting.

About The Cover: In our prowlings after antique musical instruments, we came across a charming repair shop in one of Philadelphia's quaint neighborhoods. Though the owner says he has all the work he can handle, we thought it would be nice to share this view of his bench with you.

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

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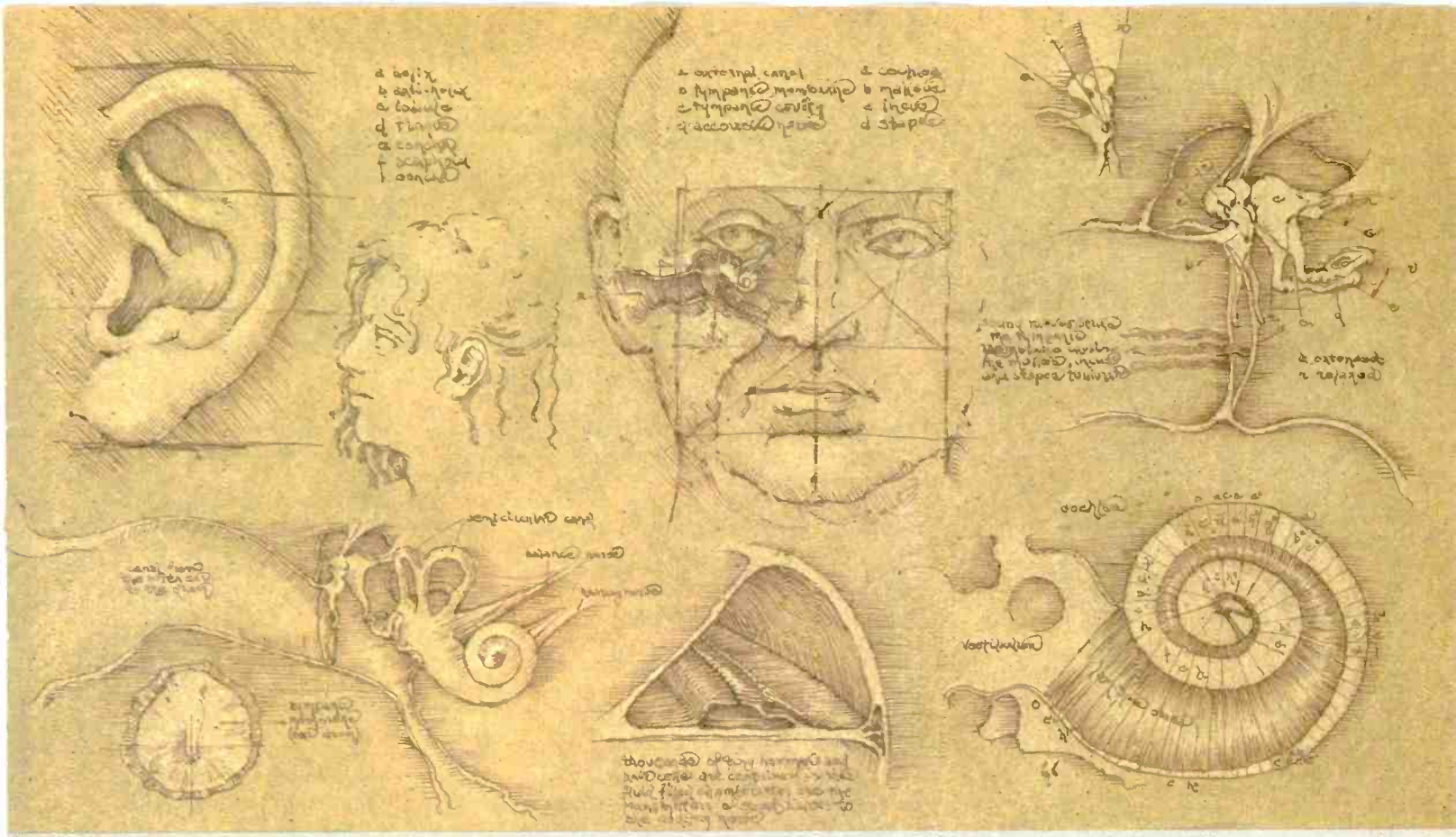

It's not your components that are getting worse, it's your ear that's getting better.

By better, we mean it's learned to pick up things in music that it was never able to before.

And that's why that system you bought may have sounded great a couple of months ago but doesn't sound so great today. The human ear, you see, is the most advanced sound receiver system in the world. Your eardrum is sensitive to one billionth of a centimeter. And it has a tiny bone called the incus that can vibrate up to 20,000 times a second.

Enough said about how good your ears are. Now what can you do to improve your system?

A general tip: Whatever you buy, buy up. You might not think it's worth the extra couple of hundred dollars now but you'll be glad you sprung for it later.

A specific tip: Consider Sony separates.

Separates offer you specs you generally can't get in non-separates. And therefore a better quality of sound. Our TAE-8450 pre-amp, for example, has a low distortion rating of THD 0.03%, a wide dynamic range of 60-70dB and accurate phono equalization (RIAA).

In addition, it offers you such features as a step attenuator gain control (volume control) that allows precise gain adjustment readings (our 2dB reading is the minimum loudness change the human ear can detect), extremely accurate tracking in 2 channels, and a quieter, longer lasting performance due to the use of low resistant sterling silver contacts. The unit also has a single peak program meter with a hold position that allows reading at the highest point of the signal wave form, thereby helping to detect overload distortion. And it also serves as a volume unit meter (vu) that allows for easier monitoring by showing the average value of a signal over a period of time rather than sudden changes within a short period.

We have separates that start at prices a lot lower than you'd expect to pay. And go all the way up to prices you're probably not ready to spend right now. So if your ears ever outgrow the system you buy we have others they can easily grow into. Why not stop into a Sony dealer and ask one of our salesmen for some help. After all, if you really appreciate music, shouldn't you have a system you can really appreciate it on?

SONY

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$235.00

The Stax SRX-II is quite simply the finest sound reproduction system you can buy. Period.

Much better than any speaker system at any price. Literally the standard for "other" headphone manufacturers.

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Now compare the facts that really matter. The SRX-II is entirely hand assembled and evaluated by the family company who created the first electrostatic headphone. A company dedicated to research — to ultimate sound. So every SRX is the product of detailed effort. Even the low mass diaphrams are individually paired — both by electronic testing and by listening.

Listen to an SRX system with program material you "know". You will be in the front row — the same room — the recording studio. You will hear perfection. The truest, clearest, most transparent reproduction ever possible. A reality now at audio dealers nationwide.

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Tape Guide

Herman Burstein

Open Reel or Dolbyized Cassette?

Q. Would you recommend a Dolby cassette recorder over an open-reel recorder at this time. Also, which machine would you consider to be superior to the others available?—Joe Szalajko, Los Angeles, California

A. While cassette machines incorporating the Dolby B system are considered to be a substantial improvement over former cassette machines, it appears that a high quality open-reel tape recorder operating at 3-3/4 ips is still better. And open-reel recorders operating at 7½ ips are even better. The quality difference between cassette and open-reel machines is less than formerly, but there is still some difference. The policy of *Audio* magazine is not to recommend specific items of equipment.

8-Track Head Adjustment

Q. I would like to purchase an 8-track cartridge player for my car, and want one with an adjustment so that the tape head can be moved up and down for proper tracking. Who wants to hear two different selections at the same time? Not me!—David E. Vogel, Tucson, Arizona

A. I do not know of any cartridge player with the head adjustment feature you are seeking. Even if you find such a machine it is unwise for anyone but a person equipped with the required knowledge and instruments to adjust the position of the tape head. In moving the head vertically, care must be taken not to disturb the azimuth alignment (90 degree angle between the tape head gaps and the long dimension of the tape). You should purchase a machine on the basis of its general quality consistent with what you wish to pay, and then have the position of the head checked by a competent technician, preferably one authorized by the maker of the machine.

Adding Erase-Defeat

Q. Can you explain how to add an erase-defeat switch to one's tape recorder? Is it safe just to open up the connection to the erase head, or would shorting the erase head be better?—Donald A. Potts, Independence, Mo.

A. A substitute load is used when the erase head is defeated, so that the amount of bias to the record head is unaffected. That is, the erase head is disconnected from the bias supply and a resistor is connected in its place. The value of the substitute load is determined by trial and error. It must draw the same amount of bias current as the erase head. The proper resistance and wattage rating of a substitute load resistor might be obtained from the manufacturer of your tape machine. Sometimes the specifications of one's tape machine state the impedance of the erase head at the bias frequency. This would indicate the appropriate ohmic value of the resistor. You can also measure the current drawn by the erase head with a *wide band* vacuum tube voltmeter (VTVM) across a small resistance in series with the erase head. Compute the current according to Ohm's law, then the resistance can be figured.

Control Button Pops

Q. I have a Signal Corps Telectro tape recorder, obtained through a government surplus house. This machine is solenoid controlled, much the same as an Ampex 354. It works fine except for one thing. Anytime I depress one of the motion control push buttons, a very loud pop is heard at the audio output. This is quite annoying, and I would like to know how I can eliminate this noise.—John W. Schuerman, Richmond, Indiana

A. Quite likely you can eliminate the annoying pop by mounting a 400 to 600 volt capacitor across the switch actuated by the control button. A value in the range of .01 to .1 μF should do it. You may also need a resistance of about 100 ohms, ¼ watt, in series with the capacitor.

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

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New from Acoustic Research

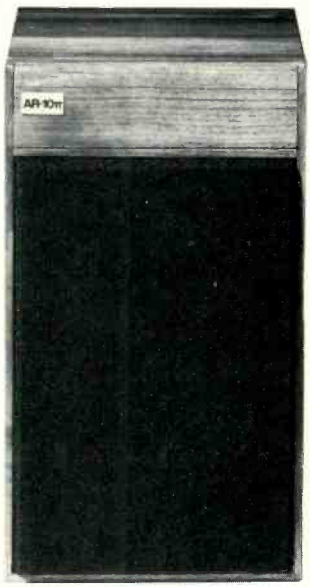
The AR-10π
A new standard of musical accuracy and an unprecedented degree of placement flexibility

Musical accuracy
The new AR-10π is the most accurate musical reproducer that Acoustic Research has ever built for use in the home. It has been designed to deliver uniform flat energy response in most listening rooms. This means that the musical balance of the input signal will be accurately transmitted to the listener, and listeners in virtually all listening positions will hear the performance in the same way. A new tweeter and crossover network make this new standard of accuracy possible.

Speaker placement
Speaker placement in the listening room is of critical importance to the musical balance of the system. That's why most speaker manufacturers give explicit instructions on exactly where their speakers must be placed for best results. The AR-10π however has been designed for maximum flexibility in this respect. It can operate in almost any location in your room with no sacrifice in accuracy.

The AR-10π can be positioned against a wall, in a corner, or even in the middle of the room.

Simply resetting a single switch will ensure the right amount of bass energy for any position – something that is not possible with conventional loudspeaker designs or equalization techniques.



Acoustic Research has prepared a comprehensive description of the AR-10π speaker system. You can get a free copy by sending us the coupon below.

Acoustic Research
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Norwood
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Dear Editor:

FTC Power: Round II

Dear Sir:

In response to Mr. Robert Tucker's article, "An Alternative View" (February), and the continued flagrant violation by several manufacturers and publishers in permitting illegal advertisements to appear at this late date:

We believe the consumer of audio amplifiers does not buy them by the watt as he would gasoline by the gallon. Just as it takes 40 square yards of carpeting to cover 40 square yards of floor, it takes a minimum number of watts to drive a given speaker system to a given sound pressure level in a particular room. Beyond this, the choice is usually one of quality. Forty square yards of $3.50-per-square-yard synthetic carpeting will cover the floor as well as 40 square yards of $25.00-per-square-yard of the finest all-wool broadloom. But, there will be a difference in the feel, the wear, and the longevity.

As Mr. Tucker stated, BGW Systems does indeed make "tanks." But our tanks come in many sizes, all rugged and all designed to give the consumer a conservatively designed product for his dollar. So, although the FTC regulation may force the consumer to pay more dollars per "brown-goods" watt, our real watts (and prices considering inflation) remain almost the same.

The sonic benefits are far from "negligible." As we stated in our article, conservative design has made it possible to build an amplifier without current limiting circuits and their inherent problems at high levels. A-B comparisons will prove this to be a far from "negligible" gain.

Mr. Tucker claims that the rule will result in reduced product information. We feel that it will result in reduced audio-fiction but much more *real* product information. Since not only manufacturers but dealers and publishers as well are covered by the enforcement provisions of the rule, the information that the consumer will receive will be based on *minimum* performance under rigid test conditions. True, there may be a good many shorter spec sheets, but what they say will refer to the actual product and not to a pipe dream of a clever copy writer.

We at BGW Systems are appalled at the apparent disregard of the law by several other manufacturers by running advertisements which do not comply. Furthermore, we feel it is the publisher's responsibility to see that his magazine prints only that material which is written in accordance with the law.

Brian Gary Wachner
BGW Systems
Beverly Hills, Calif.

Editor's Note: Mr. Wachner's letter would lead one to believe that a magazine, such as *Audio*, has a duty placed on it by the FTC's power-output regulation to police advertisements for amplifiers and receivers. This is not so. First, the courts have often held that a publisher may not censor ads unless he can show outright slander or pornography (and even this last is again open to question). Second, the FTC would bring all advertising of these products to a grinding halt were it to require the publisher to test the products; obviously an impossibly expensive task and one which many publishers cannot perform even on a single unit. Third, it is similarly impractical for the FTC to require that a publisher obtain certification of compliance with the rule from an advertiser since by advertising the product the maker is prima-facie saying that his product DOES meet the standards set up by the rule. Fourth, the rule, as promugated, makes no mention of publisher responsibility. To extend that responsibility to the publisher would be to lose sight of whose product is being advertised by making the publisher a "policeman" agent of the FTC. *Audio* has been in consumer fights before, and we applaud the basic intent of this rule. However, we cannot act as the FTC's unpaid agent. It would be cheaper to simply stop accepting ads which made power-output claims.

We therefore reject any interpretation which makes a publisher responsible for the power-output claims contained in advertisements.

Mr. Tucker Replies

Dear Sir:

Lest the first paragraph of Mr. Wachner's letter be misinterpreted, any reference to power output in Dynaco advertisements published since the November FTC Rule date conforms to the strictest interpretation of the Rule. While we strongly contest certain aspects of the Rule, we believe in full compliance until it is altered. We deplore attempts to subvert it, especially those specifications written in apparently conforming format, which neglect to mention that they ignore the stringent preconditioning requirements.

While the FTC has indicated that it will not sue for misleading advertising under the preconditioning paragraphs of the Rule until the Dynaco petition is resolved, such advertising tactics adversely reflect on our industry's credibility, and further confuse the customer. And, since neither the magazines nor the dealers are in any position to police power claims, a massive investigation and enforcement campaign will have to be speedily implemented by the FTC if those with honest ratings are not to suffer disproportionately. In the intervening months or years, more confusion could result from misinformation under the guise of compliance than from the nonsensical power rating of the past.

While we wish it were not so, too many amplifiers are indeed bought "by the watt." Were that not true, the Rule would not have been so sorely needed. BGW may find it less of a problem in their marketplace, but with several hundred thousand Dynaco amplifiers behind us, we are quite aware of typical buyer priorities.

We doubt that the Rule will have much effect on mass merchandise "brown goods" audio, other than to suppress *any* references to power ratings. We'd prefer, in fact, that the Rule *require* some rating, preferably with a minimum bandwidth requirement, as did the original New York

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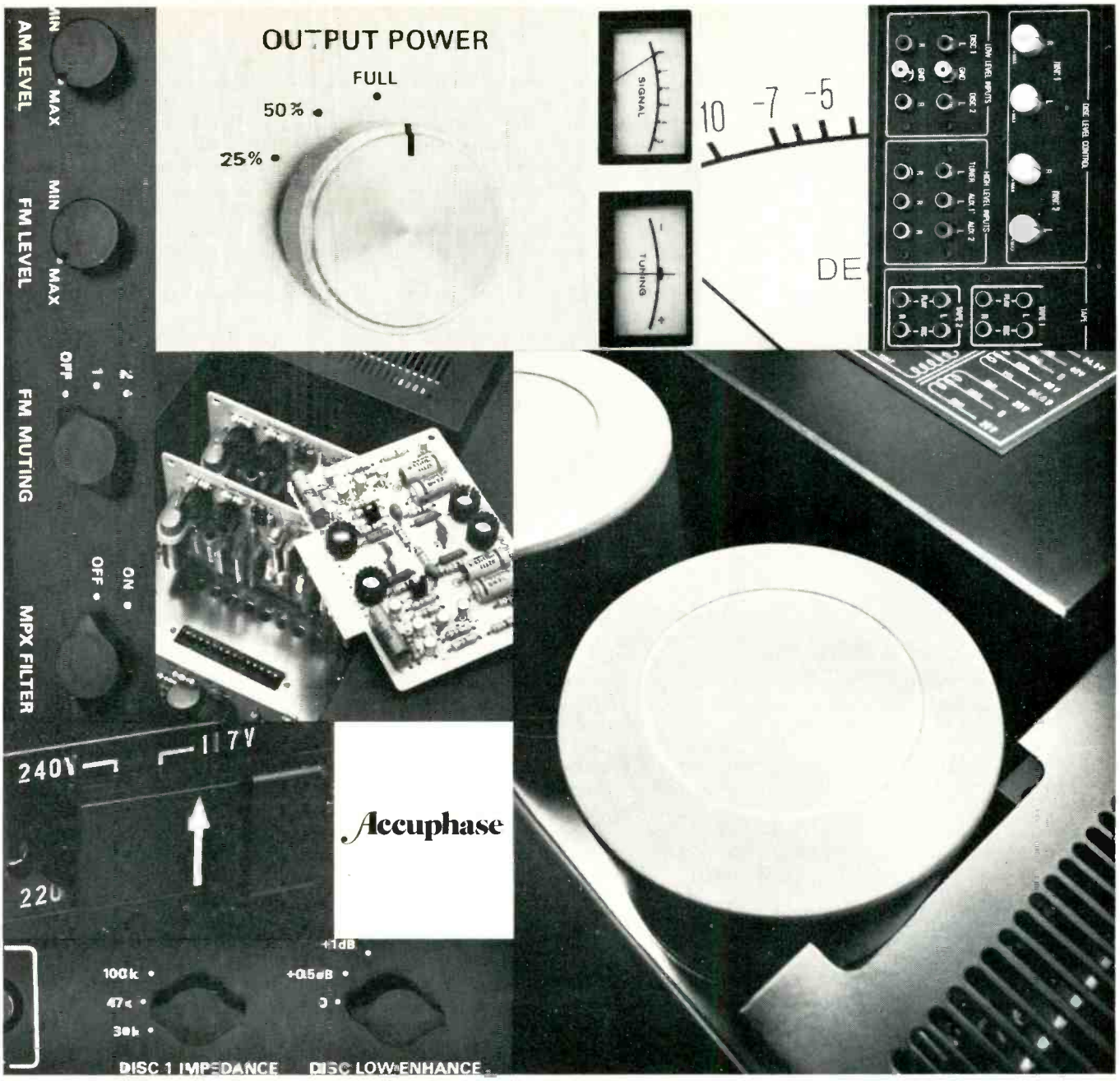
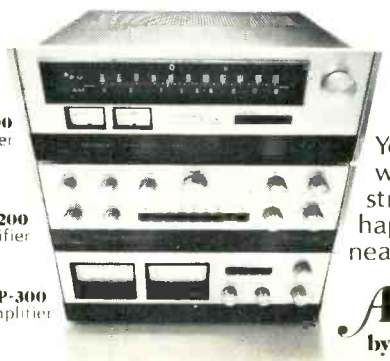


If the whole is greater than the sum of its parts, imagine what happens when each part is greater than it has to be.



T-100
AM/FM Stereo Tuner

C-200
Stereo Preamplifier

P-300
Stereo Power Amplifier

Your Accuphase retailer will be happy to demonstrate exactly what happens. To find the one nearest you, write us.

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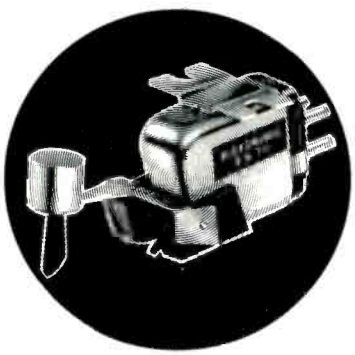
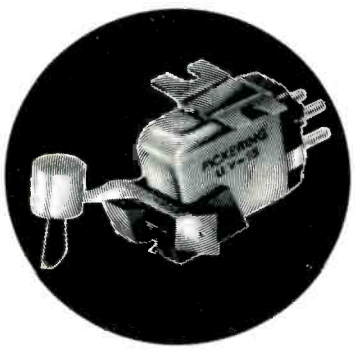


For the World of STEREO and MATRIX—XV-15/1200E

The 1200E is the furthest advance achievable today—and perhaps in the forseeable future—in stereo cartridge design and performance. Its exceptional ability to pick up all the material recorded at the lightest possible tracking forces plus its tracing ability at high frequencies make it totally unique. Pickering's exhaustive testing shows that the 1200E is superior in the flatness of its frequency response and channel separation to competitive cartridges.



For the World of DISCRETE 4-CHANNEL—UV-15 SERIES

The discrete 4-channel system requires completely new cartridges that could not only faithfully reproduce the 20 Hz to 20 kHz AM signals, but also the 30 kHz FM modulated signals. This requires exceptional ability to trace high frequency signals. The UV-15 Series cartridges are capable of satisfying all technical and aesthetic requirements for playback of both discrete and stereo discs.

For further information write to:
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City power Rule.

There is no relationship between the design requirements to conform to the Rule, and the supposed sonic benefit Mr. Wachner claims from leaving out current limiting circuits in his models. Current limiting could be left out of a cheap design too (few of these now include it), or another engineer might still choose to add it to the BGW 750A "tank" out of zealous conservatism. Given an acceptable amplifier by previous "rms" or continuous average power measurements, any change to the Rule will not improve its sonic quality one iota. Fans, in fact, degrade achievable signal-to-noise ratios in the listening area.

We concur totally in supporting the Rule's provisions which help to remove information of dubious validity from the spec sheet, and secure it from the copywriter's influence. But we believe that *realistic* power specifications at all useful impedances are helpful to the purchaser. The Rule requires complete specifications for all impedances "for which the manufacturer designs the equipment to be used." Currently, manufacturers can easily circumvent their problem of ridiculously low 4 ohm ratings with preconditioning by not "designing" the amplifier for 4 ohm use. There is no assurance that the FTC will tolerate that loophole, especially with amplifiers which have previously been rated at 4 ohms, or those which include "A+B" parallel speaker switching, or those which make reference to such use. Or do we assume that only 16 ohm speakers may be used for such parallel connections?

This is not to say that all amplifiers must be rated at all 3 common impedances, but rather that if the manufacturer so chooses, or the buyer requires that information, that the figures thus given bear some sensible relation to real capability. Only then can the buyer weigh the advantages (higher available output) or disadvantages (destructive capability) properly.

I note Mr. Wachner said that fan-cooled amplifiers and those "designed for 2 ohm use" are those least affected by the Rule in retaining existing power ratings (at least down to 8 ohms or possibly 4 ohms). But, by definition, such amplifiers must now carry 2 ohm power ratings as well!

Lest it be thought we are jousting at windmills, one example should clarify the fallacy in the Rule's requirements, though more extreme examples can be found among popular amplifiers. The Dynaco Stereo 400 has more heat sink per output transistor than any other amplifier we know of—1.2 pounds of aluminum, and 130 square inches of radiating area *per device*. We could design it to include a noisy fan, but instead we've designed it for better performance *without* a fan, and with tighter thermal protection. Reviewers have not found any need for a fan on the Stereo 400 (even though space is provided on the chassis) because thermal tripping is almost non-existent on the thousands in use.

The Stereo 400 has always been rated at 200 watts "rms" per channel into 8 ohms, and 300 watts "rms" per channel into 4 ohms, which reviews have fully supported. Under the Rule, the rating is now 200 watts per channel, both channels fully driven into 8 ohms, across the *entire* audio band of 20 Hz to 20,000 Hz, with total harmonic distortion always below 0.25%. While it can deliver a full 300 watts for some 10 minutes *without a fan* (a far cry from a "music" or "peak" rating), the even higher heat output at 1/3 power required for preconditioned necessitates a sharp reduction in rated 4 ohm power, since thermal cycling is not permitted. To keep the transistor case temperature below 85°C for an hour's operation at 1/3 power, the amplifier would have to be rated at less than 30 watts into 4 ohms, but Dynaco believes that the customer must be warned that this amplifier can deliver 300 continuous watts into his speaker.

In effect, the law requires that misleading information be supplied, unless a 4 ohm rating is not given. If it is not given, it implies that the amplifier is not designed for operation into 4 ohm loads. Further, monophonic bridge operation would yield a rating of less than 60 watts into 8 ohms by the Rule (far less than in stereo operation) when in fact the amplifier can deliver—even without a fan—more than 10 times that for long periods of time, with potentially destructive capability which the unknowledgeable consumer should be informed of.

A conventional "whisper" fan mounting gains only incrementally in this power rating, but because we are talking about relatively small thermal reductions to get inside the thermal cutout limits (they are mounted on the transistor cases), simply changing to a noisier, high speed fan blowing down into the same heat sink enables a fully comparable 300 watt rating under the Rule, with the same thermal protection.

There are other ways to this end, of course. One way is to add output devices to increase the thermal inter-

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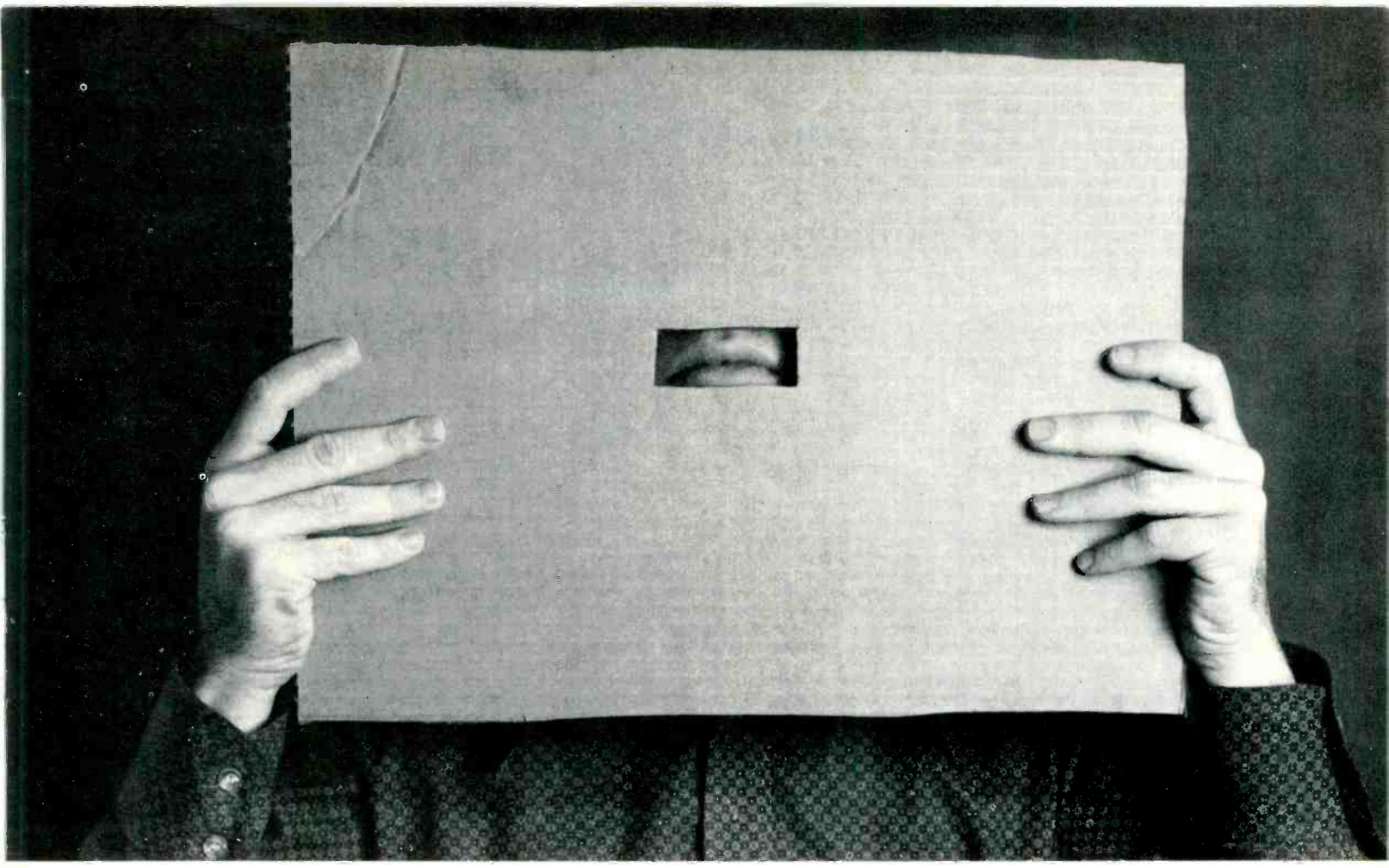


Turn yourself into a remarkable speaker demonstration.

To begin, just find a piece of heavy cardboard or corrugated carton about 14" x 20" and cut an opening in the center like the one above. Now you're ready! Grab a friend, your wife, your mother-in-law—anyone who can bear to hear you ramble on for the next 30 seconds. Hold the contraption you just made to your face so that your lips are against the opening and start talking. Now, take it away quickly as you continue to talk. Then hand it over and let the other person talk, with and without the cardboard.

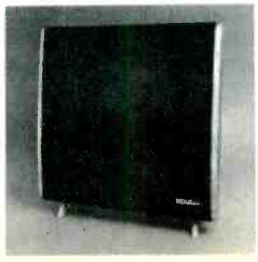
If all went well, you probably noticed a coloration in voice quality whenever the cardboard was held up.

In essence, what you just did was to simulate the way every enclosure type of system is affected by the baffle board its speakers are mounted on. You became the speaker and the cardboard became the baffle.

As you spoke without the cardboard, the sound waves reached the listener normally. But when you spoke holding up the cardboard, some of the sound waves from your voice traveled along the surface of the cardboard until they reached the edges, the way they do on a conventional speaker. The sharp discontinuity caused an effect called "diffraction," which allows these waves to be heard too, but later than the original sound. This is what produces the unnatural coloration you heard.

But the Dahlquist DQ-10 overcomes this problem through an ingenious free-air mounting configuration which has no large baffle surfaces to color the sound. At the same time we are able to reduce time-delay distortion, since all drivers are mounted in the correct acoustical plane.

The end result is sound that is so natural and open in quality that you will realize just how much coloration enclosure type speakers produce. Even if you don't want to go to the trouble of doing our little home demonstration, any Dahlquist Dealer will be happy to do it for you, using a DQ-10 instead.



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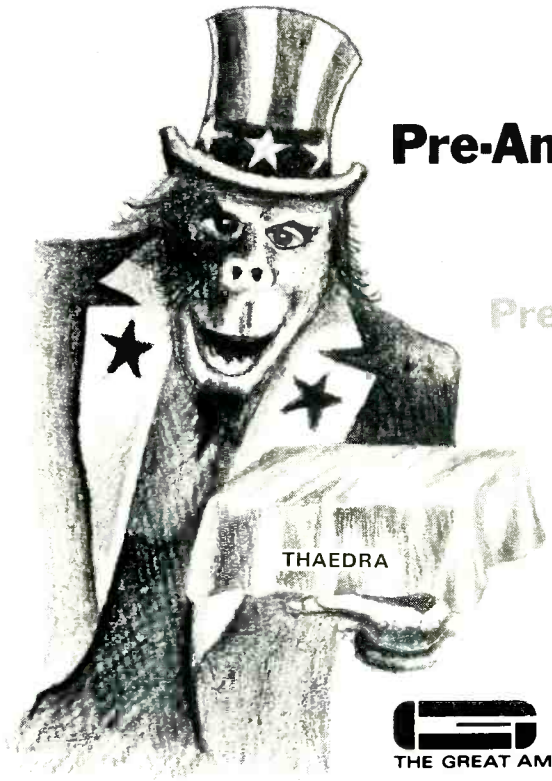

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We're too British to boast. So here's what the experts say about us.

Rather than appear immodest, we'll let the experts who write for the audio publications tell you about an automatic turntable we're quite proud of-our 810QX Transcription Series model.

High Fidelity magazine says:

"The new cam system in the 810QX is credited with providing smoother and quieter operation than in past models. Average flutter was very low at 0.05%; total audible rumble by the CBS-ARLL method was —52db. The arm has negligible friction laterally and vertically, and requires a 0.3 gram stylus force for automatic trip. Taking it all together-performance, features, styling —the BSR 810QX moves into ranking place among the best automatics we know of."

Stereo Review magazine says:

"The BSR 810QX has an unusually complete array of operating controls and adjustments, yet is simple to use. The wow and flutter were very low—respectively 0.03 and 0.045% at 33⅓ rpm and 0.05 and 0.04% at 45 rpm. The BSR 810QX, undeniably a well-constructed and attractively styled record player, was also a very easy one to operate. The controls had a smooth, positive feel and action."

This is a modest way to tell you how good our 810QX Transcription Series turntable really is. We would be pleased to send you detailed specifications. Just drop us a note.
BSR (USA) Ltd., Blauvelt, N.Y. 10913

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face area. This would enable backing off on V-I limiting too, as Mr. Wachner prefers, but at an unjustifiable cost penalty for the vast majority of users. Or, we could save money by eliminating the protection of thermal sensors entirely. Once the sensors are moved farther from the output device, and especially when their trip temperature is raised, their real effectiveness is largely nullified. None of these 3 courses benefits the consumer, or affects the reproduction quality, and two add considerable cost. Product safety even becomes a factor in some other designs for the Rule's test pushes the heat sink temperature above 100°C in some units. If the heat sink gets that hot, think what the chip temperature is, and how far beyond its safe operating area!

As to consumer confusion, let's take the case of two versions of a current amplifier which sports an impressive heat sink, but which for all its output devices, has limitations in thermal transfer to the sink. One version has been previously rated for consumer use as upwards of 200 watts per channel into 8 ohms. Another commercial version (hence not liable under the Rule) is typically rated on its much higher 4 ohm output (though the impedance is not always identified), and it is regularly advertised in the popular music magazines. If the maker chooses not to rate the consumer version's 4 ohm power output under the Rule, what is to prevent a dealer from making the sale by pointing out the obvious similarity to the commercial version, and claiming the higher (4 ohm) output?

Is it a molehill, or a mountain? One manufacturer has said he had understood that so long as at least one power rating could be affirmed under the Rule (as at 16 ohms, where the heat output is less) others on the same amplifier would not be questioned, so long as they were "reasonable" in terms of past rating practices! Thus those who believe in strict interpretation would be severely penalized for their honesty.

Another manufacturer has indicated they are "sure the FTC are reasonable people, and won't interpret the Rule too stringently, because otherwise, massive redesign would be necessary." It is unreasonable to expect the FTC to second-guess their Rule, and interpret it in a light favorable to part of the industry. Literal interpretation must be assumed, and if we do not effect change now, we must suffer the consequences, and the consumer will be footing the bill, with no apparent benefit.

(Continued on page 77)

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Is it live or is it Memorex? Who knows?

In our most recent test, we asked Ella Fitzgerald's old friend and longtime jazz arranger, Nelson Riddle, if he was listening to Ella live, or Ella as recorded on a Memorex cassette.

He couldn't tell.

We believe that's a strong endorsement of our exclusive MRX_2 Oxide formulation.

In fact, since we introduced MRX_2 Oxide, a lot of other ferric tapes have been scrambling to find something to beat it.

Nobody has.

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Is it live, or is it Memorex?

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Behind The Scenes

Bert Whyte

I'VE BEEN in the audio field a long time and I've also been a member of the audio press for a long time. As you might expect, like most of my colleagues, I have developed a pretty thick skin and a highly developed attitude of skepticism. God knows how many wild claims have been bounced off my head. If I had a nickel for every time I was shown the "ultimate" loudspeaker/phono cartridge/amplifier, etc., I could retire! Of course, out of all the welter of high-flown claims and representations have come the hi-fi products of genuine merit which have been the bulwark of our industry. And as our technological base has broadened over the past few years, some very bright, young engineers have come up with clever new products, formed companies, and become part of the mainstream of audio. Well and good. Nevertheless, as many of the "old boys" will admit, we find it wise to keep that "grain of salt" handy, just in case some of the hip, new PR types try to give us the "con."

You know, things go in cycles in the hi-fi business. For example, after years of relative quiet, electronic crossovers are becoming popular again, which means another round of bi- and tri- speaker amplification. The use of "raw" speakers, full range, woofers, mid-range, and tweeters, in "do-it-yourself" enclosures, is on the rise (as witness a new booklet on the subject by Altec). After years of concentration on receivers, there is a new trend to separate power amplifiers and pre-amplifiers.

And therein lies my tale... I had heard rumors about a certain pre-amplifier with highly unusual signal-processing facilities, and such were the claims that I frankly said "Hoo boy! I've been this way before," and made sure I took a full dose of my Skeptic® pills. Well, the rumors persisted, and I began to get some input on this unit from people whose opinion I had to respect. No one is more curious than an old audio hound, so I finally arranged to get one of these new-fangled pre-amps to see what all the fussin' was about.

I've had this unit for some months now, and I have tried every deviltry I know to fool it. I cheat it, lie to it, sneak up on it, confuse it ... everything but adjust it with a ball-peen hammer. Damn thing just keeps on working, doing what it's supposed to do. "Okay," you say, "a good pre-amplifier should do its signal-routing and amplifying of program material without adding significant noise or distortion, or adding coloration to the sound. In fact, the unit should be completely neutral and have *no* sound of its own. So what is so special about this pre-amp?" Well, this Phase Linear 4000 pre-amplifier has noise-reduction and dynamic-range expansion circuits that are extremely sophisticated and, in fact, are partially a "spin-off" from the space program. The combination of these circuits, plus several other processing aids, finally enables us to cope with some of the restrictions of dynamic range and signal-to-noise ratio of phonograph discs and, to a certain extent, several formats of magnetic tape recording.

To anticipate a question, the Phase Linear noise-reduction system is *not* in the same category as Dolby noise reduction. As is by now well-known, the Dolby is a two-pass or closed system which, through special multi-band low-level encoding and decoding, *prevents* additional noise from being added to the tape during recording. In contrast, Phase Linear's noise reduction system is of the single-pass or open-ended type, in which no encoding of tapes, discs, or FM is necessary for its operation. In other words, this is an "after the fact" noise-reduction device and it affords about 10-12 dB hiss reduction from any program source in which hiss exists. Most importantly, this noise reduction is accomplished without any degradation of the signal, such as loss of high frequencies. This seeming impossibility will make sense shortly.

The full title of this pre-amp is the Phase Linear 4000 Autocorrelator/Pre-Amplifier. The autocorrelator is the noise-reduction circuit and, as noted previously, is a "spin-off" from the space program. When our Mariner spacecraft transmits photos back from Mars, for example, the initially received resolution is quite poor. Highly advanced autocorrelation techniques gradually remove a large percentage of the detail-obscuring noise "glitches," and the results are the excellent photos you see in your newspapers.

How does the autocorrelator work? First, a few preliminary ideas. Noise energy (in our case, mainly hiss) is considered random in nature, non-coherent or *uncorrelated*. Unfortunately for us, noise energy exists continuously and uniformly within the audio passband. In contrast, music (or any *information* carrying signal) has an energy spectrum which is neither continuous nor random.

Now here are some words from Bob Carver, President of Phase Linear and inventor of this autocorrelator noise-reduction system:

"Music energy appears in *discrete* energy 'bundles' throughout the audio band and is therefore not continuous. In addition, if some musical energy appears, for example, at a particular frequency, we know for certain that even and odd harmonics will exist simultaneously throughout the passband, and that energy will not exist between these harmonics. In other words, with music we are able to 'predict' where energy is likely to occur, if we know where the fundamental is, or even if we know where only one of the harmonics is. Also, and importantly, we know where the energy will *not* appear. In other words, music is *coherent* or *correlated*."

Since pure hiss is totally uncorrelated, it is assigned a *correlation co-efficient*, which is zero. Highly correlated signals, such as a sine wave or a linear sum of sine waves, have a correlation co-efficient of one. As noted, music is a correlated signal, but the correlation value of music varies continuously from moment to moment.

The Autocorrelator may be considered a real-time Fourier analyzer with correlation co-efficient estimator. It is a very complex circuit, and the following is a simplified explanation of how it works: A series of electronic gates or "windows," each window controlling a certain frequency range and just "overlapping" its neighbor, is placed in the audio passband. These windows can be either closed or open. If it is closed, energy,

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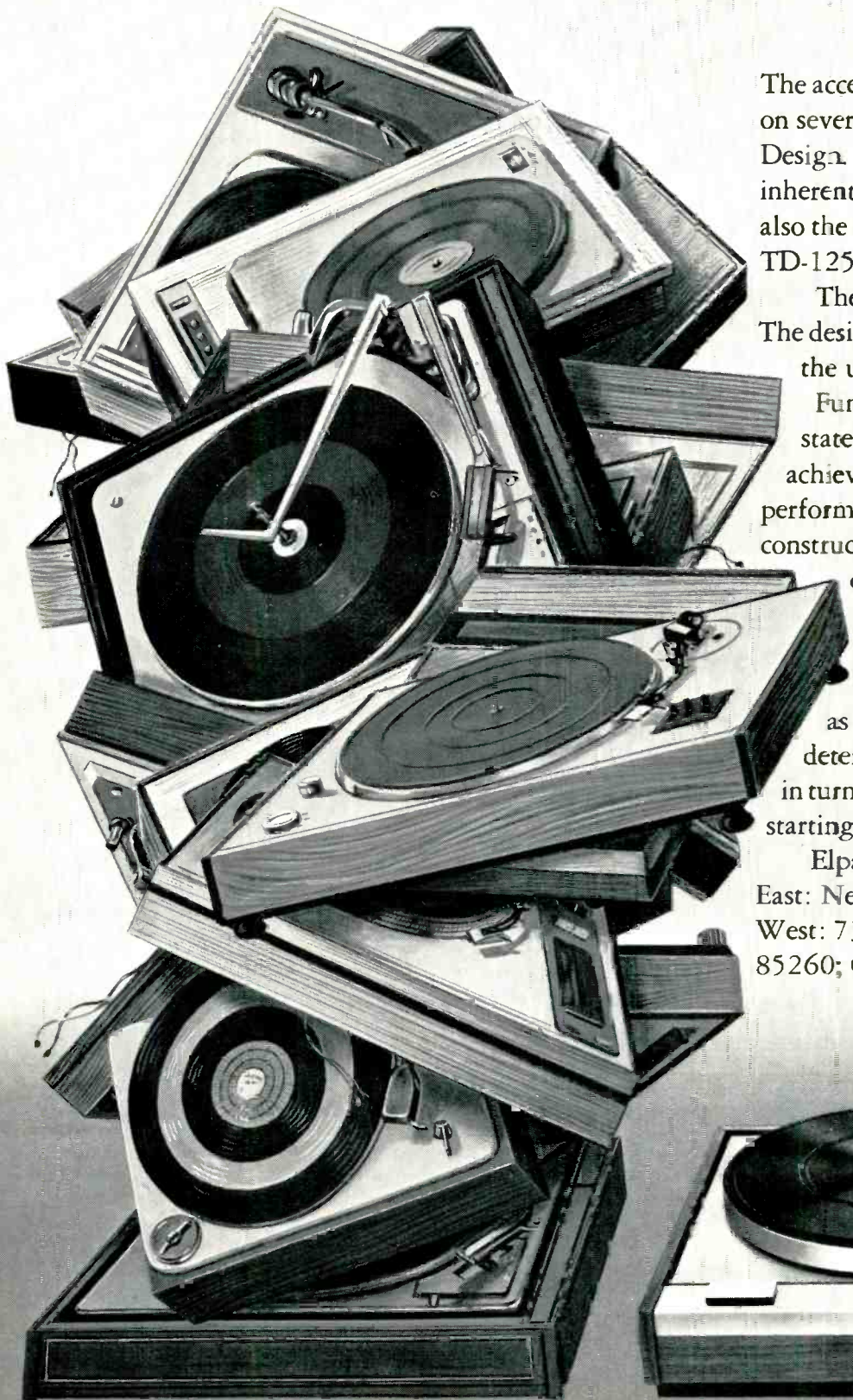
Some things hold up better than others.



The accepted concept of durability is based on several very important factors. Material. Design. Engineering. Function. And inherent value. Coincidentally, these are also the hallmarks of the Thorens TD-125AB Mark II.

The materials are the finest available. The design and engineering incorporate the ultimate in turntable technology. Functioning flawlessly, it originates state-of-the-art that others have yet to achieve. To match the impeccable performance, this Thorens is constructed to hold up . . . not wear down. It has inbred longevity instead of built-in obsolescence.

The precision performance of the TD-125AB Mark II serves as continuing proof of the Thorens determination to remain the classic name in turntables. There are other models, too, starting at $199.95.

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be it correlated (music) or uncorrelated (noise), cannot be transmitted at that point in the frequency spectrum assigned to the particular window. If the window is open, energy may be transmitted at that frequency. An operational description from Phase Linear says that each window is controlled by two sets of control circuits coupled together by diode logic "OR" gates. The primary circuit is located in the *control* band, between 200 Hz and 2 kHz. The secondary circuits are located throughout the *harmonic* band from 2 kHz to 20 kHz. The presence of energy in the control band, if above a level of –65 dB, will cause each window associated with the appropriate harmonic to open. If energy appears in the *harmonic* band at a particular frequency, each window associated with each upper harmonic of that frequency will be opened. All lower windows will remained closed. Notice that as the frequency increases, fewer and fewer windows are required to be opened. Notice also that for the autocorrelator to recover a harmonic "buried" *beneath* the noise, it is necessary that the harmonic have associated with it a lower frequency fundamental whose energy level is *above* the noise. Fortunately, this condition is common in musical energy.

In similar fashion to most noise reduction systems, the autocorrelator commences with a reduction of 3 dB at 2 kHz, and reaches 10 to 12 dB from 4 kHz to 20 kHz. As noted, the device has a circuit which estimates the degree of correlation of incoming signals and generates a control signal. This correlation function signal is combined with another signal which indicates the harmonic content of any incoming music energy. This controls a threshold level designed to detect musical information within each of the bandpass frequencies. It must be appreciated that in the music output of a phono disc or tape, the noise (hiss or uncorrelated sound) is always present "outside" the gates, and is always ready to "rush in" along with the music when a gate is opened. By automatic adjustment of the various threshold levels at which the bandpass gates are opened, the incoming signal passed through the gates is almost always of such amplitude, frequency, and correlation that the well-known "masking" phenomenon occurs, and the noise is subjectively "covered."

Along with the autocorrelator circuit, but not actually part of it, is a signal-controlled, low-frequency dynamic filter which is designed to reduce rumble, hum, and other extraneous low-frequency "garbage." Low-frequency noise reduction begins at 200 Hz, ultimately reaching –20 dB at 20 Hz. This low-frequency filter is activated when the correlator switch is put into its *On* position. There is also a screwdriver adjustment for calibrating the circuit to a particular phono cartridge. In spite of its relation to a phono cartridge, this circuit works with tape as well.

There is a correlator threshold-adjustment control on the lower right of the front panel. It is very simple to use. The correlator switch is placed in the *In* position, and the correlator control is rotated to the extreme clockwise position. In this position there is no attenuation of hiss. Turning the control slowly counterclockwise, you will perceive a dramatic reduction of the hiss. If you continue to rotate the control toward its full counterclockwise position, there will be a sudden loss of high frequencies. It is not all that critical and works in the broad area of roughly 10 to 2 o'clock. Once set, you can flip the correlator switch to the *Out* position, and 10-12 dB of hiss will come rushing into your ears.

"I've resurrected ancient mono LP discs, run them through the 4000.... You wouldn't believe how alive and open the sound was."

The other processing circuit on the Phase Linear 4000 pre-amp is the "peak unlimit/downward expander" dynamic-range-enhancement system. Of equal sophistication and very nearly as complex a circuit as the autocorrelator, this system is designed to restore the dynamic range lost in the use of compressors, peak limiters, and similar devices in the disc-cutting process, as well as the manual "gain-riding" so often used to raise soft passages above the noise. This is a four-band expander system, controlled by changes in high- and low-level signals. The high-level peak-unlimit band has a gain variation of +1.5 dB; there is 0 dB gain in what is termed the "don't care" band (the music is neither too loud nor too soft, so nothing happens); at –30 dB is the linear-expand band with a gain variation of ±1.5 dB, and the downward-expand band has a gain variation of –3 dB. Since the linear-expand and the downward-expand bands are in essence "hurrying up" the rate of decay with decreasing amplitude of signal, there is ambience truncation. To offset this, ambience is obtained by internally generated L-R and R-L signals, which are specially processed by frequency weighting and phase shifting, and then injected into the output during the linear and downward expand operations. With carefully controlled attack and decay rates and with such small values of individual expansion in each of the bands, the overall operation of the system is undetectable. Yet the increments of expansion available from the four bands add up to 7.5 dB, and this combined with the 10 dB from the auto-correlator noise reduction give us 17.5 dB, which is a very considerable increase in the overall effective S/N ratio and dynamic range.

On the lower left of the front panel is a peak-unlimit threshold control and to its right, a red LED. In use, the control is rotated clockwise until the LED just flashes on the highest program peaks. This is important, for if the control is advanced too far and the LED is continuously on, distortion will be generated. The peak-unlimit lever switch activates the circuit.

Now on to the use of the special circuits. The autocorrelator is just plain amazing in what it can do for signal-to-noise ratio with any recorded medium. Most noise reduction circuits usually perform best on material that is fairly quiet, and this is true of the Phase Linear, but the degree of improvement is far greater, and in most cases noise becomes virtually inaudible. With noisier, older material, there is residual hiss, but the overall improvement is even more dramatic than with the quieter material. I've taken tapes that were 25 years old . . . and loaded with hiss . . . and put them through the autocorrelator and the drop in hiss and the gain in clarity were astonishing. I've resurrected ancient *mono* LP discs, that sounded like a steam calliope in heat, ran them through the autocorrelator *and* the peak unlimiter. You just wouldn't believe how alive and open the sound was, with a large proportion of the hiss gone, and the heavy hand of the compressor removed from the dynamics. Early pre-recorded tapes, primitive stereo discs, all benefitted

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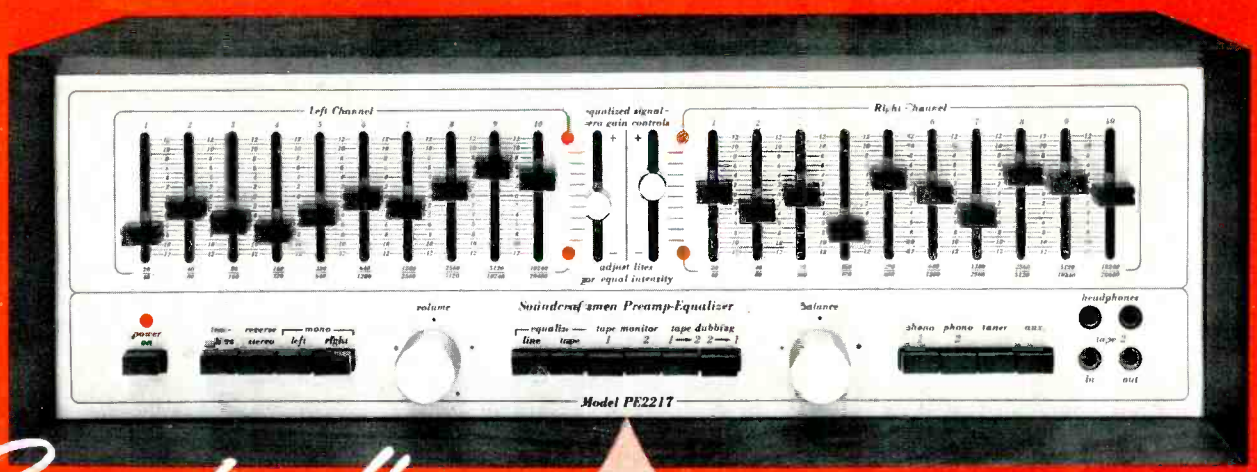

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SPECIFICATIONS

FREQ. RESPONSE — Hi-level: ±¼ db, 5 Hz to 100 KHz
FREQ. RESPONSE — Phono: ±½ db, 20 Hz to 20 KHz
THD: less than .05% at 1 volt (Typ. .01% at 1 volt)
IM: less than .05% at 1 volt (Typ. .01% at 1 volt)
SIGNAL-TO-NOISE — Hi-level: 100 db below full output
SIGNAL-TO-NOISE — Phono: 84 db below a 10mv input
SIGNAL-TO-NOISE — Equalizer: 90 db below a 1 volt input
OUTPUT IMPEDANCE: 600 ohms
MAXIMUM OUTPUT: 5 volts into hi impedance, 2.5 volts into 600 ohms
EQUALIZER LEVEL: Zero-gain controls for left and right continuously variable, for unity gain compensation
EQUALIZER RANGE: 12 db boost and 12 db cut, each octave at 30, 60, 120, 240, 480, 960, 1920, 3940, 7680 and 15,360 Hz.
MAX. OUTPUT SIGNAL: Variable master volume control allows adjustment of optimum output to match amplifier
CIRCUIT BOARDS: Military grade G-10 glass epoxy
RESISTORS: Low-noise selected carbon-film
POWER SUPPLY: Separate supply for photo and equalizer
DIMENSIONS: Walnut-grained case 7¼" x 20" x 11¼" deep
WARRANTY: 2 years parts and labor
SHIPPING WEIGHT: 28 lbs.

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includes walnut-grained cabinet or rack mounts.

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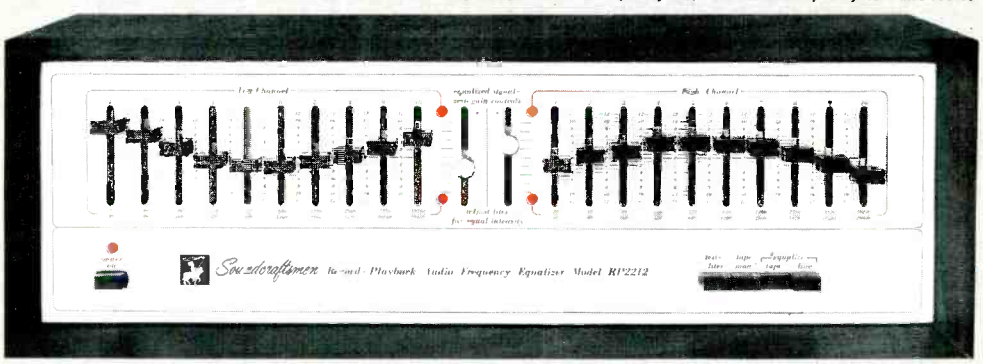

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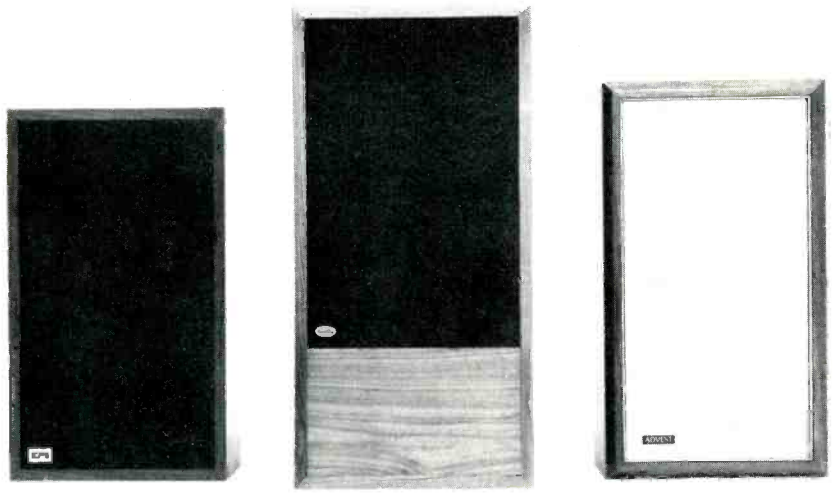
from the combination of autocorrelator and peak unlimiter. On the other end of the scale, brand-new discs, cassettes, and cartridges were run through both circuits and here again the results were dramatic. Hiss ceased to be a problem and one is a bit shaken to hear how much compression is being used today. This is true with symphonic material too, and if you want to flip, play a pianissimo section with the peak unlimiter/downward expander in operation. You'll hear a lovely *true* pianissimo. Now take the expander out of the circuit and you will immediately hear the passage jump up 3 or 4 dB in level. The same holds true for triple forte sections in symphonic music, when you run them through the expander. Man, the music becomes really LOUD, just like 15 ips master tapes. In fact, potential users of the pre-amp would do well to check fusing on their speakers, particularly if they are using high output amplifiers. Another thing the expander reveals is that commercial recorded tapes have been compressed, especially so in the case of 8-track cartridges. The autocorrelator is a nice augment to the Dolby NR system. You may be aware that although cassettes and open reel tapes may have been Dolby processed, it is possible they were not made from Dolby *masters*. Hence, there is a residual hiss on the tape, which is ever so easily removed by the autocorrelator. Speaking for a moment of the low-frequency dynamic filter, there is one company (who shall remain nameless) who is notorious for the amount of low-frequency garbage on their discs. The circuit cleans this up beautifully, without disturbing any of the low-frequency musical content.

Now, all this wonderful action of the autocorrelator and the peak unlimiter circuits would be totally useless if we could hear the systems "working." By this I mean the unfortunate swishes, pumping, and breathing sounds that plagued many of the less sophisticated approaches to single-pass noise reduction systems in the past. Nor would the autocorrelator be very desirable if it in any way attenuated high frequencies. As related earlier, I tried screwing up the system every which way. I fed the circuits with high- and low-frequency, high- and low-intensity sine waves, fed it noise pulses, played heavy, sustained organ pedals, sustained piano chords, high levels of tinkly harpsichords, and wildly assorted high and low percussion. You name it, I tried it. Nothing happened. Theoretically, the system is capable of being fooled by some sounds, among them wire brushes, which while "musical," could be treated as uncorrelated sound by the processor. In any case, I just didn't encounter any problems. I've had some of the most prominent "golden ears" in the audio business over to the house for intensive listening sessions, with special attention being paid to the possibility of high frequency attenuation, and we could not detect any such abberation.

Many uses of these autocorrelator circuits come to mind, including some ideas in the professional area. For example, many record companies, especially in England, have extensive reissue programs, and here would be the ideal way to reduce the noise from older tapes and tape copies of old discs before the music signals are fed to the cutting amplifier.

In summation, let me say that once one has become accustomed to listening to music through the autocorrelator, and when appropriate the peak unlimiter (you wouldn't use it with master tapes!), it is difficult to do without their aid. It would be logical to assume that some time in the future, the autocorrelator and peak unlimiter/downward expander would become available in a separate add-on or "outboard" configuration. In the meanwhile, congratulations to Phase Linear for a technical tour de force and a job well done.

Which speaker looks like it sounds the best.



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Audio ETC

Edward Tatnall Canby

FACTORY SERVICE? Definitely. Here is the saga of my own recent bunglings with respect to factory repairs on my own tape recorder and I trust you will find it instructive. I am all for factory repair service. Now that I have learned.

Readers may recall my story of a certain exquisitely built Japanese capstan motor which, when it failed at the slow speed, I took to a local motor repair service in New York (the easy way out, of course . . .). They looked once at the exquisite Japanese craftsmanship and just laffed and laffed. "Fix that? It would cost you a fortune." Well, apparently the Japanese agree, for I now have a new motor and my machine is operative. But this is the third motor, not the second. The first was perfectly OK but it burned itself out after approximately 45 seconds of hard use. It had no choice. The wiring-in was wrong. One slow-speed lead somehow got soldered to a dead-end terminal going nowhere. Hmmm. Wonder what happened to the first motor, when *it* failed? It took longer, but it went out with exactly the same symptoms, the fast speed remaining OK. . . . Whose fault? To this day, as you can see, I am not sure. But in the end, surely, it was my fault. My responsibility. Again, I tried the easy way.

There are plenty of excellent reasons, both positive and negative, for taking many an "easy" way. Don't think otherwise. It will be the same story for you, one of these days, whether for a motor or a tuner—or maybe something entirely different, like a Volkswagen. Same principle. Who wants to fuss with faceless, efficient (and expensive?) factory authorized service? For unless you are very lucky, that service will be both distant and dismally inaccessible. Let's say, the nearest service center is 105½ miles away. Or 2553 miles, and accessible only via a shipping job, complete with all the original packaging. Ever try putting one of those things together again, once opened?

No, they do not grow factory services on local trees. Whereas, right down your street, lives that engineer and tinkerer buddy of your who is a near-genius at fixing things, and he'll be right over in moments. What a temptation! No packing up, no moving, and it'll cost less.

Better, of course, if you are your own tinkerer and knowledgeable enough to get inside your equipment without outside aid. Then, the temptation to do it yourself is overwhelming.

Now do not misunderstand the implications. Nine times out of ten, the inspired home or near-home repair department does the right thing, quickly and easily. After all, that burning desire to fix for yourself is one of the healthiest things left in our present America, so prone to the prepackaged and the perfected automatic. The home mechanic is still a factor, and so is the more specifically expert local professional, the last manifestation of the one-man enterprise. It is in truth a pleasure to *solve* a problem in home equipment, even if it is no more than discovering that a "dead" amplifier is dead merely because a speaker lead has come loose.

So who wants Factory Service, unless to get something out of a guarantee. This is normal thinking for most of us. Right, too. Nine times out of ten.

Ah, that tenth time. Reminds me of my local country garage man, a quarter mile down the road from my place in Connecticut. Old-type Yankee, and a total independent. For years Percy kept assorted cranky foreign cars going for me, when there *was* no Factory Service, even when their carburetors dropped off and their bottoms dropped out. He could improvise, *something*, to keep me going. Moreover, if I could get the car to him, he'd drive me home again and when the job was done he'd bring the car back, and I'd drive him home. Cosy and easy. Until I got my first Volkswagen.

The VW is Different. Not *very* different, just non-standard, as per Chevies and Fords and Dodges. Now the more proficient is your local genius at repair (cars or hi fi) the more is his pride involved. Do you think he is likely to admit defeat? One day, I brought my new VW in with a stuck front-hood latch. I'd jammed it down over some unwieldy object and it wouldn't open. That man got to work and worked a good two hours—still stuck. He swore and he spat and he got out bigger and bigger tools but still it stuck. Finally, CRRACK, and it flew open. HE was happy, but I wasn't. I ended up thirty miles away at the VW agency, where a new catch was put in after approximately five minutes. That was my *first* tenth time.

The *second* time it was a lot more serious, and at last, it changed my mind for me. Much as I love friend Percy, I'm up and out at the crack of dawn, driving those 30 miles to the "local" VW agency. And there I sit, hour after hour, for lack of anybody to drive me home again until the job is done. I hate it! And it costs, too. Costs have more than quadrupled down at VW. But it pays, I find.

The circumstances concerning my tape recorder motor were similar, only more so. A whopping big machine and heavy, and I have a mildly trick back that objects, say, to reaching for a door handle while trying to hold such a machine safely in the arms. I can move it but I do not relish the thought, and go out of my way to avoid same. Hence, when the motor conked, I got a good engineer friend of mine in to help—right in my

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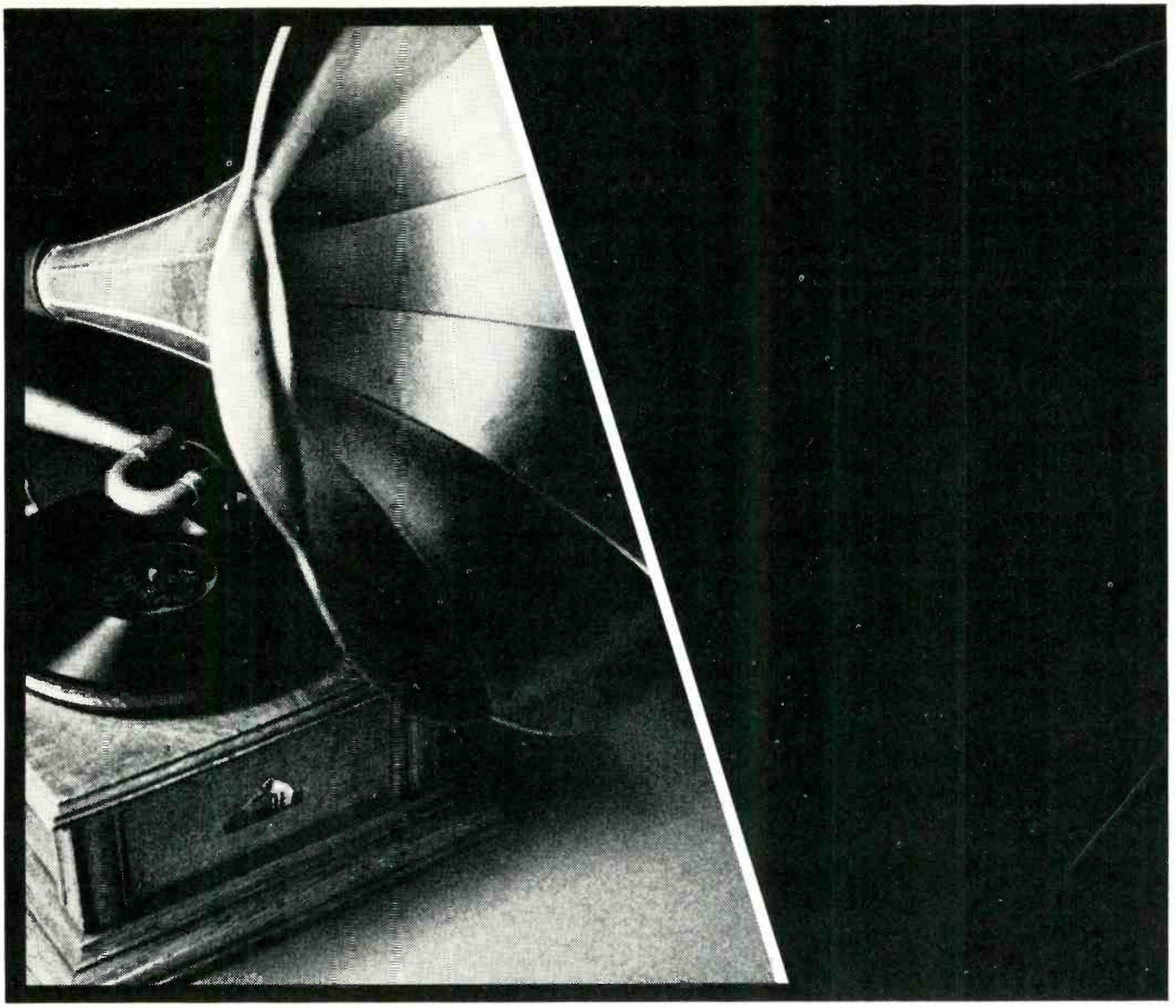

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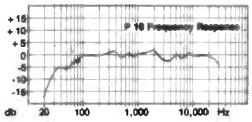

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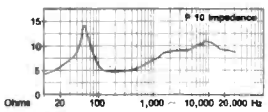

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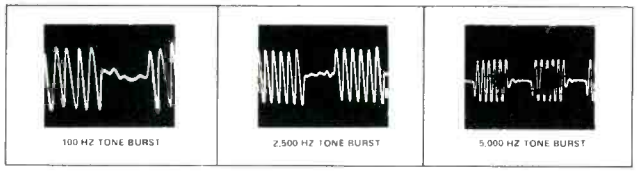

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home. He tinkered and dickered and, in the end, took out the motor for test, as we know. It came back. So what next? Definitely a bad motor.

Natch, my friend generously offered to order a new one through a local outlet, and he would install it. What else? He took the old one out. He is a most meticulous and careful operator, unlike myself, who would have lost half the mounting screws and yanked the connections free by main force out of sheer exasperation. That's me. This man, Sam, was a hi fi gift from Heaven.

So, after the usual interminable delay, the new motor arrived. Ah yes. And was installed. Ah yes. We turned it on and noted a peculiar noise—at low speed only, of course—a sort of too-loud grinding. It ran. It seemed entirely OK at the faster speed, 15 ips. Just as had the original motor. Now, you see, we were really in trouble. For it looked as though the same thing were happening all over again. Why? What? How? Was the capstan at fault, the mechanical drive? How could it be, when all was OK at the faster speed? Then the worst happened. I tipped the machine back on its rear, flat down, which is the way I often use it for editing. Why not? It's supposed to work that way. Instantly, the slow-speed grinding increased to a harshness, and the motor quite literally ground to a halt. Crazy. Stand the machine upright and it turned, though still with an uneasy noise, definitely not correct.

Now my friend Sam repairs all sorts of tape recorders as part of his over-all work in recording and electronics and, as I say, he has the meticulous approach which is absolutely necessary if you are to trouble-shoot equipment and, especially, to take it apart and *put it back together.* He makes a neat pile of the removed bolts and screws, in a dish; he's likely to write down a diagram of connections, color codes, sequences of disassembly, so that nothing untoward can go wrong. (Whereas, sure as sugar, if I tried to put screws and things in a plate, I would absent-mindly kick it, distributing the contents all over the room. I always do.) I cannot imagine Sam making a drastic MISTAKE in reassembly, a misconnection of major and disastrous proportions! It just ain't in his nature—if it is in mine. Myself, I kept a good three feet away from that machine at ALL times, and did not dare even put my big thumbs on the regular controls, for fear of doing something stupid. Of a certainty, *I* did not make a wrong connection! But was it Sam?

Do you think *I* know? Do you think

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he knows?

Frankly, when he gave up I was so discouraged that I put the cursed machine in my closet and dropped a big, soggy bathrobe over it to cover the hideous sight. I didn't want to look at the thing ever again. I would wait until I could get *another* recorder. Maybe the next one would work. Grrrrr.

Well, sanity usually prevails in my case. Later on, sheepishly, I looked down upon that bathrobe in my closet and decided to put in a long distance call. Not a very long distance—just across into the next state, in fact not really very far at all. About the usual half hour by car. I blushed over that phone. Er, you see, I have a little problem with one of your machines. Some problem! I had done the unforgivable; I had tried to have the thing fixed by myself, and had failed. It was not a matter of guarantee, for the machine was beyond that. But no Factory Service is going to approve home-based repairs, or even professional ones, that haven't worked. It's no longer their responsibility, though they will do what they can. All this, of course, like the dentist who tells you that your teeth need regular brushing and adds, diffidently, that you have Bad Breath. I had it, all right, and my tail was dragging on the ground.

And so the tide turned. Up came the bathrobe and out came the recorder and down into my double-parked VW with the help of some young muscles that happened along to save my aching back. It was easy, all in all. I was off to New Jersey.

Actually, the factory people were both pleasant and cooperative. But firm. That was understandable. A week later I picked the machine up. The guy named Dave who had done the work was out—so I did not find out what he had discovered about the original motor. The second one definitely had an N.G. slow-speed winding; the third was installed and running. The entire machine had been checked over and test run for most of a day, the pinch roller replaced, just for good measure, and the bias re-set to my specification; just a bit lower than the bias required for the newer high-bias tapes. (So I could still get reasonable results on older tape.) All in all, a very expert and conscientious job. But best of all, the machine was *operative*. At both speeds! After so long. That's what Factory Service is all about.

Now this has been written deliberately at a time when I still cannot explain exactly what happened. I doubt if I ever will be able to. It's enough, at this point, that I am back in business, even though I had to pay for my folly (as it turned out) approximately three times the cost of a single, first-off trip to Factory Service.

If the second motor, the first replacement, was wrongly connected to a dead terminal in one of its leads (I think it was the yellow lead), how could it have happened? My friend Sam is of course one logical possibility. But this flies against reason; he isn't that sort of a repair man. And he would have seen the dead-end terminal, even if he was unsure. Moreover, if he made the mistake, and the motor failed at 7½ ips but not at 15 ips, which remained entirely OK—then why did the first motor fail in precisely the same fashion, if over a longer period? An interesting mystery.

There is another alternative, which I put before the Factory Service people. You cynics may have thought of it. The mistake in wiring *occured with the first motor* and was the manufacturer's mistake. Then, you see, Sam would simply have restored the same connections, unknowingly faulty,

(Continued on page 81)

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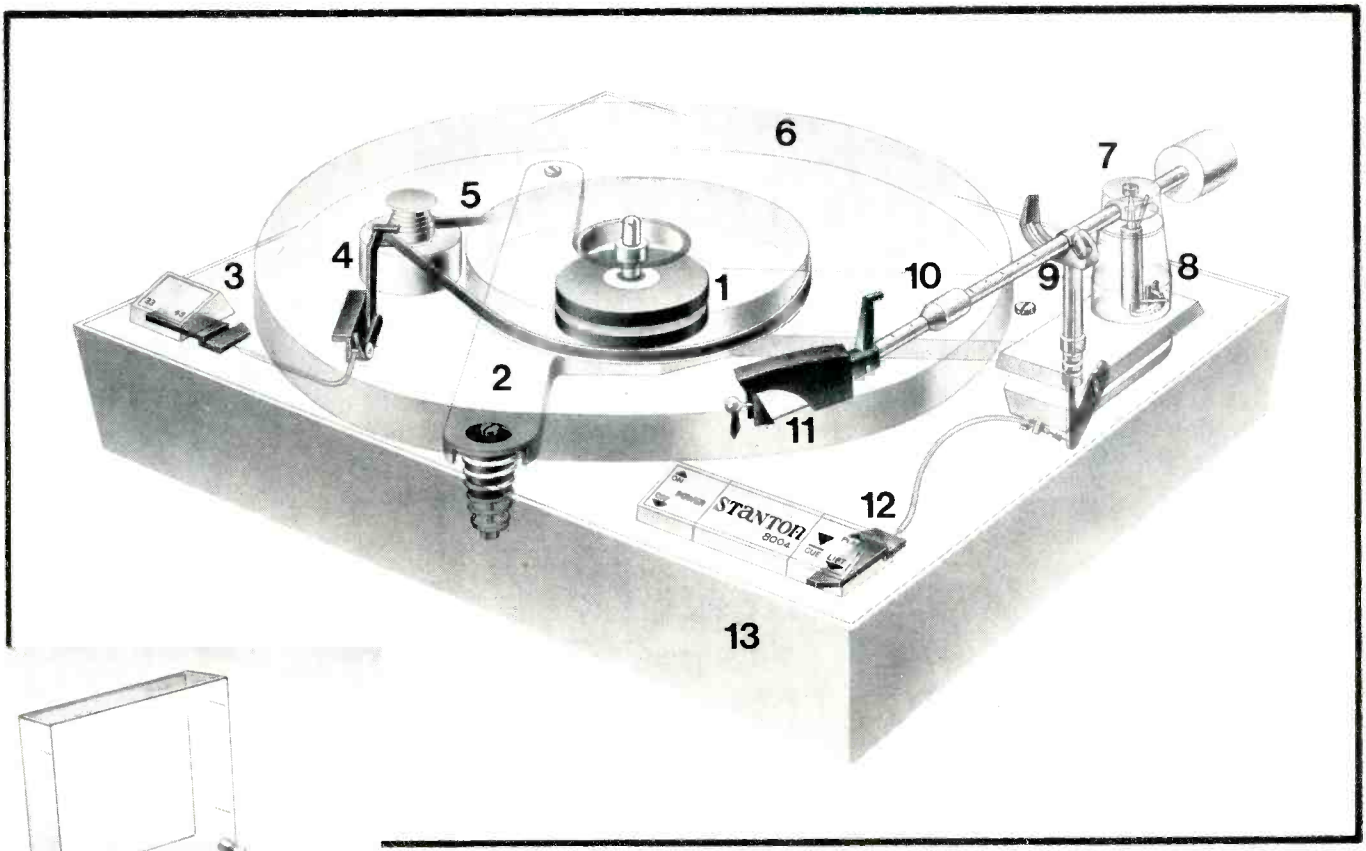

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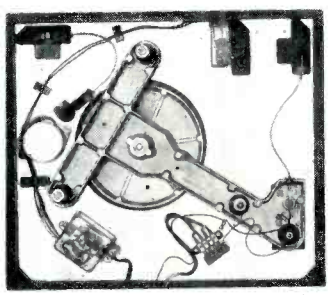
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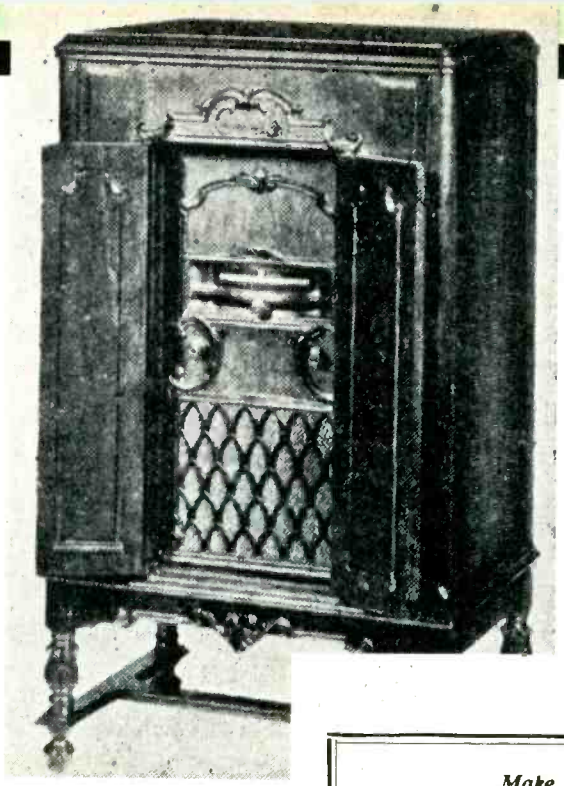

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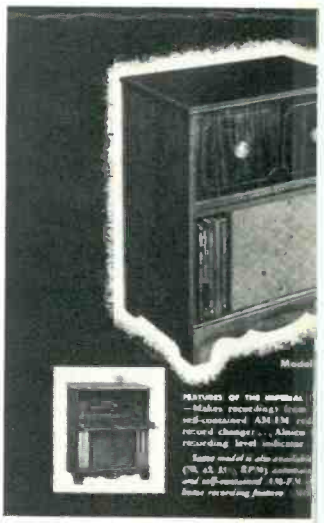

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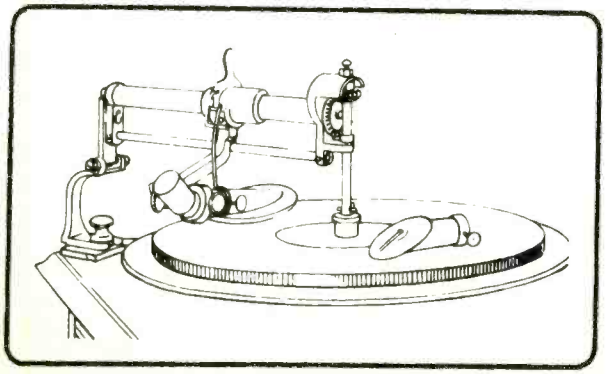

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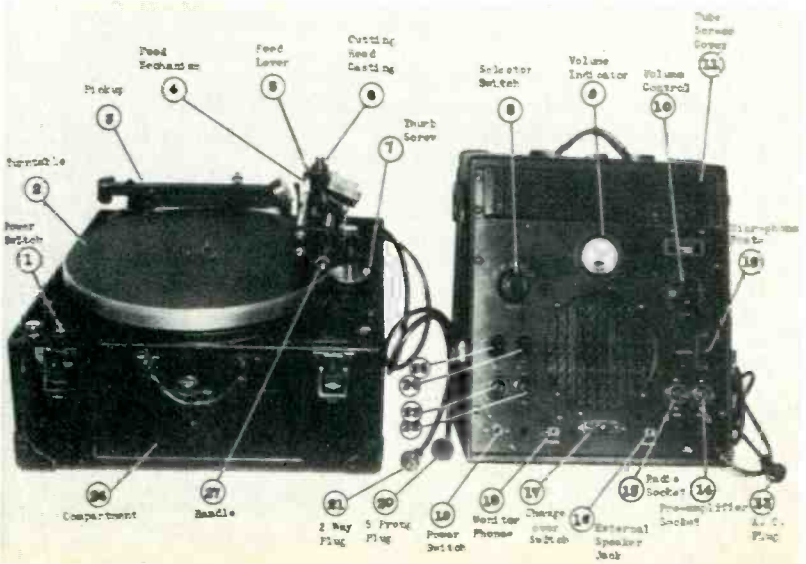

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A History Of Home Recording

George A. Blacker

HAVE YOU ever wondered how home recording was done in the old days before tape, if indeed it was done at all? The answer to that is that it WAS done, and by a fascinating variety of types of apparatus.

Edison patented the first sound recording and reproducing device—the tinfoil phonograph—in 1877, but it was impossible to make commercial recordings for sale and reproduction on these machines, though they could record and play back instantaneously without any elaborate treatment of the tinfoil sheet. While the recorders on some models of the tinfoil apparatus doubled as a reproducer, unfortunately the tinfoil phonograph couldn't play much longer than a minute and the fidelity was very poor. Most of the tinfoil machines produced were used briefly by traveling lecturers, and the "phonograph fad" of the 1870s and early 80s was short-lived. The inadequacy of the machine was probably a major contributing factor to its loss of favor.

Charles Sumner Tainter, aided by Chichester A. and Alexander Graham Bell, worked on improving the phonograph during the 1880s and the result of their efforts—the Bell-Tainter Graphophone—was patented in 1886. They replaced the tinfoil sheets of the Edison machine with wax-coated cardboard cylinders as a recording medium and fidelity of recording and reproduction was improved, though volume of sound was reduced. Thomas A. Edison, who had dropped work on the phonograph to develop the electric light and the electric utility business, was now free to resume his own research into sound recording. Spurred by the work of the Bells and Tainter, he did so. He adopted the concept of recording on wax, but made his cylinders of solid wax and of different dimensions from those of the Graphophone. The Edison cylinder of 1888 was to become the standard in size, shape, and grooving for most of the phonograph industry until production of cylinders was finally discontinued in 1929.

Cylinder phonographs and records were not generally available to the public until the early 1890s but all phonographs sold then were equipped with a recorder and a few blanks. If the recordist was not satisfied with his effort, the blank could be shaved and re-recorded. The home-recorded cylinders now in the hands of collectors testify that their sound quality, judged by today's standards, was consistently inferior to that of

5

1. First electrical home recorder; *Radiola* (1928). 2. Victor Model 207 (1928). 3. Cylinder-machine owner's manual (ca. 1907). 4. Jacket for zinc discs meant to use playback machine (worked poorly). 5. Wilcox-Gay *Recordio*. (1949) Crystal Cutter & General Industries mechanism, as in many machines of late 30s and 40s. 6. Edison Bell *Eureka* disc recording "appliance" (ca. 1920). 7. Presto EU used aluminum, wax paper, later acetates. Magnetic cutter & overhead lathe shown off disc for playback. Similar Model K used widely in 40s. (1,2,5,7, Library of Congress; 6, Hillandale News, London)

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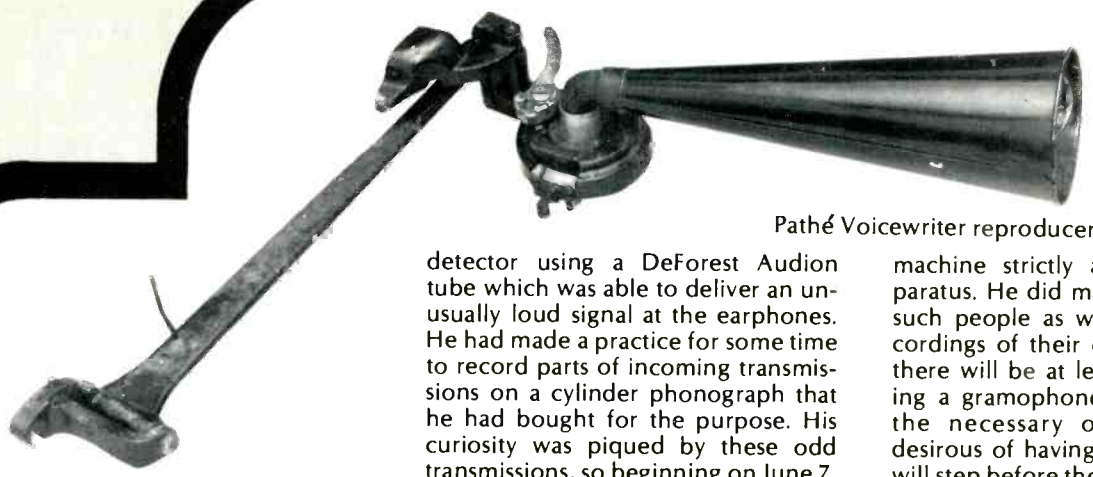

Pathé Voicewriter reproducer (incomplete)

even the cheapest cassette recorders. Still, the best of them were nearly as good as the commercial cylinder records of the day. If any reader would like to try to find out for himself how home cylinder recordings sounded in those days, he can do so by locating an old Ediphone or Dictaphone cylinder-type dictating machine and some blank cylinders; these should be available in some second-hand stores at fairly low prices. The cylinders are not the same size as the standard entertainment records, and speed and grooving are also different, but it should be possible to get a pretty close approximation of what home recording was like at the turn of the century.

The cylinder phonograph, equipped to record, even played a minor part in military intelligence operations during the First World War. A shortwave radio station, established in 1913 and operated by the Atlantic Communications Company, was one of two such stations that transmitted messages to a station near Hamburg, Germany. The other station was at Tuckerton, New Jersey. In 1914, the Tuckerton station was taken over by the U.S. Navy, since it was feared the station might be used to inform U-boats of the movements of American coastal shipping. The Sayville station must have been under suspicion as well, but monitoring of its transmissions revealed nothing—at least, not at first. Then radio amateurs along the East Coast began picking up strange noises at night, beginning at 11:00 PM and continuing until 1:00 the next morning. The sound resembled a continuous buzzing noise, with no audible interruptions such as would be typical of Morse code transmissions. One of these amateurs, Charles Apgar of Westfield, N.J., had built a highly sensitive detector using a DeForest Audion tube which was able to deliver an unusually loud signal at the earphones. He had made a practice for some time to record parts of incoming transmissions on a cylinder phonograph that he had bought for the purpose. His curiosity was piqued by these odd transmissions, so beginning on June 7, 1915, Mr. Apgar recorded excerpts from these transmissions for two weeks. He still couldn't make anything of them until one time he forgot to wind the machine as he played back one of the cylinder recordings. As the machine slowed down, the supposedly continuous buzzing noise became recognizable Morse Code. The Apgar recordings came to the attention of Chief Radio Inspector L.R. Krumm of the Bureau of Navigation in New York, who was also puzzled by the mysterious signals, and he summoned Apgar and W.J. Flynn, chief of the Secret Service, to a meeting in New York at which the records were played for Flynn. As a result, the Sayville station was siezed by the Navy and the Secret Service on July 10, 1915. It was revealed much later that the Sayville station, like its counterpart in Tuckerton, was equipped with a Telegraphone, the great-grandfather of the modern tape recorder, on which code messages were recorded prior to transmission. When the nocturnal transmissions of these recorded messages were begun, the Telegraphone was run at a much higher speed. The messages were recorded in Germany on a similar machine running at high speed, then played back at a lower speed which permitted deciphering of the code.

It may be seen from the foregoing that home recording via the cylinder phonograph was not very hard, although the acoustic recording apparatus did not lend itself very readily to espionage or bugging. The comparative insensitivity of the equipment, along with its bulk, made concealment impossible. Sensitive microphones and amplifiers were still a long way off.

For many years, the owners of disc phonographs or gramophones were unable to make records at home. Indeed, Emile Berliner, the inventor of the gramophone, conceived of his machine strictly as a playback apparatus. He did make this promise to such people as wanted to make recordings of their own: "In each city there will be at least one office having a gramophone recorder with all the necessary outfits. . . Persons desirous of having their voices taken will step before the funnel (horn) and, upon a given signal, sing or speak or they may perform upon an instrument. While they are waiting, the plate will be developed (i.e., the zinc master disc immersed in an acid bath to etch out and deepen the grooves), and when it is satisfactory, it is turned over to the electro-plater or to the molder in charge, who will make as many copies as desired."

Unfortunately, this did not come to pass, so that private recording on discs remained a relatively difficult thing for many years. In 1910, however, the Edison Bell Co. of England placed their Eureka home recording outfit on the market, thereby making home disc recording feasible—at least for English buyers. The outfit consisted of a simple overhead lathe mechanism driven from the spindle of the phonograph to which it was attached. A vertical cutterhead, resembling a type of Columbia cylinder recorder, was guided across a wax recording blank 10 in. in diameter and about ½ in. thick. After the recording was made, a reproducer was substituted for the cutterhead and the recording played back. The blanks could be replayed as often as desired, or wiped clean of existing recording by the use of a liquid solvent (which must have left a rather rough surface) or sent to the factory for processing into shellac pressings. The outfit sold for two guineas (about $12.00), and while there is no reason to doubt that it made fairly decent recordings, its fidelity must have been about comparable to that of the home-recorded cylinders.

The first home disc recording equipment to be placed on sale in America probably was the Pathé Voicewriter, which seems to have appeared in 1922 or 1923. The recording blank was a disc made of thin aluminum, about 7 in. in diameter. The recorder was nothing more than an ordinary acoustic phonograph re-

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The Nakamichi Revolution

An extravagant statement? Not at all.

For the Nakamichi 700 Tri-Tracer cassette system is so completely different from anything that has gone before that it truly represents a quantum jump in cassette technology.

A brilliantly engineered instrument, the Nakamichi 700 is an extraordinary blend of electronic and mechanical sophistication.

To cite a few innovative examples, three separate heads—erase, record, playback—afford off the tape monitoring, but more importantly, extend flat frequency response to beyond 20,000 Hz. A closed-loop dual capstan system employs a servo-controlled d.c. motor to maintain rock-steady, constant speed and a second motor takes over in fast forward and rewind. IC logic and feather-touch solenoids control all tape functions. A built-in record head azimuth-alignment beacon insures perfect recordings every time.

But enough. An extended technical description goes far beyond the scope of this ad.

Far more persuasive, we think, are these comments from a Hirsch-Houck Laboratories Test Report that appeared in the December 1973 issue of Stereo Review.

"As our test data indicate, the Nakamichi 700 is an extraordinary cassette recorder...With Nakamichi CrO_2 tape, the performance was...an almost incredible ± 1.5 dB from 46 to 22,500 Hz...The noise level, referred to the 3 per cent distortion level, was very low...−57 dB without Dolby and −62.5 dB with Dolby."

They go on to say, "We could not measure the 700's combined wow and flutter because it was below the residual level of our test tape."

Summing up, the Report declares, "...we would rank it (the Nakamichi 700) as the best cassette recorder we've tested and one of the best tape recorders of any type we have ever used."

See and hear the Nakamichi 700 and the companion Model 1000 at your dealer now. Then go out and start your own little revolution.

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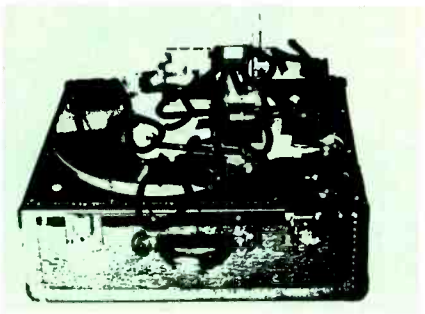
producer, equipped with a sapphire stylus that creased the aluminum to create a groove. If the metal was cut or scratched instead, the reproduction became undesirably noisy. The recorder was heavily weighted to provide the pressure needed to indent the surface of the blank, and the entire assembly was mounted on a long steel arm that could be attached to a bracket in some convenient corner of the phonograph cabinet. There was no overhead lathe mechanism to guide the recorder across the blank, so Pathe used a metal "tracker" disc, the grooves of which were engaged by a second needle, mounted in a hinged chuck built into the recorder arm. This guided the arm and recorder across the disc so as to make a proper spiral groove. I have not seen all of one of these outfits; I found a recorder in its arm several years ago, but the mounting bracket, tracker disc and recording stylus were missing. Also, I have only seen an empty envelope for one of the aluminum blanks, from which I was able to deduce the approximate diameter of the disc, and to confirm (from the printed instructions) the workings of the system. From the fact that the recording stylus and guide needle are separated by exactly 1½ in. I deduce that the diameter of the tracker disc must have been about 4 in., and that the usable recording area of the aluminum blank must have been only about 1¼ in. (perhaps less if the disc was much less than 7 in. in diameter). At the recommended recording speed of 80 rpm, recording time could not have exceeded a minute and a half.

Also during the twenties, several concerns sold pre-grooved zinc discs on which one was supposed, in theory at least, to make recordings using any disc phonograph. (These were acoustical, remember.) You put a fresh steel needle into the phonograph reproducer, and, using a megaphone to concentrate the sound, spoke or sang as loudly as you could into the horn of the machine. The needle was supposed to engrave the metal at the bottoms of the grooves in the blank, making a recording, but I have yet to find one of those zinc discs (and I've seen at least a dozen) that had an audible signal in it. The discs, all 6 in. in diameter, were sold under such names as Echo-Disc, Rekordo, Rekord, Marvel, and Repeat-a-Voice. They still turn up occasionally with old phonographs.

Home recording couldn't begin to come into its own until adequate microphones and amplifiers became available as adjuncts to the disc recording process. The acoustical system was distinctly low-fi, and technicians in the studios had a variety of expedients to help it along that were beyond the capability of the average person: sound reflecting panels, platforms upon which some musicians had to sit in order for their instruments to be picked up by the recording horn, and specially modified instruments including the Stroh violin, which had a sort of megaphone built onto it to focus its sound at the horn.

The next home disc recording equipment to be offered for sale appeared in 1930, when the Presto Company offered a recorder that used aluminum discs, similar to those



Fairchild Camera disc recorder

used in the Pathé Voicewriter. The Presto recorder, however, used a feedscrew mechanism to guide the recorder head across the blank, and a microphone and amplifier to drive the recorder. As with the older Pathé system, the Presto recorder creased the surface of the aluminum disc without tearing or scratching the metal. Application of a lubricant to the surface of the blank was helpful in minimizing the danger of this. The aluminum disc recordings had a sound quality that was generally quite satisfactory, although the surface noise level was rather high.

In 1931, RCA Victor offered their home recording system, which was built into the Model R-57 radio-phonograph combination. Harking back to the concept of the Echo-Disc, they used a pre-grooved recording blank made of soft plastic. The magnetic pick-up head of the phonograph doubled as a recorder, using appropriate switching circuits. A special blunt-tipped steel stylus was used both for recording and playback of the plastic discs. The tip of the stylus was of such a size and shape that it rode along the tops of the groove walls, deforming the plastic in the recording process. This use of a special type of stylus for recording and reproduction meant that the records could not be satisfactorily played back with a standard phonograph stylus. The 2.7 mil, 78 rpm styli of today are unable to ride the tops of the groove walls, where the sound modulation is concentrated, but track the lower portions, where there may be no sound at all, or so little that the signal is very faint and of poor quality. It is possible to get improved results from these records with a special stylus, but the signal-to-noise ratio is still unfavorable. It is safe to say that pre-grooved recording blanks never worked very well.

When vinyl acetate and similar plastic instantaneous recording blanks became available around 1933, the owners of the earlier aluminum disc recorders were able to modify their equipment to use them, with improved results, and home disc recording began at last to come into its own. Most home recorders were either part of a radio-phonograph combination, or were designed to accept signal inputs from other sources than a microphone, so that many people made a hobby of recording radio broadcasts off the air. There are some LPs available today in which certain cuts by some of the famous bands of the late 30s and early 40s are taken from such home recorded airshots.

The acetate disc recorder remained popular through the 30s and well into the 40s, when magnetic tape recorders had become sufficiently perfected and low in price to displace them. Magnetic recording had been around since the late 1890s, when Valdemar Poulsen, a Danish electrical engineer, invented the Telegraphone, a device that recorded magnetically on flat steel disc or steel ribbon. Poulsen had devised it originally as a means of making more efficient use of telephone circuitry; messages were to be recorded on the Telegraphone, transmitted at high speed on the telephone line to their recipients, who would record them at high speed and then reproduce them at normal speed. We have already seen how this multi-speed recording and playback capability was used in radio transmissions during World War I. The Telegraphone's main disadvantage was that its signal level was not very high, and since biasing of the recording medium had not yet been thought of, the distortian must have been high enough to make its use for anything other than voice recording impractical. The a.c. biasing technique was conceived by two American researchers, W.L. Carlson and G.W. Carpenter, who were investigating magnetic recording for the U.S. Navy.

The oft-told story of the capture of Radio Luxembourg in 1944 by the Al-

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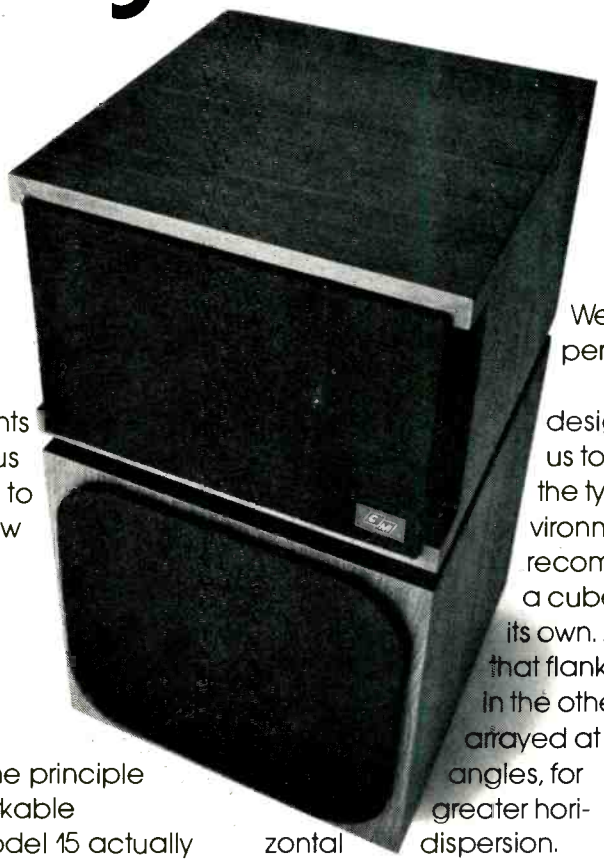

Until recently, there was a substantial amount of distortion inherent in all loudspeakers.

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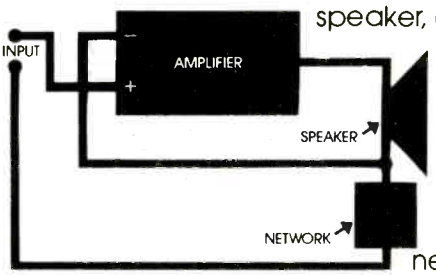
Designed to incorporate the principle of negative feedback, our remarkable new floor-standing three-way Model 15 actually detects potential distortion and corrects it.

Here's how. A built-in servo-sensing network,[1] designed as a theoretically perfect speaker, compares the Model 15's mechanical output with the amplifier's electrical input. The servo network then sends the amplifier a sufficient correcting voltage to make the Model 15 virtually distortion-free.[2]



SEPARATES "THUMPS" FROM "PLUNKS"

You get a sound with a clarity and definition you may not have believed possible. You'll even be able to distinguish between the "thump" of a bass drum and the "plunk" of a bass violin.

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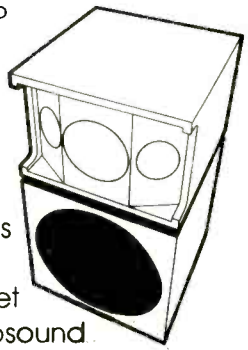

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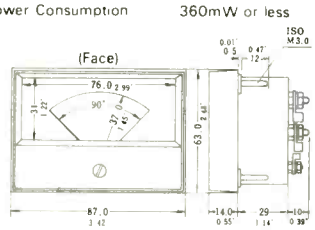
TOYO PEAK LEVEL METER is a magnetic-type, built-in meter using a needle indicator. The uncomplicated design relies on Toyo's great experience, high level technology, and extensive background as the first producer of the magnetic-type built-in meter.
The meter precisely indicates signal level peaks even in complex audio signals, and thus it can correctly monitor either S/N ratio (caused by a low signal level from amp, tape deck, etc.) or distortion at high frequencies (with too high a signal level). (Patent Pending.)

SPECIAL FEATURES

- Thanks to special materials, the meter follows level changes six times faster than the conventional VU meter, needing only 0.05 to 0.06 seconds to respond, while the normal VU meter responds only after 0.3 seconds.
- The meter has excellent sensitivity over a wide range, from -40 dB to +5 dB, so your amplifier, tape deck, etc, can easily be upgraded.
- The circuit block consists of a logarithmic compression portion, full-wave rectification portion, integration circuit, and meter driving circuit. The meter is specially designed to widen dynamic range and indicate peak signal level very accurately.
- The circuit blocks are built directly into the meter itself, as is a bulb for indirect lighting.
- Markings are specially designed for good legibility. The unit is low cost and light in weight.
- Color of scale plate: black and brownish ivory.

SPECIFICATIONS

Indication Range	−40dB~ +5dB
Frequency Deflection	40Hz~20KHz ±0.5dB
Input Level	0dB=1V rms
Input Impedance	100KΩ or more
Lamp	AC 6.3V 140mA
Responding Time (At start-up)	1 msec. or more
Recovery Time	About 2.5 sec.
Power Supply	DC 24V±1V
Power Consumption	360mW or less



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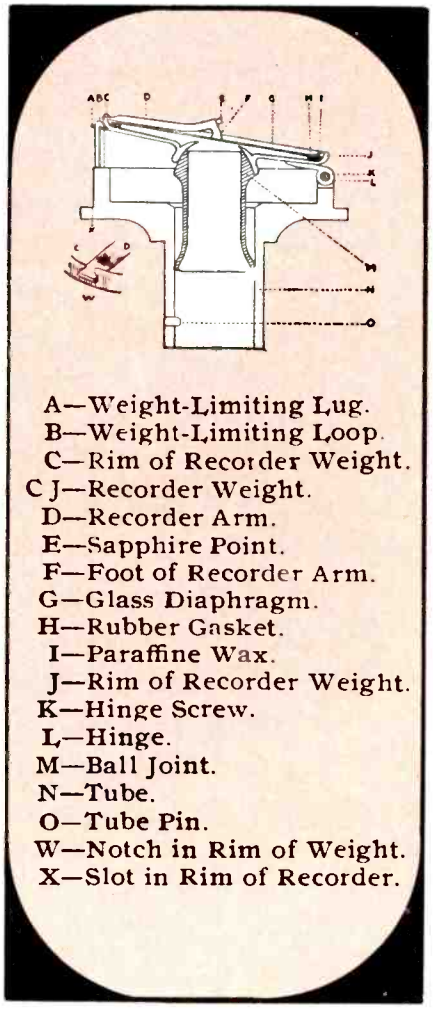
lied forces, and the discovery there of a German-installed Magnetophon, tends to obscure the fact that research and development in magnetic recording had also progressed well in America. The best-known American-made magnetic recorder was the Brush "Soundmirror," models of which were placed on the market as early as 1939. The tape sold for use with this instrument was paper-backed, but Brush wrote a letter of inquiry to the Minnesota Mining & Manufacturing Company (now known as 3M and famous as the makers of Scotch tape), asking whether the company could produce a plastic-backed magnetic recording tape. They could, and did, and shortly after the war, magnetic recording entered its years of growth which have continued to this day.



Cross section of Edison cutterhead.

It might be interesting to note that the first use of tape to record classical music took place in 1936, when the officials of BASF, the first producer of magnetic tape, used some on a borrowed Magnetophon to record a concert by the London Philharmonic Orchestra under the baton of Sir Thomas Beecham. The concert was given at the factory by special invitation of the BASF executives. This historic tape recording survived the war, and has been recently reissued, some 37 years after the original concert.

The first use of tape in broadcasting in this country was made in 1947 by the producers of Bing Crosby's radio show. The program was transcribed on 16-in. acetate discs, but because the show was assembled by a montage method, combining segments previously recorded, costs were undesirably high and sound quality poor, due to loss of quality in dubbing. Faced with the unpleasant alternatives of accepting as inevitable the poor sound or being compelled to do the show live, Crosby and his producers decided to try tape. The results of a demonstration pleased them so much that they began to tape the show for broadcast, starting in October of that year. It was not too long before the networks adopted tape for their own use. Now the average radio station would be almost completely silenced without tape, and few stations, if any, still have their old acetate disc recording equipment.

The various forms of cartridges and cassettes were developed to eliminate the bother of changing reels and threading tape, which most people (the writer excepted) seem to consider a nuisance. Improvements in oxide formulations and the tape itself have brought us improved durability and better response at lower speeds. Cartridge and cassettes have also made it possible to have music almost everywhere—in cars, boats, aircraft, and even on farm tractors. Collectors of historic recordings can benefit, too, in that historic records can be easily copied with little loss of sound quality, and the copies thus made duplicated as extensively as necessary, where it would not be economically feasible to reissue the record in disc form. Undoubtedly the end of development in tape recording has not yet come.

If you've ever heard any older home recordings made on equipment similar to what I've described here and chuckled indulgently at their shortcomings, I suggest you keep this in mind: it was only the enthusiasm of the earlier hobbyists that provided the incentive for improvement of product whose fruits we enjoy today, with our cassettes, tape recorders and, if you can afford it, videotape gear. So enjoy your equipment, but don't bet that something won't come along after a while that will make it as obsolete as the cylinder phonograph is today!

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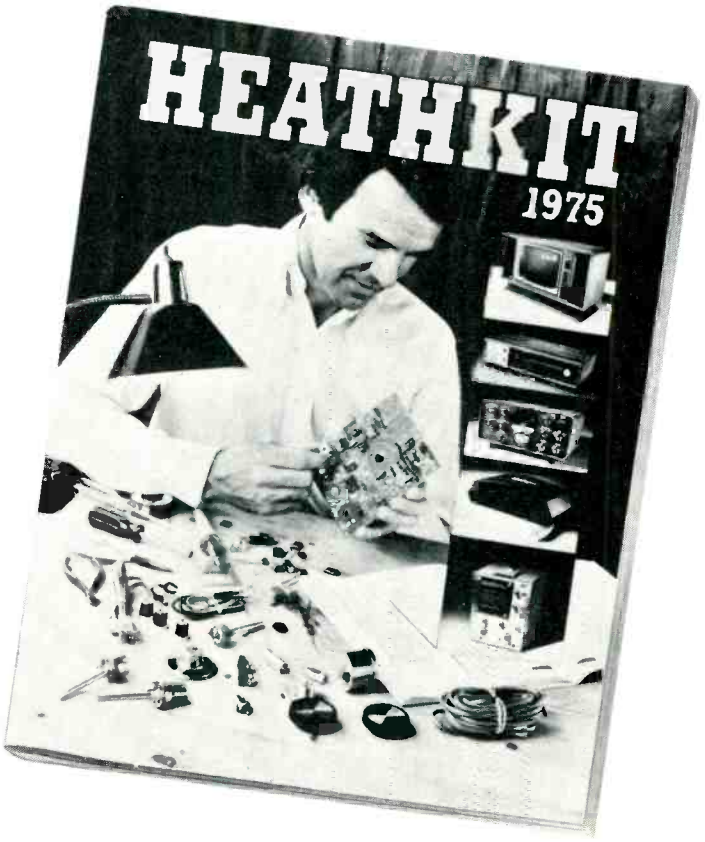

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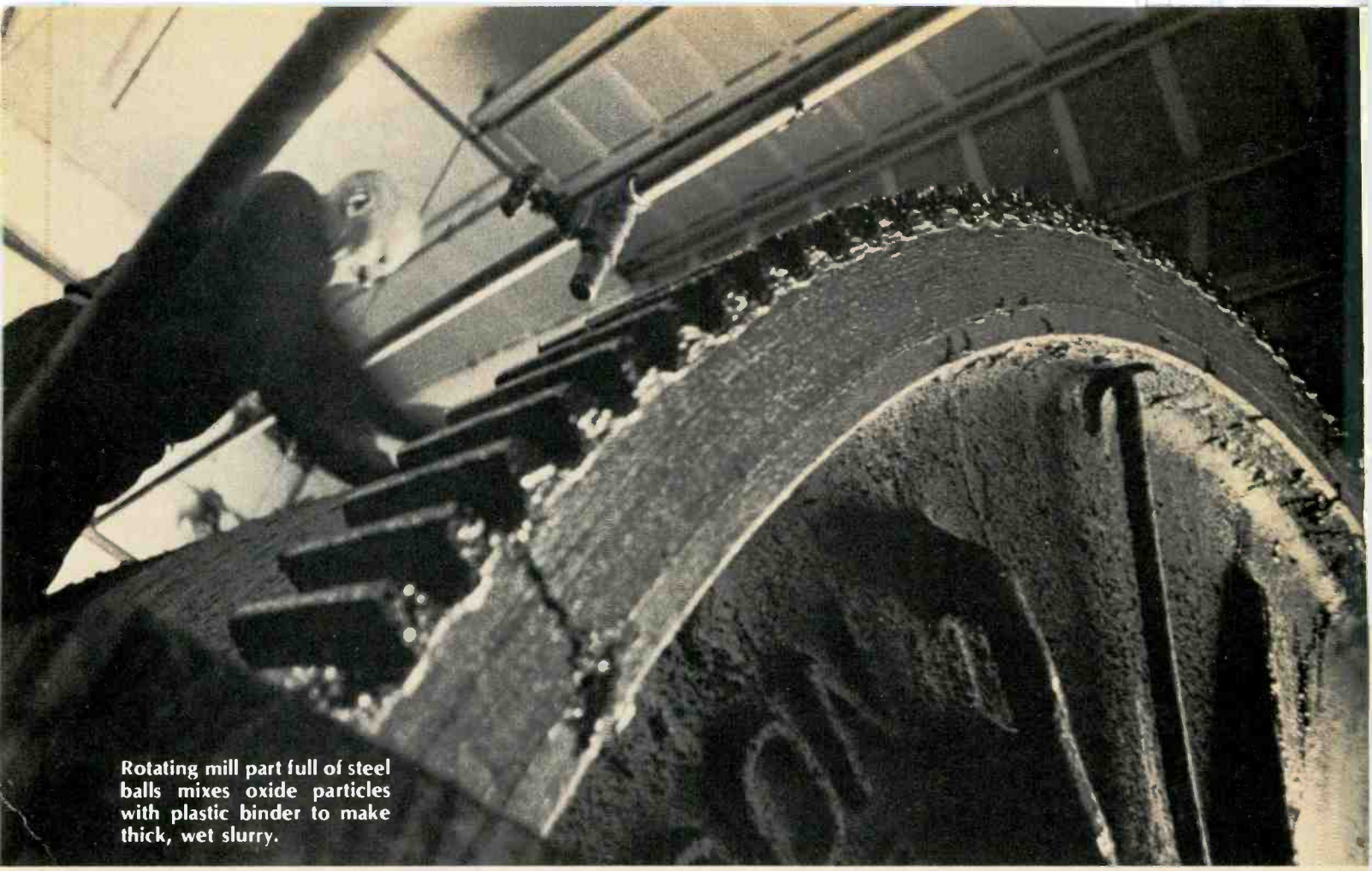

Rotating mill part full of steel balls mixes oxide particles with plastic binder to make thick, wet slurry.

Making Tape

Joseph Kempler*

CREDIT FOR the current high standards of tape recording should be shared by the tape recording equipment manufacturers and by the blank tape manufacturers, for while the equipment maker has contributed major improvements in his machines' heads, electronics, and transports, the tape manufacturer has produced higher energy tapes with precision construction through improved manufacturing technique. To help the reader understand the tape makers' role, this article offers relatively simple descriptions of most of the processes we use to make premium quality tapes designed to meet the widest variety of consumer and equipment requirements. While today's magnetic tape is produced for a great number of specific needs, this discussion will be confined to the manufacture of audio tapes for the consumer.

Magnetic tape is produced by a continuous manufacturing process in which rather few basic ingredients are transformed into a recording tape with precisely defined performance properties. Each step in the chain-like process is critical, however, and is dependent on the previous step. Nothing can be permitted to go wrong at any point in the process, or the entire batch of tape may be out of specification with little, if any, opportunity for correction. This means that strict controls must be maintained during the entire process, for any testing which is done on the finished product is at best a confirmation that everything went well.

*Manager, Marketing Technical Services
Capitol Magnetics
Los Angeles, Calif.

Raw Materials

Four basic raw materials are used in the production of tape: magnetic oxides, binder components, solvents, and the base film.

Magnetic Oxide. The most common and still the most popular magnetic material for tape is iron oxide, used exclusively for all open-reel tapes, 8-track cartridges, and a vast majority of cassettes. Although chromium dioxide enjoyed an upsurge for a while in cassettes, its popularity appears to be on a plateau. One of the reasons is that new iron oxides and novel methods of processing have made possible new iron oxide cassettes which are in many respects indistinguishable from chromium dioxide and yet are less expensive and have other desirable features. Chromium dioxide, of course, really has been instrumental in bringing the art of cassette recording to present day standards.

This article will concentrate then, on the manufacture of single-coating, iron oxide tape.

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When the magnetic oxides first arrive at our manufacturing facility, they are subjected to thorough testing. Using electron microscopes, quality control inspectors check particle size and distribution. Particles vary between five and 25 millionths of an inch in length and have a needle-like shape because the length of each particle is about five to 20 times its diameter. Particle size must be checked because different sizes are used for different products; the smaller the particle, the lower the bias, a situation which contributes to audible hiss.

The inspectors also look for "cleanliness" of particles. "Unclean" particles have arm-like branches and tiny cavities which result in lower tape quality. All material not passing inspection standards is returned to the manufacturer.

The iron oxide is also examined for its magnetic properties. Probably the most important parameter subject to intentionally large variation is the coercive force, which is the magnetizing force necessary to reduce the residual magnetism to zero. Oxide which has a high coercive force will require higher bias and record levels than a lower coercive force material. It will also require a higher erase current for the same amount of erasure. The lower recording efficiency of such a material is compensated for by its greater resistance to demagnetization, which helps strengthen the demagnetization-prone high frequencies. As a result, high coercivity tapes usually have better high-frequency sensitivity and overload properties than low coercivity materials. Coercive force and other magnetic properties, such as remanent and saturation magnetization which determine the material's potential storage capabilities, are measured with various instruments such as vibrating sample magnetometers and hysteresis loop tracers.

While still in their powder form, the magnetic materials are also subjected to a variety of chemical and physical tests to determine ease of dispersion, acidity, impurity level, and similar variables which affect the subsequent manufacturing processes and the tape quality.

Binder. The binder consists of one or more plastic resins which determine the physical properties of the tape coating and, to some extent, recording properties. Its purpose is to bind all the oxide particles together into a srrong but flexible coating and to provide a permanent bond between the coating and the film base.

Depending on the application, a number of additives may be used in the binder to modify certain properties: plasticizers can be used to make the coating more flexible, lubricants to reduce friction and wear, conductive agents to reduce static charges. Wetting agents, stabilizers, and fungicides may also be added.

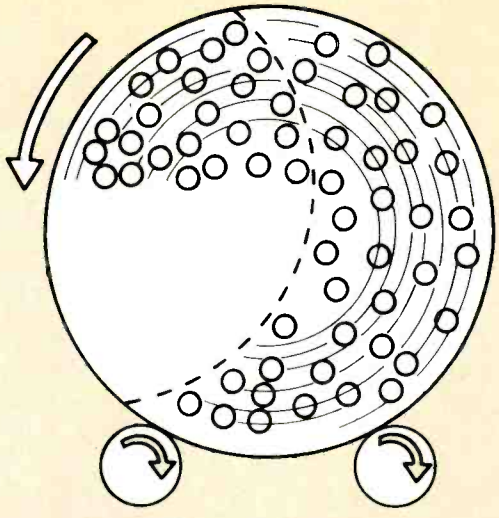
The binder resins and the additives are quality inspected in the raw material form with infra-red spectrometers which accurately analyze each ingredient for its composition and freedom from impurities.

Solvents. The purpose of the solvents is to completely dissolve the binder resins, producing a liquid dispersion suitable for coating on the polyester film base. The solvent serves as a temporary vehicle to make the dispersion and coating possible. After this is done, the solvent is evaporated entirely out of the coating.

Incoming inspection for solvents includes checks for contaminants, boiling points, and solubility; gas chromatographs and similar devices are used.

Base. Polyester film is the most widely used base for magnetic tapes today because of its superior strength, stable dimensions (even when exposed to extreme climatic conditions), and its resistance to attack by chemicals which destroy other plastics.

Polyester film is available in a number of thicknesses, each designed for a specific type of tape product. For instance, 1 mil and 1.5 mil thick polyester is used exclusively for open-reel tapes. The new standard thickness for 8-track cartridges is 0.75 mil. Cassette tapes are 0.5, 0.3, and 0.25 mil thickness for 60-, 90-, and 120-minute lengths, respectively.



Milling Media and Oxide-Slurry Preparation

MILLING ACTION DURING MILLING CYCLE

Because of the extreme thinness of film used in cassettes, the polyester for this application is tensilized. This is a special pre-stretching process performed by the film manufacturer which increases the tensile strength nearly two times.

Base film is also subjected to a large assortment of quality control measures before manufacture ever starts. It is tested for strength, thickness, smoothness, cleanliness, freedom from wrinkles and physical stresses.

Manufacturing Process

Once all the inspection and quality control tests are completed, the raw materials are cleared for production.

Milling. The first step in the manufacturing process for recording tape is the blending and mixing of all the formulation ingredients. We do this in a ball mill, a large rotating drum partially filled with steel balls. When the drum is set into motion, the balls cascade through the mixture, called slurry, and create the type of agitation and blending action necessary to produce the desired dispersion.

The ultimate purpose of milling is to produce a dispersion where each oxide particle is coated with a thin layer of binder and separated from all other oxide particles. In spite of the massive nature of this operation, it is indeed a delicate and precise process. Insufficient milling, for instance, results in an incomplete dispersion where large groups of iron oxide particles are clustered together, causing undesirable magnetic interactions. These interactions manifest themselves as increased hiss level, lower output, variations in uniformity, dropouts, and even local weak spots in the coating, which can eventually cause shedding, wear, and additional dropouts. Excessive milling can be just as harmful and may show up as a loss of high-frequency response, increase in layer-to-layer signal transfer (print through), and, depending on the formulation, may also cause a weakening of the entire coating.

Tapes have been greatly improved in recent years by progress in milling technology. Current methods of dispersion have resulted in reduced interaction losses and permitted a substantial increase in coating density without weakening either the physical or the electrical properties.

Coating. Once the slurry has reached its optimum dispersion level, it is brought to the coating machine to be joined with base film.

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coating. The drying tunnels are divided into a number of zones with individual means of adjusting the drying state by controlling air temperature, velocity, and volume. A drying rate which is too fast or too hot can cause some of the solvents to evaporate or boil off too rapidly, producing tiny pinholes and craters in the coating, which in turn will cause dropouts or noise pops. On the other hand, if the drying cycle is too slow or incomplete, the tape may be tacky and stick to itself, or even worse, may cause build-up on the recording heads and produce severe losses of output.

Surface Polishing. Before the tape leaves the coater, it is squeezed between two or more very highly polished rollers under great pressure and high temperature. This process uses the super-smooth finish of the calendering rolls to create a nearly glasslike surface on the tape which has an average finish depth of only a few microinches.

Not all audio tapes require the same degree of polish. The finest polish is usually reserved for premium cassette tapes in order to improve output at high frequencies, since for best high-frequency response, the tape must maintain intimate contact with the record and play heads. Even the slightest spacing between the head and the tape will introduce severe losses. For instance, a 10-kHz signal recorded on a casette at 1⅞ ips will suffer a combined record and playback loss of about 6 dB if there is only a ten microinch spacing between the tape and the heads. This type of separation can easily result from an unpolished surface since any roughness, even sub-microscopic in size, causes only the high points on a tape surface to come into contact with the heads. This also illustrates the need for cleaning and maintaining the heads of the recorder.

Slitting. When all operations performed on the coating machines are completed, the tape is wound onto large cores. These enormous rolls are then transported to another section of the plant where they are slit into hundreds of reels of tape in a single operation utilizing rotary blades. Slitting is done at very high speeds but under stringent control so that the film is cut in a perfectly straight line.

Consumer sound recording tape is slit to either of two widths. All open reels and lubricated tapes for 8-track cartridges are slit to a width of 0.246 inches ±2 mils. Cassette tape is slit to 0.149 inches ±1 mil.

Good guiding and trouble-free operation on the recorder is to a large extent dependent on the accuracy of slitting. For instance, width tolerances must be accurately maintained. Clearly, a tape which is too wide will stick in the guides or become damaged at the edges if forced to run under these conditions. Loss of output and dropouts on the edge track will very likely result as well. A tape which is too narrow may mistrack and cause output variations in edge channels and, in some cases, cause crosstalk.

Even if the tape is slit to the right width, but not guided through the slitting knives in a straight line, the tape will be skewed or "snaky." Snakiness of this type will produce large variations in the high frequency signal because the tape is moving past the head with a constantly varying angle with respect to the head gap, changing the azimuth correspondingly.

After the tape is slit, the individual pieces are usually wiped on both sides to clean off any loose debris generated during slitting. It should be pointed out that a slight amount of oxide deposit on the heads or on the pinch roller is not abnormal however. Some dirt accumulation must be expected because no matter how cleanly the edges are slit, they can never be as smooth and as free of debris as the surface. Also, as the tape edges rub against the guides, heads, and reel flanges, a slight edge polishing takes place, causing new debris accumulation, which is then deposited on the heads or pinch rollers. This is one of the many reasons why regular cleaning and maintenance of the recorder is necessary.

On the take-up side of the slitting machine, the slit and cleaned tape is wound onto the various reels. Most 7½-in. open-reel tape for home recording is wound directly onto plastic reels. Tape for 10½-in. reels, however, is normally wound on plastic or aluminum NAB hubs, with the metal flanges attached later.

Lubricated tape for 8-track cartridges is wound on large, 14-in. diameter pancakes, which hold 8,400 or more feet. These pancakes, without flanges, are then transferred to the cartridge assembly department where they are loaded into 8-track plastic housing. The same pancakes, incidentally, are also shipped to music duplicators throughout the world who record music on them at 120 inches per second, then load them into cartridges, and make them available as prerecorded 8-tracks.

Cassette tape used for loading into blank cassettes must be specially prepared before shipping to arrange for the provision of leaders. To accomplish leadering in an efficient way, the jumbo rolls of cassette tape are rewound, and at specific intervals of length, a section of full-width leader material is spliced in. The intervals depend on the desired length of tape in the cassette to be manufactured. For instance, if 60-minute cassettes are to be manufactured, the leader is spliced in every 282 ft.; for 90-minute cassettes, the length becomes 422 ft., and so on.

Final Assembly

Once slitting is completed, final assembly can begin. For each format the process is different.

Open Reel. Since reel tape is already on hubs, it is nearly ready for shipping. First it is visually inspected, and then bulk-erased to bring the noise level down to the virgin state.

8-Track Cartridge Assembly. Since the 8-track cartridge is designed to operate continuously in one direction, without rewinding, the cartridge has no reels and the tape is wound on a platform in a closed loop, with no ends. In operation, the tape feeds from the inside of the pack, driven in clockwise direction by the built-in pinch roller and the recorder's capstan, and travels past the various guides, the heads, the pinch roller, and back onto the outside of the tape pack.

Because pack diameters differ between take-off and take-up points, all tape layers within the pack of a cartridge must continuously slide on each other to adjust the running tension and also to provide wow-free, flutter-free motion. A good cartridge should run for hundreds of hours with no increase in tension or motion disturbance. To accomplish this, we employ a special lubricated coating on the back of the tape which substantially reduces friction and extends cartridge life.

This lubricant must also run cleanly. Any dirt deposited on the heads causes severe high frequency losses. It must not cake up on the pinch roller either, since this produces slippage, wow, and speed changes. Finally, the lubricant must not transfer to the oxide side of the tape, or it would cause dropouts.

The assembly of 8-track cartridges begins by unwinding a precise length of tape from the 14-in. pancake directly onto the cartridge platform. The platform and various components of the cartridge including the pressure pad and pinch rollers are then assembled into the base and the cover is snapped into place. The two ends of the tape hanging out from the cartridge opening are cut to a specific length to form a "drop loop." These ends are then spliced together on the oxide side using a metallic splicing tape, the track switching foil, which is designed to automatically switch between the four pairs of stereo programs recorded in the 8-track cartridge. All recorders and players for 8-track are equipped with a head that moves up and down in response to the switching action. Many users record right over the splice since the interruption in sound lasts less than half a second.

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Cassette Assembly. In the assembly of cassettes, the pre-leadered tape on the large reels is transferred to the cassette hub. The leader is securely fastened to one hub and the tape is wound on the hub until the following leader appears. This leader is cut and the end fastened securely to the other hub. The two hubs are then inserted into the cassette half, along with other components, such as anti-friction liners, rollers, shield, and pressure pad. The cover is put on next and is screwed or welded together to form the finished cassette. The labels are attached last and the cassettes are packaged into the various type of boxes.

Final Testing

In addition to important process control tests performed during manufacturing, quality-assurance tests are performed on the finished product to check the product for conformance to specifications. All tapes undergo this testing, including tape which will be loaded into cartridges and cassettes.

The three kinds of tests conducted are *physical* tests, to measure such parameters as width, thickness, density, tensile strength, friction, scratch resistance, surface smoothness, head abrasion, and temperature and humidity stability; *magnetic* tests, to check coercive force, residual flux (remanence), residual flux density (retentivity), and the squareness of the hysteresis loop; and *recording performance* tests, to check frequency response at various speeds, distortion, uniformity, noise, dropouts, print-through, and even the compatability of the tape with various recorders and their specific bias settings.

While physical and magnetic tests are standardized and do not vary with the application, recording performance tests are always geared to the particular use for which the tape is intended. Recording equipment used for performance tests consists of professional recorders equipped with heads and adjustments typical of home use conditions. In addition, some tests are performed on a large variety of different home recorders to see how the tapes will behave under somewhat less than ideal laboratory conditions.

Besides tests which are done on the tapes themselves prior to assembly, finished blank cartridges and cassettes are also subjected to complete quality assurance testing. Eight-track cartridges, for example, are tested for wow, flutter, and tension using new blank cartridges as well as ones hundreds of hours old. The tests are done under ambient conditions as well as the extreme temperature-humidity conditions which will be encountered in cars, boats, and other situations where cartridges are commonly used. Since 8-track players are often given little preventive maintenance by their owners, primarily because cartridge players are used principally away from home, particular attention is paid to accurate and trouble-free operation under unfavorable conditions of use and maintenance.

Cassettes, too, are checked for wow and flutter, torque requirements, smoothness of motion, and life. They are also checked for recording performance in the cassette since this cannot be accurately determined by pre-testing because the cassette plastic housing serves as the alignment surface in the machine and thus, at least partly, determines the azimuth adjustment between the head and the tape. A good cassette housing is made with precision molds from stable, warp-resistant plastics, and is assembled with great care to maintain the alignment of which the plastic parts are capable. Response tests measuring the effects of plastics are performed on the number of cassette recorders ranging from the simplest decks to the most elaborate three-head machines.

By now, most of you have probably concluded that a lot of effort goes into production of quality magnetic tape. Indeed, it takes a keen attention to manufacturing controls, a great deal of experience, and extensive quality control testing to produce this miraculous recording medium.

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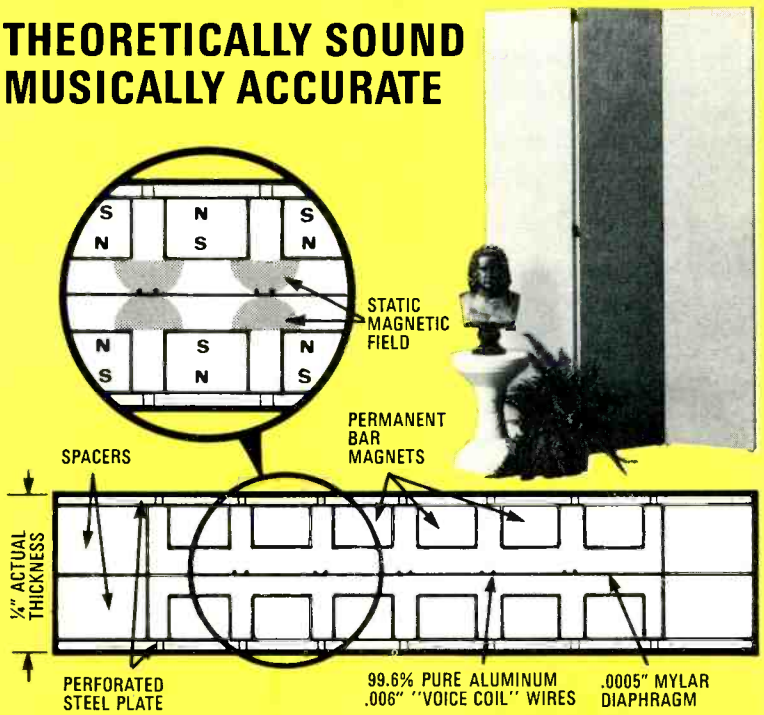

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SOUND SYSTEM

E.J. Czerwinski & G.R. Lewis*

GIVE THE VIEWERS something they can't get at home, the movie makers said, and they will come back to the theaters—with their dollars. With this in mind, and spurred on by the phenomenal success of such spectacles as *The Poseidon Adventure*, Universal Pictures hatched a plan early in 1974 for the disaster film to top all others—nothing less than the destruction of Los Angeles by a mammoth earthquake. The crowning touch would be the physical sensations of a quake created by an ultra high power, low frequency sound reinforcement system.

Universal first needed to demonstrate the acoustical and economic feasibility of the project and then find a manufacturer to supply the necessary equipment. Two of their sound directors, Richard Stumf and W.O. Watson, recalled the bass performance they had heard at the Cerwin-Vega exhibit at an Audio Engineering Society Convention and contacted us to see whether our firm would be interested in the project, and if we had any stock equipment that could be modified to suit the requirements of their earthquake idea.

Demonstrations in a Universal screening room followed, with the setup consisting of a number of stock concert bass horns (L-48-DDs driven by two 18-in. speakers in a folded 32-Hz horn) and two prototype 28-Hz corner horns. Power was supplied by a bank of 1,200-watt concert amplifiers, and the signal source was a General Radio pink-noise generator, filtered to remove frequencies above 63 Hz.

During the trials, peak SPLs in excess of 120 dB were measured in the theater, and the building's double stucco walls were given a shaking that could easily be felt outside the theater. (In fact, complaints were received from the studio commissary, some 200 feet away.) Even though low frequency response apparently needed to be extended an additional octave to increase realism, Universal budgeted some $30 million for three films using equipment designed expressly for the proposed system dubbed Sensurround® by Universal.

Tape recordings of the 1971 Sylmar quake that rocked Southern California were analyzed to determine the frequency distribution of the quake's energy, and a digital pseudorandom noise generator was developed to duplicate the signal's characteristics. Universal's legal staff began investigating possible liability for damage to theaters screening the film or personal trauma to viewers unprepared for the realism of the effect. Demonstrations of prototype equipment were arranged in Brazil and New York to assess reaction of viewers.

Because of the low frequency rolloff dictated by Motion Picture Academy standards, direct recording of the effects on the sound track was ruled out, and a control system was designed, employing pilot tones recorded on an unused audio channel to control the output of the effects generator[1].

*Cerwin-Vega,
North Hollywood, Calif. 91605

[1]This roundabout method of achieving the desired results raises an obvious question: Why haven't cinema sound standards, es-

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Belt, rim, or direct drive?

Some reasonably unbiased comments from the people who make all three.

Manufacturers of turntables with just one type of drive system —belt, rim, or direct-drive— naturally favor their own. Dual, however, makes all three, and we fully agree with Julian Hirsch who said: "It would make little difference if the platter were powered by well-disciplined hamsters on a treadmill. It is the end result that counts."

The belt-drive Dual 601. Fully automatic, single play. $270, including base and dust cover.

The rim-drive Dual 1229Q. Fully automatic plus multi-play. $259.95, less base and dust cover.

The electronic direct-drive Dual 701. Fully automatic, single play. $400, including base and dust cover.

The belt-drive system.

The main benefit of the belt-drive system is its effectiveness in filtering out motor vibration. It is a simple system that can be used with light duty motors and platters, and lends itself to low-cost manufacture.

The belt-driven Dual 601 is not compromised. It employs a high-torque 8-pole synchronous motor which drives a 4.5 pound dynamically-balanced platter, taking full advantage of a heavy platter's flywheel effect to filter out speed variations.

Thus, music lovers who prefer belt-drive single-play design can now enjoy the precision and performance of a Dual.

The rim-drive system.

In the rim-drive system, the platter is driven by an idler wheel which disengages when not in play. Since each part must be machined and carefully quality-controlled for perfect concentricity, this system is not inexpensive to make. When correctly made, it will perform not only precisely, but reliably and durably.

More audio experts—hifi editors, record reviewers, engineers and music/equipment magazine readers—own and continue to purchase Duals (with this system) than any other make of quality turntable.

The direct-drive system.

In direct-drive systems, the motor rotates at record speed and drives the platter directly, without need for intermediate coupling. The result is a somewhat quieter and smoother platter rotation than is achieved with any other system. But direct drive motors require a much more expensive technology.

The most advanced of all direct-drive systems is in the Dual 701. Among the exclusive features of its electronic motor: two sets of overlapping field coils that provide a totally gapless magnetic field that eliminates the successive pulses common to all other motor designs. Result: almost total elimination of wow and flutter.

How drive system performances compare.

As measured by the highly conservative European standard (DIN), the performances of the rim-drive 1229Q and the belt-drive 601 are identical: weighted rumble: -63dB; wow and flutter less than 0.06%. The direct-drive 701 does even better: weighted rumble, -70dB; wow and flutter, less than 0.03%.

Although the 701 specifications are more impressive than those of the 1229Q and 601, you are not likely to detect any difference unless your other components also meet the highest possible performance standards and you are an exceptionally critical listener.

So much for drive systems.

We now suggest you forget about differences among drive systems and simply decide which turntable best suits your requirements for total performance and convenience.

With a reasonable amount of bias, we also suggest your decision can be made quite happily from among the three types of Duals now available: Our automatic models with provision for multi-play, priced from $129.95 to $259.95. The belt-drive 601 at $270. Or the direct-drive 701 at $400.

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Requirements for the effects systems included a very high power amplifier which would be both stable and reliable under the unusual operating conditions and a driver-enclosure combination of manageable size and flexibility to accommodate the physical demands of a variety of theaters, yet capable of propagating bass fundamentals down to 16 Hz in a large theater at levels above 110 dB.

The difficulty of this last requirement can be seen by making some rough calculations of the amount of conventional hi-fi equipment required to do this job. A typical 10-in. acoustic suspension speaker is specified as developing 90 dB SPL in a typical 3,000-cu.-ft. room with a power input of 10 watts. The response of the system is stated as being down 10 dB at 30 Hz, so using the theoretical 12 dB/octave rolloff slope of sealed systems, the speaker should be down at least 20 dB at 16 Hz. Converting decibels to power, and noting that the speaker handles a maximum of 100 watts, it follows that 10 such systems driven at full power should be able to produce 90 dB at 16 Hz in the same room. Now consider that a good-sized theater has at least 50 times the volume of the 3,000-cu.-ft. living room and that the required sound levels consume 100 times the power of this 90 dB reference. Even allowing perhaps 10 dB efficiency gain through mutual coupling of the woofers, we are still talking about literally thousands of these small speaker systems, consuming in the neighborhood of half a million watts of audio power for the required effect! And, of course, most of the output at this low frequency would consist of doubling and other distortion components.

Considerations like these made it apparent that some radical improvement in conversion efficiency would be required to make the system practical, for, while 5,000 watts per installation might not be out of the question, 500,000 certainly would be. Therefore, only the most efficient devices, horns, could be considered. However, even this decision created difficulties of its own, because according to classical horn theory a mouth area of about 300 sq. ft. is required for optimum coupling at 16 Hz and such a horn would also have to be impractically long.

At this point, the logistical problems begin to severely reduce the range of solutions. For one thing, every theater presented a different set of physical restrictions and possibilities; what with 500 installations, custom-designing a system for each was out of the question. Whatever the final solution was, it had to be easily produced, yet flexible enough to adapt to any house, and portable and uncomplicated enough to be set up quickly by relatively untrained personnel. All things considered, the situation was like that faced by a sound contractor on a major concert tour.

The horn length requirement was largely overcome by folding the horn, since the degradation of response caused by folding does not become significant in a well-designed horn until frequencies far above cutoff are reached.

To deal with the problem of mouth area, use of surfaces within the building as reflectors seemed possible. Horn theory shows that the required mouth area for optimum coupling strongly depends on the angle into which the horn is required to radiate, and by keeping this angle small, the mouth size can be reduced considerably without unduly compromising efficiency. For example, as implied in Keele [1], a horn radiating into ⅛ space (as, for example, the intersection of the floor and walls of a square structure) need only have about 40 percent of the classical mouth area for optimum coupling in the octave above cutoff. If the radiation space is further constrained by using a tall, narrow mouth spanning a good por-

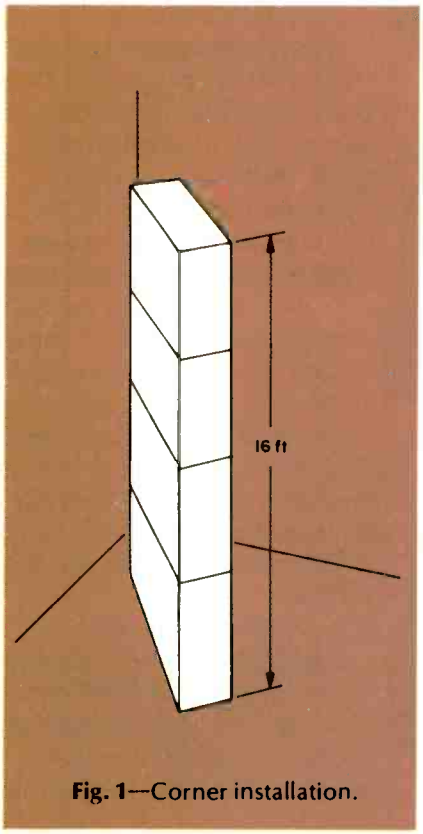

Fig. 1—Corner installation.

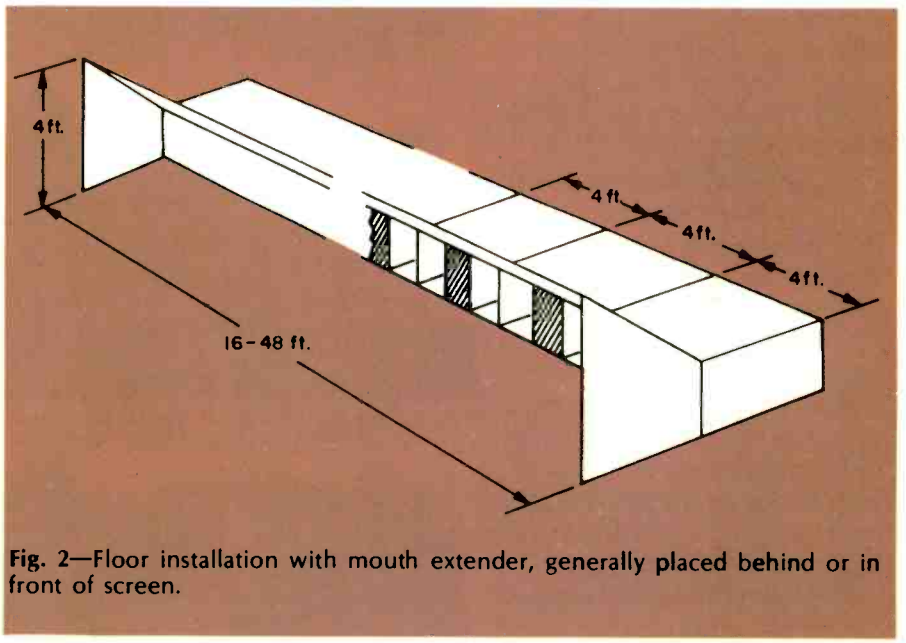

Fig. 2—Floor installation with mouth extender, generally placed behind or in front of screen.

tablished in the 1930s, been up-graded to keep pace with technical advances in other areas? The sound quality of a typical film in a typical theater is poor, indeed, all too often being inferior to that of a typical auto radio. This is not the fault of the basic optical or magnetic recording system, which could be made to give hi-fi response, but rather of antiquated standards designed to hide the flaws in the antiquated equipment still in wide use in both film production and projection. The short time available for the development of the Sensurround system did not allow for the modification of theater equipment, thus a parallel system had to be designed to run along beside the existing house system used for dialogue and music.

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Over 1,000,000 watts of A-3000 and A-1800 power amplifiers have been delivered for use in "Earthquake" worldwide.

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tion of the floor-to-ceiling distance in a corner, good results can be obtained with much smaller horns. (The principal effects of too small a mouth are some attenuation of response in the region immediately above cutoff and a periodic fluctuation with frequency of the reflection coefficient at the horn mouth. Here the nature of the signal to be reproduced worked in our favor, since dips in response are less noticeable in this two-octave low frequency band of pseudorandom noise than with continuous tones of music.)

The final corner horn design is a modular, folded 18-Hz horn in a rectangular cabinet measuring 48 in. H. by 48 in. D. by 20 in. W., which can be stacked up to four high in any convenient corner of the theater, with the mouths exhausting into the corner

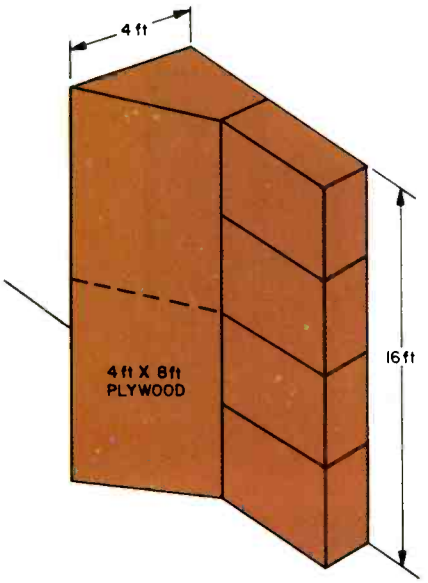

Fig. 3—Wall installation with mouth extender.

(see Fig. 1). An alternative, though less effective placement in houses lacking a suitable corner is with the cabinets lengthwise along the floor, with a wooden mouth extender attached (Fig. 2). This arrangement takes advantage of one reflecting surface, the floor, as does the wall placement shown in Fig. 3. Details of an individual module are shown in Fig. 4. The 18-in. driver faces the rear of the cabinet, utilizing the volume between the horn sections as a rear chamber. The driver radiates into a tightly constricted channel, which effects compression loading, raising the overall efficiency and helping to prevent destructively large cone excursions. The sound path divides in two, curving around the speaker chamber and expanding at an 18-Hz flare rate.

There are two principal disadvantages to extreme compression loading: the distortion generated by the slightly nonlinear relationship between pressure and volume in air, which gets worse as the amount of compression increases, and the very small effective throat area that comes with high constriction requires an increased length for a given flare rate and mouth area. Distortion and required horn length are both decreased by a large throat, but the air load on the driver falls off so fast that bottoming of the suspension becomes a problem and efficiency suffers as well. Thus, any compression loading design involves a compromise in the attempt to maintain good loading down to the horn cutoff frequency and still have acceptably low distortion.

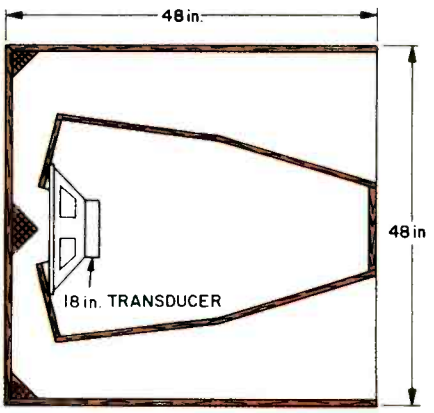

Fig. 4—Cross-section of a single module.

Perhaps the most challenging problem relating to the speakers was designing a driver which could handle the extremely low frequency range at the high power levels required. The system's specifications stipulate that each driver used must handle 1½-in. peak-to-peak excursions during the 20-Hz, 600-watt free-air burn-in period during final testing. (This works out to over 300-cu.-in. displacement per cycle—comparable to a good-sized automobile engine!) In actual use, the drivers must be able to sustain a 300-watt average power input with a high peak-to-average ratio without failure.

Of the two chief modes of failure, electrical burnout and mechanical failure, only the latter proved to be a problem. While we had already produced voice coils capable of dissipating 1,000 watts indefinitely without burning out, the very long excursions and heavy driving impulses developed by the speaker's motor assembly[2] tended to make short work of stock cones, surrounds, and spiders. After experimentation, a combination of cone and suspension and polymer treatments was found that yielded adequate excursion capability and an acceptably low failure rate.

With the transducer problems solved, we turned to the amplifier, beginning with a prototype unit intended for home hi-fi and commercial sound use. This unit, the A-3000, delivers about 750 watts per channel into a 4-ohm load, and this seemed reasonably well suited to the requirements of the system. It probably would have been easier and less expensive to design a special amplifier solely for this use, with a 1 kHz power bandwidth, for example, since wideband designs using high power, but slow operating speed transistors are prone to output stage failure unless adequate precautions are taken. One protective measure built into the A-3000 is output slew rate limiting, using networks designed to keep the output transistors from being driven to saturation when handling very fast transients. Since a saturated transistor has a much higher internal capacitance than an unsaturated one, the drive current required to charge and discharge this capacitance is greatly

[2]A widely used method of rating loudspeaker motor efficiency is the "BL product," obtained by multiplying the magnetic flux density, B, in the voice coil gap (in Webers/meter²) by the length, L, of voice coil wire residing in the gap (meters). The resulting quantity is an expression of the driving force (in Newtons) produced per ampere of voice coil current. The BL product of the Earthquake speakers is 44 N/A or about 10 lbs./A, as compared with 5 to 10 N/A for a typical low efficiency hi-fi woofer.

If Academy standards, down 3 dB at 60 Hz, could be up-dated to provide 1½ additional octaves of bass, 25 to 70 Hz, and one more octave of treble, 8 to 16 kHz, with perhaps an additional 20 dB of dynamic range, the door would be opened to a whole new dimension in cinema realism. Even films not dubbed for such a system would benefit considerably from it. Along with many others, we feel that the film industry is doing itself a great disservice by not up-grading its audio standards. The push for better TV sound is already on; why not films?

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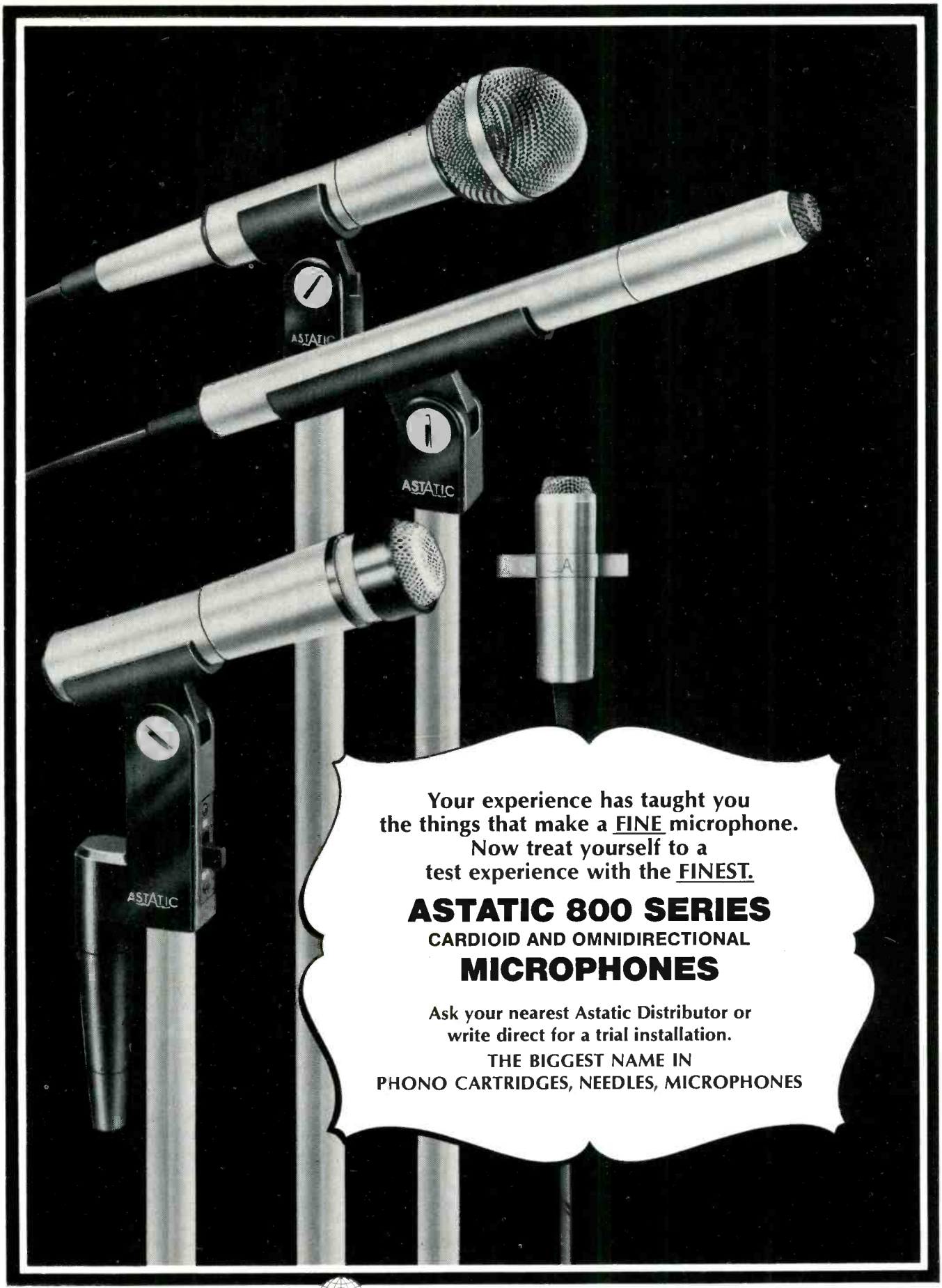

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reduced, taking much of the strain off both driver and output transistors during high speed transitions.

A volt-amp limiting circuit is also used in this amplifier. Conventional circuits of this type sense output current, which is fine for purely resistive loads (since the load current is always precisely in phase with the output voltage). But most speakers, and particularly those used in the Sensurround system, exhibit a highly reactive impedance at resonance, meaning that the amplifier's output stage may be called upon to withstand near-peak current *and* voltage simultaneously. A simple limiter circuit sensing only current cannot respond to this condition and will remain cheerfully idle while the junctions melt in the output devices. The A-3000's system senses a weighted combination of output voltage and current, and whenever this combination begins to cross the safe-area limits, the protection circuitry removes the drive signal from the amplifier.

Many have raised questions about the safety of the system, fearing that some of the old theaters may suffer structural damage under the battering of high energy sound waves. This was researched and the consensus of the engineers was that these fears are unfounded. The main structural members of virtually all buildings resonate below about 6 Hz, and the Sensurround system puts out virtually no energy below 16 Hz. During the tests at Grauman's Chinese Theater in Hollywood, however, it was necessary to install a net to catch small pieces of the elaborate ceiling moldings which began falling, shaken loose by Earthquake after decades of surviving real earthquakes.

One interesting sidelight had to do with the production of the sound track album for the film. In attempting to get the quake effects on disc, output from the noise generator was first transferred to a studio tape machine with flat response to 20 Hz. It proved impossible to cut a master lacquer using conventional mastering techniques with this tape because the high amplitude, low frequency excursions in the signal confused the automatic depth and pitch control system of the cutting lathe, which is almost never called upon to handle a signal below 30 Hz. The solution was to use the manual override of the machine, which is normally used only at the beginning of a band to prevent pre-echo, to obtain wide enough spacing of the grooves to handle the unequalized signal. The final result on the disc was a band lasting 2:42, but wide enough for some five to six minutes of more typical program material. It should provide an interesting test of the low frequency performance of any sound system.

Development work done since the system for the theaters was produced has yielded a Super Earthquake horn—a multiple-fold configuration in a slightly larger cabinet, using a higher BL woofer. The design is 2 dB more efficient than the original and boasts lower distortion, 4 dB higher output capability, and virtually flat response from 20 to 250 Hz. Unlike the earlier design, this new horn's driver is not excursion limited at the bottom of its frequency range and thus is less susceptible to overexcursion and bottoming. Plans are to make it available on a special order basis for such applications as organ reproduction and ultra-low frequency reinforcement.

Reference
[1] Keele, D.B., Jr. *Optimum Horn Mouth Size*, A.E.S. Preprint No. 933 (B-7), 1973.

Again and Again and Again

Given the time, the patience, and the money, one can connect* fifty 303 amplifiers nose to tail so that the programme goes through one after the other gradually deteriorating along the way.
Deteriorating? The fact is that apart from a very slight backround hiss — akin to a good tape recording — the programme will sound exactly the same at the end as when it started.
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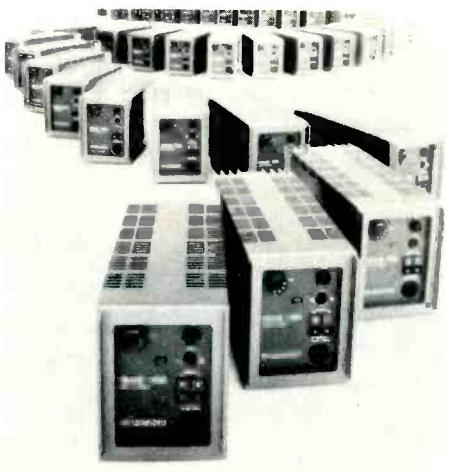

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We'll be happy to describe our complete line of speakers in detail, and send you the names of the selected group of ADS dealers in your city. Write: ADS, Analog & Digital Systems, Inc. (ADS & BRAUN Loudspeakers), 377 Putnam Avenue, Cambridge, Massachusetts 02139. Phone: 617/492-0970.

THE SOUND OF ADS AND BRAUN

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Equipment Profiles

Elekt-O-Fonie Model FU-100 Octaphonic Receiver

Front panel view of Ultima One, a lineal predecessor of the Elect-O-Fonie Octaphonic Receiver.

MANUFACTURER'S SPECIFICATIONS

Amplifier Section

Power Output: 500,000,000 ergs/second per channel, measured with one channel operating intermittently. **Rated Harmonic Distortion:** 0.0003%. **IM Distortion:** 0.0002%. **Frequency Response:** 2 Hz to UHF TV channel 82 ±0.5 dB.

Tuner Section

FM Sensitivity: –1.0 microvolts (actually supplies signal back to the broadcast station. **Signal-To-Noise Ratio:** –100 dB, with a.c. switch in *Off* position. **Stereo Separation:** At least 10 ft., depending on room size. **Image Rejection:** –100 dB, when cabinet is polished with Pledge. **Dimensions:** 508 mm H. x 254 mm W. x 400 mm D. **Weight:** In carton, 280 lbs.; net, 3 lbs., 4 oz. **Price:** $6,972.95.

Impressed with the advertised specifications of this eight channel unit, a randomly selected sample was supplied to our laboratories by the manufacturer. We would have wished to supply photos of the inside of the unit, but the manufacturer was late in supplying our sample because they were waiting for parts with which to complete this specially selected random prototype unit.

The front panel of the unit is especially impressive. Besides the 108 knobs and switches which have been human-engineered into this instrument, an accessory kit including 8 additional knobs equipped with self-adhesive backing is included. These additional knobs can be affixed to empty spots on the panel at the user's discretion.

The rear panel includes 23 necessary jacks and terminals as well as 15 useless ones. The latter connectors may be used to store Q-tips, used phono styli, and the ends of spare audio cables.

Circuit Highlights

The "front-end" of the FU-100 consists, essentially of a piece of Rochelle salt crystal, with a carefully mounted cat's whisker, coupled to a massive tuning knob and flywheel arrangement. The flywheel action is so smooth that one quick twist of the knob (and quick manual release) enables you to spin it some 142 complete revolutions or from 88 MHz up to microwave radar frequencies.

Each of the eight amplifier channels uses a new device, which, the manufacturer reports, has several advantages over transistors or integrated circuits. Mounted in sockets, for easy replacement, the new amplifying device has tentatively been given the name Vacuum Tube.®

Laboratory Measurements

We put the receiver through its paces in our lab with the following results. At an output level of 10 watts, distortion measured 10%. At 100 watts, distortion increased to 100%. Having established this one-to-one relationship between percentage distortion and wattage output, we realized that at 200 watts, distortion would be expected to read 200%. Since this is impossible, we concluded that our test equipment is at fault, and therefore accept the manufacturer's published claim of 0.0003% total distortion.

As for hum level, with our three technicians humming along for reference level, the hum measured was exactly at a frequency of 60 Hz, as was to be expected. With the muting switch turned on, there was absolutely *no sound* heard between stations on the dial. (This test was confined to listening for noise *between* stations. We therefore cannot draw any conclusions regarding sounds heard when attempting to tune in a station.)

As for preamplifier measurements, we applied a signal to the phono inputs and found that the equalization charac-

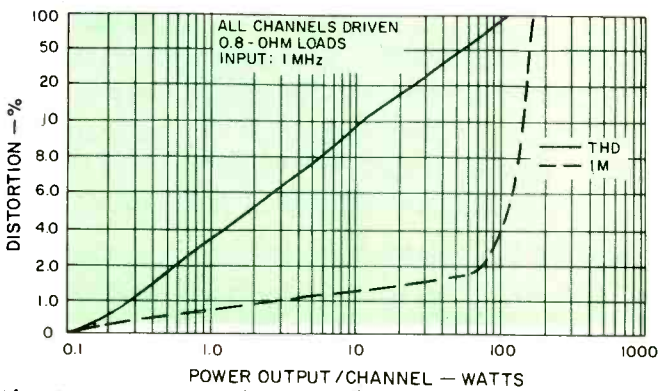

Fig. 1—Harmonic and intermodulation distortion characteristics.

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teristic of each circuit was equal in every respect to the equalization of every other circuit. Reversing input channels did not alter this equality of equalization. Output frequencies generally remained the same as input frequencies.

We call this a good example of frequency accuracy and it is this quality that allows the equipment to reproduce a soprano voice without having it sound like a baritone—which is, after all, what makes the fi so hi.

Listening Tests

As usual, our panel of experienced listeners was asked to judge the sound quality of the FU-100. While this panel normally consists of six experts, the listening tests conducted this time were confined to five panel members. (Our senior listener had to skip this session because his hearing aid battery had gone dead and no replacement was immediately available.)

A vintage 78 rpm recording of Nellie Melba was used in the first test and there was unanimous agreement that reproduced sound was tight, had excellent transient response, tingling highs, definitive mid range, and powerful, thumping bass. Listening tests were interrupted from time to time to permit listener's ears to recover and to allow the listening room to return to ambient temperatures below 85° F. (29° C) by turning off the receiver.

Final tests involved 8 channel reproduction of FM programs. This was accomplished by adjusting the selectivity of the FM section so that 4 stereo stations were received at once. A bit of dial twirling yielded reception of four programs, which together, yielded contrapuntal effects that were both discordant and full of "now" sounds.

In Summary

At $6,972.95 the FU-100 is certainly not the least expensive receiver around, but it's not the most expensive either. Readers who are interested in owning an unusual piece of electronics gear could do a lot worse, especially considering the price of this receiver. Anyone interested in purchasing our sample (test samples are *never* sold as new merchandise) can contact our laboratories and, for the cost of shipping, will be sent our unit in a factory resealed, highly colored, original shipping carton.

Professor I. Lirpa,
University of Bucharest

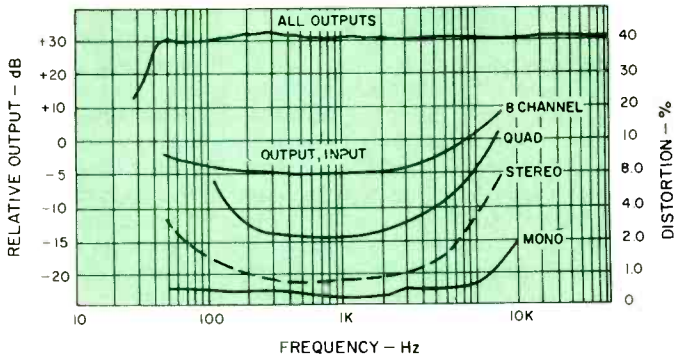


Fig. 2—FM section separation and distortion characteristics.

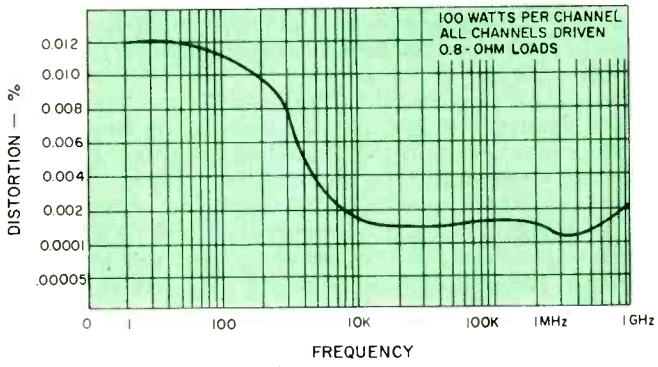
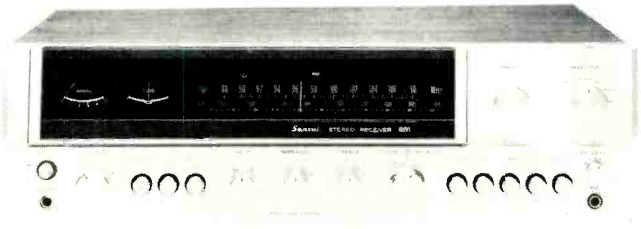


Fig. 3—Distortion versus frequency.

Sansui 881 Stereo Receiver



MANUFACTURER'S SPECIFICATIONS

FM Tuner Section
IHF Sensitivity: 1.9 μV. **Selectivity:** 70 dB. **S/N Ratio:** 70 dB. **Capture Ratio:** 1.5 dB. **I.F. Rejection:** 90 dB. **Image Rejection:** 75 dB. **Spurious Response Rejection:** 80 dB. **Frequency Response:** 30 to 15,000 Hz +0.5dB –3.0dB. **Stereo Separation:** 40 dB @ 1 kHz. **THD:** Mono, 0.3%; Stereo, 0.5%.

AM Tuner Section
Sensitivity: 53 dB/meter (internal antenna). **Selectivity:** 30 dB. **I.F. Rejection:** 80 dB/meter. **Image Rejection:** 80 dB/meter.

Amplifier Section
Power Output: 60 watts continuous power per channel, 8 ohm loads, 20 to 20,000 Hz. **Maximum THD:** 0.3%. **IM Distortion:** 0.3%. **Frequency Response:** 10 to 30,000 Hz, ±1 dB. **RIAA Phono Equalization:** 30 Hz to 15,000 Hz, ±1 dB. **Damping Factor:** 8 ohms, 45. **Input Sensitivity:** Phono, 2.5 mV; Mike, 2.5 mV; AUX, tape, 100 mV. **Maximum Input Capability:** Phono, 200 mV. **Hum and Noise:** Phono, 70 dB (IHF); AUX, 80 dB (IHF). **Bass Control:** ±10 dB @ 50 Hz. **Midrange Control:** ±5 dB @ 1.5 kHz. **Treble Control:** ±10 dB @ 10 kHz. **High Filter:** –10 dB @ 10 kHz. **Low Filter:** –10 dB @ 50 Hz.

General Specifications
Power Consumption: 160 watts at 117 V a.c., 50/60 Hz. **Dimensions:** 19 in. W x 5 5/16 in. H x 11¾ in. D. **Weight:** 29 lbs. **Price:** $529.95

Modern stereo receivers today rival the separate amplifier and tuner both in flexibility and performance capability. The most recent example tested in our laboratories is Sansui's Model 881, a trim-looking component housing enough control features to delight the most seasoned knob-twirler or switch thrower. No larger than receivers offering a fraction of its power output capability just a few years ago, the 881 has a rich, gold anodized, three-dimensional front panel with a framed, blacked-out dial area occupying more than two thirds of the panel length. Illumination is soft green for the linearly calibrated FM frequency scale, the twin tuning meters (signal strength and center channel), and the AM frequency scale. The logging scale and program source indicators light up in bright orange, while the stereo FM indicator lights up in red when a stereo signal is re-

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ceived. To the right of the dial area are a good-sized tuning knob and a rotary, five-position program selector switch.

Rotary controls, located along the bottom section of the panel, include a *Speaker* selector switch (whose most counterclockwise setting turns off all speakers), *Bass, Midrange* and *Treble* controls, a tandem *Volume* and *Balance* control, and a *Mike Level* control at the extreme right, just above the *Mike* input jack. Since up to three pairs of speakers can be connected to the 881, the speaker switch can select any pair, as well as combinations of two pairs (main, plus either of the remotes). To preclude loading the amplifiers with dangerously low impedances, there is no setting provided for operating all three sets of speakers at once.

Push buttons are used for *Power On/Off, Audio Muting* (a fixed 20-dB level reduction), *High* and *Low* cut *Filters, Loudness* compensation, *Mono/Stereo* switching, two *Tape Monitor* circuits, and FM interstation noise *Muting*. A stereo *Phone* jack is located just below the *Power On/Off* switch at the lower left end of the panel.

The rear panel, pictured in Fig. 1, has 300-ohm and external AM antenna terminals plus a coaxial connector and retaining cable clamp for 75-ohm shielded antenna cable. *Auxiliary, Phono* and *Tape Rec and Play* jacks for the two monitoring circuits are clustered under the antenna terminals, along with a DIN connector for one of the tape monitoring circuits and a convenient ground terminal for a turntable. Two sets of *AUX* inputs are provided. There is a pivotable AM ferrite-bar antenna at the center of the rear panel, just above the large, finned, power transistor heat sinks. Switched and unswitched a.c. power outlets, an a.c. power fuse, and three sets of spring-return piano-key speaker terminals are all located at the opposite end of the panel, far from the low-level inputs.

A view of the internal chassis layout of the receiver is shown in Fig. 2. The massive power transformer in the corner supplies positive and negative voltages of 45 V d.c., each filtered by 10,000 μF capacitors, as well as the lower voltages required by circuits other than the power output stages, most of which are regulated by an elaborate transistorized and zener controlled power supply module. A relay delays turn-on for a few seconds and is also used in the protection circuitry of the receiver.

Power amplifier sections are direct coupled from input to output, with a differential amplifier first stage in each channel. Identical ICs are used in the tone control, microphone and phono preamplifier circuits, preceded by a low noise NPN transistor in the case of the mike preamp. ICs are also used in the tuner section for multiplex decoding and in three of the six i.f. and limiter stages of the FM section. Two dual-element ceramic filters driving differential amplifier i.f.-stage pairs and a conventional ratio-detector are used in the FM i.f. section. A single multi-circuit IC is used for the AM i.f. circuit.

The entire layout is neat and orderly and most interwiring between circuit modules is accomplished with multiple conductor connectors, making for ease of servicing and removal of any module.

FM Tuner Section Measurements

Curves plotted in Fig. 3 show some of the FM performance characteristics of the Sansui 881. IHF sensitivity measured 1.8 μV, a bit better than the 1.9 claimed. The quieting slope for mono reception is extremely steep, reaching 50 dB with only 2.5 microvolts of signal applied. THD in mono reaches 0.5% with only 3 μV, decreasing to a very low 0.2% for stronger signals. Ultimate quieting in mono reaches 70 dB, as specified. Sansui arranged their automatic mono-stereo switching so that it operates in the vicinity of 40 μV, therefore we couldn't measure absolute stereo sensitivity. By the time a signal is strong enough to switch the set to stereo reception, stereo quieting is already 54 dB and THD is down to 0.64%. This action will prevent some users from receiving signals weaker than 40 μV in stereo.(Editor's Note: Sansui tells us that later production models have the automatic mono-stereo switching adjusted to the 20 to 25 μV range, and that Sansui dealers will adjust any unit which is not performing satisfactorily free of charge.)

For high signal strengths, best stereo S/N ratio measured -67 dB while THD decreased to 0.47%, a bit better than claimed. Alternate channel selectivity was measured at 72 dB. Image and spurious rejection were minus 75 and minus 85 dB respectively, while capture ratio on our sample measured 1.3 dB, again just a bit better than that listed by Sansui. We found the muting threshold internally set at too high a level, 45 microvolts, when you consider that even with a mere 10 microvolts, 60 dB quieting is obtained in mono. The muting threshold could have been set at this lower value, enabling users to have quiet interstation tuning, while still being able to receive weaker signals.

Fig. 1—Rear panel of the 881.

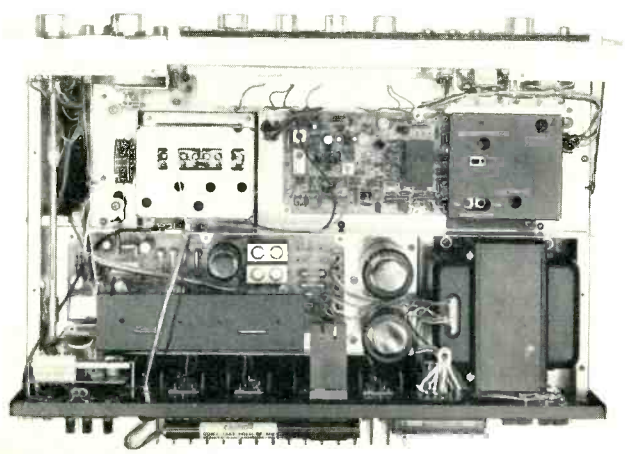

Fig. 2—Internal view.

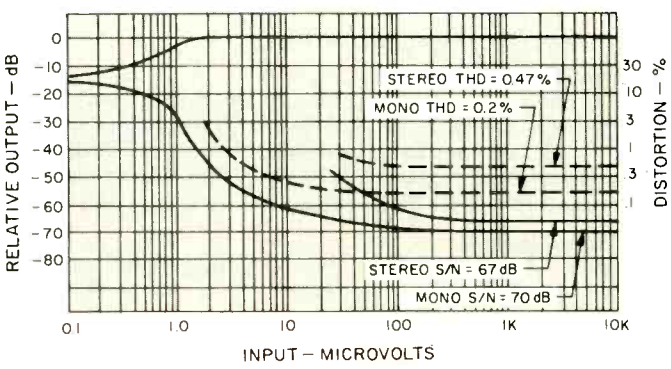

Fig. 3—FM quieting and distortion characteristics.

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Put a record on and walk away. The Philips 209 will automatically sense the disc size, select the speed, spin the platter and cue the tone arm electronically, all by itself.

Then, when the record is over, it will return the tone arm, and turn itself off. It's the only turntable that does it all.

But most important, there's virtually no detectable wow, flutter, drift or rumble. A well equipped research lab would have a tough time finding an echo of electronic noise.

The 209 is the only turntable with three DC motors. One cues the tone arm. The second transports the arm. The third, a DC servo, spins the platter. Separating the functions simplifies the operation of the turntable and eliminates noisemaking possibilities.

The DC servo motor's tacho-generator registers and corrects any speed variation. Power fluctuations can't distract from your pleasure.

We eliminated virtually all detectable acoustic feedback and rumble by freely suspending the sub-chassis.

Our precision ground drive-belt also filters out any conceivable noise that could be traced to the drive motor.

We minimized the 209's aluminum tone arm size to cut down mass related resonance. Tracking error is less than 0° 10'/cm. That means tracking error, for your ears, does not exist. Friction, both vertically and horizontally, is less than 10mg. The tone arm assembly in its rest position provides a continuous read-out stylus force gauge.

Now we're working on automating the dust cover. Any ideas?

GA 209 Quality Specs

Speeds: 33⅓ & 45 rpm — electronic/automatic selection

Speed calibration range: ± 3%

Wow and flutter: less than 0.08% — (Typically 0.03%)

Rumble: —65 dB DIN B (ARLL)

Hydraulic Cueing: motor driven, touch control actuated

Anti-skating Compensation: For elliptical and spherical styli.

Drive system: Electronic, tacho control DC servo motor and precision stabilized belt drive.

Low capacity cables for CD-4.

Manual override on all automatic operations.

Includes base, removable dust cover.

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Everything's automated but the dust cover.

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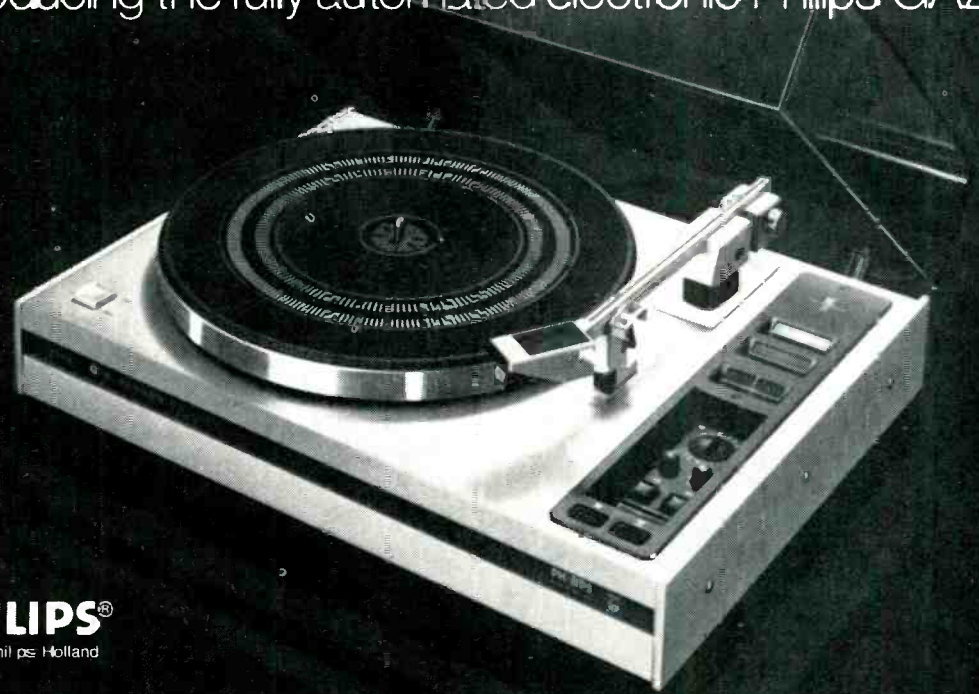

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Stereo separation, plotted in Fig. 4, measured 40 dB at mid-frequencies, decreasing to 30 dB at 10 kHz and around 35 dB at 50 Hz—excellent figures all. Distortion at frequencies other than 1,000 Hz is also plotted in Fig. 4 and remains around 0.25 percent from 50 Hz to 10 kHz in mono. In stereo there is a small rise in THD at low frequencies to 1.3% at 50 Hz and at 10 kHz. The high frequency non-fundamental signal content is primarily low amplitude beats rather than actual harmonic distortion.

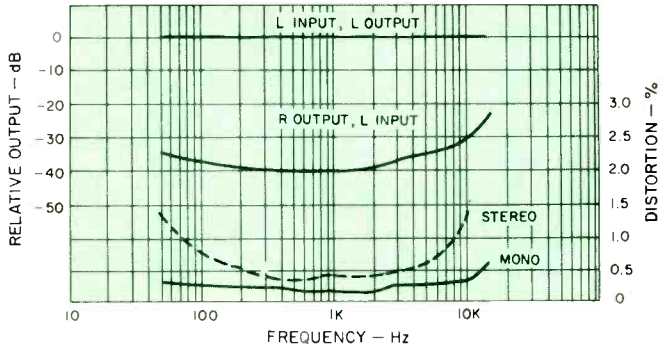

Fig. 4—FM separation and distortion versus frequency.

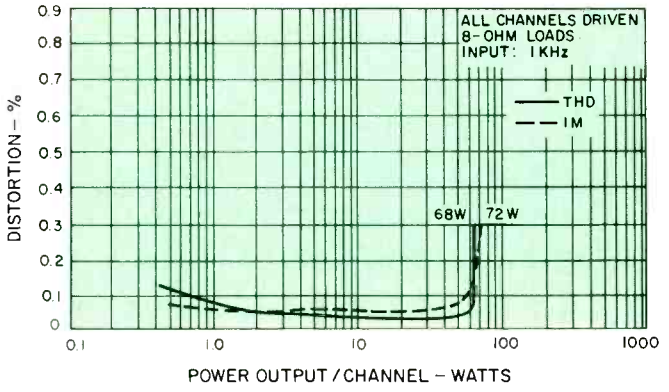

Fig. 5—Harmonic and intermodulation distortion characteristics.

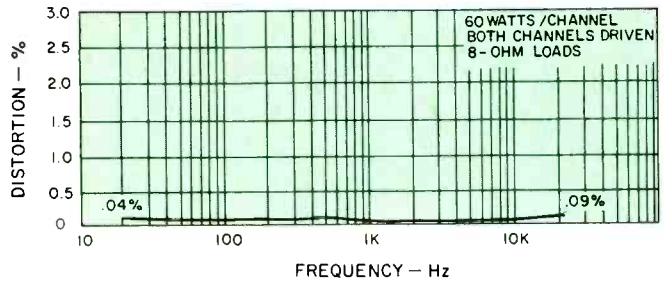

Fig. 6—Distortion versus frequency.

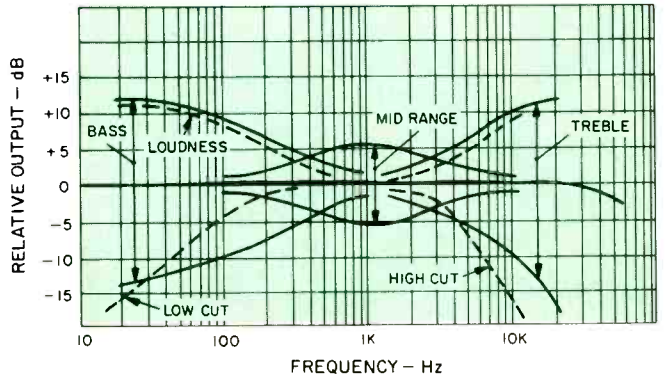

Fig. 7—Tone-control range, and filter and loudness circuit characteristics.

The AM sensitivity specification listed by Sansui is not a standard method of specifying AM performance, but if it is intended to mean 53 dB below 1 volt, that would be more than 2000 microvolts/meter. Actually the AM section measured about 250 microvolts/meter using the internal bar antenna, and about 50 microvolts sensitivity referred to the external antenna terminal and using a standard dummy antenna. This is about average for a two-gang tuning AM system such as that used here, and is adequate for most local reception.

Amplifier Measurements

At mid frequencies, the amplifier sections of the Model 881 produce rated output per channel (60 watts) with a mere 0.044% total harmonic distortion. Of course, this power specification now relates (in accordance with new FTC rules) to all frequencies from 20 Hz to 20,000 Hz, but we still find it informative to check power output capability at mid frequencies. In this case, 68 watts was produced at 1 kHz before THD reached the rated level of 0.3%, as shown in Fig. 5. IM distortion remains well under 0.1% for all power levels below 60 watts and reaches rated 0.3% at 72 watts per channel, all measured with both channels driven and into 8-ohm resistive loads. It should be noted that all power output tests were conducted *after* the receiver had been subjected to the required one hour of preconditioning at one-third rated power output delivered by each channel. No thermal cutout took place during this prolonged test, and in fact, heat sink temperatures were surprisingly low at the conclusion of this test. Even in terms of its stated full power bandwidth, the Sansui 881 is very conservatively rated, as can be seen from Fig. 6. At the 20 Hz and 20 kHz frequency extremes, the receiver delivered its rated 60 watts per channel with 0.04% and 0.09% THD respectively far below the nominal rated THD, 0.3%. Obviously, Sansui has no desire to tangle with the FTC, and we consumers can only benefit from such conservative design.

We measured RIAA equalization and found it within 1.0 dB from 30 Hz to 15 kHz, as stated. Tone control action, filter action, and loudness compensation at –30 dB are all plotted in Fig. 7. We feel that high-end compensation of the loudness circuit had too much emphasis, and preferred to do our listening, even at low levels, without the aid of this circuit, adjusting tone controls to suit our taste instead. Phono overload was an excellent 250 millivolts, fully 40 dB above nominal input sensitivity. The importance of this high overload capability has not been sufficiently emphasized in the literature, since it determines to a large extent the dynamic range which can be reproduced from records without audible distortion, independent of the output capacity of the power amplifier sections.

Hum and noise in phono was –64 dB (unweighted), which translates to –72 dB when using the "A" weighting curve. Residual hum and noise for the high level (*AUX* and *Tape*) inputs measured –82 dB, unweighted, while residual hum at minimum volume was a low 86 dB below full output level.

Amplifier and preamplifier sections performed flawlessly, providing extremely clean sound at all listening levels to our low-efficiency test speakers. Control action is good, with volume control audio taper just the way we like it. Tone controls have click-stop settings, as does the balance control at its mid-point. All front panel controls are smooth operating and each performs a useful function. The double tape monitoring facilities were used for dubbing from tape to tape with ease and are nice to have even if one tape deck is used, what with so many accessory items, such as 4-channel adaptors and noise reduction devices, available today which connect at tape monitor jacks.

FM reception was clean, drift-free and consistent with the other performance qualities of this powerful receiver. Calibration was perfect for both AM and FM and the center-of-

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Empire Does It Again!

Critics rave about our new 4000D/III* The Great 4 Channel/Super Stereo Cartridge

"...Here's a 4 channel/super stereo cartridge that tracks as low as ¼ gram. Frequency response starts at 5 Hz and goes straight to 50,000 Hz. Listening to it is incredible."

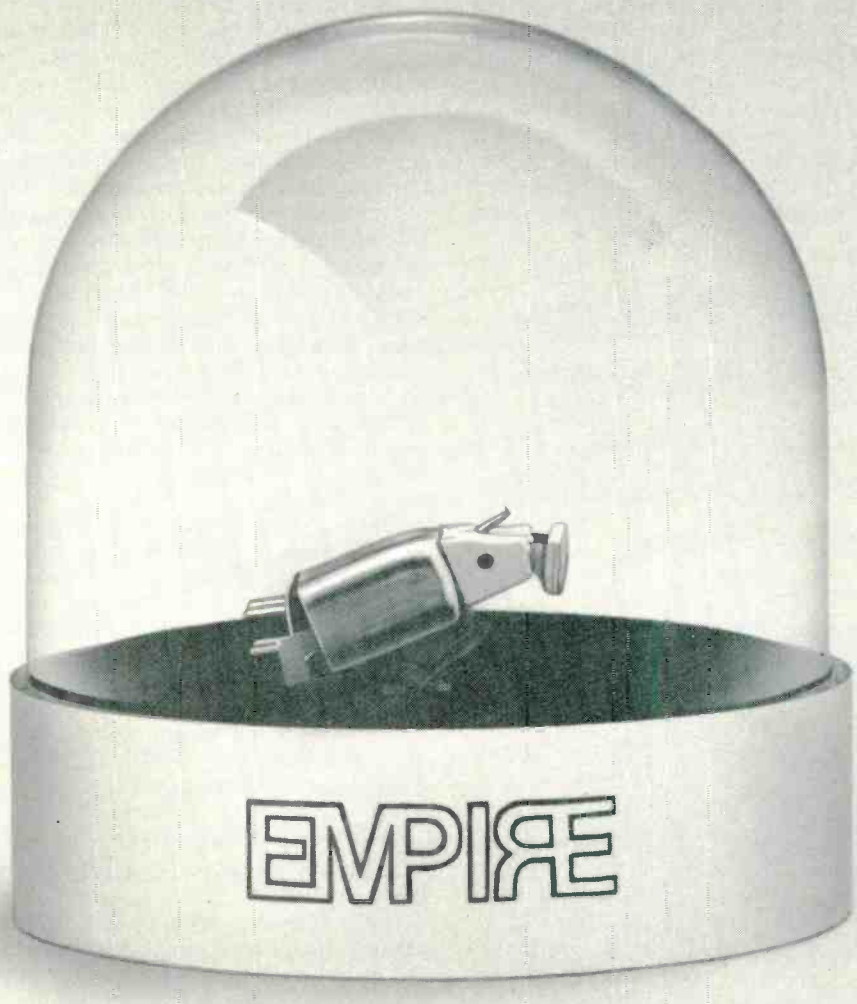
Martin Clifford, Modern Hi Fi & Stereo Guide

"...Tracked phenomenal 25 cm/sec. grooves at less than 1 gram. Goes right out to 50 kHz with less than 3 dB variation. Separation measured 35 dB (remarkable for any cartridge). Stereo and 4 channel reproduction was tops."

Len Feldman Labs, FM Guide

"...Empire's 4000 D/III provided excellent CD-4, matrix, or stereo playback with any demodulator or turntable we used. Channel balance was unusually precise. This cartridge tracked the torture bands of our test record well below 1 gram."

High Fidelity Magazine



4000D/III List Price $149.95. Other Empire cartridges from $29.95.
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EMPIRE

***Plays any matrix (SQ, QS, RM), discrete (CD-4), or stereo records.**

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channel meter corresponded perfectly with lowest distortion tuning point across the entire dial. Our criticism above of stereo threshold and muting threshold setting was reinforced during listening tests, for we lost some dozen stations that were acceptable from a noise and quality standpoint. Similarly, three stations known to be broadcasting in stereo were received only in mono because of the high stereo threshold.

We have always felt that the addition of a mid-range tone control is welcome in any system, since it affords the listener an extra degree of tone adjustment, which often can bring life to an otherwise dull recording or other program source. In the past we have objected to the availability of too much "presence" boost, and we feel Sansui has wisely restricted the mid-range action to ± 5 dB—just enough to do the job properly.

In summary, the Sansui Model 881 stereo receiver offers high power output at extremely low distortion, all the control features most listeners are likely to ever want, plus the convenience of high-quality stereo FM reception in a single, attractive package. All of this at a price of less than $500.00 makes the 881 an excellent choice as the electronic component of a top-grade stereo high fidelity system.

Leonard Feldman

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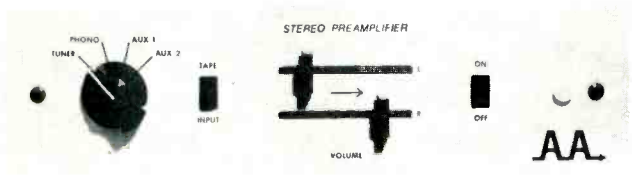
Ace Audio Zero-Distortion Preamp



MANUFACTURER'S SPECIFICATIONS

Phono Input

Sensitivity: 10 mV for 1 V output. **Input Impedance:** 47 K. **Harmonic Distortion:** 0.05% midband for 5 V output. **Hum and Noise:** 76 dB below 10 mV input. **Equalization:** RIAA ± 0.5 dB. **Overload:** 100 mV input. **High-Level Inputs** (FM, AUX 1,2)

Sensitivity: 1 V for 1 V out. **Hum and Noise:** 86 dB below 1 V input. **Input Impedance:** 50 K, no output load; 25 K, 50 K output load. **Low-Frequency Response:** Flat to d.c. **High-Frequency Response:** –3 dB at 67 kHz with –6 dB vol. set. (worst case), 190 pF output cables. **Output Load:** 50 K ohms min.

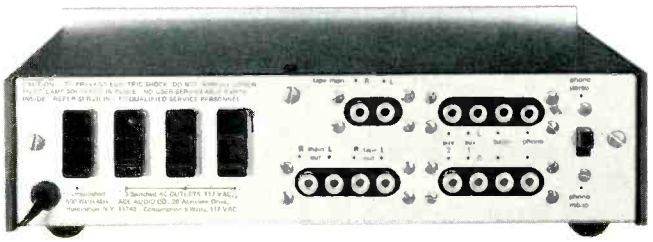


Fig. 1—Rear panel of Ace Audio ZDP Preamp.

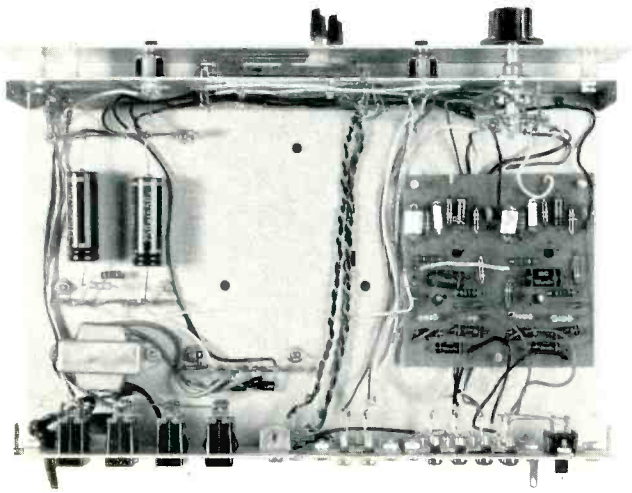


Fig. 2—Interior view.

General Specifications

Power Consumption: 3 watts, 117 V a.c. **Weight:** 3 lbs. **Size:** 11 in. W x 3 in. H x 8 in. D. **Price:** $74.95 kit; $99.95 wired.

The Ace Audio Zero-Distortion Preamp is an unusual product. As far as this reviewer knows, it is the only preamp presently on the market that has control functions and doesn't use a high-level output amplifier. Add-on phono preamps for use with amplifiers without magnetic phono inputs have been around since the advent of magnetic cartridges, but up to now, nobody has combined a basic phono preamp with a selector switch, tape monitor switch, and volume control. It is a good idea whose time has come.

This reviewer, along with others, has found that every amplifier used in the reproduction chain adds some amount of degradation to the reproduced sound. Since 40 dB of phono preamp gain is enough for most systems, a preamp with no output amplifiers and minimum controls is a *logical* idea and offers the *potential* of considerably improved record reproduction. The potential realized is a function of how good the phono preamp circuit itself is. This reviewer has made a longtime study of phono preamps which has included measurement and listening tests of many commercial units, as well as the design and listening evaluation of many discrete transistor, FET, IC, and tube circuits. Recent work with special tube circuits has shown that record reproduction can be considerably better than is being realized with present solid-state practice. Since there is a long way to go before phono preamps are perfected and since a product format, with no frills, such as the Ace ZDP, is an excellent way towards improvement, this reviewer hopes that more attempts at better phono preamp circuitry will appear on the market.

Physically the Ace Audio ZDP preamp is simplicity itself. The chassis is in the form of a shallow "U" with input and output connectors and a.c. convenience outlets on the rear section (see Figs. 1 and 2). The preamp circuit board and power supply are mounted in the main bottom area. The selector, tape monitor, and power switches, along with two separate volume controls and a pilot light, are mounted on the front sub-panel. A horizontally-grained, clear-anodized front panel is mounted to the front sub-panel with standoffs. The wiring is fairly simple and should not be very difficult to construct as a kit.

Circuit Description

Since the circuitry is quite simple, it is shown in its entirety in Fig. 3.

In the phono preamp circuit, Q1 functions as a common emitter stage that is direct coupled to the second transistor, Q2, also operating in the common emitter mode. The RIAA equalization network is direct coupled from the collector of Q2 back to the emitter of Q1 and this connection yields good d.c. circuit stability because it forms an overall d.c. feedback loop and presents a high d.c. resistance to the emitter of Q2. The a.c. closed-loop gain is set by the 150-

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We're not afraid to turn our back on you.

Introducing the RS 4744

We can afford to be very forward about our back.

Because the back of our RS 4744 stereo receiver is one of the most versatile you'll ever see. We've got phono inputs for two different turntables. And two sets of tape monitor input and output jacks. And terminals for main speakers, remote speakers, and PQ4 speakers. And three AC power outlets, one switched and two unswitched. The rest you can see for yourself in the picture above.

But what's behind our back is just as impressive as the back itself.

As *Popular Electronics** put it, the RS 4744 "met or surpassed all the published specifications we were able to test" and was "...well above average in the important performance aspects."

Take power, for example. *Popular Electronics* found the RS 4744 "conservatively rated" at 60 watts per channel, min. RMS at 4 to 8 ohms from 20Hz to 20kHz with no more than .25% Total Harmonic Distortion. Which made it "outstanding for a receiver in the RS 4744's price range." FM 50 dB quieting sensitivity was equally impressive—"a very good 3μv in mono and 35μv in stereo."

But don't take our word for it. Or their word for it. Go see the RS 4744 for yourself.

Back or front, any way you look at it, the RS 4744 is one fine stereo receiver.

*Popular Electronics, December 1974 Issue.

GTE SYLVANIA

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ohm resistor connected through the 50/6 capacitor to common. The power supply consists of a bridge rectifier and simple RC filtering.

The selector switch and tape monitor switching are about the simplest possible and, in fact, would be a good circuit to build into a box chassis for the serious listener who wants volume control and selection of several high-level sources. This reviewer uses just such a circuit with various phono preamps under test connected in as high-level sources.

One disadvantage of not having an output amplifier is that the high-frequency response of the circuit is a function of volume control value and setting and the capacity of the cable connecting the preamp output to the power amplifier input. This shouldn't really be a problem if the cable capacity is low and the lead length is kept reasonably short. Ace states the worst-case frequency response to be –3 dB at 67 kHz with the volume control at "6 dB down" from maximum using 10 ft. of Beldon 8421 cable.

Listening Test

The sound of the Ace circuit is similar to other high-quality transistor circuits. Mid- and high-frequency definition are good, though there is some high-frequency edge or "grit." Some other transistor circuits with less low-frequency distortion and phase shift are a bit cleaner and more defined. Overall, the sound is acceptably good, particularly if price is considered.

Measurements

Gain of the phono preamp was measured as 100X, or 40 dB, at 1 kHz. Equalization error with a non-inductive source is shown in Fig. 4. Equalization accuracy is very good from 200 Hz to 20 kHz, and the inaccuracy below 200 Hz, especially with a 10K load, is mainly due to a relatively small output coupling capacitor. It should be noted here that the manufacturer specifies 50K ohms as the proper load impedance for this preamplifier, though there are a number of popular amplifiers presently on the market which have 10K input impedances. This being the case, then, we elected to continue with out standard test conditions, which include testing with a 10K load as well as a Hi-Z load, to show what sort of problems may arise if the manufacturer's output load recommendations are not followed.

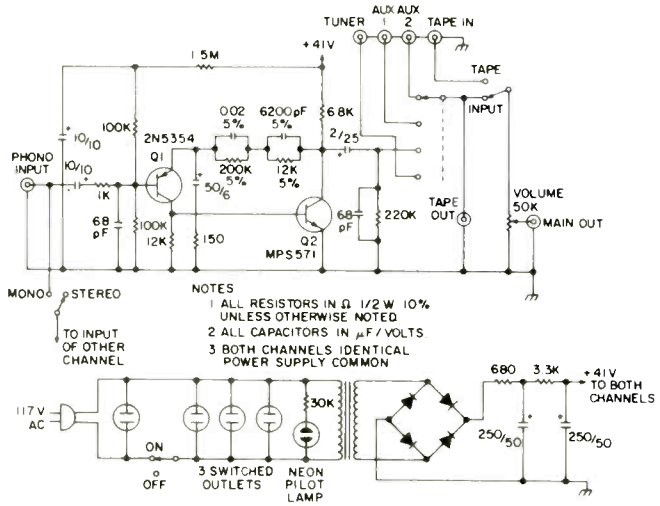

Fig. 3—Schematic diagram.

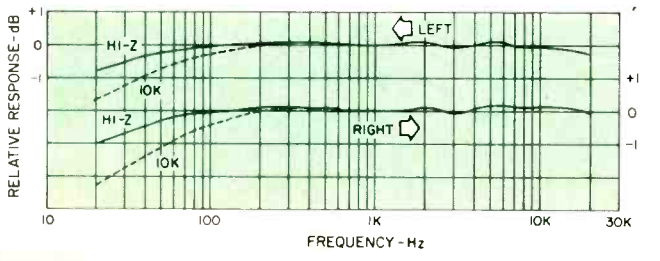

Fig. 4—RIAA equalization error with non-inductive source.

In the new test using representative samples of low- and high-inductance cartridges (see the Yamaha CA-1000 review in the Sept., 1974 issue), the response with the high-inductance cartridge was flat up to 10 kHz, rising to about +0.6 dB at 15 kHz, and +2 dB at 20 kHz. Response with the low-inductance cartridge was about +0.3 dB between 2 and 10 kHz, rising to +0.9 dB at 20 kHz. The effect of this would be to add a slight high-end brightness compared to another preamp that was flat or slightly rolled off in this test.

Square-wave response with input signal fed through an RIAA pre-equalizer are shown in Figs. 5 and 6. Fig. 5 shows the amount of low-frequency tilt at 40 Hz for a high-impedance and 10 K load. Figure 6 shows the response to 1 and 10 kHz inputs. Input and output have been overlaid for ease of comparison. Input frequency response has been limited to 50 kHz by limiting the input rise time to 7 μS.

Distortion data for the phono preamp is shown in Figs. 7 and 8. At working levels of 0.3 to 1 or 2 volts, the distortion is reasonably low. All measurements are for the right channel as it was the worse of the two; left-channel distortion was generally about 75 percent of the right. Distortion shown in Fig. 7 is for a 10 K load; with a high-Z load, it was lower at any output level. In this circuit, all distortion is more load sensitive than usual because of what appears to this reviewer to be a lack of enough loop gain to reduce these effects. In Fig. 8, the rise in distortion at low frequencies is due to the decreasing amount of feedback present. In the 5 to 20 kHz range, the rise in distortion is due to loading on the output stage of the feedback equalizer which is a reactive load of 2 to 5 K in this region.

Overload as a function of frequency and loading is shown in Table I. Overload was either the onset of clipping or, in the case of higher frequencies, visual abberation of the waveform other than clipping.

Input noise as a function of frequency and bandwidth with shorted inputs is shown in Table II. These referred input noises are quite good and would allow a transformerless Ortofon or Supex phono cartridge to be used if additional gain were available from the output section of another complete preamplifier. Hiss would be audible at the

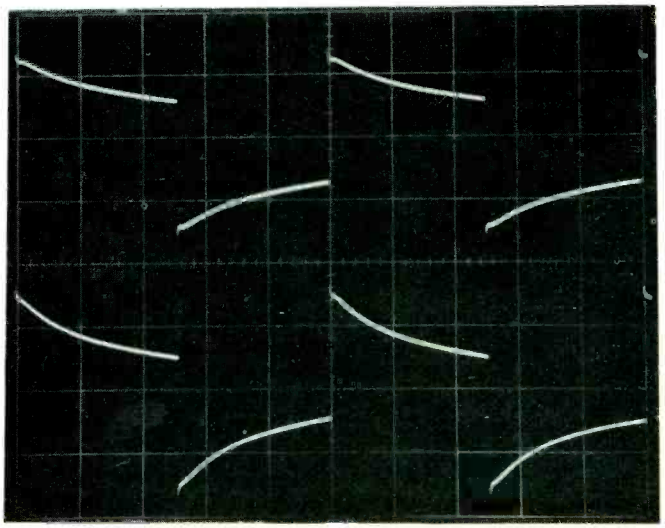

Fig. 5—40-Hz square-wave response: top, Hi-Z load, bottom, 10-K load; both 0.5 V/cm; 5 mS, cm.

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The Speaker.

Rather than starting with an existing speaker, Yamaha began with a speaker idea.

A speaker system with the lowest distortion and coloration, and the best possible transient response.

Instead of merely modifying one, Yamaha has re-invented it. And in doing so, has improved every aspect of speaker design.

We call it the NS-1000 M Monitor.

Transparency and The Dome. Existing technology has largely solved a major problem of speaker design through the use of the acoustic suspension driver: extended frequency response. Today, what's missing from most sound in most people's living rooms is something a touch more subtle. It's called *transparency*.

The hemispheric dome tweeter allows a wider dispersion of high frequencies.

But the dome's own material weight causes it to lag behind the input signal. It simply doesn't respond fast enough, creating an opaque, masked sound that lacks fine detail and definition.

The ideal dome material for midrange and high frequency drivers would be extremely rigid and, most importantly, virtually weightless.

Introducing the Beryllium Dome. Why did it take so long?

After all, beryllium is the lightest, and most rigid metal known, and has a sound propagation velocity twice that of commonly used aluminum.

Beryllium is lighter and stronger and propagates sound better than other metals.

	ATOMIC WEIGHT	RIGIDITY (ELASTIC MODULUS) kg/mm²	SOUND PROPAGATION velocity m/sec
BERYLLIUM (Be)	9.013	28000	12600
MAGNESIUM (Mg)	24.32	4500	5770
ALUMINUM (Al)	26.98	7400	6420
TITANIUM (Ti)	47.90	11000	5990
IRON (Fe)	55.85	19700	5950

But because of beryllium's inherent characteristics, it resisted attempts by any manufacturer to form it into a diaphragm, let alone a dome.

Until now.

The New Yamaha Beryllium Dome, formed by Yamaha's unique vacuum deposition process, is lighter than any other speaker diaphragm found today. So it's more responsive to direction changes in amplitude and frequency of the input signal.

Dome Tweeter Comparison

	SIZE OF DOME	THICKNESS	WEIGHT
YAMAHA NS-1000 M (BERYLLIUM DOME)	3 cm	0.03 mm	0.03 g
TYPICAL SOFT DOME	3 cm	0.3 mm	0.1 g
CONVENTIONAL DRIVER	2.5 cm	0.45 mm	1.03 g

This is called transparency. It can be noticed best in complex musical passages and can be best described as highly defined and finely detailed.

Only Yamaha has it.

Midrange: The Voice of Your Speaker. It's no secret that between 500 hz and 6 Khz is where most audible differences in speakers occur.

It's where we hear the human voice, and it is the hardest part of the frequency spectrum to reproduce accurately.

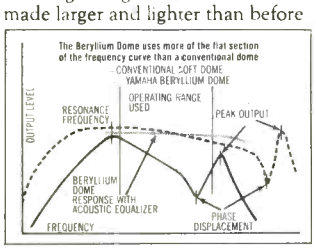
Once again, beryllium solves the problem of uneven response. Since it's so lightweight, the dome can be made larger and lighter than before possible for a midrange driver. It extends the linear portion of its response curve.

The midrange driver's frequency response is so wide that we can select only the choice flat section of its frequency response, thereby eliminating the peaks and valleys most competitors are forced to use.

The Beryllium Dome creates simply the flattest response; least colored, most natural sounding midrange of any speaker around.

Carefully designed acoustic equalizers flatten the frequency response curve even further.

The NS-1000 M Monitor is so accurate that you may even hear enhanced detail in a recording you once thought already perfect.



Re-thinking the Woofer. Some respected speaker manufacturers buy their low frequency drivers wholesale.

Yamaha doesn't buy them. We make them.

Even the very cone material itself was researched and developed and manufactured specially by Yamaha. (It's made much more dense than most cones. That means a tighter, cleaner sound.) And the frame is cast in our own foundry so we can control quality.

A plucked string of a bass sounds like a plucked string bass note.

Instead of a dull thud.

The Tangential Edge and Other Extras. Yamaha designed a special suspension system that holds the beryllium dome to the speaker frame with less contact allowing it to move more freely. It's called the Tangential Edge. (You may not hear the difference at first, but you will.)

The crossover system was specially designed to have a very low DC resistance, increasing the system efficiency.

Most highly accurate systems need a large amp to drive them properly. The NS-1000 M Monitor requires only 15 watts RMS to fill an average room with loud music, yet can handle RMS power outputs exceeding 100 watts.

By Our Own Skilled Hands. Yamaha's philosophy is one of self-reliance.

That's why, for example, we build the critical speaker components (like cone materials and speaker baskets) rather than purchase them.

That includes the speaker enclosure made from material designed for anti-resonance characteristics. (Our piano making experience was essential here.)

There are enough speaker system modifications and copies around, already.

This is something original.

Proudly Presenting the NS-1000 M. It's not inexpensive or easy to find.

The NS-1000 M is sold as right and left-hand units, and by the pair only.

They cost $960.00 the pair, when you can get them.

Yamaha is making them as fast as we can, but you may have to wait a short while until your Yamaha Audio Dealer has a pair for you to audition. (He also features Yamaha speakers based on the same technology and quality at less money.)

Patience, please.

Part of the Yamaha System. The NS-1000 M Monitor is the ultimate air suspension speaker system.

That is a strong claim to make.

In the future, Yamaha will present the ultimate power amplifier, tuner, preamplifier, and turntable. Actually advancing the state-of-the-art of the major components of a music reproduction system.

In short, the ultimate system.

We're convinced that no matter what you think is the best today, we'll make you dissatisfied with it.

Don't say we didn't warn you.

YAMAHA

INTERNATIONAL CORP., P.O. BOX 6600, BUENA PARK, CALIF. 90620

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very highest volume settings, but would be okay at normal listening levels.

Crosstalk of the phono preamp was measured on a pre-equalized basis and was found to be more than 80 dB down in the band from 200 Hz to 20 kHz, rising to −72 dB at 50 Hz, and to −63 dB at 20 Hz. This measured crosstalk of greater than 80 dB is truly excellent, and few if any preamp on the market today (particularly those with complete PC board wiring) can beat these figures.

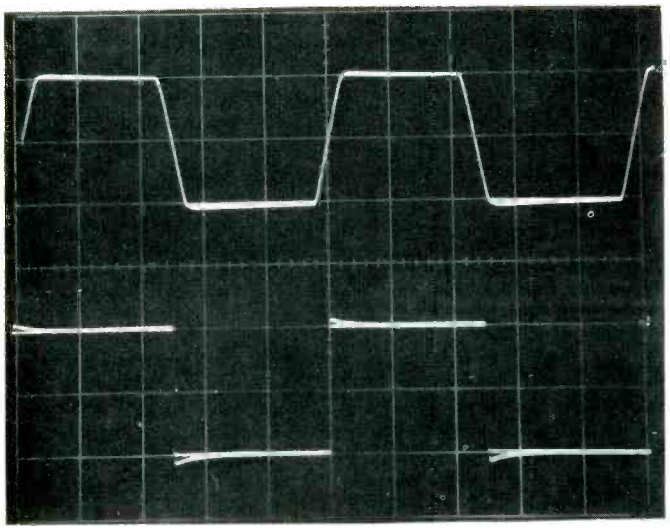

Fig. 6—Square-wave response: top, 10 kHz, 0.5 V/cm, 20 μS/cm; bottom, 1 kHz, 0.5 v/cm, 200 μS/cm.

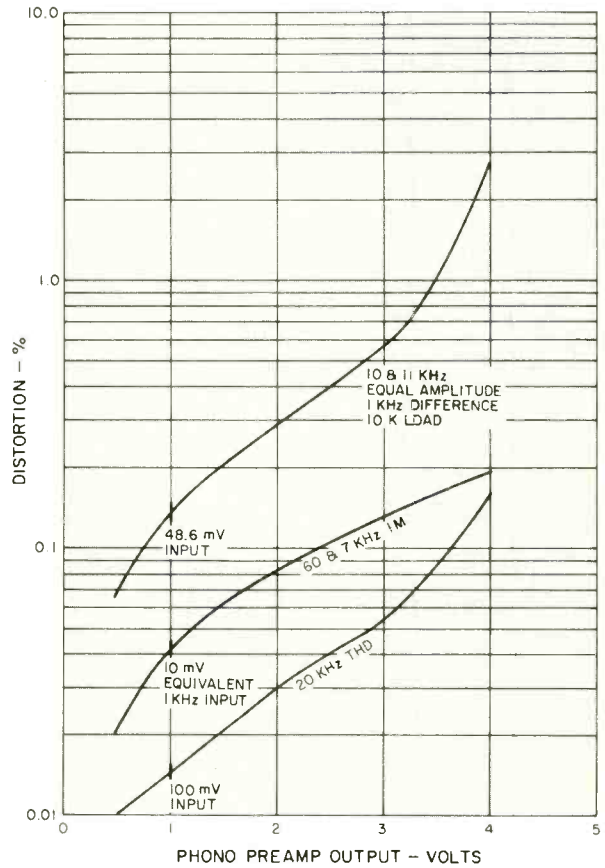

Fig. 7—IM and harmonic distortion versus output voltage.

At this point, this reviewer must comment on the use of the "zero distortion" wording in relation to this (or any other) device, as it is potentially misleading. The phono preamp circuit here does have some distortion, and indeed the manufacturer does spec its harmonic distortion at 0.05 percent at midband and 5 volt output. In addition, we had a small problem with the first of two units received for review in that some IM distortion was measured in the volume pots when current was drawn from their wipers and using the high-level inputs into lower than a 50K load. This was later found to be due to some oxidation of the control. Vigorous working of the pots apparently cleaned the contact surfaces, since no IM was then measurable. Generally, this effect should be negligible with volume and balance controls which are used dailv.

In conclusion, the Ace ZPD Preamp is a good product idea, and its performance is acceptably good, especially considering price. The ZPD's highest performance will be obtained when the unit is mated with a fairly high output phono cartridge, a power amplifier with an input impedance of 50K or higher, and speakers of at least moderate efficiency.

Bascom H. King

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Table I—Overload as a function of frequency and loading.

Frequency	Hi-Z Output	10-K Output	Hi-Z Input	10-K Input
Hz	V, rms	V	mV, rms	mV
20	12.0	8.0	12.9	8.6
100	12.5	9.5	27.6	21.0
1k	12.5	9.0	125.0	90.0
10k	7.5	6.5	365.0	316.6
20k	5.5	4.5	519.0	425.0

Table II—Input noise as a function of frequency and bandwidth with shorted inputs.

Bandwidth	Left	Right
Hz	μV, rms	μV, rms
20-20k	0.6	0.9
400-20k	0.25	0.27

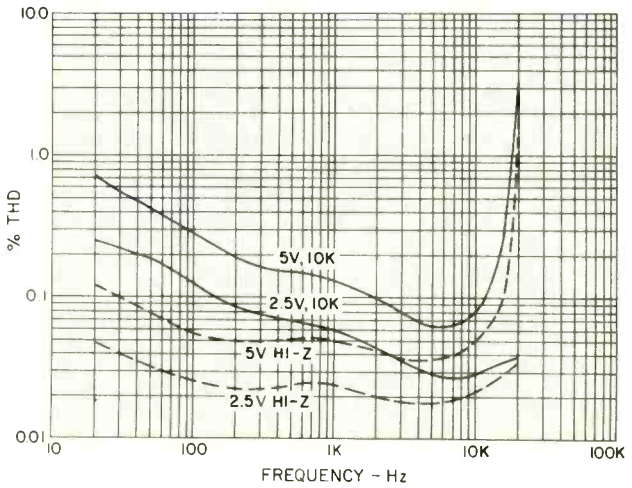

Fig. 8THD versus frequency, right channel, as a function of level and output load.

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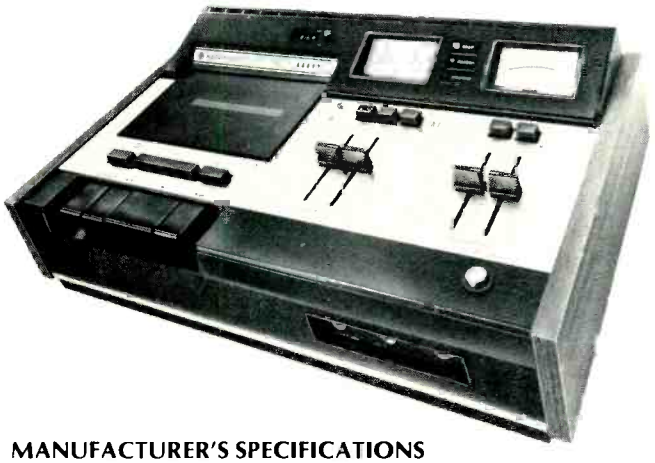
Kenwood Stereo Cassette Deck, Model KX-710



MANUFACTURER'S SPECIFICATIONS

Frequency Response: Low-noise tape, 30 Hz to 13 kHz; CrO_2 tape, 30 Hz to 16 kHz. **Signal/Noise Ratio:** 50 dB; 58 dB with Dolby and CrO_2 tape. **Input Sensitivity:** Line, 77.5 mV at 470k ohms; mike, 0.24 mV at low impedance. **Bias Frequency:** 85 kHz. **Wow and Flutter:** Less than 0.13%. **Motor:** DC servo. **Output Level:** Line, 490 mV. **Fast Forward and Rewind Time:** Less than 75 sec. (C-60). **Dimensions:** 15⅞ in. W. x 5 in. H. x 9-15/16 in. D. **Weight:** 11.7 lbs. **Price:** $249.95.

The Kenwood KX-710 cassette recorder offers a number of attractive features at moderate cost. One that is immediately apparent is the inclusion of good-sized, easily-readable VU meters mounted on an inclined panel at the back of the recorder. The scales are printed on translucent plastic illuminated from behind. This combines excellent readability with tasteful appearance. On the same panel are indicators for *Peak, Record* and *Dolby*, a 3-digit counter with reset button, and a moving tape-run indicator. Tape is inserted by placing it in a raised tray within the cassette well. It can then be positioned for playing by pushing down directly on the cassette, or on the outside plastic cover. In front of the well are the *Eject, Stop* and *Pause* buttons.

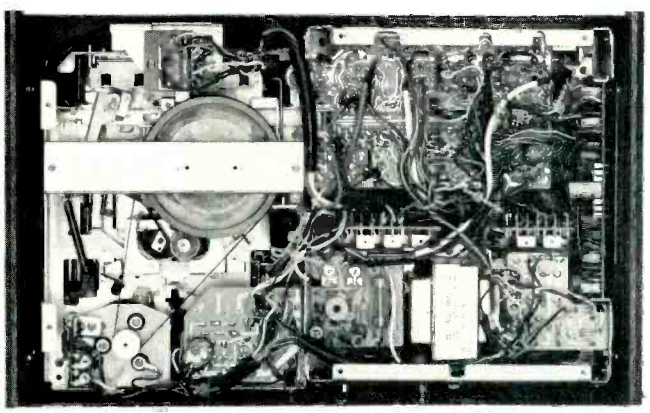


Fig. 1—Internal view.

Fig. 2—Back panel view.

Four piano-style keys control *Record, Rewind/Review, Play* and *Fast Forward/Cue*, with all functions adequately interlocked. A feature of special interest on the KX-710 (and the more expensive KX-910) uses the *Rewind* and *Fast Foreward* keys in a new way. In *Play* mode, pushing down the *Rewind/Review* key will rewind the tape, so long as the key is held down. Immediately upon release, the key springs up and the recorder resumes *playing* the tape. Pushing down the *Fast Forward/Cue* key when in *Play* will fast forward the tape until the key is released. The machine then returns to *Play* mode. With this capability, rapid shuttling and searching for beginnings and endings is greatly facilitated. In *Cue* mode a small signal is fed to the output to provide audible clues at the beginning of a recorded program. All in all, a laudable feature.

In front of the VU meters are two indicator lights and five push-button switches. The two indicators, *Normal* and *Chrome*, show the status of the recorder's equalization. The adjacent switch is in *Auto Tape* mode when it's up and *Chrome* tape equalization when it's down. Usually the button would be left up, providing equalization for current low-noise tapes, but automatically switching to correct equalization for chromium dioxide cassettes. There is a little indicator hole in the back of the new chrome cassettes detected by a feeler arm inside the KX-710 cassette compartment, which activates the switch for CrO_2 equalization. If older chrome cassettes without the detection hole are to be recorded, correct equalization is obtained by depressing the button to *Chrome*. For playing older cassettes already recorded, however, *Normal* with the button up is recommended.

Next in line are the *Memory* and the *ALC On-Off* switches. Although Kenwood refers to the latter function as Automatic Level Control, and gives a description of that in the instruction manual, it is really a *limiter* which is actually of more use to the high-fidelity recordist.

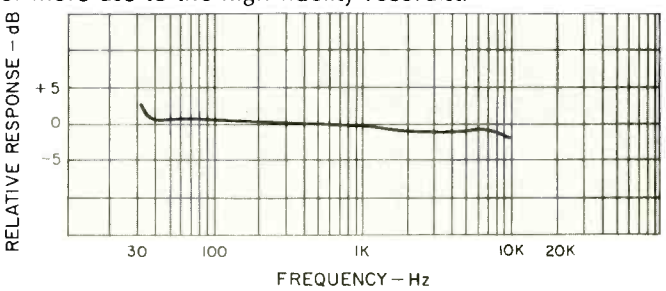


Fig. 3—Playback response using a standard DIN tape.

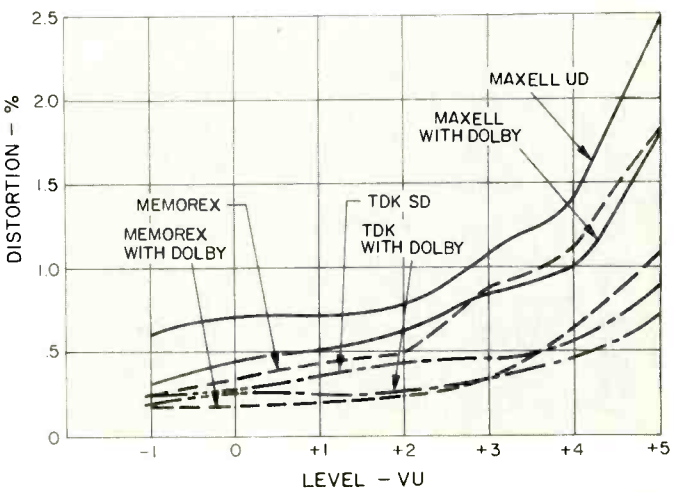


Fig. 4—Harmonic distortion at 1 kHz. Three tapes, each with and without Dolby.

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There is, of course, a Dolby On-Off switch. In addition, the Dolby FM/Copy On-Off switch permits listening to Dolby-encoded FM broadcasts in decoded form, while at the same time recording the received signal in its Dolby-encoded form. Slide-type controls are provided for setting record and output levels. On the front side of the deck are two phone jacks for the microphone inputs and a stereo phone jack for headphones. Plugging in the microphones will disconnect the associated line inputs, located on the back of the deck with the line outputs. The On-Off power switch is located on the front-right corner of the main panel. Power-on is indicated by illumination of the VU meters.

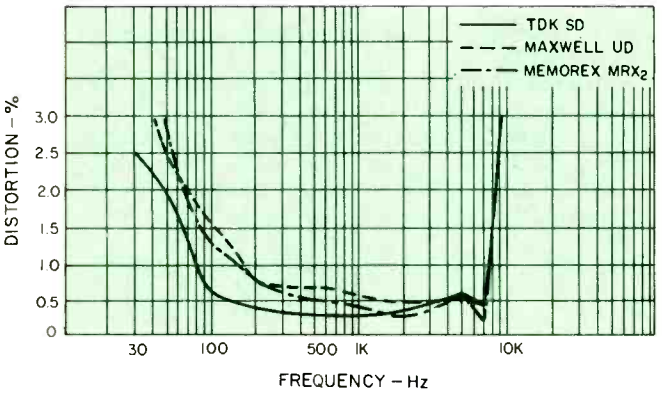

Fig. 5—Distortion across audio spectrum, three tapes.

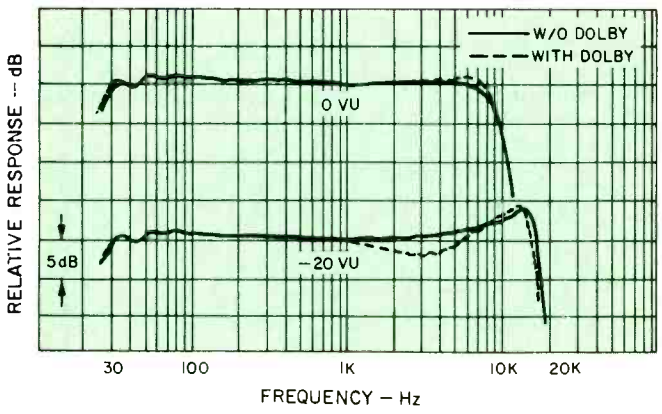

Fig. 6—Record/Playback response, Maxell UD tape, with and without Dolby.

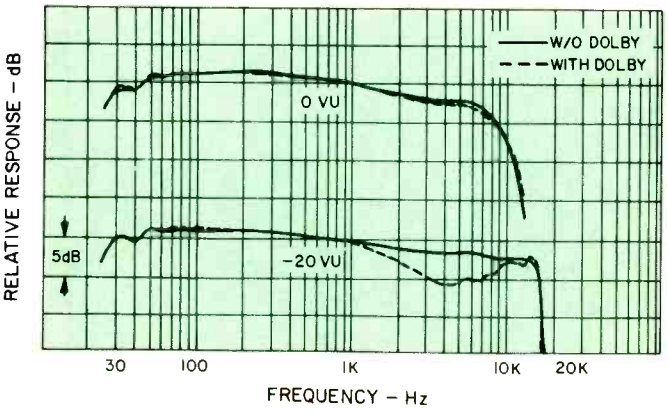

Fig. 7—Record/Playback response, TDK KR (Chromium dioxide) tape, with and without Dolby.

Performance

The Kenwood performed well in all of the tests and met or exceeded most all of its specifications. Playback response using a standard DIN tape is seen in Fig. 3. It shows maximum deviations of +2.8 dB at 31.5 Hz, and –2.0 dB at 10 kHz—all other points were within one dB. The recorder showed good Record/Play response with Capitol Music Tape, being within 3 dB from 26 Hz to 15 kHz at –20 VU and having fairly good headroom at 0 VU—being –3 dB down at 7.5 kHz (both without Dolby). Kenwood specifies 30 Hz to 13 kHz for low-noise tape, with no tolerance given. With the Dolby system in use the high-frequency response was not quite that wide. Memorex MRX_2 had fair headroom at 0 VU, –3 dB at 6.5 kHz. At –20 VU the response extended from 26 Hz to 14.1 kHz.

Record/playback response using TDK KR tape (which activated the auto-switch to *Chrome* equalization) was 3 dB down at 7 kHz for 0 VU, and within ±3 dB from 26 Hz to 15.7 kHz at –20 VU. Kenwood does not state the deviation for the specified 16 kHz response with CrO_2 tape, but in any event 15.7 kHz is so close to 16 kHz that no one's ears could tell the difference.

The KR-710 showed low distortion at 1 kHz for most low-noise tapes. Figure 4 shows the results with three tapes, Memorex MRX_2, a high density gamma ferric oxide tape, Maxell UD, and TDK's SD tape. Harmonic distortion checks were also made at 0 VU from 30 Hz to 10 kHz with several tapes, shown in Fig. 5. The curves show (typical) minimum distortion between 100 Hz and 9 kHz, with usual increases at the frequency extremes. The average A-weighted signal-to-noise ratio for six low-noise tapes was –47 dBA without Dolby noise reduction, and it was –53 dBA with Dolby, both referred to 0 VU. Using 2 percent distortion as a reference for the maximum level would result in a 4-dB increase in these figures for most of the tapes used in the testing, very good performance for a machine in this price category. With the TDK KR chrome type the signal/noise ratio was 49.7 dBA referred to 0 VU, where the distortion was 2.7 percent. With a 3 percent distortion level reference the ratio was just over 50 dBA, the specification. Using Dolby, the signal/noise ratio was 56.7 dBA using the 3 percent distortion reference, slightly less than the specified 58 dB for chrome tape and Dolby operation.

The erase figures obtained were the same as those for signal-to-noise ratio, demonstrating the ability of the unit to erase a 0 VU signal to below residual record noise. The measured crosstalk of –42 dBA was more than adequate. Our best flutter measurement was 0.04%, and 0.13% the average with DIN weighting or about 0.05% NAB. Average rewind time was 74.5 seconds, just within the 75-second specified. Tape speed was just over 1% fast with 120 V a.c. power.

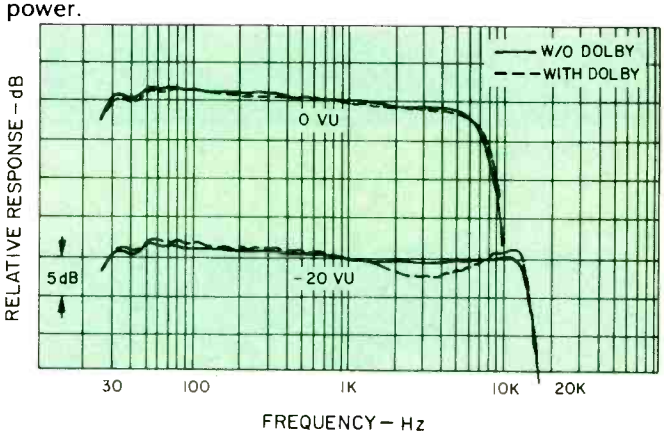

Fig. 8—Record/Playback response, Memorex MRX_2 tape, with and without Dolby.

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The drive signal output to the headphone jack was 34 mV across 8 ohms, a bit on the low side, and would require the use of sensitive phones to get good listening volume. *Microphone* input sensitivity of 0.20 mV was somewhat better than the specified 0.24 mV, while *Line* sensitivity was 78.5 mV, very close to the specified 77.5 mV.

The output for 0 VU indication playback was 460 mV, just a little lower than the specified 490 mV, but the level could be increased above this with the output controls. The VU meters were well matched and quite accurate over a range of input levels.

To test the dynamic action of the VU meters, tone burst signals were fed into the *Line* input. The amplitude was such that the meter needles would have deflected to 0 VU had it been a steady signal. Initially the bursts were so short that the needles didn't budge. As the duration of the signals was increased, the needles then began to move slightly, and when the length of the tone burst reached 110 milliseconds the needles showed 0 VU. The *Peak* indicator turned on when each channel was driven at +4.5 VU, with a turn-on time of 1 mS or less.

To prevent the 19 kHz pilot tone of FM stereo signals from adversely affecting Dolby action, a sharp notch filter is used to remove the 19 kHz signal. The Kenwood's response at the Dolby FM copy output jack was plotted. This proved to be flat from 23 Hz to above 20 kHz, excepting an extremely sharp dip of 45 dB at 19 kHz.

In-Use Tests

Personally, I found the combination of the easily-readable well-performing VU meters and the fast-responding peak indicator very easy to work with. The limiter started compressing the input at −12 VU. At a level of +20 VU referred to the normal 0 VU, the actual record level was just +2 VU.

The tape-motion controls required firm pressure for actuation, and were completely reliable throughout the testing. The slide controls used for record and output levels had a smooth, high quality feel which aided in all phases of recording and playback.

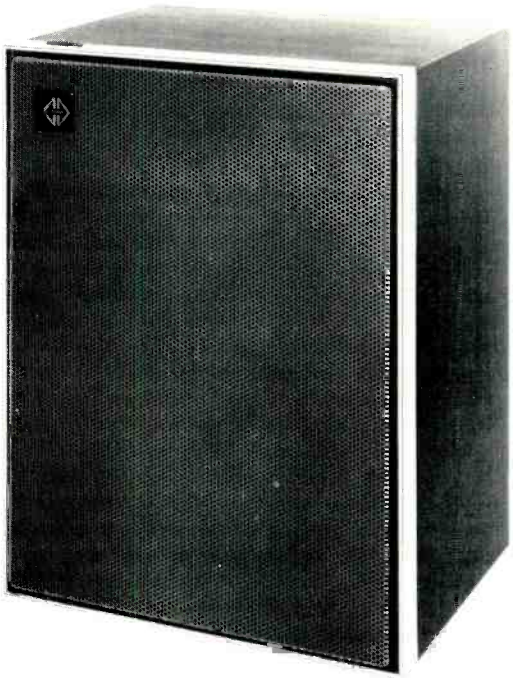
The instruction book is sufficiently detailed for most users, and a schematic is supplied with sections and functions clearly identified. General construction of the unit is good with ready access to a considerable portion of the circuitry with simple removal of the bottom cover.

Listening tests were conducted using copies made of tape originals of a trumpet and tympani fanfare and a Bach organ toccata. Memorex MRX_2 provided basically same-sound playback for both of the selections. Maxell UD was judged to be slightly better for the organ work, but seemed very slightly dulled on the trumpets. Overall, the reproduction of both selections was very good for most of the tapes tried. Try the Kenwood KX-710 with some of the new low-noise tapes, and you'll have a winning combination.

Howard Roberson

Check No. 72 on Reader Service Card

Philips Model RH-532 Motional Feedback Speaker System



MANUFACTURER'S SPECIFICATIONS

Frequency Response: 30 to 20,000 Hz. **System Type:** Three way with one 8-in. woofer, one 5-in. midrange, and one 1-in. tweeter. **Crossover Networks:** Active crossover at 500 Hz, passive crossover at 4 kHz. **Amplifiers:** Two, self-contained; bass unit 40 watts, mid and high frequency unit 20 watts. **Power Consumption:** 150 watts maximum at 117 V 60 Hz. **Size:** 11¼ in. W x 15 in. H x 8¾ in. D. **Weight:** 26 lbs. **Price:** $365.00 each.

Big sound doesn't always require big boxes. Perhaps there is no better example of this than the new Motional Feedback System now marketed in this country and manufactured by Philips of Holland. With the unassuming title of RH532, this diminutive enclosure houses a three-way loudspeaker system, two power amplifiers with a total output of 60 watts continuous sine wave power, electronic and passive crossover networks, and a special electronic sensor to monitor and control the woofer excursion. The result is an innocent looking small box that can startle you with the volume of good sound it can produce. The first ads that appeared on this system refer to it as a David among Goliaths. Jack the Giant Killer would perhaps have been as apt a title.

The enclosure itself measures 15 x 11¼ x 8¾ in. (378 x 283 x 212 millimeters if you choose to think metric). The top, bottom, and sides are finished in natural walnut, and a metal grille covers the entire front. When you pick it up to see what's on the back you realize that this is no ordinary enclosure, since it weighs a hefty 26 pounds. The rear of the cabinet does not have the familiar terminals for loudspeaker connection. Instead there are four phono connectors, two line-cord connectors, two push-button switches, one three-position slide switch, and three fuse connectors, all neatly labelled.

In addition to a very readable instruction manual, Philips supplies a 10-ft. a.c. cable, two two-channel 30-ft. audio signal cables with phono plugs at each end for connection to a pre-amplifier, and a 6-in. adaptor cable with phono sockets at one end and spade lugs at the other end for application to output terminals of a power amplifier if you wish to hook this unit onto an existing amplifier system.

The system is hooked up in the following manner. After placing the speakers where you want them to be for the best sound, the 30-ft., dual-wire, audio signal cable is plugged into the phono receptacles marked *In L-R* on the rear of one enclosure. The second such signal cable is then plugged into the receptacles marked *Out L-R* on this enclosure and run over to the *In L-R* of the second enclosure in the stereo set-up. The first cable is then run over to your signal source, either a pre-amplifier or a power amplifier output. In this way, the signals from the audio source are routed through one system to the other.

A push-button selector switch adjacent to the signal input lines lets you determine whether the speaker is to res-

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(Continued from page 67)

pond to the left channel signal or the right channel signal. Immediately below this is a three-position slide switch which allows you to control input sensitivity and source selection. The first position is labelled *Pre-Amplifier 1 V*, the second is labelled *Med. Power Amplifier 7.5V*, and the third is *High Power Amplifier 19 V*. If you are using a pre-amplifier source, then the first position is to be selected, with the other two positions reserved for those situations where you may be connecting to a power amplifier output.

Because this motional feedback system has self-contained amplifiers, the a.c. line cord is plugged into the receptacle provided. If you only have one utility outlet available near the speakers, Philips has provided an unswitched outlet that is in parallel with the input receptacle. The line cord from one speaker can then be plugged into the outlet on the second speaker, and the line cord from the second speaker run to the utility receptacle.

A red push-button on-off switch then lets you turn on the system. It here another example of Philips ingenuity crops up. When you push the power switch "on" with no audio signal applied, nothing happens. Instead of applying power to the self-contained amplifiers, a signal-sensing circuit is activated. After that any time you want to turn on the Philips loudspeaker system all that is required is to give it an audio signal. Snap, on goes the amplifier. What appears to be an innocuous piece of plastic on the grille now reveals itself as a pilot light which illuminates a Philips logo and lets you know that power is on. The power will stay on for two minutes or longer after the audio signal disappears. The signal level required to activate this turn on for the *Pre-amp* position was measured at 1.6 millivolts, which is high enough to be well above any hum level in the signal line and low enough to catch any signal that is audible.

In these days of concern for energy consumption, ecology-minded folks might feel uneasy about the use of this automatic turn-on feature as it is always drawing current. A clamp-on current probe revealed that the sustaining current of this signal-activation circuit is about 150 mA at 117 V, which amounts to 17.5 watts of continuous power consumption per speaker or slightly over five times that of a normal electric clock. Certainly the circuitry is to be admired as an example of Philips ingenuity, and if one is concerned about this amount of current draw, the system can be powered through a switched outlet on the preamplifier. The line current drawn by this system is low enough to be handled by any switched outlet capable of handling 300 watts.

The single most innovative feature about this system is the circuitry which gives rise to the name "Motional Feedback System." A piezo-electric element is incorporated in the center of the woofer cone. This miniature accelerometer is used to compare what the cone is actually doing relative to what the input signal wants it to do. The signal from this comparator is then applied to the self-contained bass amplifier to correct any differences. According to Philips, this not only results in lower distortion for the sound out of the woofer but an extremely smooth low frequency response which in a conventional system would not be possible from even much larger enclosures.

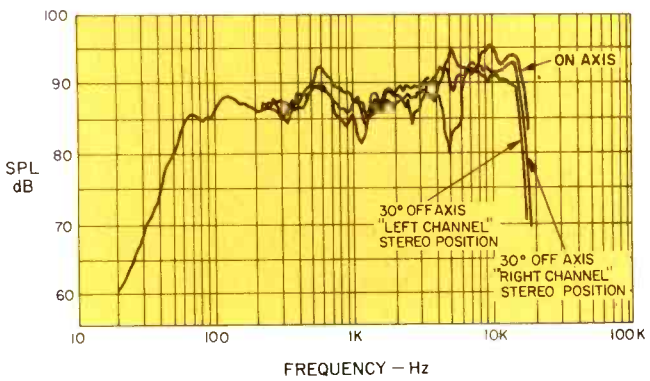

Fig. 1—One-meter anechoic sound pressure level.

While the concept of feedback from the speaker cone is well established in the audio art, Philips has developed a compact commercial version that appears to do everything claimed for it. The 8-in. woofer, mounted in a very small sealed volume, puts out a startling amount of bass for its size; the sealed volume *plus* the complete electronics are housed in the small enclosure!

The internal electronics consists of a 500-Hz electronic crossover ahead of a 40-watt bass amplifier and a 20-watt treble amplifier. A more conventional 4-kHz passive crossover is used to separate the 1-in. tweeter and the 5-in. midrange.

Philips provides a warranty that the system is free of defects in material and workmanship for a period of one year from date of purchase. To utilize this warranty the complete unit should be returned postage prepaid and insured to North American Philips Corp. or authorized service station for examination. All parts which prove to be defective under normal conditions of use will be replaced under the warranty at manufacturer's option.

Technical Measurements

Because the Philips Motional Feedback system uses a self-contained amplifier, the input impedance is independent of frequency and is determined by the input mode selector switch on the rear of the speaker. The most sensitive input has an impedance of 3K ohms. The medium-power amplifier input, for connection to moderate power amplifiers up to 45 watts per channel, measures 27 ohms. The high-power amplifier input, for connection to sources of 45 watts or higher measures 25 ohms.

The one-meter anechoic amplitude frequency response is shown in Fig. 1. Three measurements are shown, corresponding to on-axis, a 30-degree left-channel-stereo location, and a 30-degree right-channel-stereo location. The on-axis measurement has a slightly stronger high-frequency response than either of the off-axis measurements. The spectral balance for all three measurements is exceedingly good. The low bass remains good down to about 55 Hz, then rolls off at around 18 dB per octave below that frequency. There is still a respectable output even at low C or 32 Hz, which completely belies the diminutive size of this speaker system. It has a lot of bass for such a small system. The general trend in response is slightly increasing at a rate of about 1 dB per octave from 60 Hz to 18 kHz. The only indication of resonance peaks are minor ones at 5, 10, and 15 kHz in the on-axis anechoic response.

Special attention should be paid to the very smooth high frequency response of the left channel measurement. In the RH532 the tweeter is to the left of the midrange, as seen by the listener. The acoustic position of the tweeter, by measurement, is approximately 1.3 in. in front of the midrange driver. When this speaker is used in a left-channel position, the extra time delay of the sound from the outboard tweeter is just enough to cancel its forward acoustic position—giving an extremely smooth transition in the frequency response. The measurement indicates therefore that there is a slight preference for left-channel smoothness when the system is mounted in the normal or erect position with the illuminated Philips logo on top. Slightly better overall sound will be obtained if it is possible to mount the right channel speaker upside down. Because this system looks the same inverted as it does erect, except for the illuminated logo, this may be feasible in many living room situations.

The on-axis anechoic phase response is shown in Fig. 2. The woofer and midrange are in phase, that is, a positive-going voltage applied to the input will produce an in-phase positive-going sound pressure for the direct speaker sound. The tweeter has a 180-degree leading phase for the same input signal. The indicated acoustic crossovers are at slightly above 600 Hz and about 7 kHz. Two measurements are

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Live Electronic Music. Richard Grayson, Tom Oberheim. **Orion ORS 74142,** stereo, $6.98.

A modest and unusually interesting electronic music recording here. Forget the somewhat overblown backside plug—everybody's a genius on his own record. The man Grayson, though, does have a lot going. An excellent innate musical ear, a fine sense for harmony (sounds organized into semi-consonant overtone relationships), harmonic color (the same assembled in striking ways), and rhythm (patterns in time). Also, fleet fingers. He can improvise, make up music on the spot based on tunes suggested to him, in various styles and manners. Nothing really so unusual—every good pianist should be able to (and once was), though few now can. Added to all this, and of his own young generation, he has a natural sense for the electronic medium's expression, even unto live piano. He makes up electronic music on the plain piano, unadorned, and it *sounds* like electronic music. Not the sounds so much as the way it is put together.

Also, he plays harpsichord, with added delay, and also—very easily—via the loudspeaker and a host of now-standard synthesizer functions manned by his colleague Tom Oberheim, engineer. Remember John Field and Muzio Clementi? Field, the Irish piano genius of the early 1800s, played (and improvised) on Clementi pianos in London. Clementi made 'em and sold 'em, with the aid of Field's demos. Here we go again.

These two give live concerts, to much *ooh* and *ah*. Good. Their stuff is real. I liked Grayson's piano bit in the manner of Satie, via Beethoven's 9th Symphony. Very easy and well styled. I liked his piano rhythmic transitions called *Rain*, strictly out of electronic music (and merging with the same). His time-delay-harpsichord neo-Bach, after the *Prelude in C*, is remarkably interesting as fluid color harmony in the Bach arpeggio pattern, not re-

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motely like Bach himself and quite original in its coloristic organization. Not surprisingly, engineer Oberheim—who also manufactures the ring modulators, phase shifters, sequencers here used—has a musical background and has sung with the Gregg Smith Singers and the Roger Wagner Chorale, both highly pro. It takes a musician to make music, even via a ring modulator.

Actually, these little pieces are etudes in the classic sense, each economically concerned with a different aspect of the electronic vocabulary. I'd call it an excellent teaching aid for schools, colleges, where similar equipment is on hand for music production. Music is a lot more than diddling around with a lot of fancy controls! All *that* proves is that the machine works. Gotta do better—here's how.

(Continued from page 26)

with the same result. I drew only a withering smile from the factory representative at such an unthinkable thought. And a quick and very deferential reprisal. If, of course, you had brought the machine to us in the first place . . . but as it is . . . Correct, entirely correct! And my private thought is that if they *had* made the original mistake I might even have achieved a free repair. They, too, have pride in their own workmanship. But now I will never know.

I will have to admit that the first motor, failing in the slow speed as did the second one, nevertheless took a whole year of gradual deterioration in its torque before its slow speed quit, leaving the fast speed OK. Whereas the second motor's slow speed apparently failed in seconds, leaving its high speed intact. And the grinding noise was new. The first motor simply got quietly tired and wouldn't start unless I first went to the high speed, then back to slow. No grinding. Mysteries.

Anyhow, now all is well and I've been working again with the machine, at last, and with both speeds. It's pleasant! About time. There are moments like this when you feel that RESULTS, positive and definite, are worth any price at all. I think I'd pay six times as much instead of three, just to be able to get back to work this way. I feel GOOD.

P.S. Something has just been bothering me. Do I notice a very faint grinding sound in the new motor when it runs at the slow speed—which goes away at the fast speed?

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PROFESSIONALS TALK ABOUT THE NEW MARANTZ TUNER AND AMPS.

"The Marantz 1070 integrated amp is close to optimum in performance and the low price makes it an even better value."

In December, 1974, sound engineers and audiophiles were invited to examine and discuss the new Marantz Stereo Console Amplifiers featuring models 1040 and 1070 and the new Marantz 112 AM/FM Stereo Tuner. The following comments were taken from that taped discussion.

The 1070 Stereo Amp

"As far as good basic features are concerned, it's comparable to units costing twice as much."

"It maintains all the features of the Marantz 1060, plus it adds a number of its own. For instance, it now has graphic slide-type tone controls, two tape monitors and a versatile tone mode selector switch."

"With the 1070 you have a full range of tone controls like bass, mid range and treble slide controls plus preamp out and main in jacks."

"I feel strongly about the preamp out jacks. You can re-equalize tape recordings, insert equalizers or even add electronic cross-overs into the chain."

"One major feature that I like in the 1070 is its ambience circuitry. Essentially it's a speaker matrix or pseudo 4-channel. This means you can get into simulated 4-channel sound by just adding a second pair of speakers."

"In addition to the step up in power to 35 watts continuous power per channel at 0.3% total harmonic distortion, 20 Hz to 20 kHz both channels driven into an 8 ohm load, the circuitry is direct coupled."

"The circuitry is now full-complementary direct coupled to the speaker terminals. As a result, the damping factor is much improved at low frequencies where it counts."

"The output circuitry now includes a speaker protection relay circuit and turn on delay."

"There's improved thermal stability. This buys long term reliability as well as improved performance."

The 1040 Stereo Amp

"The new 1040 integrated amp is rated at 20 watts continuous power per channel at 0.3% total harmonic distortion. 20 Hz to 20 kHz, both channels driven into an 8 ohm load."

"It also has the ambience circuitry for simulated 4-channel. Most all of the features of the 1070 are on the 1040."

"It's an excellent performance component for a modest price."

The 112 Tuner

"It's got phase lock loop, a Dolby* de-emphasis switch and a number of other high-performance features. There're no gimmicks in it. Every feature is practical."

"A complete system including the 112 tuner plus either the 1070 integrated amp or the 1040 integrated amp gives performance you couldn't get in most receivers and still costs less than $500."

The Marantz 1070 Amp, 1040 Amp and 112 Tuner are just part of the exciting new Marantz component line starting as low as $199.95. Each of them reflects the kind of technical expertise and engineering excellence that has made Marantz the choice of professionals world-wide. Stop by your local dealer and see the entire Marantz line featuring an exclusive three-year guarantee** on parts, labor and performance specifications.

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CrO_2 Tape Position	40Hz – 13kHz (+2/–4dB) (+2/–3dB)	50Hz – 12Hz ±3dB
S/N Ratio (Weighted, Signal level 250 pWb/mm):		
Without Dolby†	50dB or better	49dB or better
With Dolby (Above 5 kHz)	58dB or better	57dB or better
THD (0 VU at 1 kHz) Normal Tape Position	2.0% or better	2.3% or better
Speed Accuracy	Within ±1.5%	Within ±2.0%

†Dolby is a trademark of Dolby Laboratories Inc

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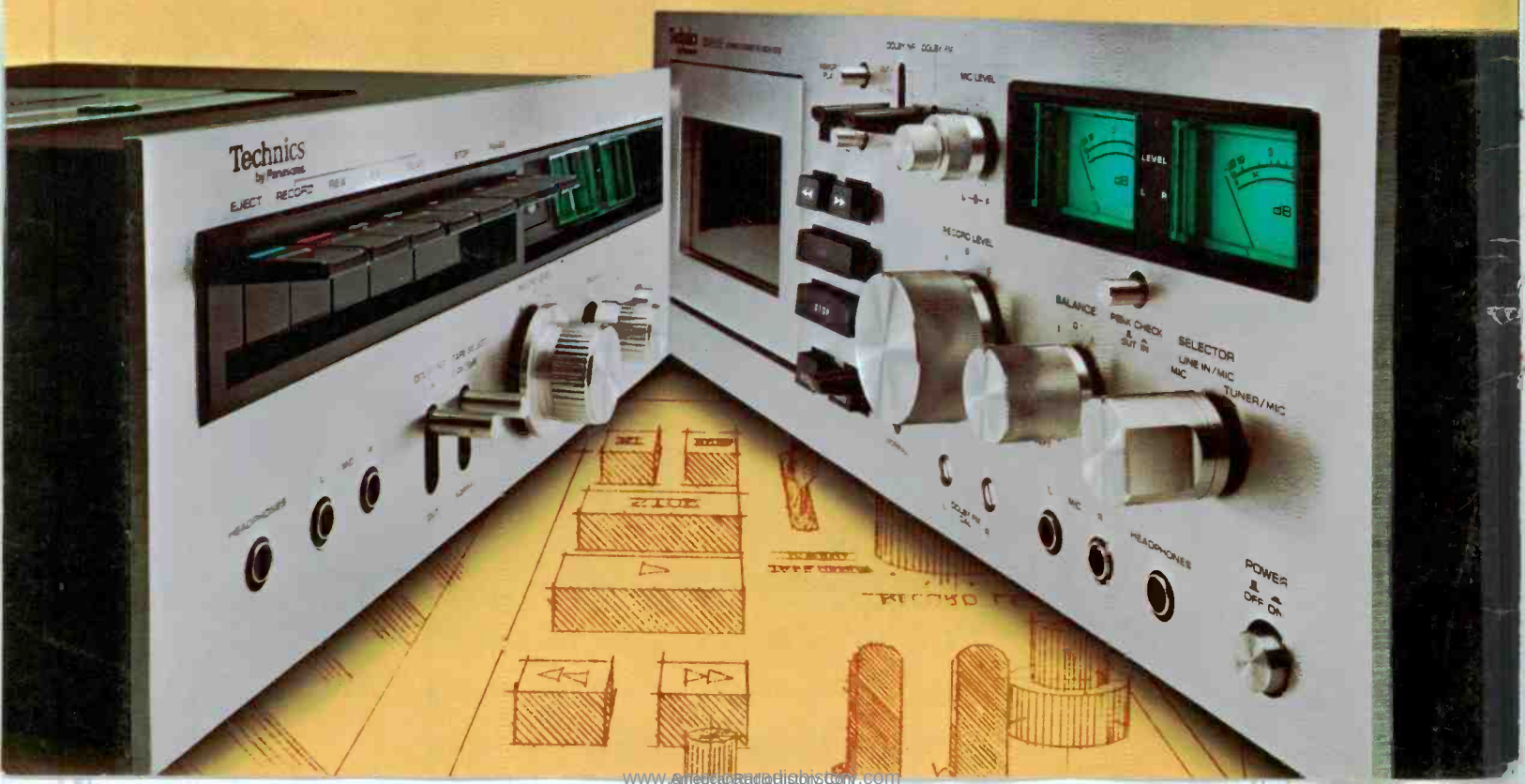

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