Model 400 Phase-Linear Review

AUDIO

FEBRUARY 1973 60¢

The Authoritative Magazine About High Fidelity ® A

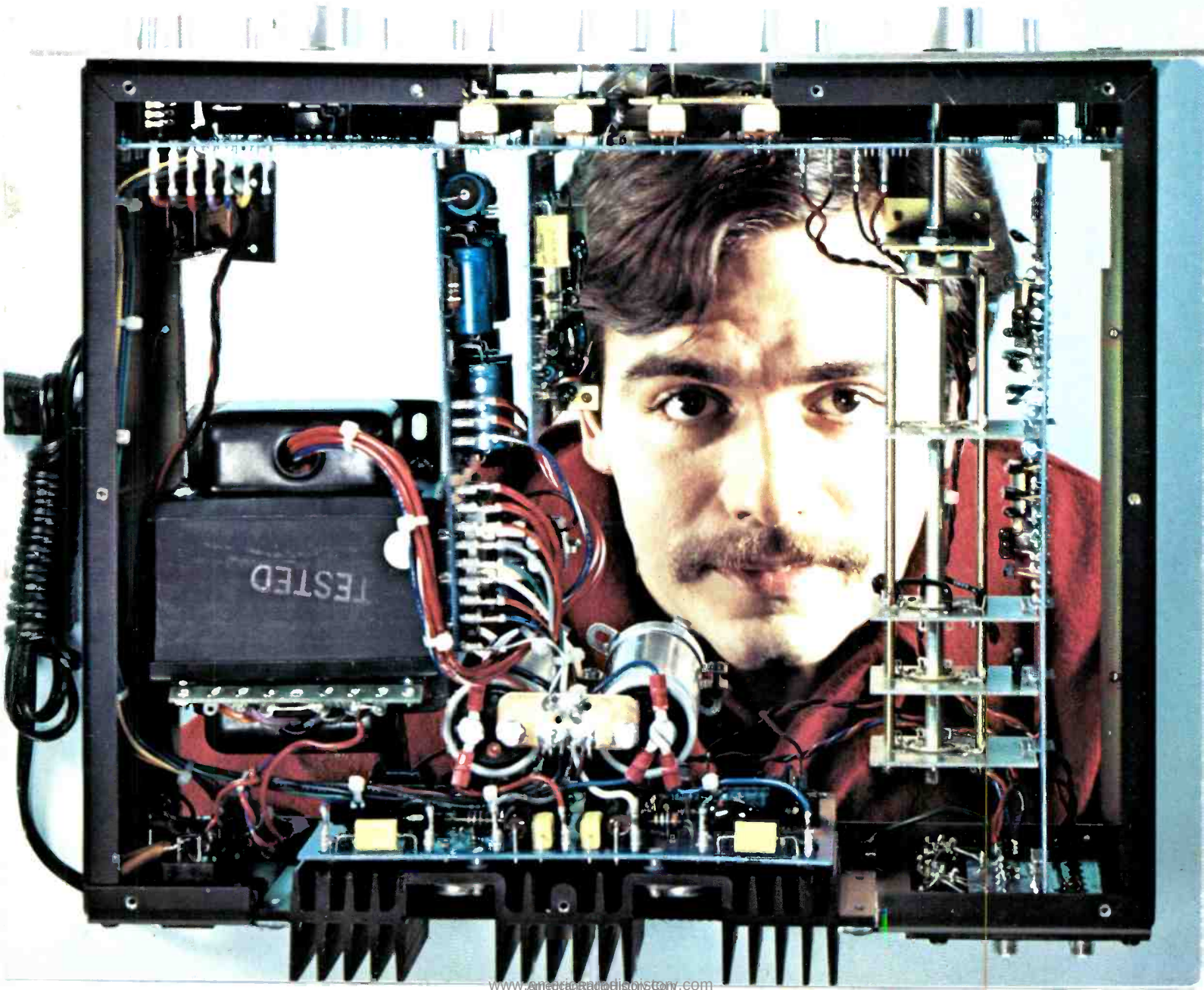
23602

What's Watts? * Buying Watts

Language of Hi-Fi--Part 8

Microphone Primer--Part 3

A Fail-Safe Amplifier Protection Circuit



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FEBRUARY 1973 Vol. 57, No. 2

FEATURE ARTICLES

EQUIPMENT PROFILES

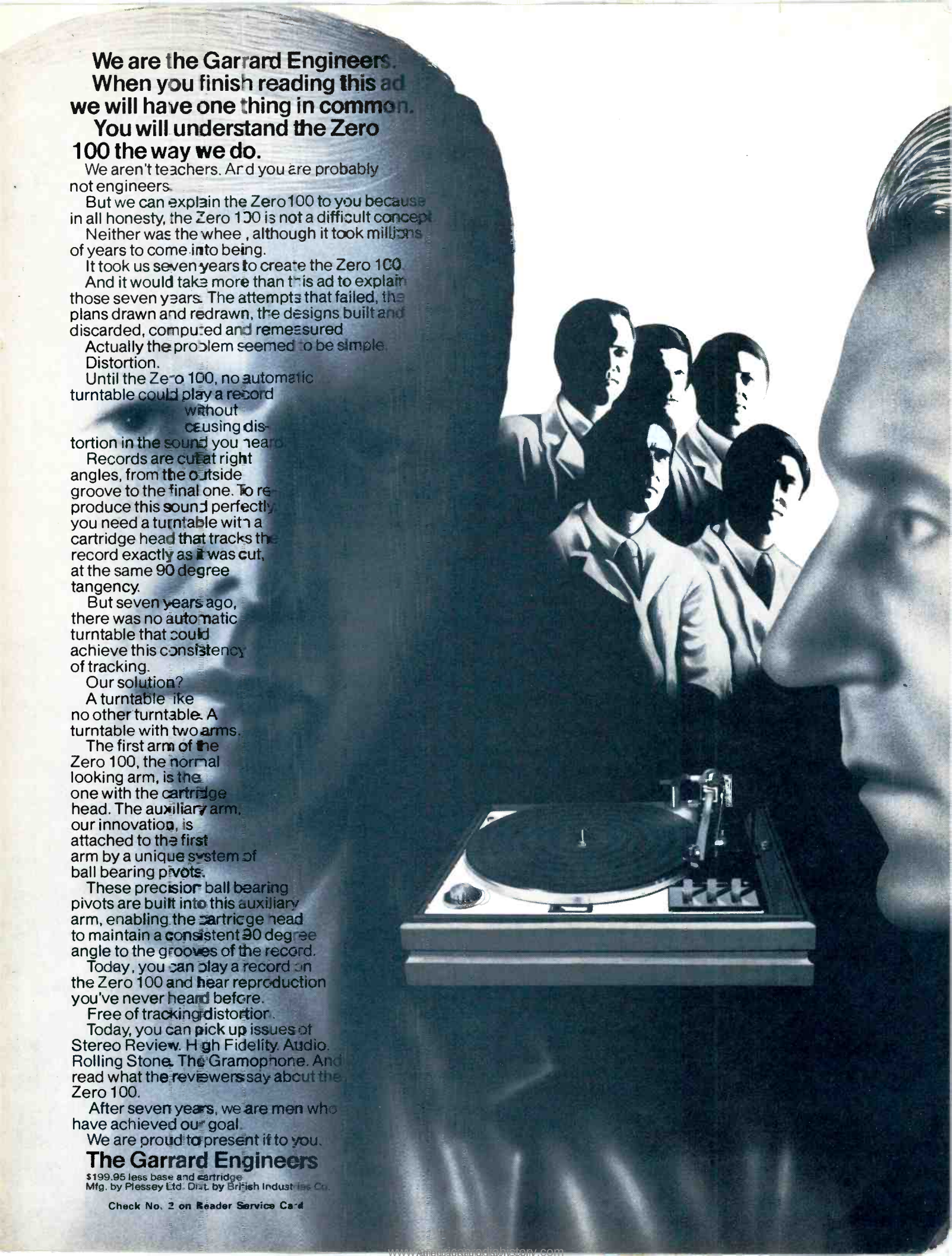
RECORD REVIEWS

AUDIO IN GENERAL

EDITOR *George W. Tillett*
ASSOCIATE EDITOR *Edward Tatnall Canby*
ASSISTANT EDITOR *Peggy Bicknell*
DESIGN *David Adams*
PUBLISHER *Jay L. Butler*
MARKETING DIRECTOR *Sanford L. Cahn*
COVER DESIGN *John Kwasizur*
SUBSCRIPTION MANAGER *Jean Davis*
ADVERTISING PRODUCTION *Sharon Mancini*

CONTRIBUTING EDITORS: *Herman Burstein, Martin Clifford, Leonard Feldman, Richard Freed, Joseph Giovanelli, C. G. McProud, Harry E. Maynard, Alexander Rosner, Sherwood L. Weingarten, Bert Whyte*

AUDIO (title registered U.S. Pat. Off.) is published monthly by North American Publishing Co., Irvin J. Borowsky, President; Frank Nemeyer, Jay L. Butler and Roger Damio, Vice Presidents; R. Kenneth Baxter, Vice President/Production; Nate Rosenblatt, Promotion Director; Mary Claffey, Circulation Director.
RATES—U.S. Possessions, Canada, and Mexico, $6.00 for one year; $10.00 for two years; all other countries, $9.00 per year. Printed in U.S.A. at Columbus, Ohio. All rights reserved. Entire contents copyrighted 1973 by North American Publishing Co. Second class postage paid at Philadelphia, Pa. and additional mailing office. Back issues, $2.00 each.
REGIONAL SALES OFFICES: Jay L. Butler, Publisher, and Sanford L. Cahn, Marketing Director, 41 East 42nd St., New York, N.Y. 10017, telephone (212) 687-8924.
Jay Martin, 15010 Ventura Blvd., Sherman Oaks, Calif. 91403, telephone (213) 981-7852.
REPRESENTATIVES, United Kingdom: The American Magazine Group, 9 Warwick St., London, W. 1, England.
Continental Europe: John Ashcraft, 12 Bear St., Leicester Square, London W.C. 2, telephone 930-0525. For Benelux and Germany, W.J.M. Saunders, Mgr., Herengracht 365, Amsterdam, Holland, telephone 24.09.08.
Japan: Japan Printing News Co., Ltd., No. 13, 2 Chome Ginza Higasi, Chuo-ku, Tokyo, telephone 541-5795.
AUDIO Editorial and Publishing Offices, 134 N. 13th St., Philadelphia, Penna. 19107
Postmaster: Send Form 3579 to the above address



We are the Garrard Engineers. When you finish reading this ad we will have one thing in common. You will understand the Zero 100 the way we do.

We aren't teachers. And you are probably not engineers.

But we can explain the Zero 100 to you because in all honesty, the Zero 100 is not a difficult concept.

Neither was the wheel, although it took millions of years to come into being.

It took us seven years to create the Zero 100.

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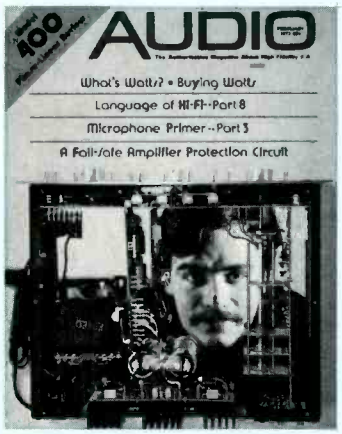

About the cover: We asked the artist to take a look at the Marantz 1120 amplifier that had just come in for review—and this was the result! The 1120 is a good example of modern design practice with a neat and tidy layout with all components accessible—without needing a can opener . . .

Audioclinic

Joseph Giovanelli

Making Live, Remote Recordings

Q. Circumstances have made it necessary for me to make a number of live, remote recordings. Can you outline briefly some procedures which might make this work easier?—Donn Petrak, Lethbridge, Alberta, Canada

A. Briefly, if you want to make an acceptable recording, take two cardioid mikes, place them perhaps two feet apart on a bar. This bar, in turn, can be mounted on a single mike stand. Face the mikes 90 degrees from one another and aim this combination at the sound source to be recorded. The sound source will strike each mike at 45 degrees. The result is really excellent stereo, with little fuss. Because of the rather close spacing of the mikes, the low frequencies are well centered, eliminating problems in disc mastering.

In addition, you may have to resort to "solo" or "accent" mikes here and there, which use would then require a mixer. This miking technique avoids the clutter of cables and mike stands on the stage, which otherwise can ruin the visual aspects of a performance.

Naturally, you must avoid overloading the tape. If you can attend a dress rehearsal or have control over the actual performance of a group, you can take all the time you need to set the recording level. This, however, is not always possible. Therefore, some kind of limiting is helpful. The limiting should be placed between the mixer and the tape machine.

This simple set of suggestions will help solve 90 per cent of your remote recording problems.

Noise Reduction

Q. Would you be kind enough to explain how a compressor/expander noise reduction system affects an audio signal in order to achieve a reduction in noise and an extension of dynamic range?—Lawrence Bobrowski, Chicago, Illinois

A. If we take the soft portions of a recording and compress them by increasing their signal level, their recorded levels on the tape will be higher than they would be if left uncompressed. These portions of the tape will have a better signal-to-noise ratio than they otherwise would have. This is achieved because the noise content, or background noise, of a tape has remained unaltered, but more signal is recorded on the tape. When this tape is played back, many listeners will not know that compression has taken place. Noise, however, will be audibly lower.

We are striving for realism in sound reproduction. Hence, the next logical step in this arrangement would be to expand the tape's dynamic during playback. This expansion would be exactly equal to the amount of compression which was introduced during the recording process. The result of this is that the full dynamic range of the program source is once again present. Because the signal-to-noise ratio, however, was greater on the soft passages than it would have been if no compression was used, the result is reflected in better overall signal-to-noise ratio during the playback process, despite the re-expansion.

Because of this improved performance, it would be possible to record with a greater dynamic range than would have been possible without this form of noise reduction. If the performance was improved by 10dB, we could increase the total dynamic range by 10dB and have no more tape hiss than would be present if no noise reduction had occurred, and no 10dB increase in dynamic range had been introduced.

What I have described are general principles of noise reduction. They are embodied in various forms. The DBX works pretty much along the lines I have described: the entire band of frequencies is compressed on recording and then re-expanded on playback. The Dolby B system takes the higher frequencies and compresses and re-expands them. The higher frequencies are the ones which are related to tape hiss in home systems. The A Dolby noise reduction system divides the audio spectrum into several bands and compresses and expands each one independently. These are just a few approaches based on this arrangement.

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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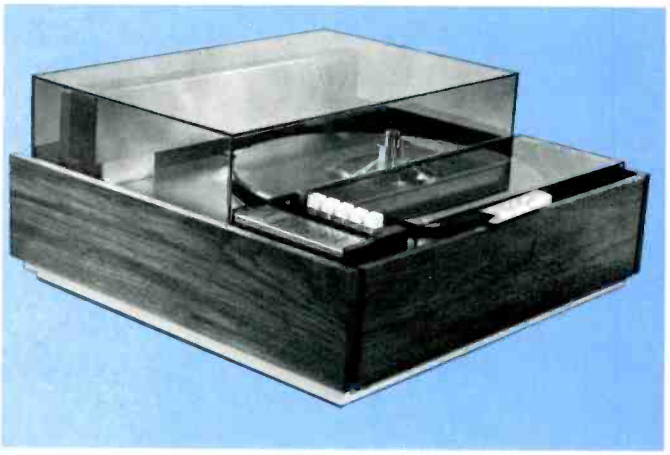
Editor's Review

Focus is on amplifiers for this issue and there is no doubt that they have come a long way since the days when 1 watt at 20% distortion was The State of the Art! In the late thirties, high fidelity amplifiers of the day usually put out five to ten watts and then we had the famous Williamson design in the forties with about 15 watts. High voltage tubes like the 6L6, KT-66 and EL 34 raised the wattage higher and then the advent of solid-state brought a gradual increase in output powers, 100 watts (*real* watts, not Music Power) will soon be rated as medium power! It is only fair to say that present-day loudspeakers *do* need much more power, as every improvement in linearity and frequency range has had to be paid for in reduced sensitivity (To avoid an acrimonious letter from you-know-who, I must exclude horn-loaded systems which have a high inherent efficiency).

I am often asked, why do amplifiers sound different but yet measure the same? The answer is: they don't. If there *is* an audible difference, then the measurements are incorrect or incomplete. Assuming we had two amplifiers with identical major parameters—including bandwidth, THD and IM distortion at all levels, same proportions of harmonics, damping factor, input impedance and signal handling capacity, stability margin and so on, then there are several possible explanations. One concerns overload characteristics. Amplifier A may clip cleanly without causing the dc supply voltage to fall unduly, but amplifier B might have an inferior power supply so the voltage will not only drop on sustained peaks but the smoothing will become inefficient and so a kind of sawtooth hum component will be superimposed on the signal. Another point sometimes overlooked concerns deviations from the standard RIAA equalising curve: even with selected components the divergency might be ½ or 1 dB. If these tolerences went in opposite directions, the total variation is large enough to be heard on a A-B comparison. Incidentally, these A-B tests would have to be made with the same program source and same loudspeakers and due attention must be paid to phono input lead lengths as an extra three foot can introduce enough capacity to make quite a difference in high frequency response.



MCA Disco-Vision

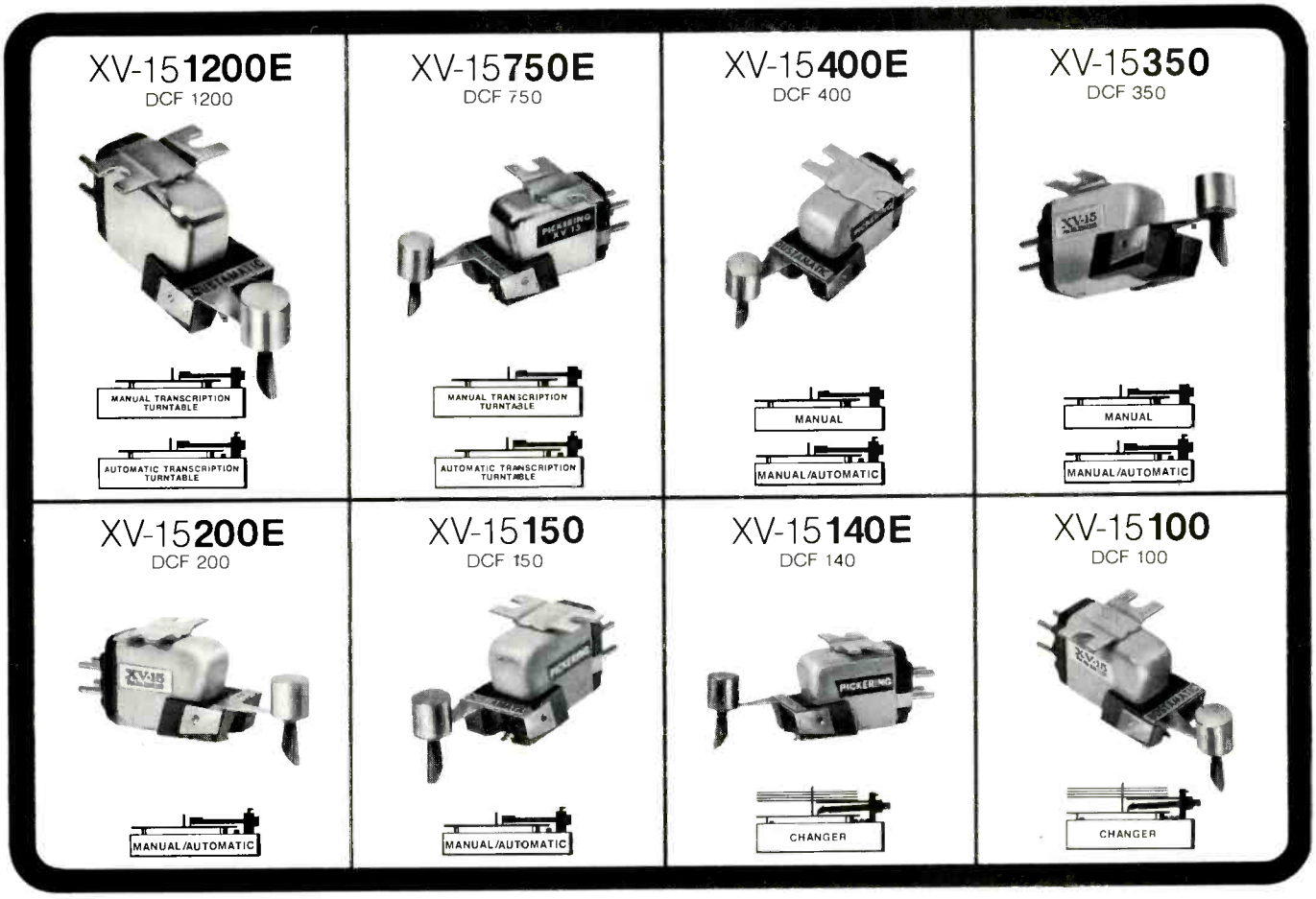
MCA have just demonstrated their long awaited Disco-Vision video disc which appears to be very similar to the Philips laser system mentioned recently in this column. The laser is a low powered helium-neon type but, unlike the Philips system, the beam is electronically "steered" to follow the information spiral. The disc itself is 12 inches in diameter and can be made of PVC or other plastic by thermo-stamping or embossing—just like conventional records. Density is 12,500 tracks per radial inch and playing speed is 30 revolutions per second. Playing time is 20 to 40 minutes—depending whether color is used. In addition to the full TV bandwidth, the discs can accommodate two audio channels. Two playing units will be available—a single disc player and an automatic model which will take 10 discs and prices are expected to be around $400 and $500 respectively. In operation, the output signals are fed to a TV set via the antenna input and then switching to an unused channel.

MCA have a film library of over 11,000 titles and presumably some of them will become available on discs—which incidentally ought to be relatively inexpensive. The question is—will a laser system eventually replace our present recording system? How long would a MCA disc play with just two or four audio channels? And would such a system be immune from the pops, crackles and scratches that defy our record cleaners? It's an interesting possibility anyway.

Response Curves

Seen outside a Philadelphia so-called Adult Bookshop, a large sign advertising "8-tract tapes, $2.99." Somehow, I doubt whether they would have any of Billy Graham's though . . . *G.W.T.*

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



There's a "right" Pickering cartridge for every record player, and only Pickering has developed a way for you to be absolutely certain you select the "right" cartridge for your high fidelity music system.

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Low-noise tape

Q. My tape recorder is adjusted for Scotch 203 (low-noise) tape. However, if I were to use a good brand of tape that isn't low noise, would this cause loss of quality? If I were to also use a Dolby unit, would this transcend the loss due to use of other than low-noise tape?—(Michael W. Bryan, Havelock, North Carolina)

A. A tape machine adjusted for low-noise tape has the following differences compared with a machine adjusted for conventional tape: (1) slightly more bias current; (2) slightly more signal drive current; (3) slightly less treble boost. Hence if you employ conventional tape with a machine set for low-noise tape, you tend to have a drop in treble response; and somewhat excessive recording level (resulting in increased distortion), which is partly offset by the extra bias. Use of a Dolby unit would not overcome these results. The Dolby, however, would reduce noise level.

Dirty heads

Q. Will a less expensive tape player, or dirty heads, or worn heads, or magnetized heads ruin or destroy part of the sound on a tape when the tape is played back on such equipment?—(Tim Erickson, APO San Francisco)

A. Magnetized heads, or any other magnetized body which the tape contacts, will tend to erase the sound on the tape, particularly the higher frequencies. Also, magnetized objects tend to add noise to the tape.

Bias switching

Q. I am going to buy a new tape deck this year and am specifically interested in a deck that has a bias switch to change from low-noise tape to regular tape. In your opinion, does a switch such as this actually work well without the equalization being changed?—(Robert A. Ward, Cleveland Heights, Ohio)

A. I see no reason why the bias switch should not work well. If there are no simultaneous changes in equalization (treble boost should be somewhat less for low-noise tape) and in record drive current (should be somewhat more for low-noise tape), the chances are that the manufacturer has adopted a compromise setting for the bias change, so that you are getting most, but perhaps not all, of the benefits of low-noise tape. See what happens if in recording you supply more signal to the tape—about 2dB more—when using low-noise tape. If distortion does not go up audibly with an increase in record level, you will have improved on the signal to noise ratio.

Calibrating VU meters

Q. I wish to adjust the bias and calibrate the VU meters of my tape recorder, using Sony SLH-180 tape. I have all the necessary equipment. What procedures do I follow?—(Dennis Thompson, Enid, Oklahoma)

A. If record equalization is fixed, you increase bias as much as possible without undue sacrifice of treble as measured in playback. If record equalization is variable, do the following. Simultaneously record and play a 1,000 Hz tone (or a 500 Hz tone if the manufacturer of the tape machine recommends this), meanwhile increasing bias until you obtain maximum output in playback. Then further *increase* the bias until output of the 1,000 Hz signal *drops* about ½dB. Now adjust record equalization for flattest possible treble response as measured in playback. It may be necessary to make *very slight* further changes in bias in order to get desirably flat treble response. All this assumes you have first cleaned and demagnetized the heads and adjusted them for correct azimuth alignment.

The VU meter should be adjusted to read 0 VU when recording a 400 Hz signal at a level that produces 1% harmonic distortion as measured in playback. If by chance the meter is a peak reading rather than average reading device, then the reference level should be 3% harmonic distortion instead.

Storing tapes

Q. What is the proper way and place for storing my tapes?—(John W. Ross, Campbell, California)

A. It is advisable to store tapes under conditions approximating "normal room temperature" and free of excessive humidity or dryness. It is preferable to store tapes end up rather than flat. After a tape has been recorded, it is advisable to store it tail out—that is, with the last part of the recording at the outside of the reel. This tends to reduce apparent print-through during storage. And it tends to relieve stresses that accumulate during storage, because the tape has to be rewound prior to playing. High winding speeds tend to create stresses that may distort the tape during long storage. Hence if long storage is contemplated, it is desirable that the tape be stored after operation at normal speed rather than at high winding speed.

More on Low-noise tapes

Q. My questions concern the tapes which are designated as low-noise, high-output. I am aware that a machine must be specifically equalized and biased for a particular tape in order to realize the potential of that tape. But if one has a machine whose bias and equalization are set for Scotch 203 or its equivalent, then: (1) What type of performance can one expect from these tapes; (2) Will is make a difference as to what speed is used? (3) Are there any tests one can make to judge a tape's performance so comparisons can be made? (4) What effect does Dolbyization of the signal have on the tape's performance?—(Gilbert J. Hansen, Pittsburgh, Pennsylvania)

(Continued on page 81)

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You can. In 4-channels. With a Panasonic discrete system. Panasonic chose discrete as its 4-channel standard for a lot of reasons. First, it has the highest degree of speaker separation and steady sound positioning of any type of 4-channel system. And in addition to playing discrete 4-channel tapes and records, a Panasonic discrete system enhances the sound of stereo tapes, records, and radio. Because of our Quadruplex™ circuitry.

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Behind The Scenes

Bert Whyte

Several months ago I reported on the status of the eight-track tape cartridge format. I related that 1971 had been a sort of "soft" year for hardware sales in this medium, although the sales of recorded cartridges continued their upward trend. Then at the CES this year, we were inundated by a flood of new models of cartridge machines for home and automotive use. The burgeoning of interest in the cartridge format stems from a general upgrading of the quality of both hardware and software in this medium, and most especially, in the adaptability of the cartridge to four-channel sound. There are even those who envision the cartridge as a true high fidelity medium, their reasoning being that since cassettes and cartridges both use magnetic tape, it is just as technically feasible to improve the sonic qualities of cartridges as was the case with cassettes. In fact, it is pointed out that the tape cartridge operates at 3.75 ips . . . twice the speed of a cassette, which should be some advantage in the initial stages of any improvement program. Before we summarily dismiss such a notion of a high fidelity tape cartridge, it must be conceded that just because cartridge tape is back-lubricated, this does not preclude the use of specially formulated oxides which can afford extended high frequency response. One must also admit that improved magnetic heads for the cartridge format are a relatively straight-forward matter with today's advanced head technology. As to the admittedly poor signal-to-noise ratio of cartridges, they can be Dolbyized, just the same as cassettes. As a point of interest, the always busy New York hi-fi rumor mill has been buzzing with news that either Columbia or Ampex Stereo Tapes, or both, will produce Dolbyized eight-track cartridges. Obviously, if this comes to pass, at present one would have to use a typical Advent/Teac/Concord outboard Dolby box to playback the cartridges. It goes without saying that tape cartridge players with built-in Dolby IC chips would soon appear on the market.

Okay . . . so we can make a true high fidelity cartridge. And now comes a chorus of protesting voices . . . "who needs it?" Why do we want tape cartridges which are admittedly bigger and clumsier than the handy cassettes? Most cartridges are played in cars, which even in the models with the quietest interiors, have much higher ambient noise levels than exist in homes and apartments. So why bother with fancy cartridges in which the extended high frequency response would be swamped by the noise of the mobile environment? And why have hi-fi cartridges when the sound systems in most cars, especially the loudspeakers, are of such poor quality? All of these are valid questions, but there are some answers.

Central to the whole idea of tape cartridges and the reason for their continuing high volume of sales, is that they are an excellent medium for listening to music in an automobile, from a purely mechanical and handling viewpoint, and of course, afford selectivity and choice of music. Their endless loop principle and ease of insertion in the playback unit makes tape cartridges relatively safe to use in a car with minimum diversion from the business of driving. Even when discounted, tape cartridges are generally more expensive than the equivalent Lp records. It was only logical that many people did not want, or could not afford, to duplicate the music they listened to on cartridges in their car, with disc recordings for playback in their home. Thus, in increasing numbers these people are acquiring eight-track tape cartridge playback decks, and incorporating them in whatever kind of music system they have in their homes, and their tape cartridges are performing "double duty." Needless to say, with the much quieter ambience of their home listening room, compared to their car interiors, many are a bit shocked by such things as tape hiss, crosstalk, print-through and other ills of the cartridge not audibly apparent in the car. These people who make dual-use of their tape cartridges are obviously those to whom a really high quality cartridge would have an immediate appeal.

However, strong though these reasons be for the introduction of a high fidelity tape cartridge, the most compelling reason of all is the potential of this medium for quadraphonic sound. It was a comparatively simple thing to re-assign tracks in the tape cartridge, so that instead of four two-channel programs of music, we had two four-channel programs. This change, of course, reduced the playing time of the cartridge, which necessitated the use of a thinner tape to accommodate some of the longer classical works. As it stands now, a quadraphonic cartridge is of approximately 50 minutes maximum duration. Now it must be realized that a quadraphonic cartridge is true *discrete* four-channel sound. Apart from the program break occasioned by the endless loop tape cartridge format, (and of course without the high fidelity) the quadraphonic cartridge is the equivalent in "discreteness" of a four-channel open reel tape. Quadraphonic cartridges and associated playback equipment are one of the least expensive ways to "get into" *discrete* four-channel sound. And by all odds, quadraphonic cartridges offer a larger selection of *discrete* four-channel sound than either open-reel tape or CD-4 disc.

The rub in all this of course, is that the quadraphonic cartridges suffer from the same sonic ills of their stereophonic brethren. Frequency response isn't too bad . . . out to about 7-8 kHz, but we could certainly use more . . . if we could get it without the penalty of more tape hiss. The tape hiss is really the crux of the matter. On stereo tape cartridges it is bad enough hearing the hiss in front of you. On quadraphonic cartridges you get the hiss both front and rear, which is not only disconcerting, but in the case of classical music recorded with hall ambience in the rear channels, the ambient reflections are swamped by the tape hiss! The situation cries for the application of Dolby noise reduction, and hopefully the Dolby IC chip will save the bacon, from the standpoints of minimum spade requirements for the inclusion of the circuit in cartridge playback units, and moderate cost.

While we are on the subject of tape cartridges it is worth noting that the recording of cartridges in the home is rapidly gaining momentum. Capitol's Audio Devices division, whose "Audiopaks" blank cartridges has dominated the field, tells me that sales of blanks have been increasing significantly over the past year. Scotch has a new low-noise oxide blank cortridge which is enjoying brisk sales. There are a number of tape cartridge recorder/playback units on the market. One of the latest and perhaps indicative of a new

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On the left cup of each Koss Quadrafone is a 2-channel to 4-channel switch. Flip it to 4-channel and four separate Koss dynamic driver elements (two in each cup) surround you with breathtaking, full-dimensional quadraphonic sound from either your matrix or discrete system. If you thought the Sound of Koss was superb in 2-channel, wait until you hear it in 4-channel.

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There are two plugs on Koss Quadrafones. If you haven't made the switch to 4-channel, you only use one of them. The black one. Which you insert into your present stereophone jack on your 2-channel system. That automatically connects the two drivers in each ear cup in parallel. So what you'll have is nearly double the bass radiating area and an unbelieveable increase in efficiency over the full range. Which should make the switch to Koss Quadrafones worth it even if you haven't made the switch to 4-channel.

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Slip on a Koss Quadrafone and you'll slip into any seat in the concert hall. Because Koss Quadrafones feature volume-balance controls on each ear cup. That puts any seat in the concert hall at your fingertips. From the middle of the concert hall one minute, to front row center the next. And you don't even have to leave the comfort of your own living room.

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generation of this type of unit is the 3M/Wollensak Model 8055. This stereo recorder/player has a special timing counter which displays elapsed time in minutes and seconds, along with a special cueing system that insures that you are at the beginning of the tape when the unit is placed in the record mode. To further uncomplicate the always tricky business of recording on endless loop tape cartridges, the Model 8055 has an automatic eject system which prevents accidental erasure of previously recorded material. The unit can also move the tape in a fast-forward mode at 2½ times normal speed. This of course would ultimately be significant if one wanted to Dolbyize the tapes using an outboard Dolby box, since after recording the Dolby signal for record calibration, you could advance to the 4th sequence and then run fast forward until you could read the playback of the signal at the beginning of the first sequence. Signal-to-noise ratio of this unit is claimed to be better than 50dB, with a frequency response of 40 to 15 kHz. Giving 3M the benefit of the doubt that these are probably fairly accurate figures, this unit certainly qualifies as high fidelity in anyone's book. I hope to bring you a personal report on this intriguing unit before long.

You will recall that in my last report on tape cartridge sound several months ago, I had taken my new car to Mr. Harold Wally, of Wally's Tape City in New York, for a new speaker installation to replace the miserable squawk boxes that were original equipment on the car. I related to you the total involvement of Mr. Wally in the auto stereo business. He has been in the field since it's inception, and his place is famous for custom installations, even in tricky sports car situations. Mr. Wally rightfully points out that the speakers used in most new car cartridge systems are not only cheap and of poor quality, but were not specifically designed for use in car stereo systems. Furthermore, he states that the placement of the speakers is strictly a haphazard affair, with little or no regard for proper baffling. Placed in kick panels, or underneath dashboards, bass response is poor or almost nonexistent. Mr. Wally is now on his fourth generation of speakers, designed to work efficiently in his favorite baffle, the doors of the car. The speakers are six inch units with stiff, but light cones with a flexible surround and a dome in the throat for high frequency dispersion. The baskets are understandably shallow so that they can fit into a wide variety of doors. Magnet structure is on the order of a half pound or more, rather than the puny ¾ to 1 oz. slug found on the usual car speaker. Even though car doors vary widely in their internal construction, depending on whether the windows are electric or manual, Wally usually can find a reasonable place to mount the speakers. Wally stated that getting a decent bass response is the name of the game in car stereo installations. With his special speakers fitted snugly into the door with flanges sealed, the volume of entrapped air in the door is sufficient to give some good baffling and the bass response is quite respectable. With the superior efficiency of Wally's speakers I can now drive the system to louder levels than one could tolerate, with minimal distortion at that highest level. The rear speakers mounted on a shelf above the car trunk, were changed and replaced with Wally's special 6x9 units with a hefty 15 oz. magnet. With the entire trunk area acting as baffle, the bass response was quite good. The overall system sound employing the speakers in the door and the units in the rear, is fairly smooth and wide range, and is so much cleaner and more enjoyable than the original there is simply no comparison. Tooling down the road, and listening to a nice classical recording or some good mood music of my choice, sure beats the random afflictions of the radio. Wally's installations are neat and as they say in racing circles . . . "quite sanitary". He has several models of speakers, with the best going for about 35-50 dollars installed depending on the complexity of the job.

To end this epistle on tape cartridges, and to show you the extent to which some people go to improve their car listening, one reader writes that he installed four 5 inch tweeters and *two ElectroVoice 15 inch woofers* in his car trunk, plus KLH Model 17 speakers in back of the rear seats! This array is driven by an inverter-powered Dyna 120, with PAT 4 pre-amp! The mind boggles!

One final note . . . Mr. Wally says that trying to convert normal car stereo players to four-channel is much too difficult, and that a four-channel player of the type made by Motorola, Panasonic or Pioneer should be used as an add-on, which can be removed when you trade your car. That is next for me, with Wally telling me a simple change or wiring to the front and rear speakers and I'll be immersed in quadraphonic sound!

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The price? An enlightened $459.50 (suggested retail), including a handsome walnut finish cabinet. The 7065 highlights a line of Sony receivers starting under $200. Sony Corporation of America, 47-47 Van Dam St., Long Island City, N.Y. 11101.

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WHAT'S NEW IN AUDIO

Rola Celestion Speakers

These British-made systems are now being imported by Hervic Electronics Inc., of Los Angeles. Shown is the Ditton 66 which uses a 12 inch bass unit with a 12 inch "slave" radiator. Hervic are also handling the Connoisseur belt-driven turntable which lists for $129.20 complete with dust cover and teak base.

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Elac-Miracord Turntable

Benjamin have just released a new automatic turntable which costs only $99.95. It features all-push button operation, precision cueing, built-in stylus force dial and anti-skating device. Model number is 625 and it will accept all standard phono cartridges. Two bases are available, Model RB-6 molded type at $6.50 and Model WB-600 in oiled walnut at $15.00.

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Onkyo Integrated Amplifier

Onkyo announce a new amplifier which has an output of 26 watts per channel (continuous rating). This is Model A-7000 and other features include stepped tone controls, two switched speaker outputs, two tape recorder sockets, 2 phono inputs and high and low filters. Power bandwidth is said to be 10 to 70 kHz. IM distortion is less than 0.3% at rated output with a THD of 0.1%. Price: n/a.

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New Receivers from KLH

Model 55 is an AM/FM receiver with an output of 32 watts (continuous) and featuring a 3-gang FET front end, high and low filters, ceramic i.f. filter and main & remote speaker switching. Price: $199.95.

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Model 21 is a small self-contained AM/FM receiver with an output of 5 watts into a specially designed 4 inch speaker having a long-traverse voice coil. Frequency contouring is employed to achieve an exceptionally good bass response. Price: $119.95.

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KLH has always made a lot of very good loudspeakers. Now we make a lot of very good receivers, too. And like our loudspeakers, our receivers deliver an inordinate amount of performance at a very modest price. For instance our new Model Fifty-Five is an AM/FM stereo receiver with power, dependability and every feature you could possibly want—all for $199.95.* Team it with our nifty Model Thirty-Two loudspeakers and our new automatic turntable made especially for us by Garrard (includes base, dust cover, Pickering cartridge and diamond needle) and you've got a super system for just about $300! Or step up to a pair of Sixes with the Model Fifty-Two. Or match a pair of Seventeens with the Model Fifty-One. Or simply mix and match them anyway they sound best to you. It's fun. It's easy. And it really doesn't cost a whole lot of money. So why settle for someone else's "bargain" system, when you can get the best for less? Complete KLH component music systems. At your KLH dealer now.

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Leonard Feldman

Buying Watts and Other Things

ONCE YOU'VE gotten past the traumatic decision involving audio power requirements of your ultimate system, you'd think the choice of an amplifier (integrated, basic, or part of an all-in-one receiver) would be relatively simple. You've waded through the literature regarding power ratings. You now understand that continuous power ratings (often erroneously dubbed rms power) are more meaningful (and less inflated) than "dynamic power", "music power" or "IHF music power". You've learned to steer clear of products which feature "peak power" or even "instantaneous peak power" ratings. You've even selected your speaker systems and been told by the speaker manufacturer's brochures how much power you should supply to them (and, perhaps, how much power you'd better *not* supply—ratings in this area are still quite vague) and you're ready to shop for the electronic "heart" of your system-par-excellence. It's only then that you are faced with a host of *new* decisions.

Watts Versus Features

Basically, an audio amplifier has one primary raison d'etre. It's supposed to accept low-amplitude electrical signals which represent your various program sources and *amplify* them until they are powerful enough to drive your loudspeaker systems. It should perform this task without introducing distortion, and the broadest definition of distortion means the introduction of any differences to the output signal as compared with the input signal. That means differences in *content* (harmonic or intermodulation distortion) as well as differences in relative amplitude of the frequencies contained in the original signal (flat frequency response). Writers in this field have, at various times, suggested that the ideal amplifier is best described as a "piece of wire with gain" and not a few manufacturers have, over the years, used that cliché to describe their products.

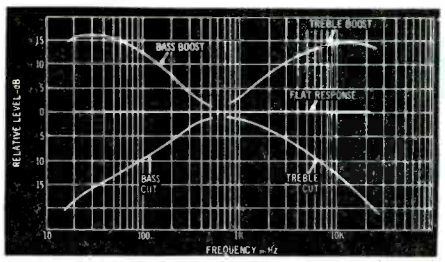

Fig. 1—Typical range of adjustment afforded by most tone control circuits.

In point of fact, though, as you begin to examine the amplifier products currently available, you find that this single objective is augmented by countless features including controls, switches, lights, jacks, sockets and other seemingly unrelated appurtenances which, at first glance, even seem to contradict the stated objective of "pure" amplification. It is these features that we'd like to sort out in terms of their usefulness (or superfluousness) in a high fidelity music reproduction system.

Tone Controls

Only the arch-conservative purist will argue against the need for bass and treble tone controls in a modern hi-fi system. They're needed, we are told, to correct for all manner of sonic deficiencies which exist elsewhere in the system—such as poor lower bass response in our speaker systems, improperly equalized program source material, highly absorbent room furnishings (which gobble up the "highs") and the like. Yet, as you tour the audio shops (and the homes of your friends who own hi-fi setups), make a note of how few listeners actually move their bass or treble knobs away from the sacrosanct "flat" settings. There may be an ego problem here. To depart from "flat response" is to tacitly admit that "some other part of the system" is anything but flat and that implies poor judgment on the part of the audiophile in his "system assembly". On the other hand, the majority of "tone control" circuits may simply not be suited to the required "sound tailoring" job at hand. Consider Figure 1—the typical range of control afforded by the usual bass and treble controls. If, indeed, the deficiency noted in a particular system involves the need for boosting frequencies below, say, 150 Hz to make up for poor lower bass reproduction, the typical tone control cannot correct this situation without simultaneously boosting frequencies from about 500 Hz down, a solution which leads to so-called "barrelly" sound.

Selectable Crossover

Some amplifiers switch positions (two, three or even more) which predetermine at what frequency boost or attenuation begins when the tone controls themselves are rotated. Thus, as shown in Fig. 2, it would be possible with such an arrangement to set up a response curve which only emphasizes (or attenuates) the extremes of frequency which require such alteration.

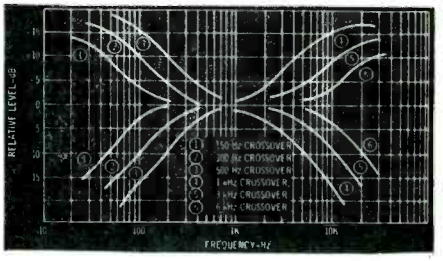

Fig. 2—Selectable crossover tone controls offer greater choice of tonal correction possibilities.

A lovely feature *if you need it*. Obviously, if your tendency is to leave the tone controls in their flat position (or even by-pass them by means of a suitable switch sometimes provided for that purpose), then the added cost of selectable cross-over tone control circuits is not for you.

Graphic Equalizers

On the other hand, if your listening acuity is such that even selectable crossover tone controls fail to adjust the response to what you consider to be correct, you may want to consider an amplifier with *more* than the usual bass and treble controls. The first step in this direction is to be found on several models which now offer mid-range tone controls, as well as bass

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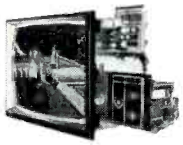

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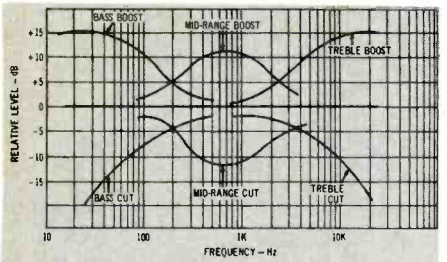

Fig. 3—Mid-range tone control permits additional response alteration.

and treble. As shown in Fig. 3, this extra control offers adjustment of mid-frequency emphasis. Early versions of this feature used to be called "presence" controls, in that they tended to emphasize the sound of vocalists—since vocal programming is primarily in the mid-audio range.

If your acoustic environment is such that even *three* tone controls won't suffice, there are amplifiers on the market that sport as many as *five* separate tone controls, each able to control a specific segment of the audio frequency spectrum. The name "graphic equalizer" has been applied to such multiple tone control arrangements and, if self-contained segmented tone controls still don't satisfy you, you can purchase *separate* graphic equalizers with ten, twelve or even twenty-four segmented controls. The action of a five-segment graphic equalizer built into an integrated amplifier is shown,

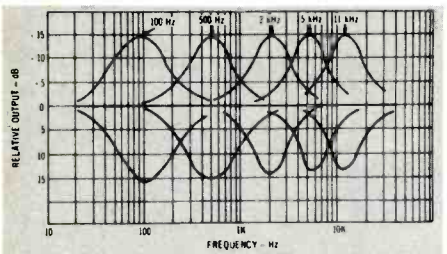

Fig. 4—A five-segment tonal equalizer provides even more accurate tailoring of overall frequency response.

graphically in Fig. 4. Obviously, the more segments—the more circuitry, and the more circuitry, the higher the cost.

Tape Monitor Facilities

Speaking of "add on" devices to your amplifier, manufacturers of such devices ought to be eternally grateful to some remote tape-recorder manufacturer of yesteryear who had the bright idea of building separate "record" and "playback" heads into his machine, plus enough electronics for both to operate simultaneously. This clever innovation permitted the recordist to "monitor" the results of his recording efforts a fraction of a second after the tape has been recorded—providing he could feed the output of his tape-deck's playback preamplifier into a suitable input on his amplifier—the *same* amplifier he was using as a program source for *making* the recording. In order to do this, amplifier manufacturers provided a switch called "Tape monitor", which is nothing more than a means for "breaking" the signal path at a suitable point in the amplification chain. The program to be recorded is fed to the tape-deck from the "source" side of the "break", while the resultant recorded signal is fed to the other side of the "circuit break"—the side that ultimately leads to the loudspeakers or output of the amplifier. Once this "break" became universally available on most component amplifiers, it also served as the necessary connection point of all manner of devices (including the graphic equalizers that are bought separately) which could be "added" to a system. Were it not for this simple circuit-interruption point, it would be impossible, for example, to add any of the four-channel decoders which now permit easy conversion of stereo systems to quadraphonic sound.

Some amplifiers now feature two or even three tape-monitor jack-pairs. Among other things, this permits the user to record onto two tape recorders simultaneously or to dub from one recorder to another. Again, if you are *not* that heavily involved in recording work, the presence of two or more tape monitor circuits is a redundancy you should not have to pay for.

Phono Inputs

Speaking of "doubles", many amplifiers offer multiple pairs of phono-input jacks. In some, both pairs are identical and offer equal sensitivity, regardless of which pair is used. These arrangements are intended for the owner of, say, a record changer and a manual turntable who might want to do casual, extended listening via his record changer but may want to "single play" more critical recordings on a manual turntable. In yet another arrangement, some amplifiers are equipped with pairs of phono inputs which have different sensitivities. For example, the PHONO 1 inputs may be designed for cartridge outputs in the range of from 1 to 3 millivolts, while the PHONO 2 inputs may accept cartridges having outputs from 4 to 8 millivolts. Obviously, if you *know* what the nominal output of your phono cartridge is and do not plan to own two record playing facilities, there's really no point in spending the extra money for the dual phono input feature.

Filters, High and Low

The use of filters for the "elimination" of turntable rumble and high frequency noise (record scratch, tape hiss, FM background noise) is, at best, a compromise remedy. There's no question about it—filters *do* alter what is often "perfectly flat" frequency response. Rumble consists of very low frequency signals (usually below 60 Hz) and in order to reduce its effects, an amplifier's response must be attenuated at very low frequencies. Unlike "bass tone control action", however, such filters are designed to start cutting at or about the frequencies which are

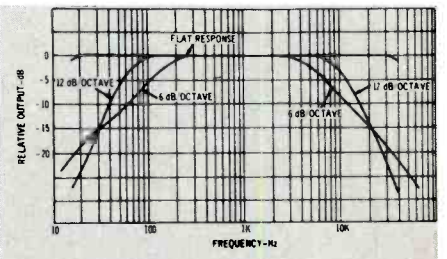

Fig. 5—Filters attempt to cut out unwanted rumble and hiss without destroying too much of musical value.

involved. This is illustrated in Fig. 5. The action of two kinds of low frequency filters is shown. Note, that the more gradual sloping response curve has to start cutting frequencies at about 150 Hz in order to provide 15 dB of attenuation at 30 Hz. This filter has a slope of 6 dB per octave. The preferred 12 dB per octave filter (steeper sloped line) needn't start altering frequencies above 100 Hz to afford the same 30 Hz attenuation. These two values of "slope" are generally found in high-frequency filters, as well. Both filter types must necessarily bite into musical content, and if you don't suffer from turntable rumble or record scratch hiss, is there any point in "buying" filters as part of your amplifier arrangement?

Microphones and Mixing

The breach between "professional" amplifying equipment (normally associated with recording studio or broadcast use) and "consumer" equipment continues to narrow and quite a few amplifiers sold for home use now include microphone input jacks. Some of these simply avail themselves of the high amplification capability of the phono preamplifier stages—removing the required RIAA record equalization and connecting the microphone input jack to these circuits by means of a position on the selector switch. This simple arrangement really offers very

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little more flexibility than the microphone inputs already available on your tape recorder, unless you take special delight in using your entire high fidelity system as a public address system in your living room. There are, we are told, people who suffer from an affliction which is the reverse of "mic fright". They love to hear themselves over loudspeakers—it seems to provide the extra sonority akin to that special sound one hears when singing in a tiled shower. If you get your kicks that way, than the extra mic position on your amplifier's selector switch will provide that extra ego stimulant at very little extra cost.

If, on the other hand, you want to "mix" live sounds with other program sources, the amplifier you choose should be equipped with a separately controlled microphone preamplifier circuit—one which is capable of being mixed in with other program sources and one which has its own level control, apart from the master volume control, so that you can attempt that "professional" mix of program" just like the recording engineers do". If you're really serious about "live recording", however, you may be better off using one of the many "outboard" microphone mixers which not only contain preamplification but provision for four or six microphones to be connected—each with its own associated level control. Outputs of most of these mixers plug simply into a high-level (Aux) input on your amplifier or receiver.

Input Level Adjustment

While a manufacturer has total control over the audio level of AM and FM radio signals recovered in his receiver product, he cannot predict what levels of phono signal, tape signal and the like you're likely to feed into the other various inputs of his product. If you pick products that all produce voltage outputs that are about equal and also equal to the internally supplied AM or FM detected audio signals, you're in luck. When you switch from one program source to another, you won't have to race to the volume control to adjust for differences. More than likely, however, one or more of your signal sources is going to be greater in amplitude than the others and when switching from or to that source, it can be quite annoying (if not disturbing) to experience extreme level shifts. One of the ultimate refinements offered by some receiver manufacturers and quite a few amplifier makers consists of a group of input level controls, each associated with a particular pair of input jacks. These enable you to carefully adjust all program source voltages so that as you switch from one program source to another, loudness remains constant.

The idea is lovely and of course, it does cost money in terms of extra controls on the amplifier or receiver. Allowing, even, that you are that much of a perfectionist, there is still room for redundancy. For example, if your tape player has its *own* output level control, you can set it to correspond with radio levels. If you own a separate amplifier and tuner, the tuner may well have an output level control too, obviating its need on the input of the amplifier. About the only instance in which separate input level controlling is not likely to be available other than on the amplifier is that associated with phono listening. However, as we've already pointed out, many amplifiers offer a choice of input sensitivity here, so you may not encounter too great a level shift even in the case of records.

For The Amplifier That Has Everything

The remaining few niceties that we'd like to mention fall into the category of "luxury" features that really don't contribute audibly to the performance of an amplifier but are, nevertheless, available as "convenience" features. We will not comment upon their "usefulness' but simply mention that they can be had—all at added cost since all involve additional circuitry and/or mechanical parts additions.

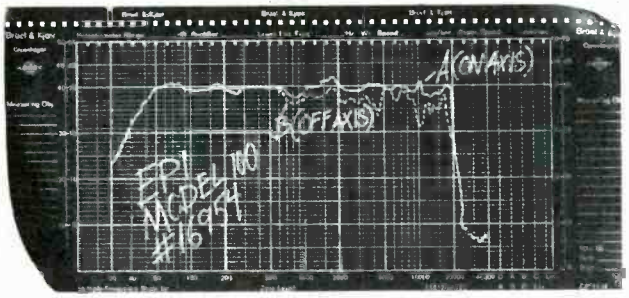
Included in this group are such things as attenuator switches, program indicator lights and level meters. The attenuator switch, which may not be familiar to most readers, is simply a switch which, when thrown, reduces overall listening level by about 20 dB. It's supposed to be used when the phone rings and you want to lower listening level so that you can hear the party on the other end of the line. Obviously, you could turn down the volume, but the theory here is that by throwing the switch during the phone conversation you can restore *exactly* the same listening level you had before after the phone is hung up. We leave that one to your own judgment.

Program indicator lights are great fun to watch as you rotate your program selector switch or push the selector buttons. Unless your amplifier is equipped with a remote control cable with which you can switch programs from many feet away, we fail to see what information they add in operating the amplifier, since you can read the designations around the selector knob just as easily at the time of program selection. Of course, some people forget easily, I suppose, by the time they reach the comfort of the listening chair or sofa, so if it's lights you want, lights you shall have.

Recently, level meters have found their way onto home amplifiers. Often, they provide a good indication of how much power is being supplied to the loudspeakers and, with today's more powerful amplifiers, this often serves as a warning device if the meter calibration is accurate. It is not rare to "blow up" or destroy a speaker by feeding it too much power and if you watch the meters, this tragedy can sometimes be prevented. If, however, the meters are used to establish correct recording levels, it must be fairly stated that most recorders (even cassettes) have more accurately calibrated record-level meters for this purpose, so once again, the presence of meters on an amplifier for this purpose may be a useless redundancy.

It has not been our purpose to put down any of the modern features and controls associated with the current crop of solid-state amplifiers. On the contrary, we think that manufacturers have brought a great deal of ingenuity and innovation to their products. Receivers and amplifiers sold for home use today often exceed the performance capabilities and control flexibility of the professional equipment of just a few years ago. All we're saying is that the prospective purchaser of a home music system should try to evaluate his needs before taking the plunge and, if possible, purchase the correct amount of power *and* the appropriate features which he is likely to use in the foreseeable future. Admittedly, as one goes up the scale in power and price, one generally finds more and more of the features we've discussed, so that it's often difficult to separate the "features" from the power rating and low-distortion capability of some products. There are exceptions, however. *Some* low-power units offer very low distortion plus a host of control features such as those we've discussed. Some super-power units offer a minimum of extra controls and switches and a maximum of good audio performance. You're likely to find just about everything you want in between if you shop carefully and knowledgeably. The point of the whole story is: but anything you need—but *use* what you buy if you really intend to get your money's worth. AE

EPI'S LINEAR SOUND. YOU HAVE TO SEE IT TO BELIEVE IT.



This is what EPI's Linear Sound looks like.

Everybody talks about linear sound.

But only EPI has EPI's Linear Sound. And there's a difference.

CURVE "A"

See the curve marked "A" on our linear response graph? We recorded curve "A" in the usual manner, placing our microphone (a B&K Model 4133) directly in front of our EPI speaker.

That's a remarkable thing, that curve "A". From way down on the bass end all the way up to the high treble end, it's practically a straight line.

What you see is what you hear: a pure, uncolored, natural sound from top to bottom. With no artificial boosting of the bass to impress the innocent. And all the nuances and overtones at the treble end that, on ordinary speakers, just fade away.

CURVE "B"

Now look at curve "B", and you'll see something even more remarkable: another virtually straight line.

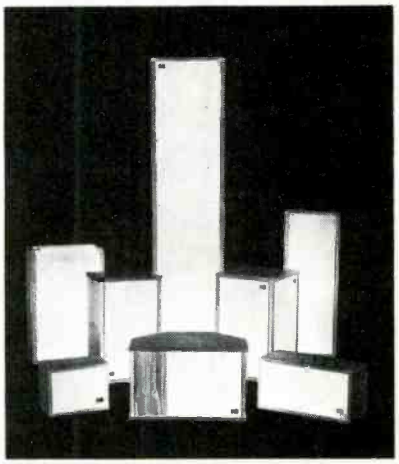
What's remarkable about this is that curve "B" was recorded by placing our mike at a point 60 degrees off axis. So EPI's speakers disperse Linear Sound not just straight ahead, but in all directions, and at all frequencies.

In fact, up to 15KHz, the off-axis dispersion is down only an average of 3db. This is the result of EPI's unique one-inch linear air spring tweeter.

What does that mean?

It means that when you're listening to music, you can sit anywhere in the room, and you'll be hearing that big, full, natural sound you've just seen on our graph.

EPI's Linear Sound. It comes out of eight great speakers, from $55 to $1000, made only by Epicure Products Inc., Newburyport, Mass. 01950.



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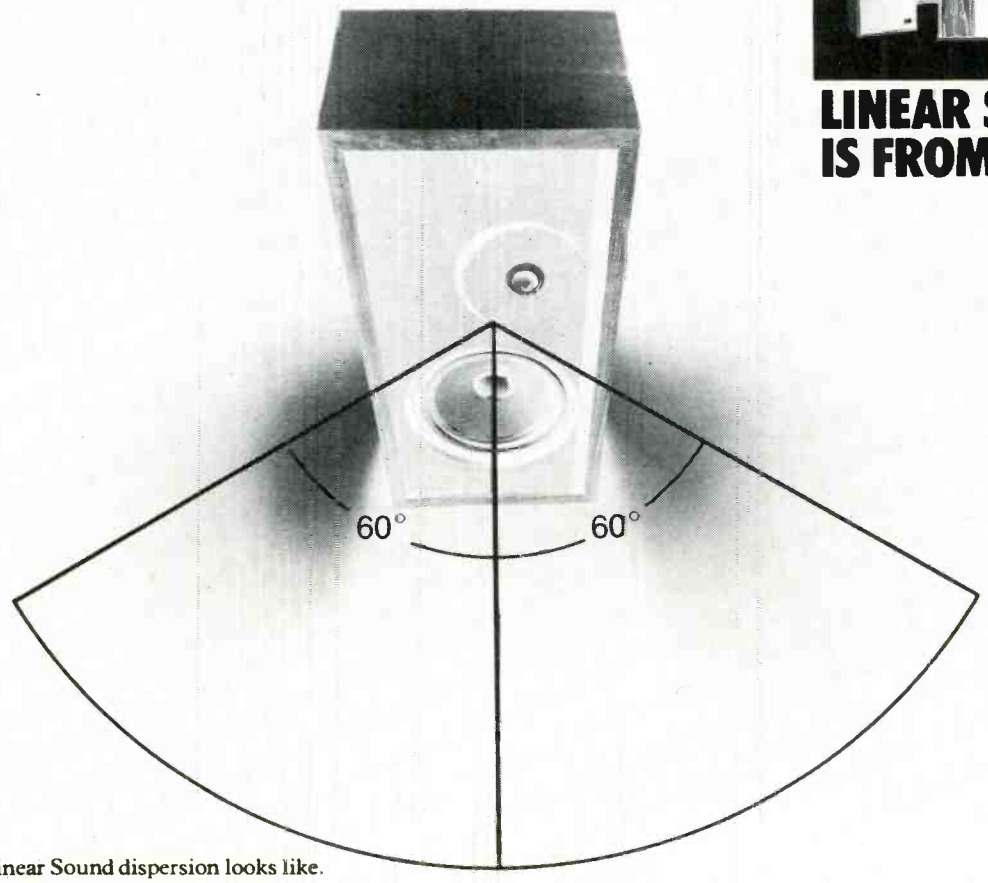

This is what EPI's Linear Sound dispersion looks like.

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Audio ETC

HOME SYNC

Edward Tatnall Canby

TRY IT YOURSELF! That is my first thought, each time a new basic category of hi-fi equipment hits our markets. Especially in my favorite area, intermediate semi-pro equipment that offers professional-type sound and facilities in consumer-sized and consumer-priced packages. So when four-channel sync tape suddenly loomed up, this last year, I was vitally interested. That was for *me*. I had already started a project—just waiting for it.

This kind of sync is that celebrated, lavishly costly and enormously bulky pro recording system known best to the public as "16-track," whereby recorded channels can be "laid down" on tape while others on the same tape play along, in strict real time, synced via playback through their recording heads. The finished music, or what have you, emerges step by step like a sort of collage, to take final form later via mixdown. The aesthetics of the medium are fascinating—for here there is no "original," no single live performance; and so a fundamental dogma of all past recorded art is challenged. There's not necessarily even one location; the tracks may be made anywhere, at any time, or erased and redone and usually are. Even the added ambience is synthetic, out of all time and place. Sync recording is very much the wave of the present, and probably the future, too, as it reaches into new areas, even including so-called classical music.

But, ingenious as they are, this is one area where our consumer tape recorders haven't been able to venture until now. Studio sync equipment, sixteen tracks, more or less, is simply unimaginable in any home, at any price. Reluctantly, we've had to settle for a bit of overdubbing here and there, plus separate record and playback for our two stereo channels, making possible some pretty good tape tricks, but not the real thing. Quadraphonic, however, has finally done it. You need four channels to play with. And if you're going to have four channels on home-feasible tape, you might just as well make them sync while you're at it—at least in the semi-pro area and along the fringes, where costs will allow the extra facilities. That's how it has happened.

TEAC's earlier four-channel recorder line, adapted from two-channel gear, had an add-on sync unit quite some time ago. This year, with second-generation true four-way recorders coming on the market, the sync is built in permanently in several lines (starting out from Japan, of course) and without a doubt more are in the offing. It's a splendid idea for those who for one reason or another want to be their own sync artists. I grabbed at the lowest priced unit available, partly because they had one, partly because I was curious as to how *inexpensively* this new art could in fact be put to use in the home. It was the cheaper of two alternative TEAC models, the 2340, built compactly for seven-inch reels at home speeds, 7½ and 3¾ ips. (The larger unit takes ten-inchers and runs at 7½ and 15.) Sony is also out with a sync recorder, fancier and, I would gather, aimed at a somewhat higher pro level—at higher cost. It, too, should be investigated in a hurry, if your cash supply is bigger.

Both these lines, and more to come, will give you the basic equipment to produce your own genuine "Sarge Pepper"—for wasn't that classic Beatle album done entirely via four-channel equipment? Something to imagine!

So, instead of $50,000.00 and an acre of studio space, now I have a mere half a thou of equipment and I can carry it around the house without even straining a finger. The TEAC 2340 is, astonishingly, only about half the size of most semi-pro two-channel stereo recorders. And yet it will sync any combination of its four simultaneous tracks, record or play, and it has mixing and switching for eight inputs—four mics and four hi-level—with appropriate red-light indicators to tell you what's doing what. That's something. To be sure, it helps to have small fingers. And there are some basic and necessary problems in detail that have arisen in the paring-down from, say, $50,000.00 to a hundredth of that figure. But the absolute essentials are there. So—what to do with them?

A VERY big question. I can hear dozens of readers muttering themselves out of this picture—OK, OK, for kids and rock freaks; but *Sergeant Pepper!* That ain't for me, buddy.

Well, that is why I am here. Since my age is approximately three times that of any known rock freak, I do not qualify. But I did put on a show, occupying me for many weeks out of two successive summers (I anticipated the sync recorder before there was such a thing), which made abundant use of the new machine, and I am forever sold on the whole system. Marvelous! You can do anything. That is, once you teach yourself to operate no less than 16 separate volume controls plus a dozen-odd switchings all at once, making no mistakes.

So the first thing you do is just what you do when you buy your first new car. You go out and drive—at maybe five miles an hour. (Unless you're a hot car nut or something.) I spent a couple of days doing some *very* tentative "driving" and making an utter fool of myself most of the time. Not on my big show—that could wait. First thing I tried was a short anonymous sixteenth century choral work in four parts, designed originally for a Spanish cathedral, called *Christus Natus est*, Christmas. I hooked in one mic, on one channel, and sang me the basso part. Then I went back and — oops! Wrong switch.

After about 50 tries, I managed to get down, complete and in total sync, all four parts of this little piece, bass, tenor, alto and soprano. All produced, of course, by my own vocal cords. Wow! The most awful sound you ever heard. You see, I can't sight-read music and twirl volume controls at the same time, especially when singing soprano. And my levels were all wrong, so I couldn't hear the other parts rightly in my phones, and thus I kept getting out of step and out of tune. I played the mess to some of my Canby Singers (who had sung the piece, very beautifully) and in two seconds they were rolling on the floor. There was a high note in the soprano part right at the end which I forgot about in my preoccupation with switching—until I got to it; so I let out a hideous yawp into the mic and *almost* succeeded. That was the payoff. My falsetto is not of the best. So there's one thing you can do with sync.

My main project, once I learned TEAC's controls reasonably well (after all, there's a minimum that you *have* to have) was much more serious and it worked out a lot better. Another multi-media show—the last one, "Henry," having been done three years ago with two stereo recorders and two pairs of unconnected and un-synced channels, playing approximately together. This one celebrated the 50th anniversary of a home community founded by my father and friends in 1922. My own movies, taken in the 1930s, were one visual element. Simultaneous relevant films taken recently went onto another projector, and color stills, including Kodachromes as far back as 1938 by me (earlier than that, they faded out to magenta) made up the third picture area. The photo-continuity was to be accompanied by speaking voices—my part—plus appropriate music. Three speaking elements, 1, a narrator, reading in total darkness between major segments of the show—it turned out to be me; 2, taped "interviews" with inhabitants of the place, making relevant points to go with the pictures, and 3, spoken "quotes," from many sources, which generalized the idea of a living community, or commune—we lumped the two, though ours is a very sedate and conservative place, relatively speaking.

The taped narration was easy. I did it on my regular stereo recorder in a studio, a whole year before. Two takes of each segment, and that was that. I'm pretty used to reading into microphones. I put it down mono, on both tracks, for flexibility in later use. We ended up dubbing it mono onto all four tracks of the sync recorder. A fine big effect, in the "darks," as we called them, which joined our picture segments together.

The taped interviews were a disaster. I had warned—but to no avail. The interviewers made the classic mistake of using a portable cassette recorder with built-in mic, usually set up in a noisy living room and mostly with anywhere from three to a dozen people on hand—virtually all of them hopelessly off mic. You could transcribe some of the spontaneous comments, of course; they were good. Write them down. But my people wanted to use the originals!

I did discover, interestingly, that the little machine recorded a much wider range than it could play back via its own head. When the cassettes were played through the fancy Advent 201 cassette deck, whole ranges of sibilant *ss* sounds came out, for a much improved intelligibility. We copied hours of interviews from the cassettes in this manner—and ended up using exactly two brief samples. Amplified through hall-sized speakers, the background noise and confusion was, as I knew it would be, simply horrendous. Take heed! You can improve a *well recorded* cassette sound if you play it via a quality narrow-gap head. But bad recording cannot be turned into good.

With this in mind, a whole year earlier, I had insisted that the third vocal element, the spoken "quotes," would be done *right*. These were to be read, by many different voices, and the idea was to pre-record them, then copy them off—later—onto the sync tracks. So I set up my equipment and for weeks I ran sessions under optimum conditions (optimum in terms of home use, with a good machine and a home soundproof studio). The people had to come to me; I didn't go out to them. They sat down in my studio chair, began to sweat and get scared, and then, hands shaking, the script rattling so they could scarcely see it, they would tremulously start in reading.

Amazing how most normal people are scared stiff of the friendly microphone—even a private one in a familiar home spot! They just go to pieces. I spent most of my time joshing, reassuring, trying to banish that ole devil, stage fright, in its modern and totally irrational guise. Of course, a few of the people had done acting of one sort or another. Fatal. *They* think all the world's a stage, to quote Shakespeare, and they boom and blast into the mic, a few inches away, as though All Those People were out there in the thousands, hanging on every shout. Ugh! Give me an amateur any day. I had a time, taming these boom-voices down to mic size.

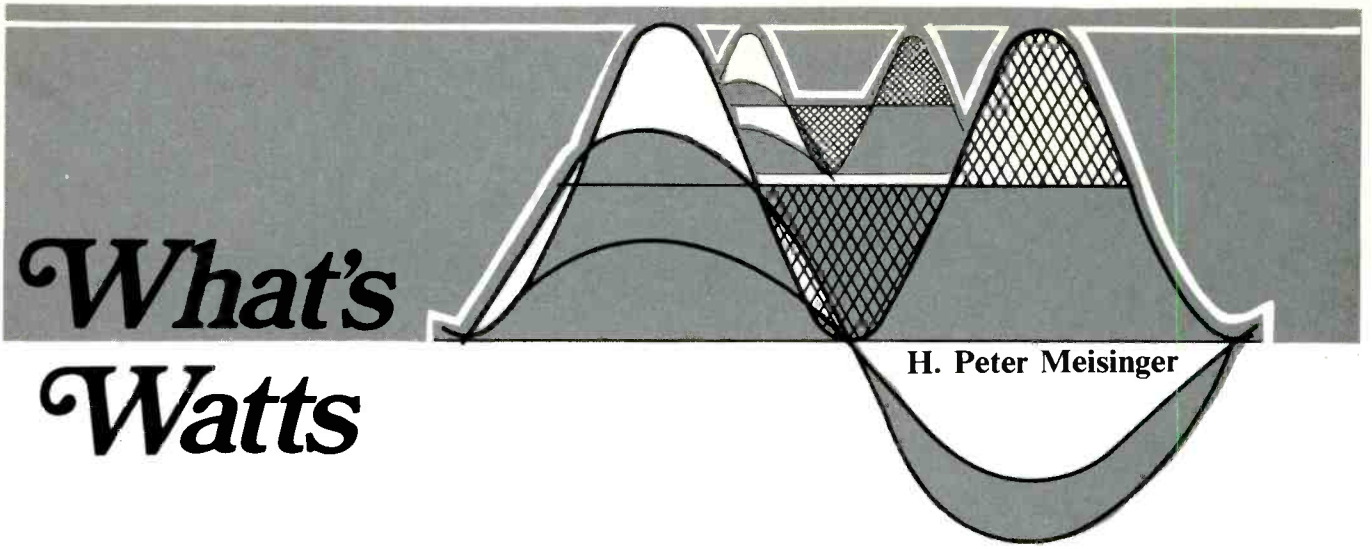
I ended up, that summer, with about a half dozen 10 in. reels of tape filled with a hundred different voice recordings, all done mono on two stereo tracks at 7½ ips. No Dolby was available, but the background sound was *low*—which was what I wanted. That allowed for free dubbing and large amplification, when the time came for the big show itself.

On an impulse, as a stunt, I did a practice job on a KLH Model Forty One stereo recorder—I created a vocal "fugue", using four or five different voices, speaking the same text. Only two channels, but the effect was—for my ear—just terrific. Everybody talking at once, yet the overlapping entries of the text, beginning with the key words *"Communes, then, are . . . "* gradually built up the sense in a way that seemed to me to be wholly modern and at the same time very much like the musical sense of an actual fugue-lacking only the harmonic pitch relationship. (Even that was approximated, as the different voices entered at different speaking pitches, men and women.)

I played this pseudo-synced vocal fugue at a public meeting where many of the people who had done the recordings were present. You can imagine their astonishment. Each of them had visited me in all privacy, made his or her recording, and had gone away not even knowing who else had been to visit, or was still to come. And here they all were, busily talking *simultaneously*, at least a dozen of them! The good thing was that every voice was doing its best to "project" as a solo, without any sonic competition; that was the studio condition as each original recording had been put down; and so their combined charisma, every one talking out his very best, was quite overpowering! Such is the force of the new medium, of which sync recording is the final fillip. I hadn't even got to that yet. But you can see how it was going to work out. Indeed, I took the original of the fugue, a year later, and synced it neatly onto four channels, instead of two, via the TEAC 2340. This time, the fugued people were talking out of all the corners of the room. I didn't even have to re-do the job from the originals.

How come? One of the most splendid incidental facilities on the sync four-channel machine is its ability to take down a new recording *without a beginning click or thump,* soundlessly. I know this is not exclusive to four channels. But with sync it is *essential*, because the essence of the whole technique is to be able to layer recordings in time, to lay them down, or remove them, right alongside other tracks. Editing-out of clicks, etc. is not possible. You can't cut one track without cutting them all. If your new "layers" were to herald themselves with that old fashioned thump or click at each beginning, your entire scheme would be useless, and the same for endings. On the TEAC 2340, then, you can add a new segment of sound on any individual track, or any combination, in sync with what is already present (which you can hear via sync playback), and there is not the slightest sound to indicate either beginning or ending of the new segment, other than the signal itself. See what I mean?

(Continued on page 80)



What's Watts

H. Peter Meisinger

In the early days of hi-fidelity, amplifier power ratings were quoted in watts. To the early hi-fi component manufacturer, the advertised watts in reality meant average watts. As hi-fidelity became more popular, a myriad of new inflated power ratings began to appear. (e.g. music power, peak power, etc.). In a seeming attempt to clarify power ratings, "the rms watt" has come into recent usage.

Recently, a great deal of discussion has taken place regarding the use of the term rms watts (1). The industry, in general, has adopted the use of the terms rms power, or rms watts. Many of the well-known testing laboratories also use these terms. Unfortunately, the terms rms watts, and rms power are incorrectly used.

In the laboratory, amplifier power is determined by measuring the voltage across a calibrated resistor with an rms voltmeter. This would lead to the seemingly logical conclusion that the watts determined in this manner would be rms watts. This is simply not true.

Ammeters and voltmeters that are used to measure alternating currents or alternating voltages invariably are calibrated in terms of the rms value of a sine wave unless otherwise specified. However,

1. The product of rms volts times rms amperes yields *average watts*, not rms watts.
2. The product of rms amperes squared times the circuit resistance yields *average watts, not rms watts.*
3. rms voltage squared divided by the circuit resistance yields *average watts, not rms watts.*

First, let us deal with voltage and current (amperes). The circuit shown in Figure 1 indicates an alternating current sine wave generator whose peak voltage is determined by the oscilloscope to be one volt. The generator is loaded by a one ohm resistor. Since current (amps) = $\frac{\text{volts}}{\text{ohms}}$, the numerical value of the current will be the same as the numerical value of the voltage since the divisor is equal to one (ohm).

Figure 2 illustrates the instantaneous current (I), instantaneous voltage (E) and instantaneous power in a resistive circuit.

The peak power is equal to the product of the peak voltage and the peak current.

$$P_{peak} = E_{peak} I_{peak}$$

Similarly, the power at any instant in time is equal to the product of the instantaneous voltage and instantaneous current.

$$W_{inst.} = E_{inst.} I_{inst.}$$

The instantaneous power curve of Figure 2 is this product, and is seen to be a sine wave of double frequency without negative values.

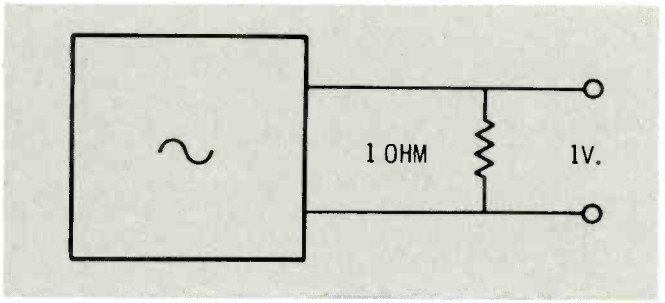


Fig. 1—indicates an alternating current sine wave generator whose peak voltage is one volt.

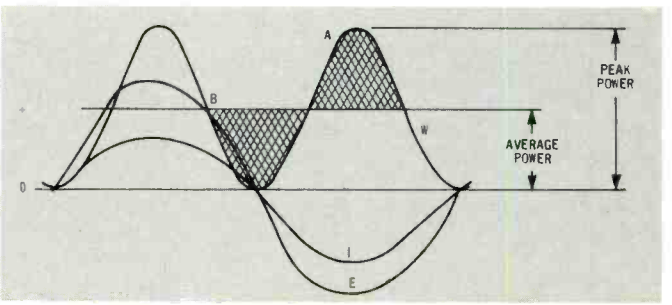


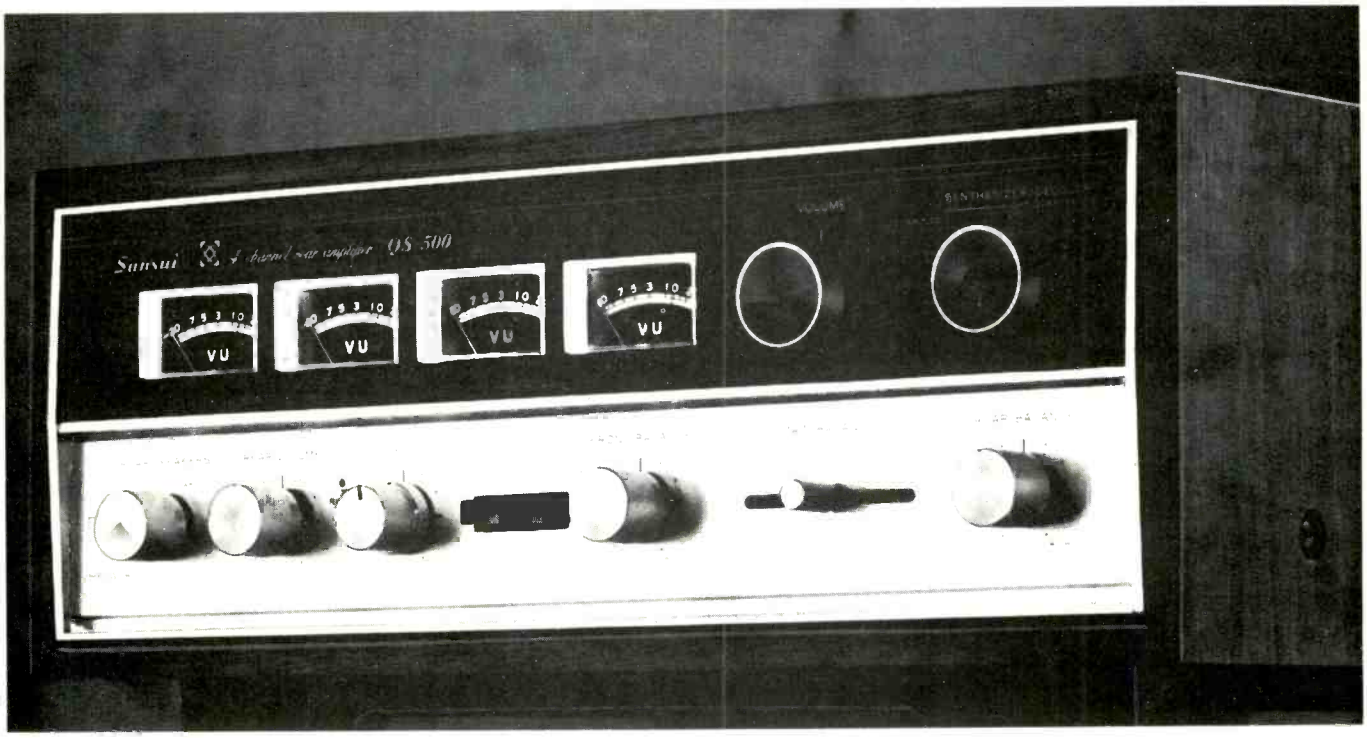
Fig. 2—illustrates the instantaneous current voltage and power in a resistive circuit.

(1) J.R. Ashley "What's a Watt (rms)?" *J. Audio Eng. Soc. Vol. 19, p. 793 (Oct. 1971)*

J. G. McKnight comments on "What's a Watt (rms)?" *J. Audio Eng. Soc. Vol. 20, p. 46 (Jan-Feb 1972)*

John Eargle and Bart Locanthi "RMS Power: Facts or Fancy" *J. Audio Eng. Soc. Vol. 20, p. 45, (Jan-Feb 1972)*

if you go for four channel...



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Buy yourself a miracle for as little as $214.95 That's all it takes to get your conventional two-channel stereo to do anything any total four-channel receiver and control center can do, now or in the future.

The Sansui QS500 and QS100 converters are complete Four-Channel Synthesizer-Decoder-Rear-Amplifier-and-Control-Center combinations that transform standard two-channel stereo totally. The only other equipment you need is another pair of speakers.

You can decode any compatibly matrixed four-channel broadcasts or recordings and reproduce them in four authentic channels. You can detect the ambient signals present in most two-channel recordings or broadcasts and propagate them through the rear channels. In Sansui matrixing, the exclusive phase-shift technique prevents the cancellation of some signals and the change in location of others that occur in many matrixing systems. And the exclusive phase modulators restore the effect of the live sound field.

You can plug in a four-channel reel-to-reel or cartridge deck or any other discrete source. In the future — if you should have to — you can add any adaptor, decoder or what-have-you for any four-channel system for disc or broadcast that anyone's even hinted at. And a full complement of streamlined controls lets you select any function or make any adjustment quickly **and** positively.

The QS500 features three balance controls for front-rear and left-right, separate positions for decoding and synthesizing, two-channel and four-channel tape monitors, electrical rotation of speaker output, alternate-pair speaker selection, and four VU meters. Total IHF power for the rear speakers is 120 watts (continuous power per channel is 40 watts at 4 ohms, 33 watts at 8 ohms), with TH or IM distortion below 0.5% over a power bandwidth of 20 to 40,000 Hz. In its own walnut cabinet, the QS500 sells for $289.95

An alternate four-channel miracle-maker is the modest but well-endowed QS100, with total IHF music power of 50 watts (continuous power per channel of 18 watts at 4 ohms and 15 watts at 8 ohms). In a walnut cabinet, it sells for $214.95

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A line drawn equidistant between the peaks and valleys of the power curve represents the average power and is seen to be equal to fifty percent of the instantaneous peak power. This is graphically illustrated by observing that the shaded top section of the sine wave fits perfectly into the shaded adjacent valley. This represents the average power.

Since the average power line is drawn at the mid-point of the power curve,

$$\text{Average power} = \frac{\text{Peak voltage} \times \text{peak current}}{2} = \frac{\text{E peak}}{2} \times \frac{\text{I peak}}{2}$$

In Figure 1:

$$\frac{1}{2} \times \frac{1}{2} = .707 \times .707 = 0.5 \text{ watts average power}$$

$$1 \text{ rms} = \frac{1 \text{ peak}}{2} = \frac{1}{2} = \frac{1}{1.4} = 0.707 \text{ of the peak value}$$

Therefore, the rms value of voltage or current equals .707 of the peak value, or conversely, the peak value equals 1.414 times the rms value.

NOTE: This is true for voltage and current, not power.

In dealing with voltage and current, the terms "rms" and "effective" are used interchangeably. The real significance of *rms* (or *effective*) voltage and current is the fact that it will cause the same amount of heat to be generated in a resistance as a numerically equal d.c. source. In other words, *average* sine wave a.c. watts generate the same amount of heat in a resistance as a numerically equal d.c. source. The watt-hour meter in your home measures average watts or heating effect, not rms watts.

rms, when used with voltage or current, permits $W = I^2 R$ and $W = \frac{E^2}{R}$ to be used alternately between direct current and sine wave a.c. since the heating effect is the same in either case.

An additional proof of the above was rather simply done using one of the new scientific pocket calculators. All computations were made to ten places, however, with the limited number of sampling points only three place accuracy can generally be assumed.

Table 1 shows the calculation of average and rms current and voltage and average and rms watts.

Column 1 lists the instantaneous value of voltage (or current). Thirty six values were computed (every five degrees of phase angle). There were totaled and divided by 36 to give us the average value of voltage or current. Average value is useful in electronic circuits. For example, the full wave rectifier where average electron drift is important.

Column 2 shows the rms value of the voltage or current in Figure 1, which is also the average value of the power in Figure 1. Each of the instantaneous values in column one were squared. The column was then totaled and divided by 36 (the number of instantaneous points computed). Computations were made to ten places with the pocket calculator. The average turned out to be precisely 0.5, the same value shown in the graphical construction above.

Since $W = I^2 R$ $\quad W \text{ max} = I^2 \text{ max } (1) = 1 \text{ watt peak}$

Since we are dealing with a one ohm load, each of the values in column two indicates instantaneous power as well as the square of the instantaneous current or voltage.

rms stands for root-mean-square. This means that we take the square root of the average of the squares. Since 0.5 is the average of column two, 0.5, or .707 equals the rms value of the voltages or currents squared shown in column two, and 0.5 represents the average of the power shown in column two.

It is important to note that each of the instantaneous values shown in column two represents the instantaneous current squared or the instantaneous voltage squared or the instantaneous power.

Some misinformed individuals have thought rms power to be .707 of the peak power. It sounds logical since rms voltage and current are .707 of their peak values. Let us examine the true value of rms power just to prove how untrue this really is. The figures in column two represent the instantaneous power in figure one. Column three shows the squares of each of the instantaneous power values of column two. The average of the sum of the powers squared is 0.375. The rms value of power is therefore, .375 = 0.6123724357. Quite a different value than .707, showing that rms power is not 0.707 times the peak power.

The 0.612 figure for rms power serves no useful purpose and I suspect has never been used for amplifier power ratings.

In dealing with power, we want to deal with the heating effect of a.c. as we deal with the heating effect of d.c. The watt is a unit of power (or rate of energy transfer), and is equal to:

10^7 ergs per second, or
3.4129 btu per hour, or
44.27 Ft-lbs. per minute, etc.

Therefore, amplifiers would be more properly rated for continuous sine wave average power (watts). rms (effective) values are fine for voltage and current but should not be used for power.

Recently, it has been implied that the use of the term rms power is just another ploy by sales departments to advertise inflated power ratings. If this were true, manufacturers would quote rms power figures as 0.612 of the peak power. However, many recent interviews reveal that this is not true. Manufacturers are measuring average power and then improperly advertising rms power. Since average power = 0.5 peak power and rms power = 0.61237 peak power (not .707).

$$\frac{.5}{.61237} = .816 \text{ to } 1 = \text{ratio of average to rms watts}$$

or

$$\frac{.61237}{.5} = 1.22 \text{ to } 1 = \text{ratio of rms to average watts}$$

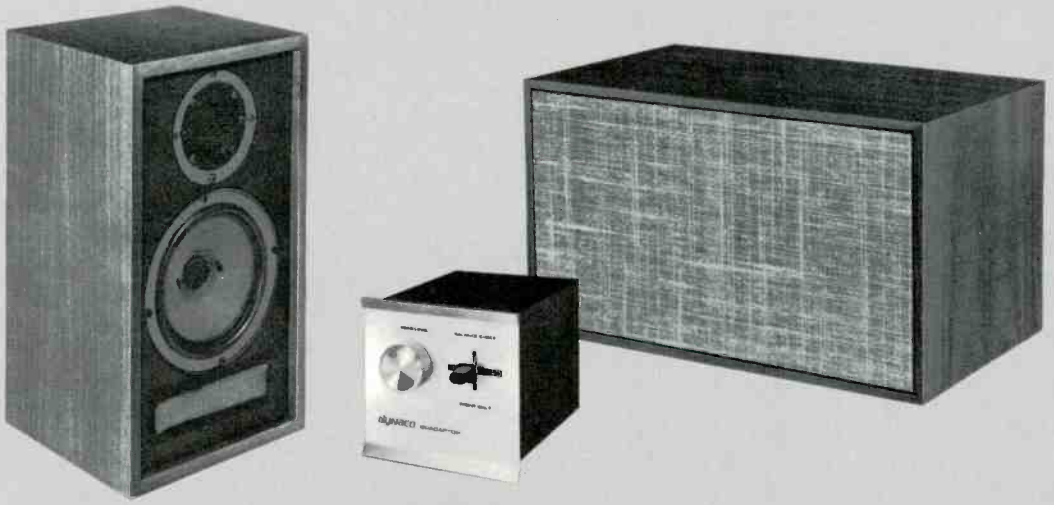
Therefore, the manufacturer that measures 100 watts average power and quotes 100 watts rms power could legitimately quote 122 watts rms power. Current industry practice may be fallacious, but it is not dishonest.

1. The average value of a sine wave voltage or current equals .636 of the peak value.
   1a. The peak value of a sine wave voltage or current equals
   1.57 of the average value
2. The root mean square (rms) value of a sine wave voltage or current equals
   .707 of the peak value
   2a. The peak value of a sine wave voltage or current is equal to
   1.414 times the rms value
3. The square of the sine wave rms voltage divided by the circuit resistance equals the *average* watts (power), not rms watts

$$W_{avg} = \frac{E^2_{rms}}{R}$$

   NOTE: This is the average, not the rms watts.
4. The square of the sine wave rms current multiplied by the circuit resistance equals the average watts (power), not rms watts.

AVOID 4-CHANNEL CONFUSION



Quality Quad Sound Now At Low Dynaco Prices

Dynaco's $20 Quadaptor decoder delivers full 4-Dimensional sound now from encoded records in any of the compatible matrix formats. More important, it recaptures the elusive ambience, or realism, which has always been a part of your **present stereo records** too, but which you've never been able to hear before.

No phase shifting gimmicks; zero distortion; all the sound that's always been there, with correct placement and proportion. It's Dynaco's simpler way to fully decode (U.S. Patent #3697692)—at the output of your present amplifier. **You don't need a new amplifier.** Use your stereo system to the fullest while the 4 channel hassle settles down.

Superior audio performance is a Dynaco tradition. Fine craftsmanship is evident in even our least expensive speaker. The compact A-10 (8½" x 15" x 8") nearly duplicates the famous A-25's sonics. It uses the same woofer magnet and the identical tweeter in an oiled-walnut **wood** (not plastic) cabinet at a fraction of the A-25's price. The A-10 fits in any bookshelf, or is easily hung on the wall with brackets supplied.

The best buy A-10 is the first choice for inconspicuous back speakers in quad systems, perfectly complementing your present larger Dynaco (or other similar-sounding) designs. Smooth, articulate, wide-range clarity; near-perfect transient response for precise delineation. Verbatim reproduction with prodigious power handling capability makes the A-10 the obvious choice for main speakers, too, where space is at a premium.

Dynaco never rips you off. To prove it, a diagram on our demo record (from your dealer, or send coupon) shows you how to try 4-D sound without even the Quadaptor if you have 4 similar speakers.

SPECIAL DIRECT OFFER ON 4-DIMENSIONAL DEMO RECORD

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3060 Jefferson Street, Philadelphia, Pa. 19121

Enclosed is my check or money order for $2.95. Please send me the new Dynaco/Vanguard 4-D demo record postpaid. Limited to USA residents only.

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In Canada write: DYNACO OF CANADA LTD., Montreal, 760, Quebec, Canada

$$W_{avg} = I^2 \text{ rms } R$$

5. The product of the rms voltage and the rms current equals the average watts (power), not rms watts.

$$W_{avg} = E_{rms} \times I_{rms}$$

6. A wattmeter reads average, not rms watts.
7. The average power in a circuit is one half of the peak power.

$$W_{avg} = 0.5 \text{ W peak}$$

8. rms power is equal to .61237 of the peak value.
There are no instruments (voltmeters, ammeters or wattmeters) that are calibrated in terms of rms power. Furthermore, it is a rather useless term.

$$W_{rms} = .61237 \text{ W peak}$$

9. Since
$W_{avg} = .5$ Wpeak
$W_{rms} = .61237$ W peak
.61237 = 1.22 to 1 = ratio of rms to average watts

$\frac{.61237}{.5}$ = 1.22 to 1 = ratio of rms to average watts

$\frac{.5}{.61237}$ = .816 to 1 = ratio of average to rms watts

TABLE I
VOLTAGE CURRENT AND POWER VALUES FOR FIGURE I
E max = 1 volt I max = 1 volt W max = 1 watt

Degrees	E inst. (volts) or I inst. (Amps)	I inst.^{2} or E inst.^{2} or W. inst. (Watts)	W inst.^{2}
5	.0871557427	.00759612349	.00005770109
10	.1736481775	.0301536895	.00090924499
—	— — — —	— — — —	— — — —
175	.0871557427	.00759612349	.00005770109
180	—0—	—0—	—0—
TOTAL	22.90376554	18.	13.49999998
Average	$\frac{22.90376554}{36} = .636$	$\frac{18}{36} = 0.5$	$\frac{13.49999998}{36} = .375$
RMS	.636 to 1 = ratio of average to peak voltage or current	0.5 = .7071067812 .7071067812 to 1 = ratio of rms to peak voltage of current	.375 = .6123724357 .6123724 to 1 = ratio of rms to peak watts

Microphone Directory

Addenda

MANUFACTURER	MODEL	Directional Pattern	Operating Principle	Case Material	External Finish	Impedance, Ohms	Frequency Response, Hz to kHz, −7 dB	EIA Sensitivity, dM	Mic Connection	Cable Length, Ft.	Cable Plug Type	Dimensions, In.	Weight, Oz.	Mounting Method	Price	SPECIAL FEATURES
SENNHEISER	MD 211-U	Omni.	*	Metal	Dull Chrome	200	40-20k ±2.5	−149.3	XLR	15	XLR	⅞ x 5	5	Stand or Boom	154.00	Very flat frequency response. *Pressure transducer.
	MD 415	Card.	*	Metal	Gold	200	60-15k −2	—	Tuchel T3260	18	Din.	1¾ x 6	11	Stand or Boom	141.00	**Pop., resistant. *Pressure gradient transducer.
	MD 421U	Card.	Pres. Grad.	Synth. Fiber	Dull Gray	200	30-17k	−148.5	XLR	15	XLR	7 x 1⅞ x 1¾	14	Stand or Boom	129.00	Continuous bass roll-off attenuator.
	MD-420-2	Close Talk	Pres. Grad.	Metal	Lt. Dull Gray	200	200-10k	−146	Tuchel T-3080	15	Tuchel T-3080	1½ x 5¼	4	Stand or Goose Neck	−2 65.00	Noise-canceling mic.
	MD-420-2T														−2T 73.00	
	MK12	Omni.	Cond.	Metal	Gray	10	20-20k	−121.5	Att.	15	Min.	½ x 1½	3.2	Tie Clip	227.00	Lavalier type.

The best time to upgrade your component system is before you buy it.

If you're a typical reader of this magazine, you most likely have a sizeable investment in a component system. So our advice about upgrading might come a little late.

What you might have overlooked, however, is the fact that your records are the costliest and most fragile component of all. As well as the only one you will continue to invest in.

And since your turntable is the only component that handles these valuable records, advice about upgrading your turntable is better late than never.

Any compromise here will be costly. And permanent. Because there is just no way to improve a damaged record.

If the stylus can't respond accurately and sensitively to the rapidly changing contours of the groove walls, especially the hazardous peaks and valleys of the high frequencies, there's trouble. Any curve the stylus can't negotiate, it may lop off. And with those little bits of vinyl go the high notes and part of your investment.

If the record doesn't rotate at precisely the correct speed, musical pitch will be distorted. No amplifier tone controls can correct this distortion.

If the motor isn't quiet and free of vibration, an annoying rumble will accompany the music. You can get rid of rumble by using the bass control, but only at the expense of the bass you want to hear.

Experienced component owners know all this. Which is why so many of them, especially record reviewers and other music experts, won't play their records on anything but a Dual. From the first play on.

Now, if you'd like to know what several independent test labs say about Dual, we'll send you complete reprints of their reports. Plus a reprint of an article from a leading music magazine telling you what to look for in record playing equipment. Whether you're upgrading or not.

Better yet, just visit your franchised United Audio dealer and ask for a demonstration.

You'll find Dual automatic turntables priced from $109.50 to $199.50. That may be more than you spent on your present turntable, or more than you were intending to spend on your next one.

But think of it this way. It will be a long, long time before you'll need to upgrade your Dual.

Dual®

Dual 1215 S, $109.50

Dual 1218, $155.00

Dual 1229, $199.50

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Exclusive U.S. Distribution Agency for Dual.

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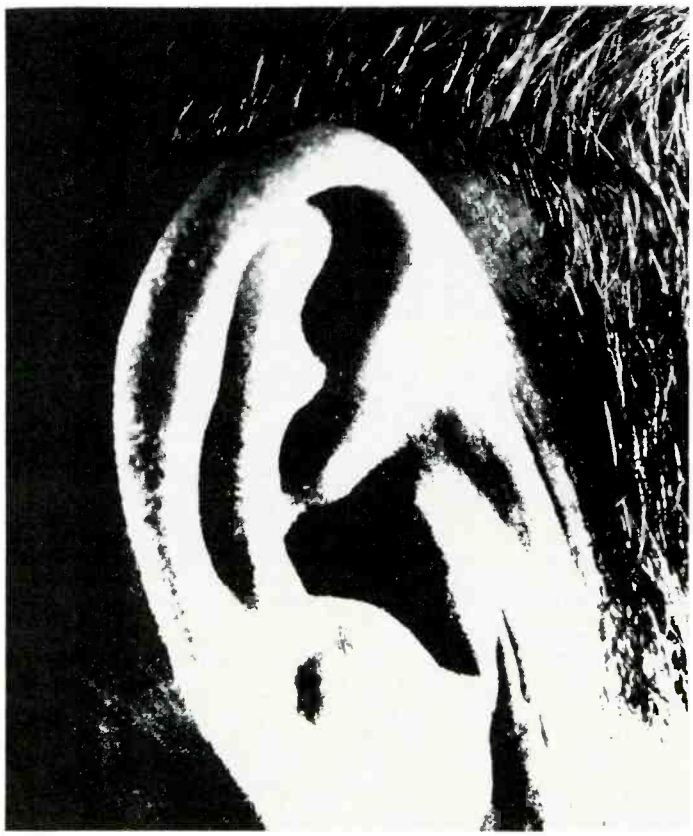
Martin Clifford



The Language of High Fidelity --Part VIII

THERE'S NOTHING BETTER than the onset of well-deserved sleep that succeeds a hard day's work. But, given a quiet enough room, with outside and inside noise down to a minimum, then the malicious intent of a single mosquito humming its act of vengeance will be noticeable in the sense that you'll hear it. The sound power output of this insect, beside which a bee is a behemoth, is maximum at the source and might represent a microwatt, a millionth of a watt, or less. But that is at the source. Lying prone, some six or eight feet away, the sound decreases to a fraction of its original amount. It is difficult to say by how much since high pitched sounds, in traveling through air, decrease in strength much more rapidly than low-pitched sounds. And the mosquito is quite far removed in pitch from the bass tones of a pipe organ. And so what does alert you is a sound power of a fraction of a millionth of a watt.

Thinking in the other direction, you might turn on your hi fi system so the sound level reaching your ears is about 1 watt. Purely on the basis of these unscientific revelations, your hearing has a sound power range of more than a million. Actually, the power range of human hearing has a factor of several million or more, from sounds that are barely perceptible under ideal hearing conditions to the point at which they become somewhat painful.

The Loudness Of Sound

The loudness of sound is a measure of the *intensity* of the sound. Loudness levels are described in terms of decibels, abbreviated as dB. If you want to take 0 dB as your reference level, that would be the end of your auditory yardstick at which you might just barely hear sound, but wouldn't be too sure about it. Down at 0 dB you might become conscious of the noise of your own breathing and your heart beat interfering with this test.

Someone trying to attract your attention and whispering to you from about five feet away might produce a sound intensity of 10 dB. An auto in good condition about twenty feet away might raise sound pressure to 50 dB. On a Saturday afternoon your supermarket is probably around 60 dB and so if you and a friend are shopping-talking, the conversation is being carried on at around 70 dB. Pneumatic street drills, steel girder riveting, and on-ground nearby jet engines can push sound pressure up to 90, 100 or more decibels. At which point you should leave, cover your ears, or stuff them with cotton, for you are at the threshhold of pain.

Now let's translate this in terms of audio power. 10 watts isn't all that much: most amplifiers and speakers today have much higher ratings. And yet if you have a listening position of about 10 feet from a speaker system utilizing 10 watts of audio power you will have passed the threshhold of pain, or somewhere between 100 and 120 dB, depending on the characteristics of your own hearing mechanism. That's not too surprising, though, since you are listening to a sound power level that's many millions of times greater than the mosquito we started with.

Manufacturers often talk and write about performance specifications, particularly their wide frequency range, as an indication of their equipment's quality. But how does this relate to "listening quality"? Speaker manufacturers publish nearly identical specifications—but these are of interest only as theoretical abstractions, since no one can significantly relate them to "listening quality."

Bozak Speakers have only one purpose, we call it the "Bozak Ideal"; to recreate your favorite sounds technically and musically—rock or Bach—in all of their subtle detail and thrilling power. With clean, true-pitch bass, clearly defined mid-tones and clear, warm treble.

Bozak's Sonora speaks for itself too! Designed especially for those with an ear for superb sound but with limited budget, as well as space, Sonora has more quality for its size than any other bookshelf speaker available. Hear them at your Bozak dealer today. You'll discover that *every* Bozak is *all* Bozak!

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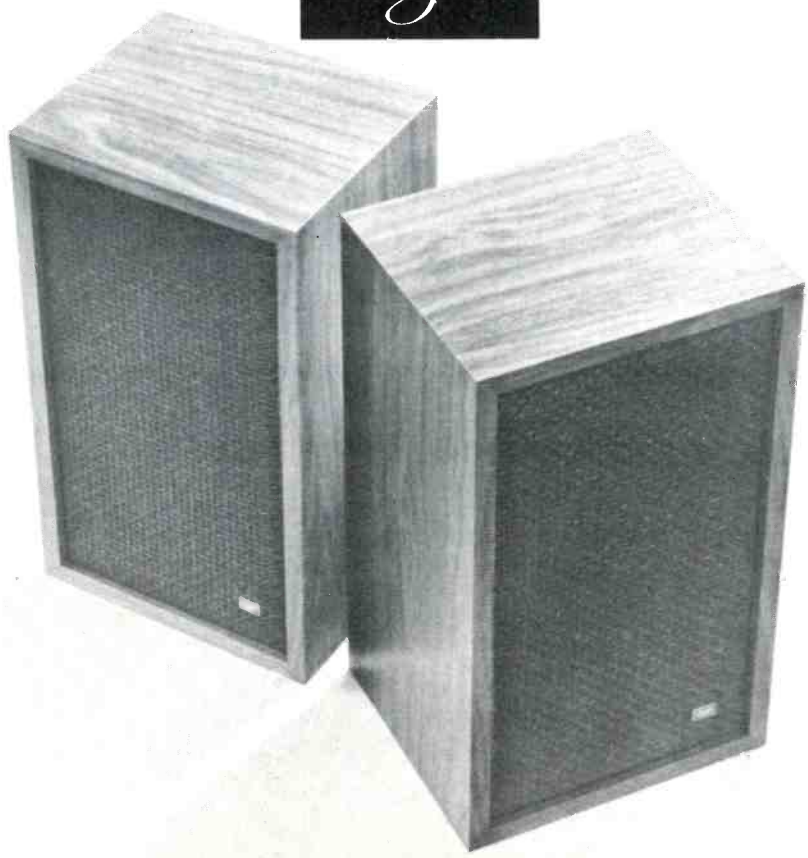


Sound Characteristics

We live at the bottom of an ocean of air, walking through it, breathing it, polluting it, pushing it. And when we disturb it we get sound. But air consists of molecules, and so we get sound by upsetting their random scattering behavior, compressing them at times, rarefying or separating them at others. It may seem difficult to categorize such a situation, but we can and we do.

Sound has three dependable characteristics: loudness, pitch, and quality. Working backward, the quality of a sound depends on the number of overtones or harmonics. The pure tone of a pitch pipe sounds dispirited compared to the richness of the human voice at the same tone, harmonic laden. Pitch is determined by the frequency of the sound wave and the larger the number of sound vibrations per second, the higher the pitch. Listening pitch range depends upon a person's age, sex, health, disposition to tell the truth about hearing ability, and the loudness of the sound. It can extend from 20 Hz to 15,000 Hz, but is probably in a narrower range for most people.

Many people can hear up to 10,000 Hz, with those having a hearing ability above 10,000 and going to 15,000 or possibly 20,000 Hz becoming a select crew. Down at the other end, the problem is twofold. Once we get below about 50 Hz, it is very difficult to get pure tones. Thus, if you're listening to the low-down pipes of an organ, what you think may be 30 Hz, is more probably the second harmonic, or 60 Hz. In listening to a complex tone, it is entirely possible for the fundamental to be inaudible. What we hear will be harmonics.

Loudness is another factor. You might be able to hear a pure tone of 30 Hz if it were loud enough. And so one of the characteristics of human hearing is that we need more sound power down at the low-frequency and to be able to hear the lows in proper proportion to the rest of the audio range. You can test this yourself with an ordinary, non-sophisticated, non hi fi receiver. Tune in a station with a thumping good bass and make sure the volume control is way up. Now turn down the control for 'quiet' listening and you'll find the bass has practically disappeared. It isn't that the volume control has preferential militancy against bass. Blame it on your ears. That's why, in an orchestra suddenly reaching a pianissimo passage, the man with the bull fiddle doesn't have to decrease his sound output as much as the artist with the piccolo. And while we're with this orchestra, you might note that the difference in dB between the softest and loudest passages is the *dynamic range.*

	RATIO OF SOUND POWER INTENSITY	RATIO OF SOUND POWER INTENSITY IN DECIBELS
1	0	
	10	10
	100	20
	1,000	30
	10,000	40
	100,000	50
	1,000,000	60

Fig. 1—A comparison of sound power or sound intensity and the corresponding change in decibels.

Fig. 1-A—A comparison of sound power or sound intensity and the corresponding change in decibels.

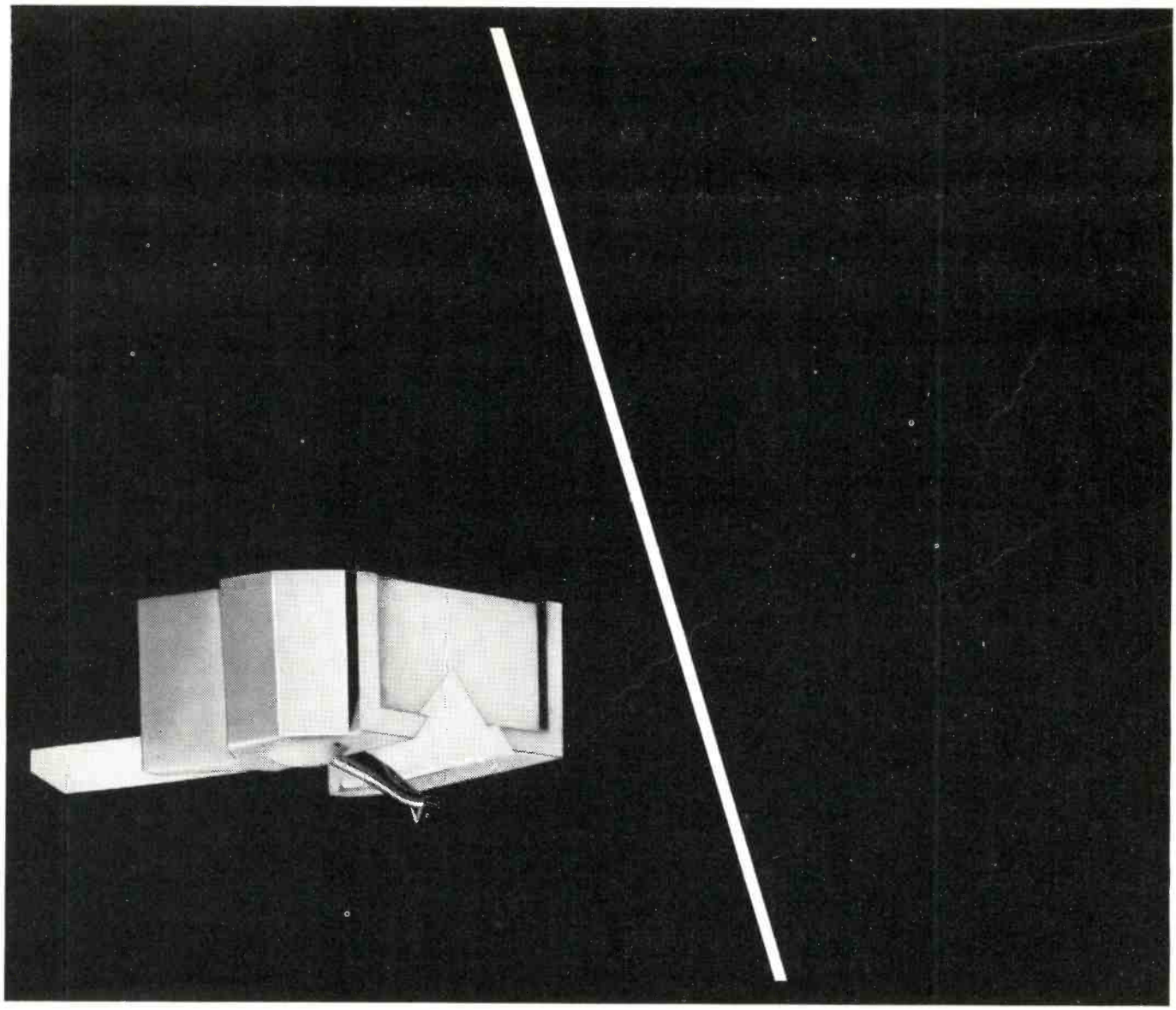
Some Sound Differences

The sensitivity of the ear to loudness isn't all that simple, for it depends on both pitch and the sound power level. And a certain increment in sound power is required before we can perceive that a change has been made. If, for example, you are whispering at a sound level of 5 dB and raised your voice by just 1 dB, the difference would not be noticed. It is because a definite percentage increase in sound intensity is required before a change can be noticed that we use the decibel whose value represents the smallest loudness change we can be aware of in the middle range of sound frequencies. As an example, assume we have two tones at the same pitch. If these two tones differ by three dB, the second will have twice the power of the first, hence will sound twice as loud. If we go to 6 dB, the second tone will sound four times as loud. In effect, we get a doubling of sound loudness for each 3 dB increase. The decibel, then refers to a difference in the level of sound intensity. A decibel is a comparison unit. And because this is what it is, it has no name, such as those we assign to other units of measurement—6 inches, 20 gallons, etc. If you insist on a definition, a decibel is a logarithmic comparison or ratio between two power levels. Logarithmic, not because we want to make things difficult for hi fi listeners, but because that is the way the human ear responds to sound pressure levels.

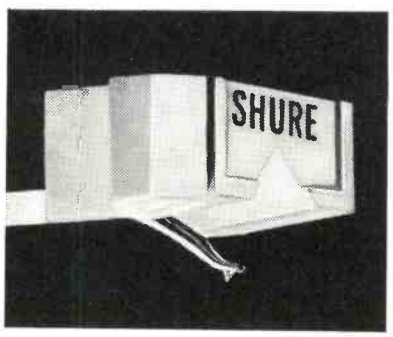
Figure 1 is a table that compares the ratio of the intensities or the powers of two sounds and that same relationship expressed in decibels. Note, in the column at the left, if we increase sound intensity by a multiplication factor of 10, the decibel change is simply an increase (not a multiplication) of 10. If, for example, you have an amplifier with an output of just 1 watt and decide to exchange it for a unit with an output of 100 watts, what you will gain will be 20 decibels, or the logarithmic ratio between 100 and 1. It takes a gain of 1,000,000 to 1 to get a gain of 60 dB. Figure 1 also shows that if you start with a 1 watt output and go to 10 watts, you will need to go to 100 watts, to get the same dB increase. However, if you are already at 100 watts (and the amplifiers in many receivers and power amps do have such a rating), then you would need to go up to 1,000 watts, 1 kilowatt, before getting another 10 dB increase.

When Is a Watt Not a Watt?

An amplifier with a power output of 10 watts can drive you out of your room and skull. And yet, if you have an amplifier with a power output of 50 watts (and if, theoretically, you could listen to it) you would not notice the difference if you increased the power output by an additional 10 watts, going from 50 to 60. 10 watts in both instances, with one that is ear shattering and the other barely noticeable. The answer is in the word *difference.* In the first you might be going from 1 milliwatt, or a thous-



The three-dollar bill.



The stylus shown above is phony. It's represented as a replacement stylus for a Shure-cartridge, and although it looks somewhat authentic, it is, in fact, a shoddy imitation. It can fool the eye, but the critical ear? Never! The fact is that the Shure Quality Control Specialists have examined many of these impostors and found them, at best, to be woefully lacking in uniform performance — and at worst, to be outright failures that simply do not perform even to minimal trackability specifications. Remember that the performance of your Shure cartridge *depends* upon the stylus, so insist on the real thing. Look for the name SHURE on the stylus grip (as shown in the photo, left) and the words, "This Stereo Dynetic® Stylus is precision manufactured by Shure Brothers Inc." on the box.

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SHURE

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andth of a watt, a change of 40 dB. In the second example, the change would be from 50 to 60 dB, and the ratio here (60 divided by 50) is about 1.2 dB, and that amount of change is hardly noticeable.

Loudness Vs Pitch

Loudness is sound pressure; pitch is frequency. If you have two tones of the same frequency, it takes about 3 dB for the second tone (still of the same frequency) to sound twice as loud as the first. In terms of power output, assume the first amplifier has an output of 10 watts with 1 watt of signal driving power. The output in dB is 10. Still using a tone of the same frequency, and the same amount of signal driving power, the second amplifier could have an output of 20 watts, or twice as much power output as the first. The output would be 13 dB. A 100% increase in power output in this example results in a tone that sounds approximately twice as loud.

But extremely few compositions are written for single tones. Even that perennial favorite of the novice pianist, "chopsticks," does have some tonal variation. The saving grace is that the ear is extremely sensitive to changes in pitch. In the middle regions of the sound scale, a change in pitch of only three tenths of one percent is generally noticeable. And so, while sound must literally blast us out of our listening seats to get our attention that a change of sound pressure or loudness has taken place, just a slight movement up or down the musical scale flashes a warning signal to our listening apparatus.

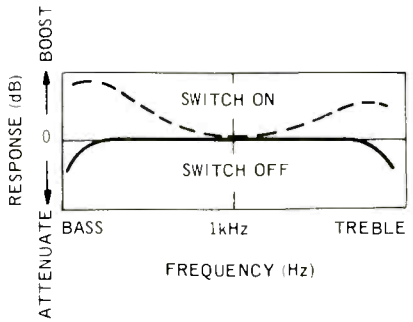


Fig. 2—The loudness control compensates for deficiencies in human hearing at low levels at the extremes of the listening range.

Loudness Vs Volume Controls

On the front of your receiver or power amp you will find two controls, one identified as *loudness,* the other as *volume.* The function of the volume control is obvious. It controls sound power output so that what you hear covers the range from oh so quiet to tympanum shaking. The loudness control, sometimes called loudness contour, and not to be confused with the volume control, governs a circuit which counteracts the reduced sensitivity of the ear to very low and high notes at low volume levels. The loudness control which compensates for the way the human ear behaves, boosting extreme sound ranges at low volume settings. And so, if you have your volume control turned up, switch the loudness control to its *off* position. Fig. 2 is a graph that shows the behavior of the loudness switch. In the midrange it has no effect, but it compensates for our hearing rolloff down at the bass and up at the treble ends.

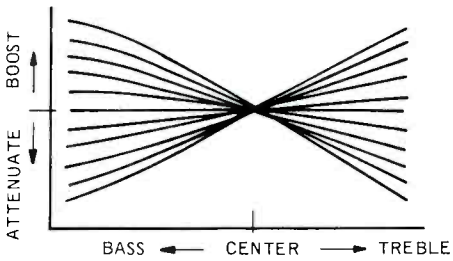


Fig. 3—Frequency characteristics of a CR type tone control.

Volume Vs Balance Controls

The purpose of the balance control is to govern the amount of sound coming from left-right speakers. Without this control you would need to position yourself rather precisely to get optimum stereo effect from your two speakers. The balance control lets you sit to the right or left of center and to compensate, not only for your position, but for the fact that the two speakers might have different efficiencies. The balance control, of course, is nothing more than a special purpose volume control. However, the balance control doesn't work quite the way you might think it does. If you turn it to the right, it doesn't increase right-channel volume but actually reduces left-channel volume. It's all relative, anyway.

Tone Controls

Unless you are a juke box afficionado and have an unsatisfied desire for strong bass, or if you have a predilection for treble, the best place to keep the tone controls is in their 'flat' position, clearly marked on the panel of your receiver or power amp. Tone controls are best used sparingly and their constant manipulation indicates a form of nervous apprehension not curable by music. The purpose of the bass and treble controls isn't to supply the owner of the power amp with some kind of musical dictatorship, but to compensate for the listening room, or possibly for the speakers, to overcome minor deficiencies in the recorded material, or to satisfy the idiosyncrasies of a pair of ears. With good, new LP records or tapes played on good equipment in a representative listening room, extreme tone control settings are almost never required.

In its simplest, bargain basement form, as found on portable radios, a tone control is just a combination of a capacitor with a resistance. A tone control of this type doesn't boost anything. It makes bass sound stronger, but does so by cutting down on treble.

More suitable to hi-fi applications is the CR type tone control (Fig. 3) which boosts or reduces frequencies above and below a turnover point. For even more precise, active control, negative feedback techniques are used. Known as an NFB type tone control,

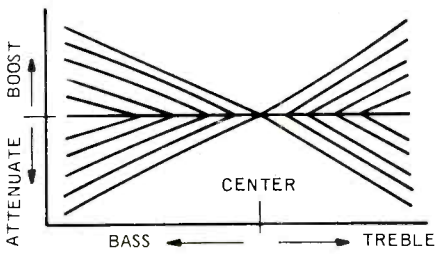
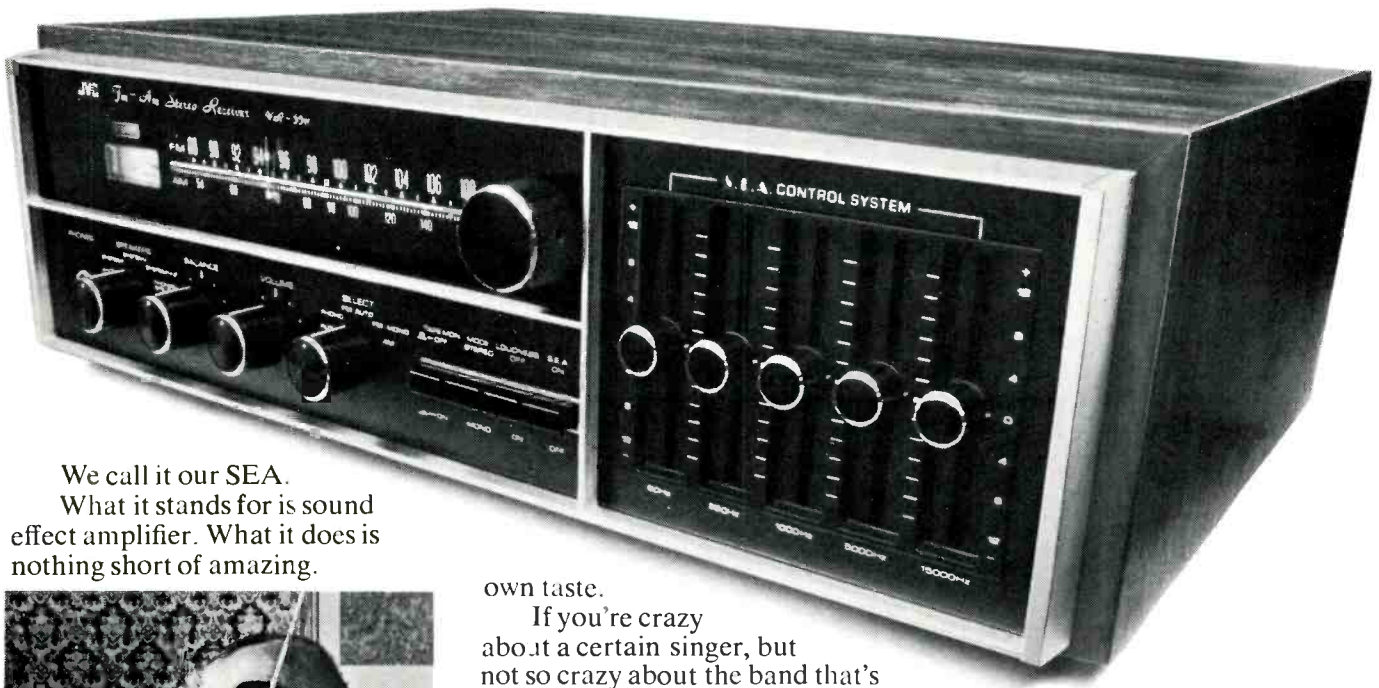


Fig. 4—Frequency characteristics of a NFB type tone control.

it requires rather elaborate solid-state circuits. Fig. 4 shows the frequency response characteristics.

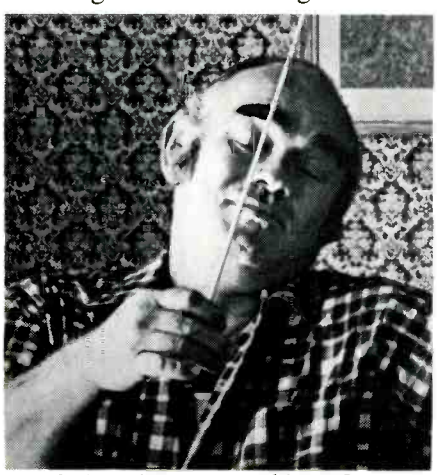
On some amplifiers, the tone controls work on the left and right stereo channels simultaneously, while others may have separate controls, usually concentric double knobs for governing the left and right channels separately, advantageous when your listening room presents some acoustic problems.

This receiver gives you more control over Beethoven's Fifth than Beethoven had.



We call it our SEA.

What it stands for is sound effect amplifier. What it does is nothing short of amazing.



It breaks up sound into five different frequency ranges, instead of just the usual bass and treble. So you can tailor sound to your own taste.

If you're crazy about a certain singer, but not so crazy about the band that's playing with him, you can bring up the voice and push the music into the background.

The same thing can be done to emphasize a particular section of an orchestra. Or even a particular instrument.

And since there's not much point in having a great receiver with not-so-great acoustics, SEA lets you compensate for the shape of your room and the furniture in it.

But the nicest thing about the SEA system is its ability to create entirely new sounds by mixing and altering other recorded sounds.

This SEA receiver also has a linear dial scale with "Bull's Eye" tuning. Which takes the guesswork out of tuning FM.

Another great thing about this powerful FM/AM receiver: it's ready to handle 4-channel sound any time you are. Because it has all the necessary inputs and outputs for 4-channel sound.

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JVC

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Filters

The word 'filter' is possibly an unfortunate choice for it connotes an improvement or a greater obtainable purity with its use. Alas, not so. The purpose of a filter is to attenuate low or high (or both) sound frequencies. Low and high filters, sometimes labeled as *rumble* or *bass* filters and noise or scratch filters, respectively, on hi fi equipment, have functions as shown in the curves of Fig. 5. The bass filter is designed to cut off, or more

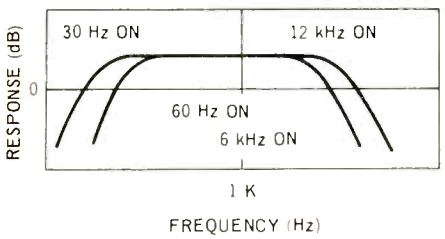

Fig. 5—Filter characteristics.

precisely, to attenuate by so many dB, the sound spectrum below a certain point, generally somewhere between 100 and 50 Hz. This is particularly useful if you have a turntable that generates some hum and rumble. Note this isn't a particularly good technique, because the price you pay is the elimination, or, at least, the attenuation of a part of the musical spectrum. If your equipment works best with the bass filter set in its maximum position, it would be advisable to consider a cure.

The high filter attenuates frequencies above 8,000 to 10,000 Hz to eliminate scratching and hiss from records, tapes or FM reception. Again, you pay a price in the loss of sound you should be hearing. Tape hiss can be cut down quite a bit by the use of a Dolby unit which you can incorporate into your present hi fi system, or, if you haven't as yet bought your cassette or open reel unit, just make sure they are 'Dolbyized'. As far as record noise is concerned, it is the better part of hi fi valor to make sure your discs are clean, that your stylus is not only clean but in good condition, and that tracking pressure is correct. Using your scratch filter as a substitute is an easy, but not a good way, out. The ideal position for filters is in the 'off' position.

Crossover Networks And Level Controls

The purpose of telling you about loudness, volume and tone controls is to show you that we don't have to accept sound as it is. We can manipulate it and shape it, as though it were just so much malleable clay. And if, as a purist, you think this is a terrible thing to do, consider the effect you have on sound every time you move around a room, or what you hear 'live' depends on where you sit, and on your musical training, and on the state of health of one ear versus the other. Not all soup tastes best unseasoned.

It is true that during the manipulative process of setting filter, loudness and volume controls the sound is still in the form of an electric current, but you can also change it when it emerges as sound energy just by shifting speaker positions or altering the acoustic contour of your listening room by adding some throw cushions or removing a rug.

We changed sound to suit personal tastes. And as musical tastes change, there may come a preference for sound that more closely resembles the original. Call it musical sophistication.

Sound can not only be modified, but split as well. Your speaker systems contain crossover networks and quite possibly one or more level controls.

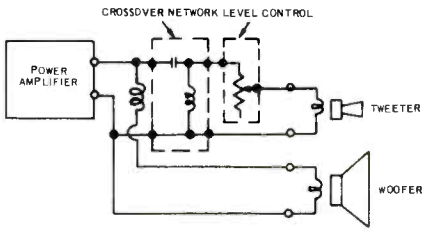

Fig. 6—Crossover network and level control.

(Fig. 6). Crossovers are electronic circuits that split the sound spectrum into low and mid/high range for 2-way systems, low, mid- and high- for 3-way. Ordinarily, the crossover consists of coils and capacitors, with the coils as ferrite types. The border frequencies at which sound ranges are continuous are called crossover points. (Fig. 7) Because they are not tunable, they do not always deliver equal response in each sound range.

The level control is a 'kissin cousin' of the volume control and works the same way. It consists of a variable resistor, a potentiometer or 'pot' which dissipates part of the signal. And so, it is just a simple attenuator which allows the medium or high sound ranges to be suppressed or boosted to a limited extent a helpful way of matching the speaker response to the acoustics of your listening room. That word 'boosted' though, is a misnomer. No resistive network, acting alone, ever boosts anything. It just sounds as though it does. All it can do is to weaken one part of the sound spectrum relative to some other part. But if your sound system has volume to spare, the price is quite small.

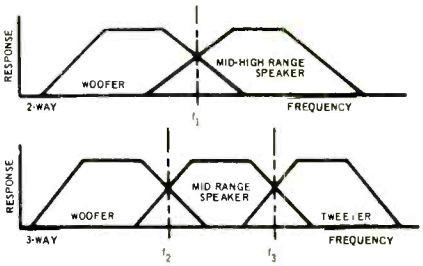

Fig 7—Graphs of 2-way and 3-way crossover networks; f1 is the crossover for the 2-way; f2 and f3 for the 3-way.

Noise

Sound doesn't always reach us in its original pristine purity. On its way to us from the FM station it can be sullied by other signals, both man-made and natural. Atmospheric noise, auto ignition noise, noise from inside fluorescents and outside neons, electrical noise from motors. That's still not all. The insidious enemy is at work right inside your hi fi system. Currents produce noise when they flow through parts, such as resistors. Your record player is a combined music and noise maker. And, invisible though they may be, in your home you are surrounded by magnetic fields whose varying strengths enable them to induce hum voltages into your hi fi system. The sum of this electronic ecological disaster is grouped under one heading—noise. It consists of a mixture of random signals, plus all unwanted signals such as hum, hiss, rumble, interference and distortion. Signal-to-noise ratio, abbreviated as S/N, is a comparison or a division—the amount of wanted signal divided by the amount of noise. The ideal is to make S as large as possible and drive N down to zero. The ratio is always given in dB. 50 dB is about a minimum requirement. A signal to noise ratio of 20 dB means the signal is 100 times as large as the noise. With a ratio of 30 dB the signal is 1,000 times greater. When you get up to 60 dB, the signal is a million times as large as the noise. But if this is any solace to you, remember it takes just one small swimming fly to spoil a plate of soup.

(to be continued)

In practice, s/n measurements are usually expressed as a voltage ratio. A s/n of 40 dB would be equivalent to a voltage ratio fo 100.
-Ed.

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FAIL-SAFE AUDIO AMPLIFIER DESIGN

Brian G. Wachner*

High power, solid-state audio amplifiers are not new to audiophiles. Shaker table amplifiers, which are used in our aerospace programs to test equipment for mechanical stress failure, have been capable of delivering more than ten kilowatts at low audio frequencies for more than a decade. The 1960's saw a dramatic transition from tube equipment to solid-state electronic equipment. But because early power transistors had limited voltage ratings, a step-up out-put transformer was necessary to produce voltage swings large enough to drive speakers (see fig. 1). Even now we still find manufacturers of public address systems using step-up output transformers to provide a 70-volt line.

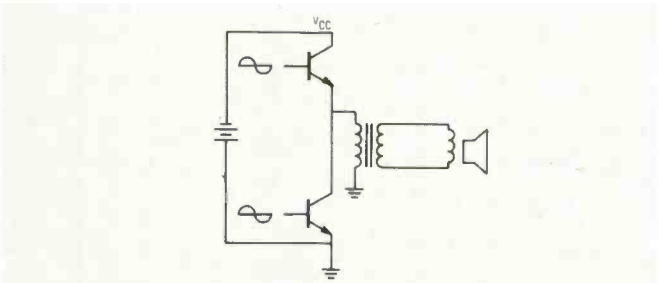

Fig. 1—Transformer coupled output stage.

As the technology in the semiconductor industry improved, the break-down voltage ratings of power transistors also improved. Capacitor-coupled designs (see fig. 2) came into

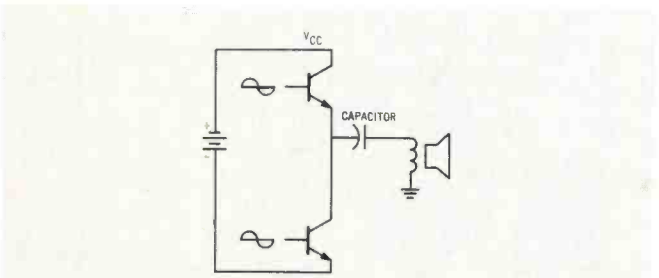

Fig. 2—Capacitor coupled output stage.

vogue. Soon afterwards, a few brave audio amplifier manufacturers entered the market with direct-coupled output stages instead of the traditional indirect-coupled output stage. As a result of the experiences of these early audio amplifier manufacturers, substantially all high performance audio amplifiers now use direct-coupled output stages. But the evolution of the dual supply, direct-coupled output stage has not been trouble-free.

The utilization of a direct-coupled output stage requires that the speaker system be connected in series with the output stage transistors and the power supply. If a transistor should fail, then excessive current would flow directly through the speaker system, producing extensive speaker damage. With transformer and capacitor-coupled output stage designs, the power supply voltage simply cannot appear at the output terminals of the amplifier, so no speaker damage can ever result from transistor failure.

* BGW Systems.

Direct-Coupled Output Stage Design

At the outset it is important to understand just what happens in a typical direct-coupled output stage when a power transistor develops a short from its collector to its emitter. The diagram (fig. 3) is a simplified direct-coupled output stage and shows the speaker system in direct series with the output transistors and power supply. There are no transformers or capacitors to serve as a "buffer" to prevent excessive current from flowing through the speaker. A collector-to-emitter short of one or both output transistors places the speaker system directly in series with the power supply. This, of course, means "instant death" for prized woofers and tweeters unless excessive power supply current can somehow be prevented from reaching the speaker system before its point of destruction.

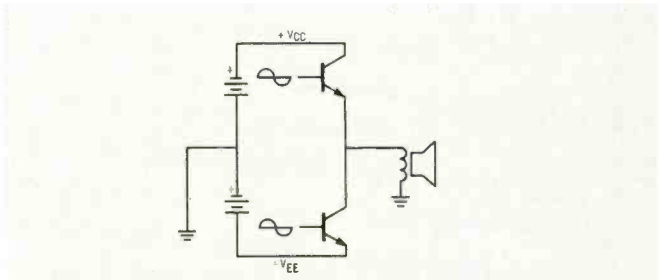

Fig. 3—Direct coupled output stage using split supplies.

Those manufacturers who use fuses generally place the fuse either in the power supply leads to the output transistors or in series with the speaker (fig. 4). The obvious problem with this approach is that a fuse must be large enough to carry peak amplifier output current, but small enough to melt if an output transistor should fail, i.e., develop a collector-to-emitter short. These contradictory requirements are rather unfortunate and mean that a fuse must have a relatively long melting time. If the fuse were called into play, by the time it melted the speaker system may have been destroyed.

Those manufacturers who use relays to protect the speaker system generally place the relay contacts in series with the speaker (fig. 5). When an output transistor fails, the relay opens and removes the speaker system from its potentially destructive current source. But a relay is a mechanical rather than an electronic protective device, and it is extremely slow to react so the speaker system is more likely to be destroyed before the relay has had an opportunity to open.

What is ultimately required to save the speaker system from output transistor failure is a fast reacting electronic circuit capable of diverting excessive current flow in the

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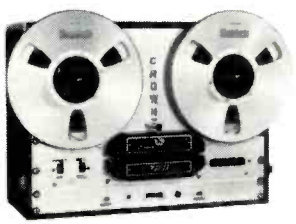

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Delivers 75 watts RMS per channel at 8Ω ■ IM distortion less than 0.05% from 0.01w to 75w at 8Ω ■ S/N 110dB below 75w output ■ Takes 5¼" rack space, weighs 20 lbs. ■ $429 rack mount

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failure mode. Electronic computers requiring regulated low voltage direct current power use an electronic "crow bar" to prevent similar potentially destructive current surges from reaching expensive integrated circuits. This "crow bar" is a silicon controlled rectifier (SCR) which operates by actually shorting the power supply to prevent excessive current from damaging delicate integrated circuits. The same SCR crow bar circuitry is used in all BGW amplifiers. (fig. 6). No fuses are necessary. There is no chance for human error and no having to run out to the local hi-fi store if a fuse should accidentally blow.

Output Stage Design Considerations

There are several constraints that dictate the circuit parameters which output transistors must be capable of meeting. They are (1) breakdown voltage specification, (2) current handling capability, (3) gain bandwidth product, and (4) safe operating area. The mechanical and thermal characteristics of output transistors and their thermal resistance also are important factors.

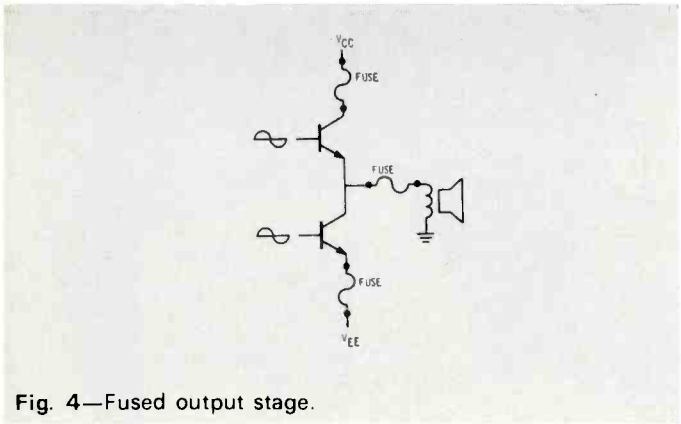

Fig. 4—Fused output stage.

As an example of output stage design, consider the parameters for an amplifier that is capable of delivering 200 watts into an 8 ohm load, and 250 watts into a 4 ohm load. The equations that relate power output to voltage, current, and load resistance are shown below. Solving these equations for the above example output stage, the following table can be constructed:

Output power	250 watts	200 watts
Voltage rms	31.6 volts	40.0 volts
Current rms	7.9 amps.	5.0 amps.
Peak voltage	44.5 volts	56.5 volts
Peak current	11.1 amps.	7.0 amps.

By inspection, we see that the peak voltage occurs for the 8 ohm load but that the peak current occurs for the 4 ohm load. Our power supply must be capable of handling the peak current and peak voltage requirements required by the various output stage load resistances, which in this example are two.

Although our peak voltage requirement is technically only 56.5 volts (and occurs for the 8 ohm load), power supply regulation and the desire for a few volts "headroom" suggest that the power supply voltage requirement should be somewhat greater, say about 70 volts. The output transistor breakdown voltage is, at a minimum, twice the power supply voltage. Hence, we require output transistors with breakdown voltages of at least 140 volts. Ohm's Law tells us that the output transistors must also be capable of handling peak currents of at least 11.1 amps, (the peak current for the 4-ohm load). Thus, our output transistors must have a breakdown voltage of at least 140 volts and be capable of handling peak currents of at least 11.1 amps.

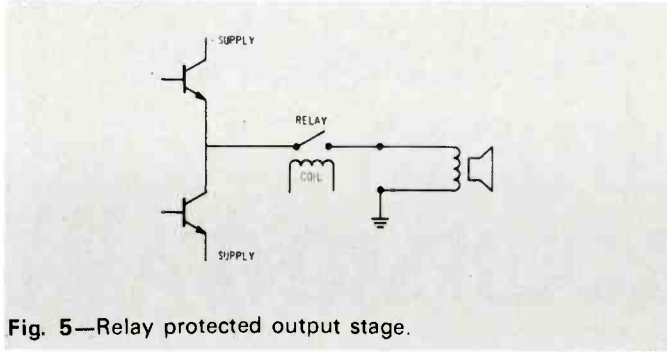

Fig. 5—Relay protected output stage.

Today there are four basic types of power transistors: single diffused, triple diffused, epi base, and multiple emitter site double diffused. A comparison of the specifications of these various types in tabular form would look like the information presented in the following table:

These devices are all NPN types, since the availability of high voltage, high power PNP types is limited to epi base transistors. Practically all large amplifiers use NPN output devices, so we will confine ourselves to quasi-complementary designs. The devices which have the largest safe operating area are the single diffused types. These are the most rugged, but also the slowest. The 2N6259 clearly can handle over three times as much current at 75 volts as the triple diffused DTS410.

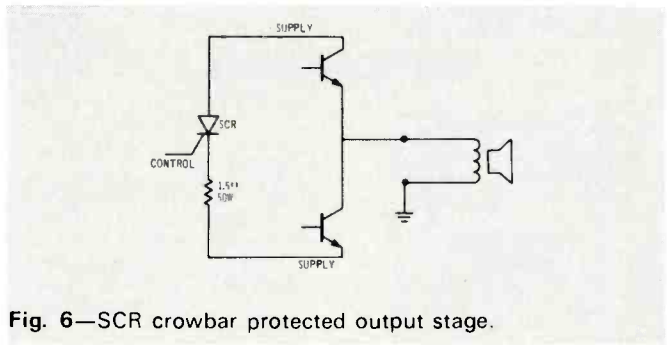

Fig. 6—SCR crowbar protected output stage.

Now let's finish our analysis of the output stage and determine the safe operating points which the transistors must be capable of handling. We have made the following assumptions: The power supplies are fixed at plus and minus 70 volts, the maximum power requirement is 250 watts into 4 ohms and 200 watts into 8 ohms. The problem is to determine how many of each type of device in parallel are necessary to produce a unit that will not exceed the manufacturer's safe operating area at a maximum operating case temperature of 70 degrees centigrade, since hotter temperatures would prove hazardous to the transistor and cause burns if accidentally touched.

Equations

$$\text{Watts}_{rms} = \frac{(\text{Voltage}_{rms})^2}{\text{Load Resistance}}$$

$$\text{Voltage}_{rms} = \sqrt{\text{Power} \times \text{Load Resistance}}$$

$$\text{Current}_{rms} = \frac{\text{Power}}{\text{Voltage}_{rms}}$$

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Peak Voltage = $\sqrt{2}$ voltage $_{rms}$

Peak Current = $\sqrt{2}$ current $_{rms}$

$$Watts_{rms} = \frac{(Voltage_{rms})^2}{\text{Load Resistance}}$$

$$Voltage_{rms} = \sqrt{\text{Power X Load Resistance}}$$

When the output of the amplifier is crossing through zero volts and we are driving a resistive load, we have 70 volts across the output transistors and no appreciable collector current. But when the output of the amplifier is at 56.5 volts (peak voltage for the 8 ohm load), we will have approximately 13.5 volts (70.0 – 56.5 volts) across the power transistors. The current will then be, according to Ohm's Law, 7.1 amps. (which is equal to the peak current for the 8 ohm load). Now we must examine the voltage and current conditions impressed on the output transistors for each point in the cycle of a sine wave. Using 5 volts increments, we would generate a table that looks like the following:

We can determine the minimum number of devices of each type that must be paralleled to handle the power requirements of our output stage design. For the 2N6259, by inspection we see that at 25 volts output, the current into 4 ohms is 6.3 amps. (line 6 of the table). The safe operating

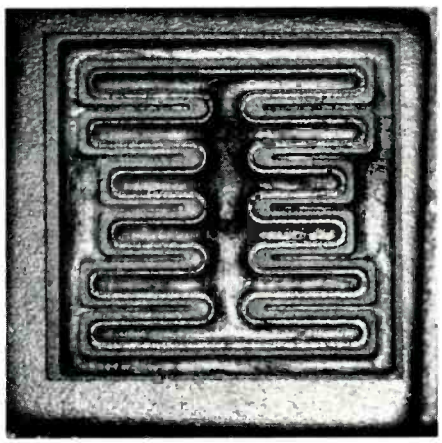

Fig. 7—Photomicrograph of 2N6259 chip.

area capability is only 4.1 amps., so 2 devices must be placed in parallel for safe operation. Checking each line of the table to make sure that we are within the manufacturer's safe operating area requirements using two transistors in parallel, we find that we are. Continuing this exercise, we will obtain the following results:

Device type	Number Required
2N6259	2
RCA 410	3
DTS 410	4
2N5634	3

The results are striking and point out that the penalty we pay for extra bandwidth is quite extreme. If we were to use triple diffused devices such as the DTS410, a very popular transistor, we would require twice as many transistors as compared to the single diffused example. Using these fast devices, we are able to produce full power at higher frequencies (above 20 kHz), but this capability is not required for audio use. Conservative design practice does not allow any possibility for output devices to be overstressed, regardless of how long the overstress lasts.

At BGW Systems, two types of devices are used. The BGW professional line uses large single diffused devices

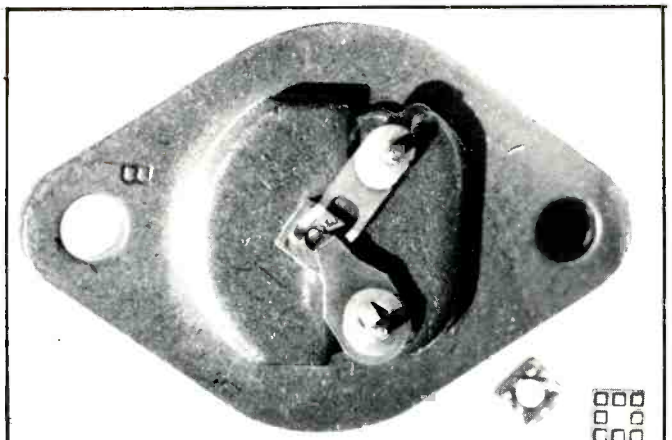

Fig. 8—Showing inside view of a RCA 410.

such as the 2N6259 for maximum reliability and controlled bandwidth. Professional experience has shown that it is sufficient to have half as much power available for the mid- and high-range transducers as for the low frequency transducers. Our hi-fi amplifiers use the double diffused multiple emitter site devices such as the RCA410. These amplifiers will produce full rated power at 20 kHz. This type of transistor has all the advantages of the triple diffused part, but also has a significantly larger safe operating area.

The size of the transistor die, the actual semiconductor chip inside the familiar TO-3 transistor case, varies with the type of process used to diffuse the device. For example, the 2N6259 chip measures approximately 0.250 x 0.250 inches. This is an extremely large geometry device, and a photomicrograph of the dies is shown below (fig. 7). The double diffused and triple diffused devices are much smaller. The RCA410 is approximately 0.135 x 0.135 inches, or about 30 percent as large as the 2N6259 device. This large size difference also accounts for the much larger power handling ability between the two devices. The 2N6259 can dissipate 250 watts as opposed to 125 watts for the RCA410. The RCA410 chip is soldered to a copper slug which is placed on the steel header. A compression clip with little protrusions corresponding to each emitter is then placed on top of the die. Spring tension clips make contact to the emitter and base contacts, and are soldered in place. A photomicrograph of two assembled RCA410's and a 410 die and clip are shown below (fig. 9).

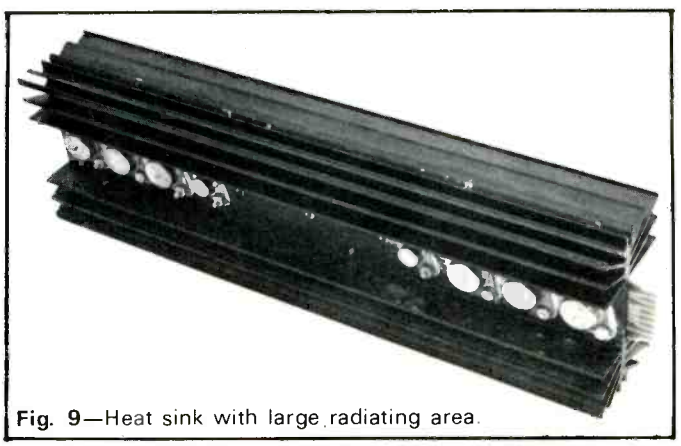

Fig. 9—Heat sink with large radiating area.

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Today, the musical artist has a new instrument at his command—the recording studio. It's an instrument that can capture sound, manipulate and mold it, stack it and scramble it, equalize and echo it—a contemporary creative tool with possibilities confined only by the borders of imagination.

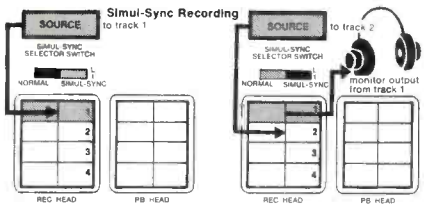
Some might call this musical soundfoolery, an adulteration of the pure musical art form. But throughout history, the truly creative artist has always used whatever instruments were available to reproduce the music he heard in his mind. The artist is no different today—but the instruments he uses are. And this has resulted in a dynamic new range of musical experiences for us all.

The creator—a 4-channel studio that fits on a shelf

With the needs of the contemporary artist in mind, TEAC tape technologists set out to design a precision musical instrument that would provide studio electronic flexibility and studio performance accuracy—yet be compact enough for home use and priced within the bounds of reason. The result: the creator, TEAC's amazing Model 3340 4-Channel Simul-Sync™ Tape Deck—a recording studio that fits on a shelf.

The 3340, backed by TEAC's exclusive two-year Warranty of Confidence,* is carefully crafted in the TEAC tradition of professional quality. 10½" studio reels; a quick and gentle three-motor transport; four studio-calibrated VU meters; eight input controls for complete mic/line mixing; dual bias selection; 7½ and 15 ips studio-accurate speeds. And Simul-Sync.

Simul-Sync: what it does and how it works



Overdubbing has become a familiar term to every knowledgeable musician. Simply, it means a) recording a voice or instrument on one track of a multi-track tape machine, b) adding another voice or instrument to a different track at a different time, and c) matching the two tracks so it sounds as if they were recorded simultaneously when played back. To overdub properly, the artist recording on the second track has to listen to the material recorded on the first track while performing in perfect synchronization to it.

That's where the problem occurs with most tape recorders. Conventional record/playback monitoring systems only let you listen to the previously recorded material off the playback head. That means a time delay between the track being recorded and the track being monitored. A small delay, to be sure, but large enough to make perfect synchronization virtually impossible.

TEAC engineers solved the problem with Simul-Sync. They designed a studio-tolerance 4-channel record head, then added electronics that allow each track on that head to be switched independently to either record or playback modes. By doing so, they completely eliminated the time lag and permitted the artist to add track after track—all in absolute synchronization with each other.

The TEAC Simul-Sync head, operating in conjunction with a 4-channel erase head and a hyperbolic playback head capable of reproducing either stereo or 4-channel material, served as the foundation for the TEAC 3340 concept. It also opened the door to a whole new realm of musical creativity and enjoyment.

Exploring the realm

Here are just a few of the sonic effects possible with the TEAC 3340:

1. Unlimited overdubbing. Up to nine individual instruments or voices can be recorded at different times without any track being used beyond second generation. Sensational signal-to-noise ratio is the result.

2. Professional quality mixdown. All four channels to a single track or ¼-track stereo masters. The optional TEAC AX-20 Mixdown Panel makes it a quick and easy process. Individual controls also allow for desired mixing level for each channel.

3. Special effects. Enter the world of psycho-acoustic phenomenon where the creative juices can really start flowing. Things like echo, cross echo, 4-channel rotating echo and pan pot effects (with AX-20 Mixdown Panels). You can put echo on some instruments and not on others. One-man group arrangements, with a single artist playing all instruments and singing all vocal parts. Backwards recording, an effect that gives any instrument a totally new sound. Dual speed recording, mixed down in perfect sync. With all these effects at his disposal, the professional musician can quickly save the cost of a 3340 in reduced studio experimental time alone.

4. Pseudo-quad recording through ambient delay to the rear channels. And, of course, full discrete 4-channel record and playback.

5. Are you creatively curious? If so drop TEAC a line, and ask for the "Meet the creator" booklet. It describes all of the 3340 effects in detail and explains how each is done. And it's free.

If creative involvement is what you're after, meet the creator—the TEAC 3340 4-Channel Simul-Sync Tape Deck. (or the 7" reel, 3¾—7½ ips version, the 2340).

When it comes to creative recording, they perform miracles.

*TEAC or one of its authorized service stations will make all necessary repairs to any TEAC tape deck resulting from defects in workmanship or material for two full years from the date of purchase, free of charge to the original purchaser.

The TEAC 2340 and 3340 are priced at $759.50 and $849.50, respectively. For complete information, please write to TEAC, 7733 Telegraph Road, Montebello, California 90640. In Canada: White Electronic Development Corp., Ltd., Toronto. TEAC Corporation, 1-8-1 Nishi-shinjuku-ku, Shinjuku, Tokyo, Japan. TEAC EUROPE N.V., Kabelweg 45-47, Amsterdam—W.2, Holland. Hi-Fi, S.A. Alta Fidelidad Hidalgo 1679, Guadalajara, Jal., Mexico.

TEAC®

The sound of a new generation

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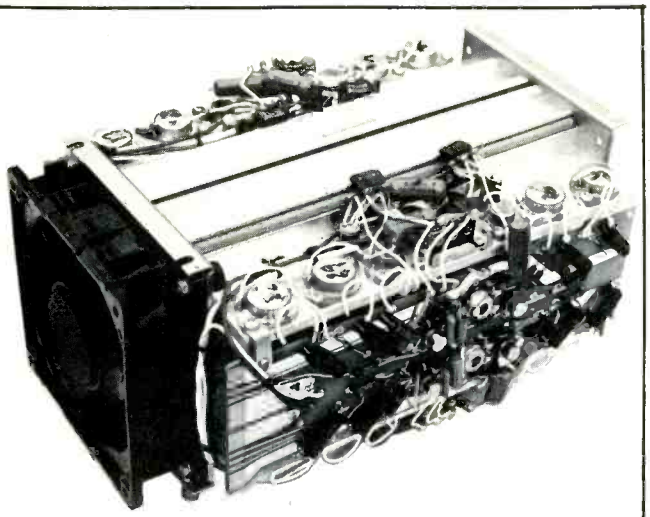


Fig. 10—Forced air sink used with high power amplifiers.

The material chosen for the transistor package or case has been shown to affect the life of the transistor. It has recently been demonstrated that steel packages will outlast aluminum by many years under repeated thermal cycling. In these tests the transistors are thermally cycled from 40 degrees centigrade to 130 degrees centigrade with 16 watts of dissipation until failure occurs. The results indicate that the aluminum package will fail after less than 5,000 cycles, while the steel package typically is good for more than 100,000 cycles.

Heat Dissipation

A major problem that confronts all manufacturers of solid-state audio amplifier equipment is how to dissipate the heat produced by the output transistors. The term used to measure the ability of a radiator to dissipate heat is called "thermal resistance." There are three components of thermal resistance in any output state: There is the resistance from the junction to the transistor case, the resistance from the case to its heat

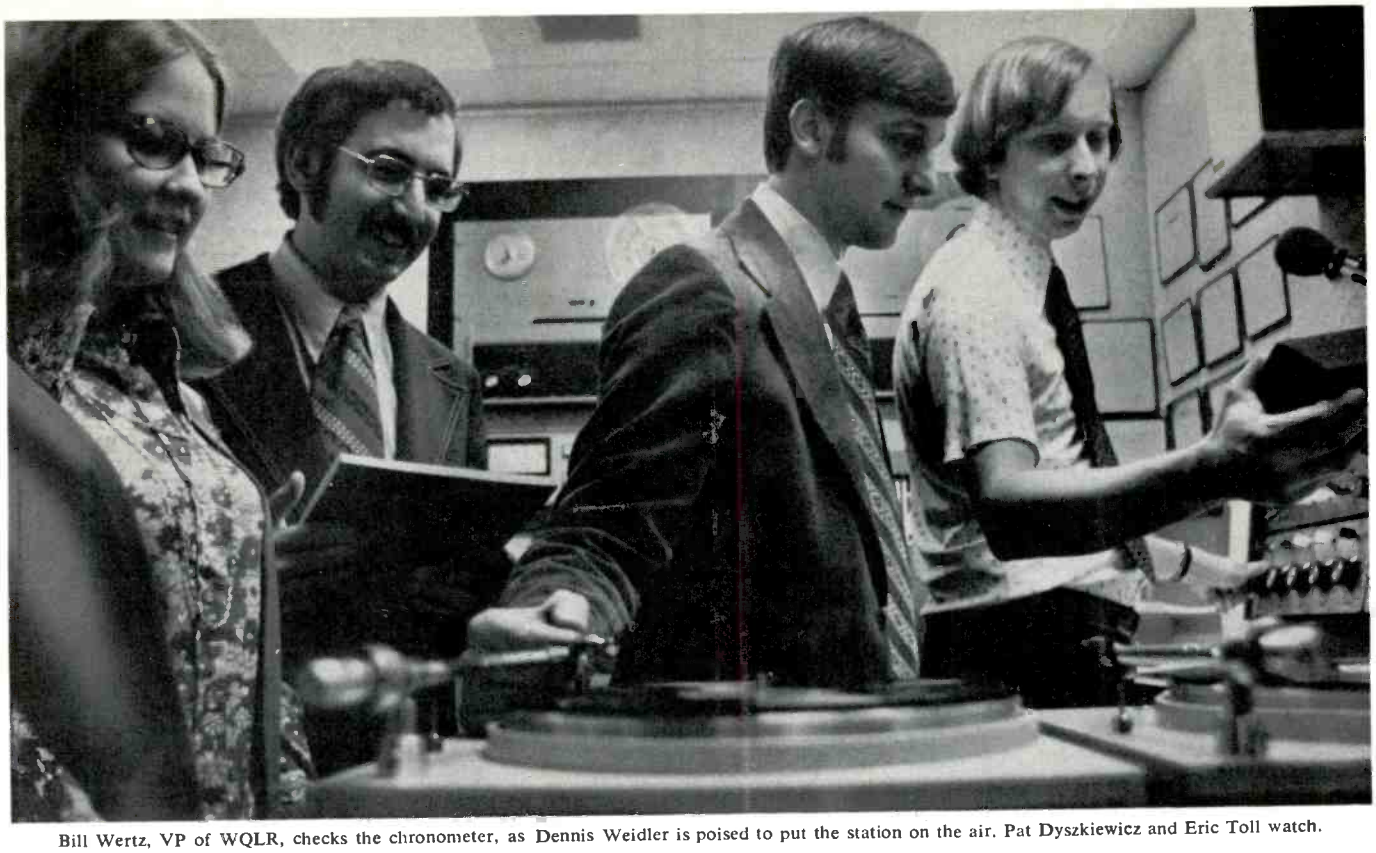
TABLE I

Line	Output voltage	Output current 4 ohms	Output current 8 ohms	Transistor Collector-Emitter voltage (Vce 70-Vout)	Safe operating area current values at 70° C case temperature* 2N6259	RCA410	DTS410	2N5634
1	0 volts	0 amps	0 amps	70 volts	2.5A	1.4	1.0	.9
2	5	1.3	.63	65	2.8	1.5	1.2	1.1
3	10	2.5	1.3	60	3.0	1.7	1.5	1.4
4	15	3.8	1.9	55	3.4	1.7	1.7	1.8
5	20	5.0	2.5	50	3.6	1.9	2.0	2.3
6	25	6.3	3.1	45	4.1	2.1	2.2	2.4
7	30	7.5	3.8	40	4.5	2.5	2.4	2.6
8	35	8.7	4.4	35	5.3	2.9	2.6	3.1
9	40	10.0	5.0	30	6.0	3.3	3.4	3.8
10	45	11.2	5.6	25	7.5	3.8	3.5	4.5
11	50	—	6.3	20	9.0	4.5	3.5	5.6
12	55	—	6.9	15	11.2	5.3	3.5	7.5

*From manufacturer's data sheets.

TABLE II

Process	Manufacturer	Type	Maximum continuous collector current	Breakdown voltage	Safe operating area 50 volts	Safe operating area 75 volts	Gain Band-width
Single diffused	RCA	2N6259	16 amps.	160 volts	5 amps.	3.2 amps.	0.6 Mhz
Triple diffused	Delco	DTS410	3.5 amps.	200 volts	2 amps.	0.9 amps.	4.0 Mhz
Epi base	Motorola	2N5634	10 amps.	140 volts	3 amps.	1.1 amps.	1-3 Mhz
Multiple emitter double diffused	RCA	RCA410	9 amps.	200 volts	2.5 amps.	1.75 amps.	4.0 Mhz



Bill Wertz, VP of WQLR, checks the chronometer, as Dennis Weidler is poised to put the station on the air. Pat Dyszkiewicz and Eric Toll watch.

Stanton. Brings on the new.

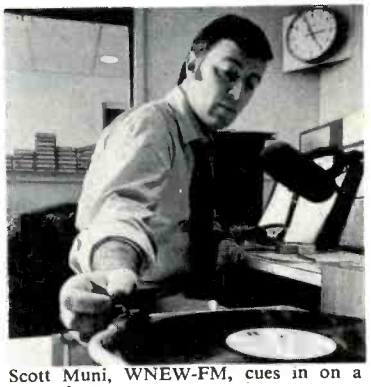
A new Station, and a new sound hits the air in Kalamazoo, Michigan. WQLR STEREO starts serving the market in June, 1972 with all new equipment and new programming.

Every cartridge on every tonearm at WQLR is a Stanton. Vice President, Bill Wertz states, "We chose Stanton because we were starting fresh and we needed to impress the community with the quality of our sound from the very first on-the-air minute. Naturally, the well-documented reliability of Stanton's 500 series cartridges helped influence our choice."

Artie Alaro makes the WOR-FM sound, while Eric Small Sebastian Stone and Promotion Director, Kim Glian look over a new album.

Radio stations all over the nation specify Stanton.

For on-the-air use, Stanton 500 series cartridges have the ability to withstand rugged handling without any lessening of audio quality. They meet all standards for reliability and sound quality, both in on-air playback usage, and in the production of transfers. These characteristics, which assure high quality sound with minimum maintenance, make them ideally suited not only for professional use, but for home stereo systems as well.



Scott Muni, WNEW-FM, cues in on a new release.

Engineer Brian Morgan of WDRC AM/FM, gets ready for on-air playback.

You can enjoy the professional audio quality of Stanton Products whether your purpose involves broadcasting or home entertainment.

Write today for further information to Stanton Magnetics Inc., Terminal Drive, Plainview, New York 11803.

STANTON

All Stanton cartridges are designed for use with *all* two and four-channel matrix derived compatible systems.

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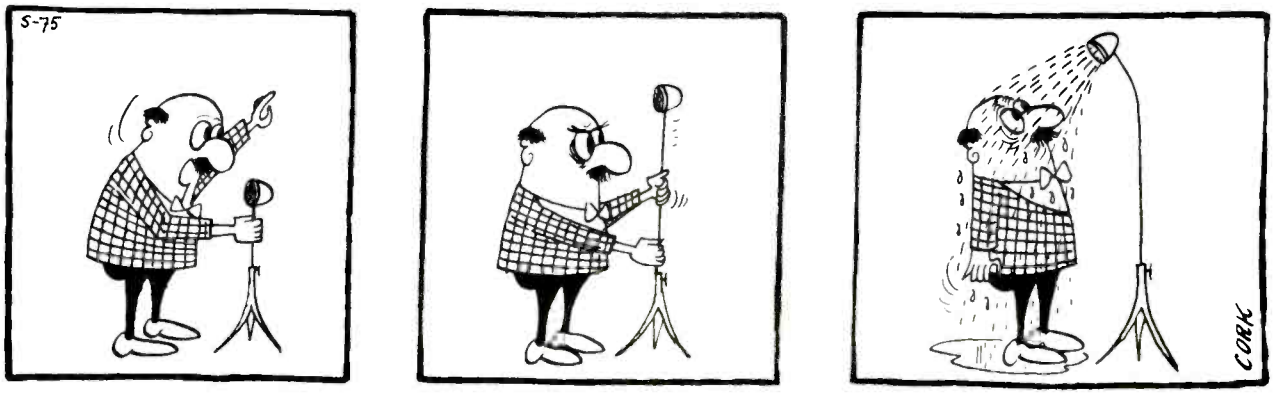
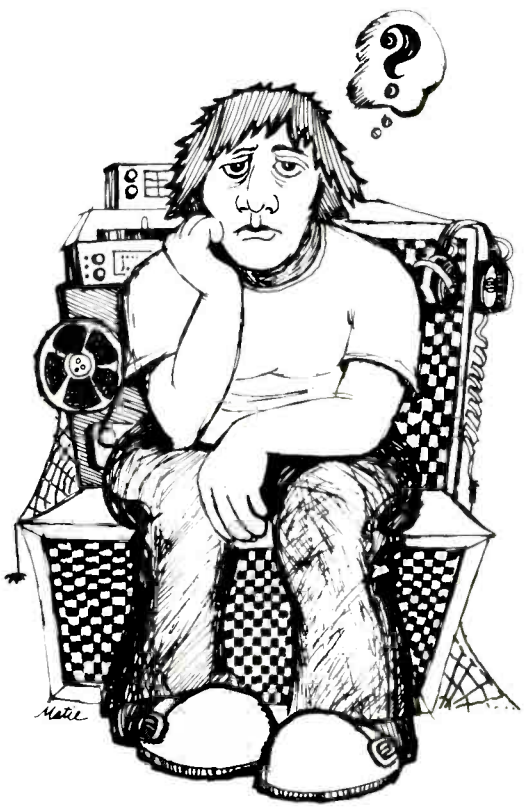
sink, and finally, the thermal resistance from the heat sink to the air. Thermal resistance numbers are expressed in terms of degrees centigrade per watt. Calculating the temperature at any transistor junction only requires that we add the three thermal resistance coefficients of the three components mentioned above, and then multiply by the power dissipated (expressed in watts).

Of the three components of thermal resistance mentioned, it is only the thermal resistance from the heat sink to the air (or ambient) that can most easily be lowered. An amplifier capable of delivering several hundred watts requires considerable heat sinking for safe, conservative operation. Each of two heat sinks used in the BGW Model 500 has over 560 square inches of heat radiating area (Fig. 9).

In industrial amplifier design, forced air cooling is more practicable. A forced air quadrant heat sink (Fig. 10) is used in the BGW Model 4X250 which delivers 1,000 watts of output power.

1. "Second Breakdown and Safe-Area Ratings of Power Transistors," by C. R. Turner; *Reprinted from EEE Magazine, July 1967, Volume 15, Number 7.*
2. "Thermal-Cycling Rating System for Silicon Power Transistors by W. D. Williams; *RCA App. Note AN4783.*
3. "Evaluation of Hermeticity of Aluminum TO-3 Packages under Thermal-Cycling Conditions," by D. Baugher, *RCA Reliability Report St-6071.*
4. "High-Speed, High Voltage, High Current, Power Transistors," *RCA Tech. series, PM-81.*





At Pilot, our best four-channel receiver is our best stereo receiver.

It takes a lot more than adding two plus two to produce an outstanding four-channel receiver.

Technological change must be anticipated, as well as the needs—present and future—of those who will use the equipment.

Unfortunately, not all companies recognize this.

Fortunately, Pilot does.

We knew from the beginning that many of you would not be able to make the switch to four-channel all at once. That's why the Pilot 366 four-channel receiver (30/30/30/30 Watts RMS into 8 ohms) incorporates an ingenious "double power" circuit that permits you right off to enjoy the full power of this receiver in stereo (60/60 Watts RMS into 8 ohms).

Not only does the 366 provide advanced SQ circuitry, but it can also reproduce any other matrix system currently in use. Plus it will extract hidden ambience information from conventional stereo material.

Naturally, the 366 is fully adaptable to any discrete system.

We didn't stop there, however, in considering the manifold uses of this receiver. An ultra-sensitive FM tuner section (1.8μV, IHF) has a special detector output to accommodate proposed FM four-channel transmissions.

Finally, we saw to it that setting up in four-channel would be a simple operation. The 366 provides a special balancing signal, we call it Pilotone®, which makes channel balancing a virtually foolproof procedure.

No matter how you use it, the very things that make the Pilot 366 our best four-channel receiver also make it our best stereo receiver.

And yours too.

For complete information and the name of your nearest Pilot dealer write: Pilot, 66 Field Point Road, Greenwich, Conn. 06830.

The Pilot 366 Four-Channel Receiver $499.90*

*Manufacturer's suggested retail price

A SUBSIDIARY OF NATIONAL UNION ELECTRIC CORPORATION

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A MICROPHONE PRIMER: CONCLUSION

Jim Long

Output Level or Sensitivity

Microphone output level or sensitivity is a way of expressing the microphone's "output" when 1, loaded in a specific manner (R_L) and 2, driven with sound of a specific "loudness." Output level is usually given at a single frequency. Two commonly used frequencies are 1000 Hz and 250 Hz. The 1000-Hz measurement is used for speech-frequency, communication-type microphones, and the 250-Hz measurement is used for the wide-range microphones more likely to be employed by the serious amateur and professional.

Sensitivity often is expressed as "–60 dB." This figure is absolutely meaningless. It could refer to several valid, though different, rating methods now currently used by the American audio industry. If the actual voltage delivered to the amplifier input is desired, some or all, depending upon which rating method is employed, of the following additional information is required to give the "–60 dB" meaning: 1, the sound pressure level driving the microphone, 2, the internal impedance of the microphone *(R_G)*, and 3, the load on the microphone *(R_L)*. The two most used sensitivity specifications are discussed below.

Open-Circuit Voltage Rating

This rating is most frequently applied to high-impedance microphones, but may be applied to microphones having any source-impedance value. The open-circuit method states explicitly the load *(R_L)* as open circuit. In practice, measurements may be made as long as R_L is about 20 times that of R_G. The error would be limited to about 0.1 dB. A microphone rated according to the open-circuit method would read, stated completely:

Sensitivity = –60 dB re/1 volt/microbar.

The "re" (referred to) is the key to our question of what voltage drives the amplifier, and is part of the sensitivity statement because the rating is expressed in dB. Decibels, like per cent, are a *relative* measurement. If we want an *absolute* answer from the dB sensitivity rating, we must answer the question "relative to what?" As an example, we could say that board "A" is three times the length of board "B." That's relative. If we want to know exactly how long board "B" is, however, we must know the length of "A." If "A" is three feet, then "B" is, absolutely, 9 feet. Returning to the npen-circuit microphone voltage rating, the only difference is that the reference is "1 volt," rather than "3 feet."

So now we have a reference for the dB expression of microphone output. But what about the final piece of additional information, the sound pressure level at the microphone? This final information is also contained in statement 1, as "1 microbar," the amount of sound pressure which results when 1 dyne of force is applied to an area of 1 cm^2. To make us feel at home, one microbar of sound pressure is that put out by a typical symphony orchestra playing *mezzo forte*.

Sometimes, the "1 microbar" will be given as 74 dB. This is simply because someone thought it more convenient to speak of sound pressure in terms of dB instead of microbars. Of course, you must have a reference, and this reference has been set up as 0.0002 microbars, the "threshold of hearing," the "smallest" sound we can hear. There is nothing sacred about this threshold of hearing; it is simply an empirical figure based on the reactions of a large group of people. Sound pressure given is decibels re .0002 microbars is generally called sound pressure level (SPL).

At any rate, the microphone rated at –60 dB re 1 volt per microbar will deliver into an open circuit, with a 1 microbar sound pressure input (or 74 dB SPL), a voltage that is 60 dB below 1 volt. Table II shows the relationship between decibels and volts (to save a lot of slide rule work) and shows

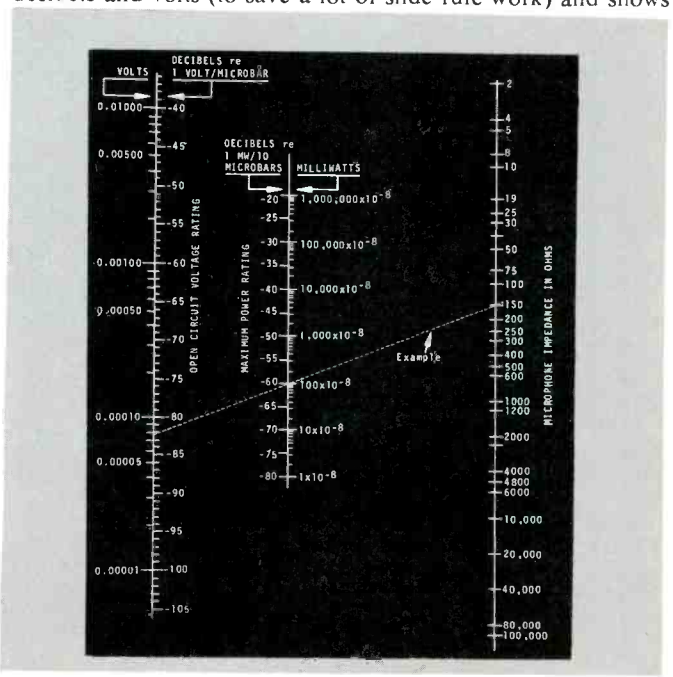
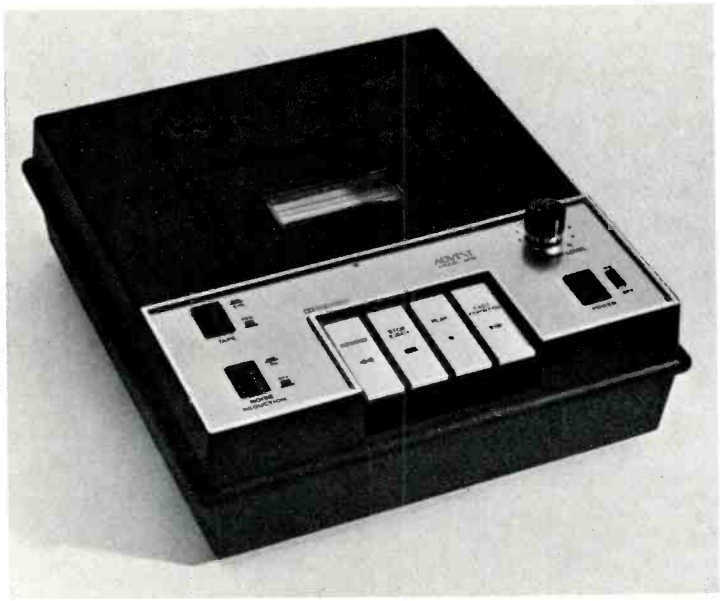


Table II—Microphone sensitivity nomograph for converting open-circuit voltage sensitivity ratings to maximum power ratings and vice-versa.

(Send in the Coupon for a List of Dolby Cassette Releases.)

A Turntable for Cassettes



The Advent Model 202 cassette playback deck is the first full equivalent in tape equipment of a precision turntable for records.

Designed for highest-quality playback of recorded cassettes, the Advent 202 employs the Dolby System of noise reduction. It also provides proper playback equalization for both iron-oxide and chromium-dioxide cassettes — including a soon-to-be-issued series of premium-quality cassette recordings on Crolyn from Advent.

The 202 is an ideal machine for anyone more interested in listening to cassettes than in recording his own. It is also a perfect source deck for any cassette dubbing application, including the growing number of professional uses.

With the number of Dolby cassette releases increasing rapidly (there are more than 400 now, and the majority of new releases employ the process), the time is ripe for a cassette player designed to realize the full potential of pre-recorded cassettes. It is clearly possible now to make cassette releases that equal (and in some ways surpass) the sound quality of the best records. The 202 will yield everything any pre-recorded cassette can offer.

The transport mechanism of the 202, very low in wow and flutter, is designed to stand up to heavy everyday use. It has a precise tape counter for easy location of recorded selections. Its controls are simple and positive in action. And its overall operation day after day is easier than that of most record-playing equipment. Included with each 202 is a head-cleaning cassette that helps make normal maintenance quick and simple.

For schools, libraries, and other institutional users, a special version, the 202 HP, comes equipped with a headphone amplifier and jack. The 202 HP and a set of headphones provide about the lowest-cost high-performance sound system imaginable, one that will probably become a starter system or dorm system for some people with tight budgets and high aims.

Using the coupon below will bring you full information on the 202 and a list of dealers where you can hear it. We also have compiled a complete and up-to-date listing of cassette releases employing the Dolby System that we will be happy to send you.

We hope you will test our feeling that the time has come for a high-performance cassette player.

Thank you.

Send to: Advent Corporation, 195 Albany Street, Cambridge, Massachusetts 02139

Please send information on the Advent 202 and a complete list of present cassette releases employing the Dolby System.

Name_____

Address_____

City_____ State_____ Zip_____

Advent Corporation, 195 Albany Street, Cambridge, Massachusetts 02139.

Dolby is a trademark of Dolby Laboratories, Inc.

Crolyn is a trademark of DuPont.

60 dB below 1 volt. Table II shows the relationship between decibels and volts (to save a lot of slide rule work) and shows 60 dB below a volt to be 0.001 V or 1 mV. The value of microphone impedance, R_G, is generally not important in open-circuit measuremtnts, because R_L is so much larger than R_G that a negligible amount of the voltage E_G is lost across the internal impedance.

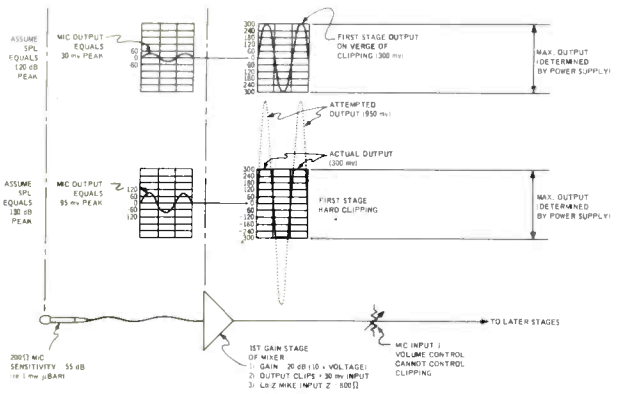


Fig. 27—The mechanism of input overload.

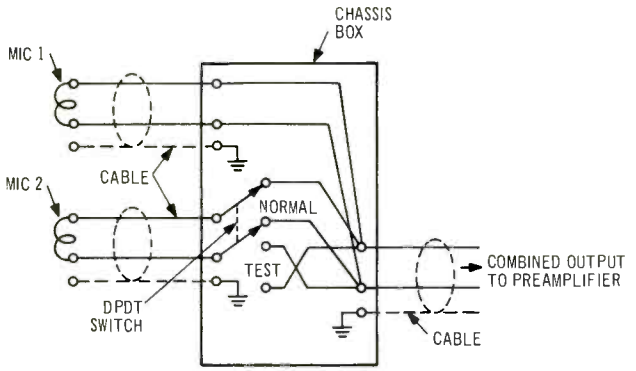


Fig. 28—Phase-reversing box for parallel testing of microphones.

Maximum Power Rating

This method employs an R_L equal to the microphone's own internal impedance, R_G. Thus we need to know, in this method, the value of R_G. *Note that the rating is given in power* delivered to the load *(R_L)* and *not in voltage*, as in the rating method described above. A microphone rated according to the maximum power rating would read, stated completely:

Sensitivity = 60 dB re 1 mW/10 microbars.

The new output reference is 1 mW, rather than 1 volt. The sound pressure if *10* microbars (94 dB), 20 dB above the 1-microbar reference described previously. Thus, the microphone will deliver into a load equal to its own impedance, and with a 10 microbar sound-pressure-level input, a power that is 60 dB below 1 mW. Table II shows the relationship between decibels and mW's (to save, again, a lot of slide rule work) and shows an output of 100 × 10^{-8} milliwatts or 10^{-9} watts.

Of course, our original question was the *voltage* delivered to an amplifier, not power! If R_L and R_G are, for instance, 150 ohms, the microphone will deliver to the load the following voltage:

$$P_L = \frac{E_L^2}{R_L}$$

$$E_L = R_L \times P_L, \text{ where } P_L =$$

where P_L = 1×10^{-9} watts (the power delivered to the load), and

R_L = 150 ohms.

Therefore,

$E_L = 150 \times 10^{-9}$,

$E_L = 15 \times 10^{-6}$,

$E_L = 3.2 \times 10^{-4}$ volts = 0.318 mV.

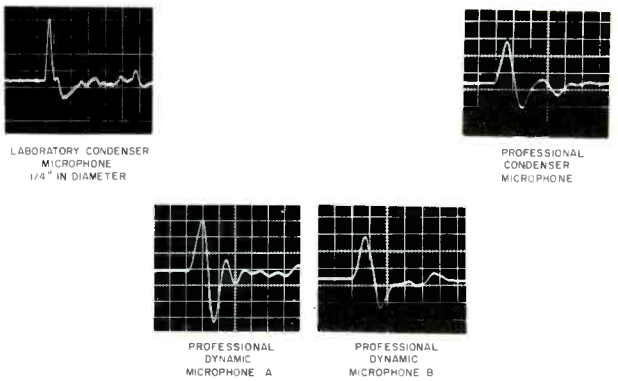


Fig. 29—Responses to a discharging capacitor (50 μS per major division on horizontal time axis).

Other voltage values corresponding to R_L's above or below the values of R_G may be determined. For example, the effectively open-circuit termination provided by some high-quality home tape recorders will be driven with an E_L 6 dB above 0.32 mV, or 0.64 mV. This may be compared directly to the 1-mV output of the microphone described in the open-circuit-rating section if 20 dB is added to compensate for the difference in reference sound pressure level between the two ratings. The corrected voltage output would be 10 mV, about 24 dB "hotter" than the low-impedance microphone's 0.64 mV output.

As another example, the 600-ohm termination provided by some other high-quality solid-state recorders, designed to work with "low impedance" microphones, would be driven about 2 dB below the 0.64-mV output, or 0.51 mV. (R_G/R_L = 600 = 0.25 in Table II). Allowing of course, for actual sound pressures different from the reference 10 microbar (94 dB), a comparison of the 0.51 mV figure to the manufacturer's specification on the voltage input required to drive the recording meters to 0 VU would determine the compatibility of the microphone with the recorder.

Table II permits conversion from the maximum-power to the open-circuit voltage rating, or vice versa. For instance, the maximum power rating given above of –60 dB re 1 mW/10 microbars corresponds to –82 dB re 1 V/microbar.

Hitachi has the deck for you whether you want 8-track or cassette.

CASSETTE STEREO TAPE DECK

TRQ-2000: Built in "Dolby" sound reproduction system eliminates tape noise by a cycle of sound compression and expansion. A 4-pole hysteresis synchronous motor and balanced flywheel reduce wow and flutter. Special tape selector permits use of chromium dioxide tapes. Hitachi's Auto Stop system automatically halts the motor and switch when the tape end is reached. 3-digit tape counter. Two VU meters. Convenient push button and slide controls. $229.95.*

TRQ-262: A large-scale flywheel and 4-pole hysteresis synchronous motor drastically reduce wow and flutter. And included are shut-off device, pause button, clearly visible level meters for right/left channels and level indicator along with easy push button controls. $149.95.*

8-TRACK CARTRIDGE TAPE DECK

TPQ-144: Automatic switchover to 4-channel or 2-channel operation according to the type of cartridge you insert. Unique easy loading system. The motor is an elaborate 4-pole hysteresis synchronous outer rotor design usually found only in the most costly hi-fi equipment. Integrated circuits assure improved frequency characteristics and top reliability. $129.95.*

TRQ-134: Hitachi's Auto Stop system automatically halts the motor when the tape end is reached. Two VU meters are provided for accurate level adjustment. Easy loading mechanism. Fast forward winding possible. Auxiliary features include headphone jack, program indicator lamp, slide volume controls, program selector button and a pause button. $149.95.*

No matter what you want in 8-track or cassette . . . Hitachi has the deck for you. For more information, write, **Dept. A-3, Hitachi Sales Corp. of America, 48-50 34th St., Long Island City, N.Y. 11101**

Quality always comes first at
HITACHI

*Suggested retail.

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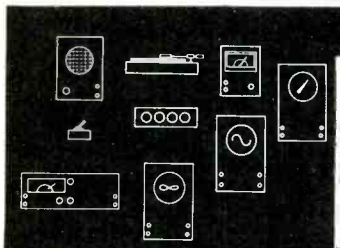
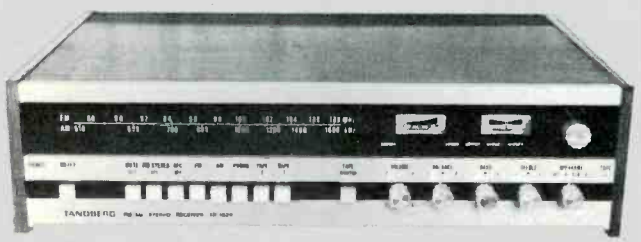


EQUIPMENT PR



TANDBERG TR 1020

MANUFACTURER'S SPECIFICATIONS

FM Section:

IHF Sensitivity: 2.0 uV or better. **S/N Mono**: 68 dB; **Stereo**: 66 dB. **THD**, Mono: 0.3%; **Stereo**: 0.4%. **IF Rejection**: 100 dB. **Image Rejection**: 70 dB. **Selectivity (Carrier down)**: 68 dB. **Spurious response**: 100 dB. **Capture Ratio**: 1.8 dB. **Muting Threshold**: 10 uV. **Stereo Separation**: 35 dB at 1 kHz. 38 kHz suppression: 50 dB. **SCA Suppression**: 74 dB.

AM Section:

IHF Sensitivity: 50 uV (external antenna). **Selectivity**: 42 dB. **IF Rejection**: 40 dB. **Image Rejection**: 40 dB. **THD** (30% Modulation): 0.5%.

Amplifier Section:

Power Output: 40 watts per channel, 8-ohms; 52 watts per channel 4-ohms, continuous power, both channels driven, 1 kHz input. 38 watts per channel, continuous power, 8 ohm loads, both channels driven, at any frequency from 20 Hz to 20,000 Hz. **Power Bandwidth**: 7Hz to 30,000 Hz. **THD**: 0.2% at rated output. **IM Distortion**: 0.2% at rated output. **Damping Factor**: 48 (at 8 ohms, 1 kHz). **Frequency Response**: 12 Hz to 70,000 Hz, -1.5 dB. **Input Sensitivity**: **Phono**: 2-8 mV, adjustable; **Tape 1, Tape 2**: 130-250 mV, adjustable. **S/N, Phono**: 68 dB referred to 4 mV input signal:**Tape 1, 2** 82 dB referred to 260 mV input signal. **Preamplifier output**: 900 mV. **Recording output**: 800 mV. 800 mV.

Dimensions: 17" w. x 4¾" h. x 12¾" d. (including knobs) **Weight**: 20 lbs. **Retail Price**: $429.90.

Remember when the people from Tandberg startled the audio industry by proving that a reel-to-reel tape recorder could deliver full frequency response and true high fidelity at a speed of 3¾ inches-per-second? No tricks were involved, just careful engineering, precision assembly and good quality control that set the standard for other manufacturers of tape products to follow for years afterward. Well, to quote from a recent Tandberg advertisement, ". . . the guys who brought you the world's best tape recorders" now bring you an outstandingly designed receiver—their first entry in the purely electronic component category of components.

The Tandberg TR-1020 is not *really* that much smaller, trimmer and lower-profiled than competitive products in the same power output range—it just looks that way, thanks to an outstanding job of styling and human engineering done by Tandberg's engineers. With power off, the front panel looks like three floating strips of anodized aluminum. Nomenclature is clearly printed in black and—wonder of wonders—it's large enough to read without squinting. The upper portion of the panel, blacked out until power is applied, contains a well illuminated FM and AM dial scale whose illuminated red pointer segment is illuminated only when FM or AM operation is selected. To the right are two meters, a signal strength meter operative in both AM and FM service and a center-of-channel meter for FM tuning. The tuning knob is located at the extreme upper right and is coupled effectively to a heavy flywheel. Major operating controls are all neatly arranged in a single row below the dial area and include ten push-push buttons for such functions as on/off, FM muting, AFC, FM, AM, PHONO, Tape 1, Tape 2 and Tape Monitor. Rotary controls include a master volume control, balance control, dual concentric clutch operated bass and treble controls and a speaker selector switch with positions for main, remote and main plus remote operation of speakers as well as an off position for headphone listening. The left end of this row contains the usual stereo headphone jack while, at the extreme right there is a phone jack labelled "Tape 3", about which we shall have more to say presently.

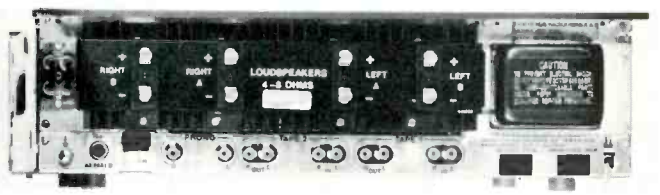


Fig 1—View of rear panel.

If you didn't read the instruction booklet, you'd think that the controls just named would be all that are available, until you pull down on the lower aluminum bar which is actually a hinged door that discloses eight more pushbuttons. These offer Stereo, Mono Left, Mono Right, Loudness, Low Filter, High Filter (two kinds) and Preamp record. All but the last are self-explanatory and make for a most flexible control center, but that last button fills a very real need that many of us have been aware of for some time. When that button is depressed, all the control facilities such as tone controls, filters, loudness and the like are inserted *ahead* of the tape 3 output jack referred to earlier. Thus, the serious recordist can brighten, filter, boost or otherwise rebalance an old recording that he or she is trying to transcribe onto tape. What a simple but clever idea!

The real panel, shown in Fig. 1, contains eight screw-terminals for making speaker connections for two pairs of stereo systems. Each pair of terminals also has, located between

OFILES

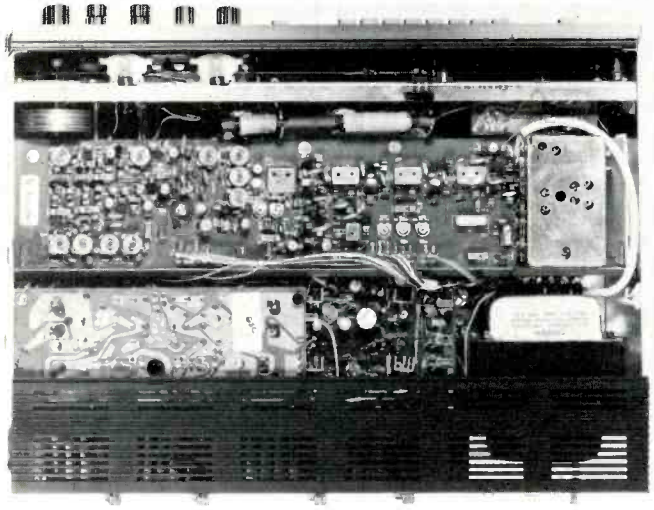


Fig 2—Inside view

them, a polarized receptacle for "plugging in" speakers without having to re-wrap wire leads every time speakers are disconnected. The model we tested did not come equipped with the appropriate plugs, however, so we could not try out this feature and had to resort to conventional wire-wrapping of speaker leads. At the extreme left of the panel are a pair of preamplifier-main amplifier jumpers which can be removed if you want to use the preamplifier and power amplifier sections separately. Phono inputs as well as inputs and outputs for Tape 1 and Tape 2 are located along the lower edge of the rear panel, as are a switched and unswitched convenience ac receptacle and receptacles for antenna connection. Two plugs were provided for this latter receptacle, each coded differently so that the FM antenna cannot be inadvertantly connected to the am receptacle holes and vice versa. The plugs do not involve soldering, and only a small screwdriver is needed to connect the transmission line from either an FM or external AM antenna to the appropriate plug. There is also a receptacle which will accept a 75-ohm coaxial cable connector. A thumbscrew terminal for system ground completes the back layout.

Three more controls are located on the bottom of the receiver. These are input sensitivity controls for phono, tape 1 and tape 2 inputs, enabling you to balance levels when switching from one program source to another or from self contained AM and FM to one of the external program sources. This refinement is hardly ever found on all-in-one receivers and it, like so many of the other features found in the TR-1020, is most welcome.

Figure 2 shows the inside of the chassis, with the included walnut cabinetry removed. The "cabinet", by the way, is one of the cleverest enclosures we've seen yet. It really consists of two side wood panels and an interlocking top panel. To service the instrument, only four side screws need be removed and all panels slide apart, yet, when fully assembled, the enclosure looks and feels like a beautifully crafted piece of furniture. Internal layout of the TR-1020 is superb, for while

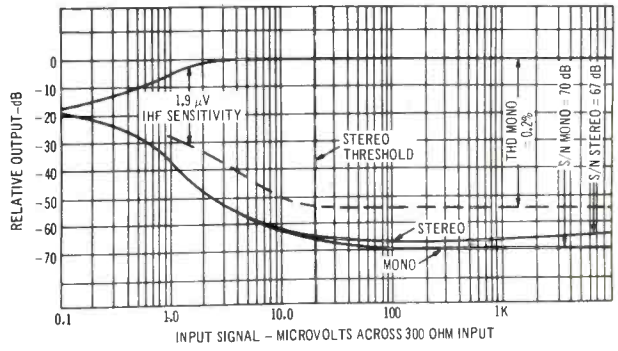


Fig 3—FM performance

an enormous amount of electronics has been crammed into a relatively small cubic volume, circuit boards are arranged so that almost every part is accessible without having to disassemble the entire receiver. Circuit features include an FET mixer in the AM section, dual-gate MOS-FET's used for both RF and mixer stages in the FM front end which is electronically tuned (there is no variable capacitor—only varactor diodes), multi-pole FM-IF filters and a well designed stereo multiplex circuit with positive, automatic switching from mono to stereo. The power amplifier section employs a true complementary symmetry circuit and utilizes two separate power supplies—one for each amplifier channel for minimum interaction between channels.

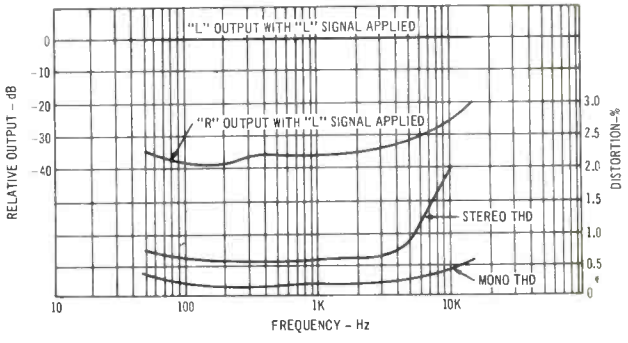


Fig 4—Separation, stereo and mono distortion.

Electrical Measurements

One of the characteristics that sets apart a really exceptional FM tuner section from the run-of-the mill variety is the steepness with which it begins to reject background noise as signal strength is increased. The Tandberg TR-1020 is unexcelled in this respect, as can be seen in the curves of Fig. 4. With only 3 microvolts applied, S/N already reached a very usable figure of 51 dB. At 10 microvolts, S/N was

over 65 dB—and, more important, the figure was the same for mono and stereo. Ultimate THD in mono reached a low of 0.2%, as claimed and, again, that low distortion was reached with barely more than 10 microvolts of signal applied. Ultimate S/N ratio reached 70 dB in mono operation (higher than claimed) and 67 dB in stereo. Aside from these impressive numbers, that means that relative to 100% modulation both the residual 19 kHz pilot and the residual 38 kHz component are at least "down" 67 dB or more, otherwise they would have contributed to our reading.

Mono and stereo THD were plotted for all usable audio frequencies in Fig. 4. Mono THD remains at about 0.2% for all frequencies between 100 Hz and 5 kHz, reaching maximums of 0.4% and 0.6% at frequencies of 50 Hz and 15 kHz respectively. Stereo THD is equally impressive at 0.6%, though this reading came out a bit higher than claimed by Tandberg. The rising THD at higher frequencies in stereo is caused by "beats" rather than by actual harmonic distortion and should therefore not be regarded as a serious or audible problem. We have been including this data in recent reports primarily to show how various manufacturers fare in this regard. A 2% "beat", as read at 10 kHz, is actually a very low order of this phenomenon—about the lowest we have read for any receiver tested in this way.

Stereo separation met published claims, with separation decreasing from its mid-band value of 36 dB to 33 dB at 50 Hz and 25 dB at 10 kHz.

If you re-read the manufacturer's published specifications with regard to amplifier output power you will note that Tandberg is about as thorough and conservative in its power statements as anyone could be. If all manufacturers stated this many facts about their power output capability in a given product the confusion which prevails would soon disappear. As a matter of fact, however, the TR-1020 does considerably better than is claimed for it. For example, we measured 0.2% THD with 45 watts per channel output driving 8-ohm loads simultaneously in both channels—this against the 40 watts per channel claimed. If you prefer to rate the THD for maximum power output at 0.5%, then the amplifiers will each produce 50 watts per channel under the same load and driving conditions. At all power levels below 30 watts per channel, we found that we were reading the residual THD of our own signal source, which we know to be about 0.04%. There was absolutely no evidence of rising THD at low power levels—usually associated with cross-over distortion in class

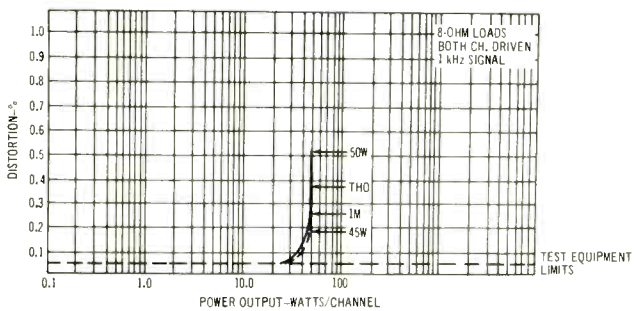


Fig 5—THD and IM characteristics.

"B" circuits. IM distortion, shown in Fig. 5 along with the few THD measurements that we could significantly portray, was also well below our test equipment "limits" and reached its rated 0.2% at 45 watts of output per channel, as opposed to the 40 watts claimed by Tandberg.

A plot of frequency versus THD at power levels of 1 watt, 20 watts (half rated power) and 40 watts is shown in Fig. 6. Again, for all but the very lowest frequencies we were limited by our test equipment, indicating that at frequencies above

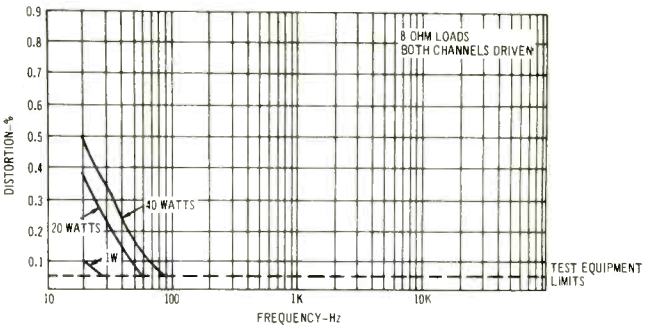


Fig. 6—THD v frequency

70 Hz or so, THD at all power levels tested was below 0.04%! Even at 20 Hz, we were able to obtain 40 watts per channel from both channels driven simultaneously at a THD of 0.5%. Power bandwidth, shown in Fig. 7, extended from 5 Hz to 50 kHz, a good deal wider than claimed. The curve is referenced to 40 watts output at 0.5% THD. If one backs off on the THD to Tandberg's 0.2% reference, power bandwidth still extends from 7 Hz to 35 kHz, a bit better than claimed.

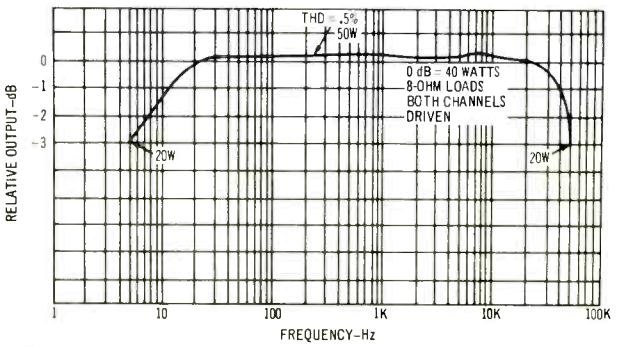


Fig. 7—Power bandwidth

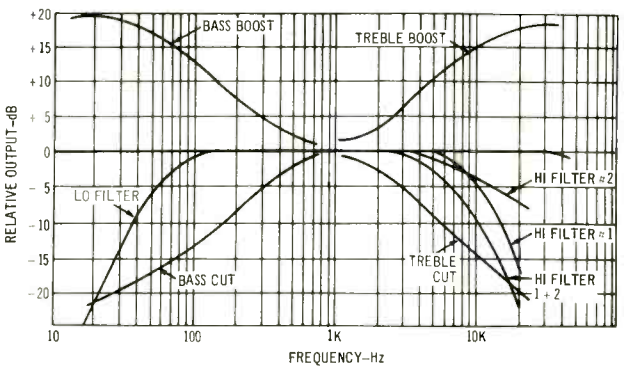


Fig. 8—Tone control and filter curves

Figure 8 graphically shows the tone control action and filter response of the TR-1020. The low frequency filter has a slope of 12 dB per octave, making it highly effective in reducing rumble. The two high-frequency filters may be used singly or together, to produce the roll-off characteristics shown in the curves.

Listening Tests

I am convinced that part of the joy of operating a well designed receiver is in the use of its control and switching features. It's often hard to separate actual sonic performance from front panel flexibility. The Tandberg TR-1020 excels in both areas. While we normally read operating manuals

The Big New Sound in Cassettes

AKAI gives you the most perfect cassette recording in the world today!

That's a mighty big claim. But we can prove it.

Our GXC-65D Stereo Cassette Recorder is innovatively engineered with ADRS.* This exclusive system eliminates almost all high frequency distortion above 8,000Hz.

But we didn't stop there.

We combined ADRS with Dolby. And then added AKAI's exclusive GX (glass and crystal ferrite) head.

Illustrated below are the actual output curves of a 13,000Hz signal from a Dolby equipped cassette deck without ADRS, and a comparable curve from the new AKAI GXC-65D.

Without ADRS

With ADRS

The clear, undistorted signal is a pleasure to behold. And a greater pleasure to hear.

What's more, the GXC-65D is equipped with AKAI's Invert-O-Matic—automatically reverses the cassette inside the recorder for continuous repeat/reverse. And the Invert-O-Matic mechanism is *unconditionally guaranteed* for two years—parts and labor.

So you can stop sitting around waiting for perfect cassette recording. Listen to the GXC-65D. Your ears will make up your mind for you.

*Automatic Distortion Reduction System

AKAI™

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carefully when evaluating a new piece of equipemnt, we must confess that one marvelous feature of this receiver escaped us until we started to listen to the unit. In the course of moving the speaker selector switch to its A+B position (we were trying out twin pairs of speakers to judge power adequacy), we inadvertantly pulled on the speaker-switch knob. Suddenly, the "signal strength" meter began to move in correspondence to the audio program we were listening to. Sure enough, it's supposed to! When this switch is pulled outward, that meter becomes a power output meter, offering precise readings which can be correlated with actual power reaching your speakers. A calibration chart is provided in the instruction manual for 4, 8 or 16 ohm loads and the meter, which is peak reading, reads the highest power supplied by *either* channel at any given instant.

In the course of listening to FM, we found the muting circuit to be highly effective and "pop" free. If we may make a suggestion, however, it is our feeling that 10 microvolts is too high a setting for the mute threshold—5 microvolts would enable us to receive more perfectly noise-free stations and still take advantage of interstation tuning silence, thanks to the remarkable quieting capability and limiting characteristics of the tuner section of this receiver. Of course, this is a relatively minor point, since the muting circuitry can be disabled altogether if desired. With muting off, we picked up no fewer than 52 listenable signals, of which 24 were received in stereo. Normally, with this many stations received in our area we should have picked up more stereo signals, however noisily. The TR-1020, however, has its stereo switching threshold set at 10 microvolts as well, so that some of the stations we heard were really broadcasting in stereo, but at signal strength which we received they would have been too noisy for satisfactory stereo enjoyment. In this case we are in perfect agreement with Tandberg's settings of this circuit.

Amplifier sound is superb at every listening level, but we were particularly impressed at how transparent and clean the sound seemed to be at very low, background listening levels. This, by the way, is a good way to test overall amplifier performance since it often shows up flaws that would be masked at higher listening levels. In this case there were no such flaws. Because there is plenty of power to spare—even with our low-efficiency speaker systems, we were able to turn up phono level for really big sound and in doing so we fully appreciated the more than 65 dB of dynamic range made possible by the TR-1020's low, low noise and hum level which was still all but inaudible at the loud levels at which we set the controls.

We did some experimenting with the "preamp controlled" Tape 3 output described earlier. We purposely played one of our "1954 vintage" operatic LP records which, while still remarkably free of surface noise (it's a performance of Boheme that we don't particularly care for artistically and so it hasn't been played to death), was notably lacking in high frequency response. By juggling the treble controls and the high frequency filter, we were able to produce a tape recording of this relic that actually sounds better than the disc in terms of overall balance. Let's see you try *that* without having a studio console replete with professional equalizers, filters and a host of other signal processing devices!

If the Tandberg TR-1020 sold for around $600.00 we'd say it was competitive with other receivers in that price class and still has a few features going for it that other $600 units omit. At under $430.00, it's a bargain. The "guys from Tandberg" have, indeed, done it again! *Len Feldman*

MANUFACTURER'S SPECIFICATIONS

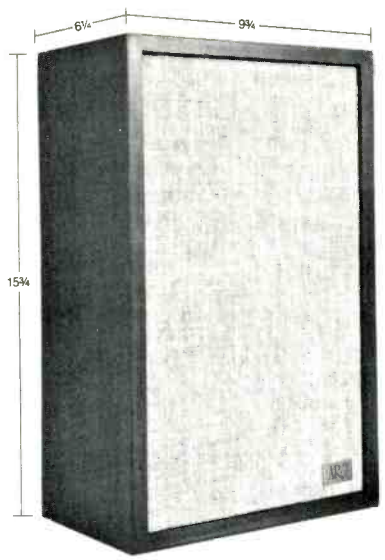
Power: Greater than 200 watts/channel rms, both channels driven. **Power at clipping:** Typically 250 watts/channel rms into 8 ohms, 400 watts/channel rms into 4 ohms, 125 watts/channel into 16 ohms. **Frequency response:** 0 to 0.25 mHz at 1 volt. **Harmonic or IM distortion:** Less than .25%. Typically less than .05%. **Damping ratio:** Greater than 1000:1 at 20 Hz. **Rise time:** Less than 1.7 microseconds. **Phase Shift:** Leading 0 degrees, lagging 12 degrees at 20 kHz. **Sensitivity:** 1.4 volts for 200 watts into 8 ohms. **Input impedance:** 39k ohms. **Dimensions:** 19 inches wide, 7 inches high by 10 inches deep. Will accommodate a standard rack mount. **Finish:** Light brush gold, baked enamel and black anodize. **Price:** $499.00.

PHASE LINEAR 400 AMPLIFIER

During the past year or so there has been a definite trend towards high power—or rather Super High Power amplifiers. There are several explanations for this: the popularity of rock music, the appearance of several high quality, low sensitivity loudspeakers like the B & W 70 and AR LST, and the recent availability of suitable high voltage transistors at a reasonable price. In June, 1971, we reviewed the Phase-Linear 700 and the reviewer, C.G. McProud said, "The hum and noise figures were well below anything we have encountered before, better than 100 dB below the 350 watt/channel output . . . we wouldn't hesitate to recommend the Phase Linear amplifier to anyone who wants and can accommodate its enormous power capacity." A few months later, Bob Carver of Phase Linear explained the thinking behind the 700 (February, 1972). In brief, the concept is to design for high power and then let the dc power supply operate on a music power basis above that point. In other words, the dc voltage is constant for short duration peaks but would fall with pulses of long duration or continuous power. This technique is open to objection for ordinary amplifiers but defensible with very high power amplifiers having a large overload margin. If the voltage was stabilized within 2% on the 700 the cost would probably be more than double—not to mention cooling problems and the increased weight!

Bob Carver points out that all power supplies work by storing energy in the filter capacitors which in turn deliver that energy in the form of power to the load. As energy storage ability is proportional to the square of the voltage but only directly proportional to the capacity, a small increase in voltage results in a much higher energy storage than a similar increase in capacity. So the use of a high voltage supply not only gives a greater voltage output swing but it also gives a margin for overload peaks.

So now we come to the "Son of 700—the 400 which is rated at 200 watts per channel and costs only $499. The power transformer is somewhat smaller than the one in the 700 and



AR-7

a new standard of excellence in a speaker of small size

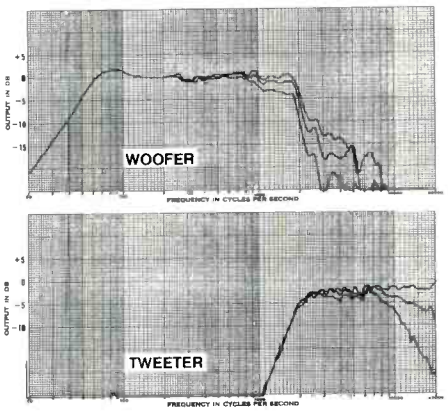
The AR-7 is the smallest speaker system Acoustic Research has ever designed. It is purposely small.

Recognizing the space demands imposed by four channel stereo music systems, AR decided to develop a small speaker to permit installation in areas where our larger speakers are not appropriate. At the same time, this speaker must offer the extended range usually associated with speakers of much larger dimensions.

That the AR-7 has achieved both design objectives is clearly evident.

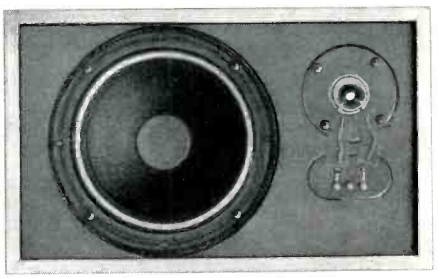
The size (9¾ x 15¾ x 6¼) is such that four AR-7's occupy less cubic volume than a single AR-3a.

The accuracy of the sound is such that we show these power response curves and guarantee each AR-7 speaker to match the curves within ± 2dB. Such accurate, full frequency range performance from an enclosure of this size did not come easily. It required years of development and state-of-the-art technology.



The woofer of the AR-7 uses such advanced design and manufacturing techniques that its low frequency response extends substantially below that of competitive speakers of far greater size.

The tweeter of the AR-7 is similar to the tweeter used in the highly acclaimed AR-6. It produces smooth, wide dispersion sound. Both the woofer and the tweeter use high temperature voice coils, permitting higher power handling capability.



Though the AR-7 was designed primarily with four channel stereo installations in mind, its accurate wide frequency response makes it a wise choice for high quality two channel stereo systems.

AR-7's come packed two to a box and sell for $60.00 each.

Acoustic Research, Inc.
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Fig. 1—Showing input and output connections.

the total weight is only 35 lbs. instead of 45. The appearance is very similar, same kind of meters, same light brush gold finished panel. Unlike the 700, there are no input level controls or indicating lights—other than those illuminating the meters. There is no power on/off switch as this function will be performed by the preamp.

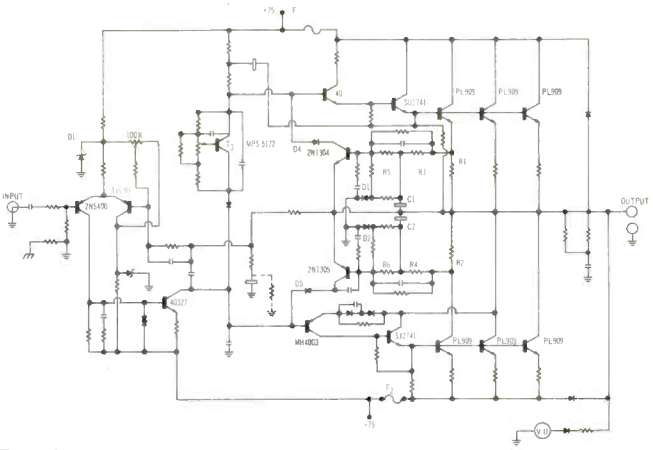

Fig. 2—Basic circuit arrangement.

Circuit Details

The basic circuit is shown in Figure 3. R1 and R2 act as sensing resistors and the voltage developed is applied to the bases of the 2N1304 and 2N1305. R3, R4, C1 and C2 form part of a timing circuit which generates a voltage proportional to the current taken by the output transistors. Excessive current generates a voltage which turns on the 2N1304 or 2N1305 which in turn cause the diodes D4 and D5 to conduct and switch off the input signal. A bi-directional silicon controlled rectifier (not shown) is connected across the speaker terminals to act as a "speaker saver" (Just imagine what kind of pulses might be applied to your loudspeaker if you dropped the phono cartridge on a record with the volume control turned up!). The SCR acts as a clamp, operating in 75 milliseconds—faster than any fuse.

Measurements

Figure 3 shows the power output measured with both channels driven into 4 ohm loads. It will be seen that each channel develops more than 380 watts under these conditions. At full continuous power, the dc supply fell from 150 (75 plus 75) to 126 so the music power figures will be well over 500 watts per channel! Power bandwidth curves are not shown as the amplifier delivered full power from below 10 Hz to at least 40 kHz. In spite of the elaborate protection circuits I did not have the courage to go higher! Frequency response was 2 dB down at 4 Hz (dc coupling is used, but there is one capacitor at the input) and 2 dB down at 110 kHz. Figure 4 shows the square wave performance at 50 Hz and 15 kHz. Stability was checked with simulated electrostatic speaker loads etc. and the 400 would seem to be unconditionally stabile. Hum and noise was difficult to measure with any degree of accuracy but it was certainly better than 100 dB as claimed. Sensitivity came out at 1.8 volts for full output. It was noted that there was a small "thump" two or three seconds after switching off. This was not considered serious—just a little disconcerting at first!

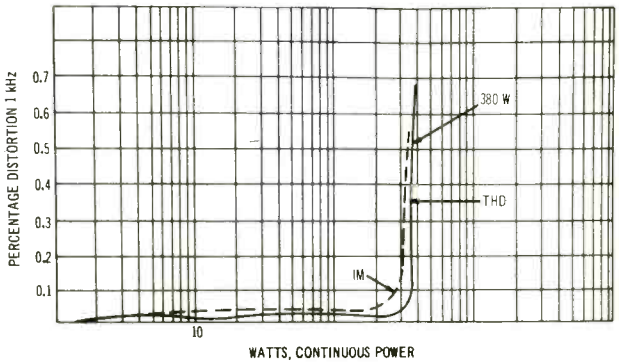

Fig. 3—Power output, IM and THD.

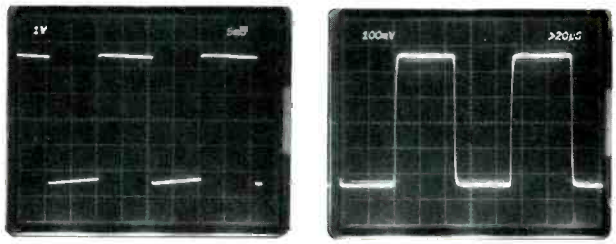

Fig. 4—Square wave response at 50 and 15 kHz.

Phase Linear make a lot of claims for the protection circuits so, after all the tests had been completed the amplifier was subjected to all kinds of ill-treatment in culminating with a 400 watt square wave at the speaker terminals which was then shorted with two screwdrivers. This drastic test only succeeded in welding the screwdrivers together—the amplifier was unharmed. Full marks to Phase Linear. . . .

Listening Tests

For test purposes, the 400 was used with a Sony 2000F preamp and a pair of EPI 400's or AR LST's. Under domestic conditions, the VU meters did not peak much over the halfway mark. However, some rock afficiados did manage to get the pointers swinging into the red but the sound was clean with no sign of overloading—although it was uncomfortably loud. For me—anyway! But many people do not realise just how much power is necessary to handle peaks without clipping and they would be surprised to see how high those VU meters would read occasionally—even when listening at a relatively low power level.

How does the 400 compare with the 700? Well, in theory the 400 has lower distortion below 10 watts or so as a secondary bias loop is used to control crossover parameters. However, the matter is really academic as we are comparing magnitudes of the order of 0.005%! As to power output, the 700 gives you nearly 3 dB more power at a cost of $100 a dB; if you *really* need the extra power, it's worth it. If not, buy the 400.

Check No. 82 on Reader Service Card *T.A., G.W.T.*

(Continued on page 62)

All in the family.

In the space of a few short years, the critically acclaimed Revox A77 has established itself as the tape recorder of choice for the knowledgeable enthusiast.

Now, from the same dedicated design team that created the Revox A77 come two new meticulously engineered components, an FM tuner and a stereo amplifier, that extend performance to the limits of current technology.

Take the Revox A76 FM stereo monitor tuner. With its incredibly sensitive front end, unique dual action IF strip, specially developed discriminator circuit and two regulated power supplies, the A76 represents an entirely new approach to FM signal processing.

In fact, the Revox A76 sets new performance standards in a half dozen different categories.

But simply quoting a list of specifications, however fine, doesn't begin to describe the capabilities of this remarkable instrument.

For what distinguishes the Revox A76 from all the rest is its uncanny ability to capture the weakest signals with a clarity and a freedom from noise that is truly startling.

As for the Revox A78 stereo amplifier, it does everything a superb amplifier should do. And it does it just a little better.

Together or separately these remarkable components are a fitting addition to the Revox family and provide further proof of what we've said all along...

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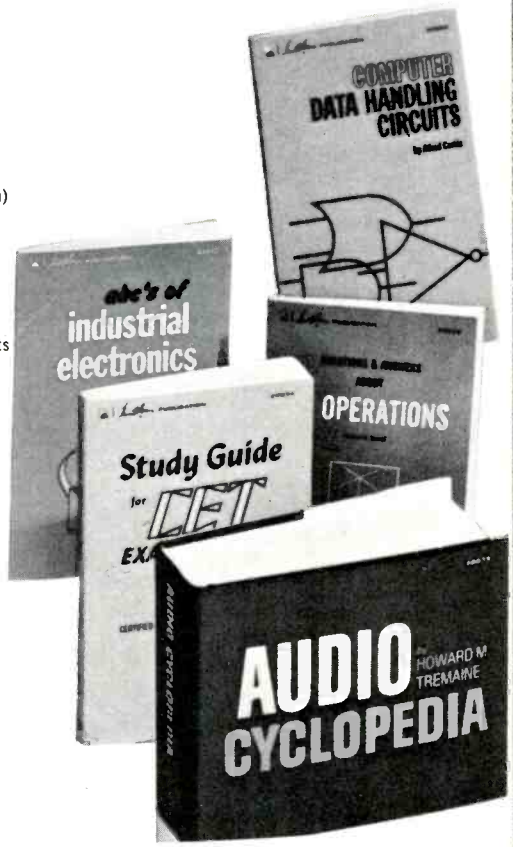

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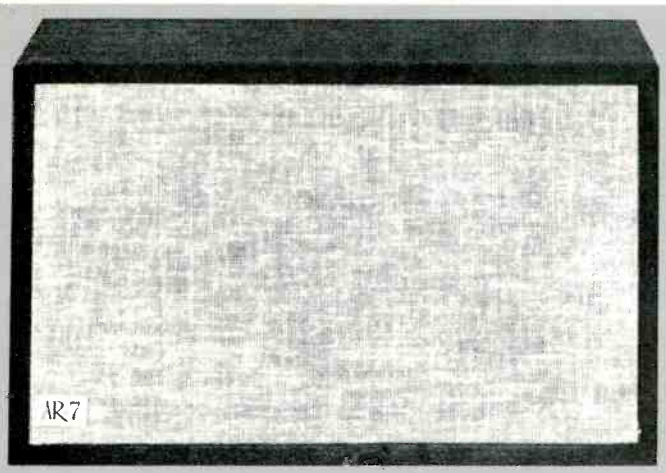


AR-7

MANUFACTURERS SPECIFICATIONS

System Type: Two way, totally enclosed. **System Components**: 8 inch bass, 1½ inch cone tweeter. **Crossover Frequency**: 2000 Hz. **Frequency Response**: 40 to 20 kHz. **Recommended Amplifier Power**: 15 watts (min.) **Nominal Impedance**: 8 ohms. **Dimensions**: 9 by 15 by 6¼ inches deep. **Weight**: 11lbs. **Price**: $60.

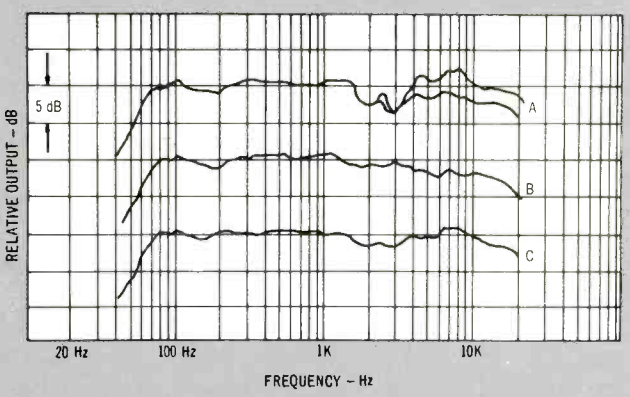


Fig. 1—Response with one-third octave pink noise. A was taken on axis, B at 45 degrees off-axis and C is an average at 5 positions.

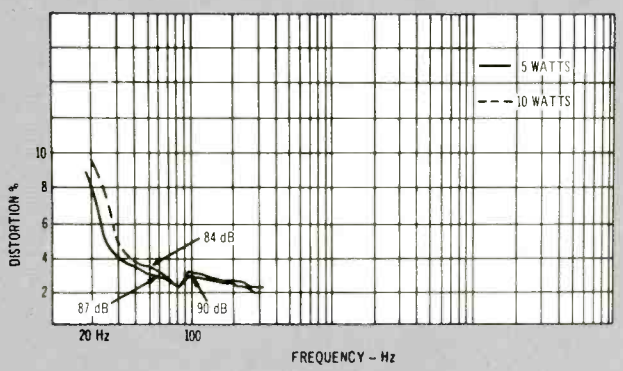


Fig 2—Low-frequency distortion and SPL.

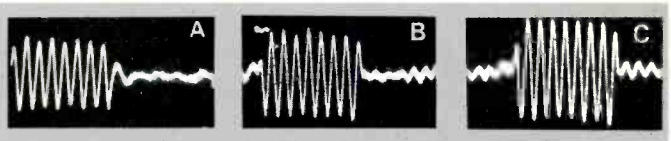


Fig 3—Tone burst responses: A is 100 Hz, B:500 Hz and C: 5000 Hz.

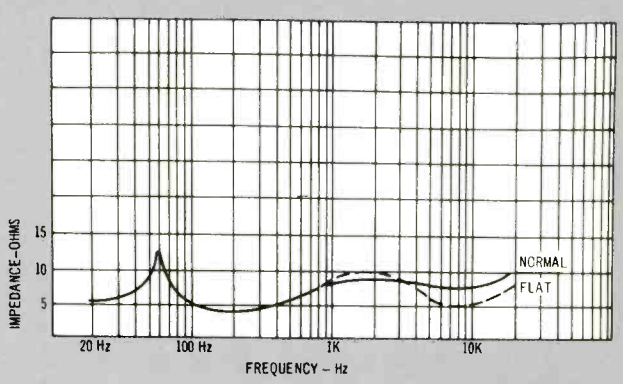


Fig 4—Impedance characteristics.

Latest addition to the AR range, and the smallest, is the AR-7 Measuring only 15 by 9 by 6¼ it turns the scale at only 11 lbs.—compared with the big LST at 90 lbs.! Nevertheless, it can give a very good account of itself as we shall see. The tweeter is a 1½ inch type very similar to the one used on the AR-6 but the crossover frequency is 2000 Hz instead of 1500 Hz. A two-position level control is fitted and, like all AR systems, the AR-7 is guaranteed for 5 years. And like the other systems, it is an acoustic suspension type with a sealed enclosure. System resonance is just under 60 Hz—truly remarkable for such a small box.

Measurements

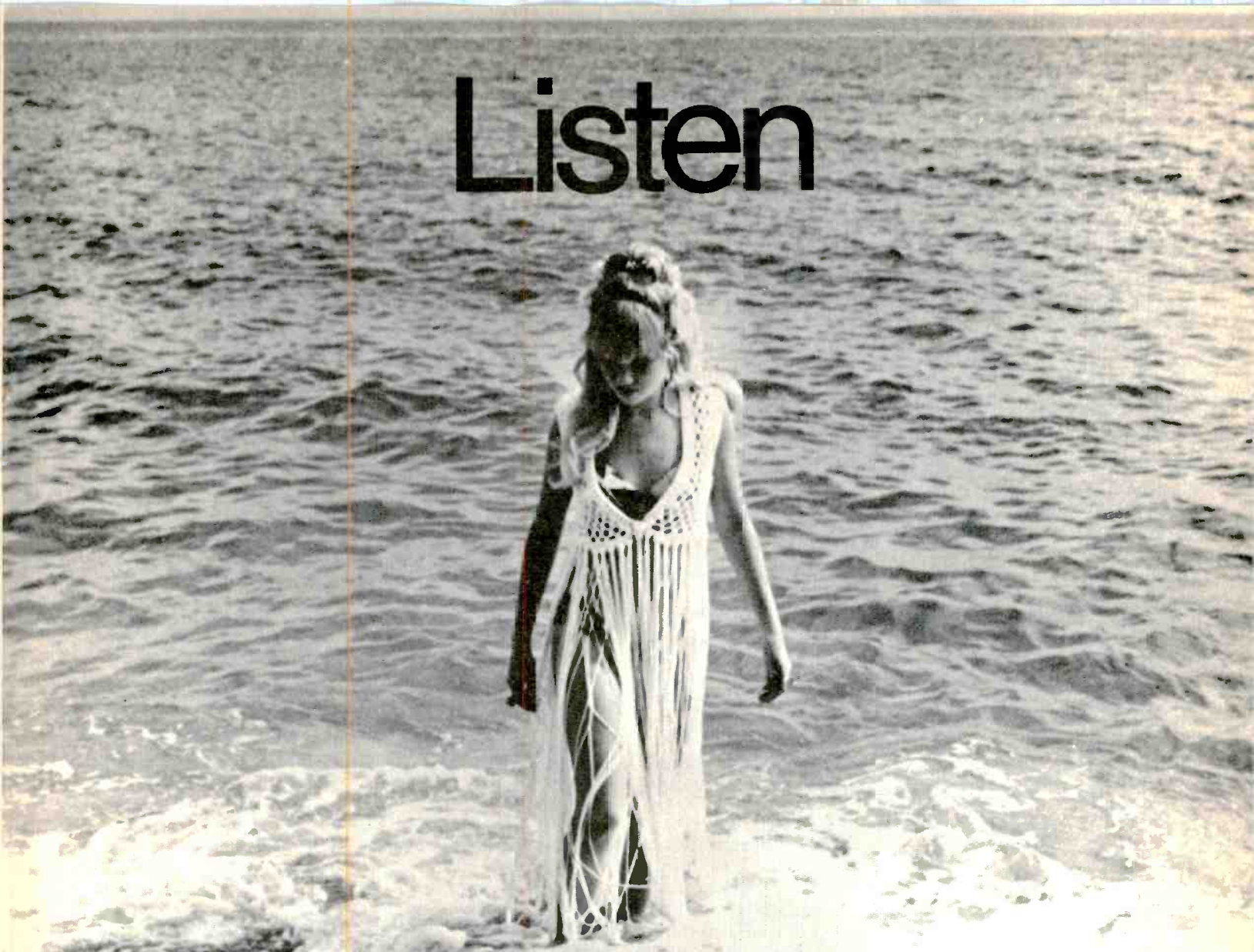
Figure 1 shows the response measured with one-third octave pink noise. A was taken on-axis with both positions of the level switch, B at 45 degrees off-axis and C is an average of 5 positions. Response is very smooth, particularly in the important region from 200 to 2 kHz and it will be seen that dispersion is good. Low-frequency distortion and some SPL measurements are shown in figure 2. The system would handle 41 watts (continuous, sine wave) at 41 Hz and 62 watts at 100 Hz without audible doubling or other signs of distress. Figure 3 shows the tone-burst responses at 100, 500 and 5000 Hz and the impedance curve is given in figure 4. Average was 8 ohms with the lowest point at 5 ohms.

Listening Tests

Sensitivity was about average for this kind of system—which means that a power level of some 20 to 25 watts is needed. AR put the minimum power requirements at 15 watts which seems reasonable. Because of their small size (and price) four AR-7's would be ideal for a quadraphonic system in a small or medium size room and a total power of 50 watts would be adequate. The overall sound quality is typical AR—low coloration, a smooth treble, and a clean bass with low distortion. We predict that the AR-7 will become the standard for other speakers in the under $100 class and supplanting some speakers of even greater cost.

 T.A., G.W.T.

Listen



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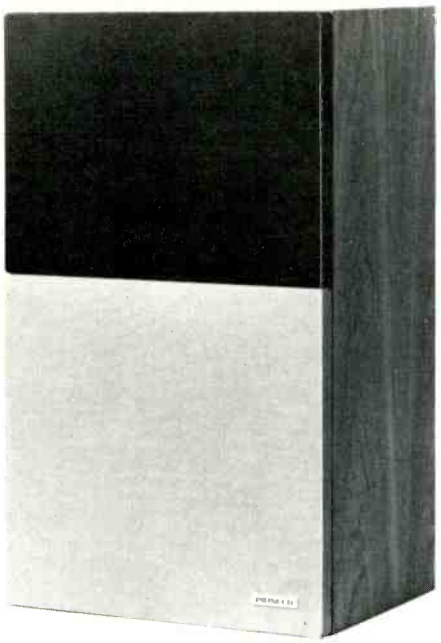

PIONEER CSR 300

MANUFACTURERS SPECIFICATIONS

System Type: Two way, reflex. **System Components:** 10 inch bass, 2 inch horn unit. **Crossover:** 6,300 Hz. **Frequency Response:** 45-20 kHz. **Power Handling Capacity:** 40 watts. **Nominal Impedance:** 8 ohms. **Dimensions:** 13 inches wide by 22 high and 11 deep. **Weight:** 26½ lbs. **Price:** $119.95.

The Pioneer CS-R300 is a rather unusual speaker system—both in styling and design. The grill cloth (which is removable) is a striking combination of black and orange which will fit into many contemporary furnishing schemes—it is a matter of opinion whether you want your loudspeakers to merge into the background or as pieces of furniture in their own right. But, here your wife may have the last word . . . .

The bass speaker cone has a sharper angle than usual and it is fitted with a dural center dome to extend the high frequency response. Crossover point is just over 6 kHz—much higher than in most two-way systems. It is claimed that this reduces distortion at transition frequencies. Be that as it may, it certainly reduces design problems with the high frequency horn unit which can be quite small. The horn diaphragm is made of aluminized polyester and a variable level control is provided. This is mounted in a recess at the rear, just above the spring clip input terminals which, incidentally, we prefer to some screw type connectors as there is less chance of shorting. The system is not totally enclosed but is a tube-vented reflex. Main system resonance is just under 80 Hz.

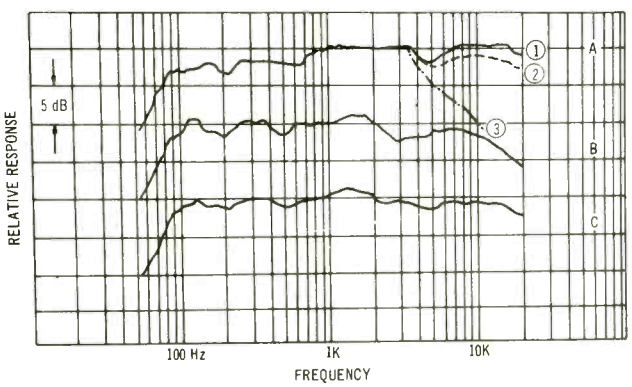

Fig 1—Response with one-third octave pink noise.

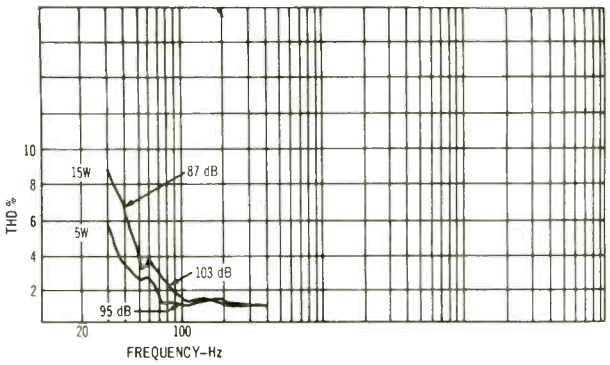

Fig. 2—Low-frequency distortion and SPL.

Measurements

Figure 1 shows the response measured with one-third octave pink noise. A was taken on-axis, B at 45 degrees off-axis and C is the average at 5 positions. Also shown at A is the response with the level control at high and normal positions. Low-frequency distortion figures are given in figure 2, together with some representative SPL measurements. The system could handle considerable power without distress and at 40 Hz doubling was not audible below an input level of 102 watts. At 70 Hz doubling was heard with an input of 42 Hz but at 100 Hz the signal could be increased to 112 watts! Sensitivity is considerably above average and a white noise signal at 10 watts produced a SPL of 100 dB at one meter. Tone-burst responses at 100 Hz, 1 kHz and 5 kHz are shown in figure 3. The impedance curve shows two peaks of around 20 ohms but did not fall below 8.5 ohms as can be seen from figure 4. White noise tests showed a slight coloration in the mid-range with the level control at maximum.

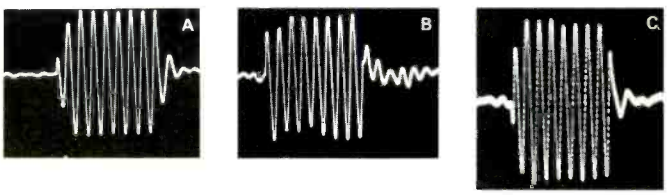

Fig. 3—Tone burst responses. A is 100 Hz, B: 1 kHz and C: 5 kHz.

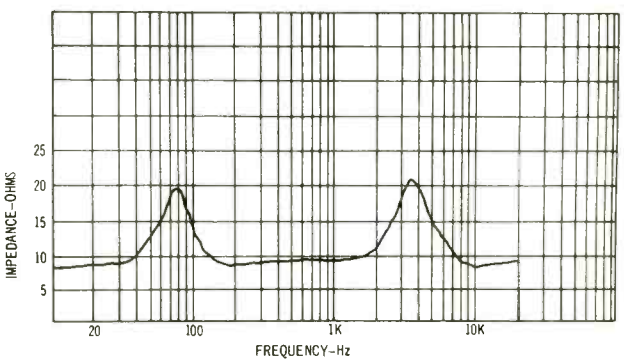

Fig 4—Impedance v frequency.

Listening Tests

Because of the *systems* high sensitivity, a low-powered receiver was used for most of the tests. Logically enough, the one used was a Pioneer 424 which is a relatively inexpensive receiver costing only $179.95. However, it puts out an honest 14 watts per channel and power was more than adequate for a fair-sized room. Bass was solid and tight—more like a totally enclosed system, in fact. The upper mid-range was rather forward compared with our lab standard and the sound had an immediate, *projected* quality. Stereo image was excellent—better still with the units angled inward. At these positions the overall sound quality had less "presence"—but a lot depends on room acoustics and a little experimenting is always worthwhile.

All-in-all, the Pioneer CS-R300 can be recommended to those who require a good system at a reasonable price and one that could give outstanding results from a modestly powered receiver. Styling is of course a matter of personal taste—all we can say is that the orange and black color scheme was much admired by the distaff side.

T.A., G.W.T.

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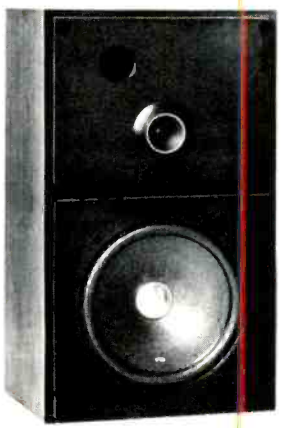

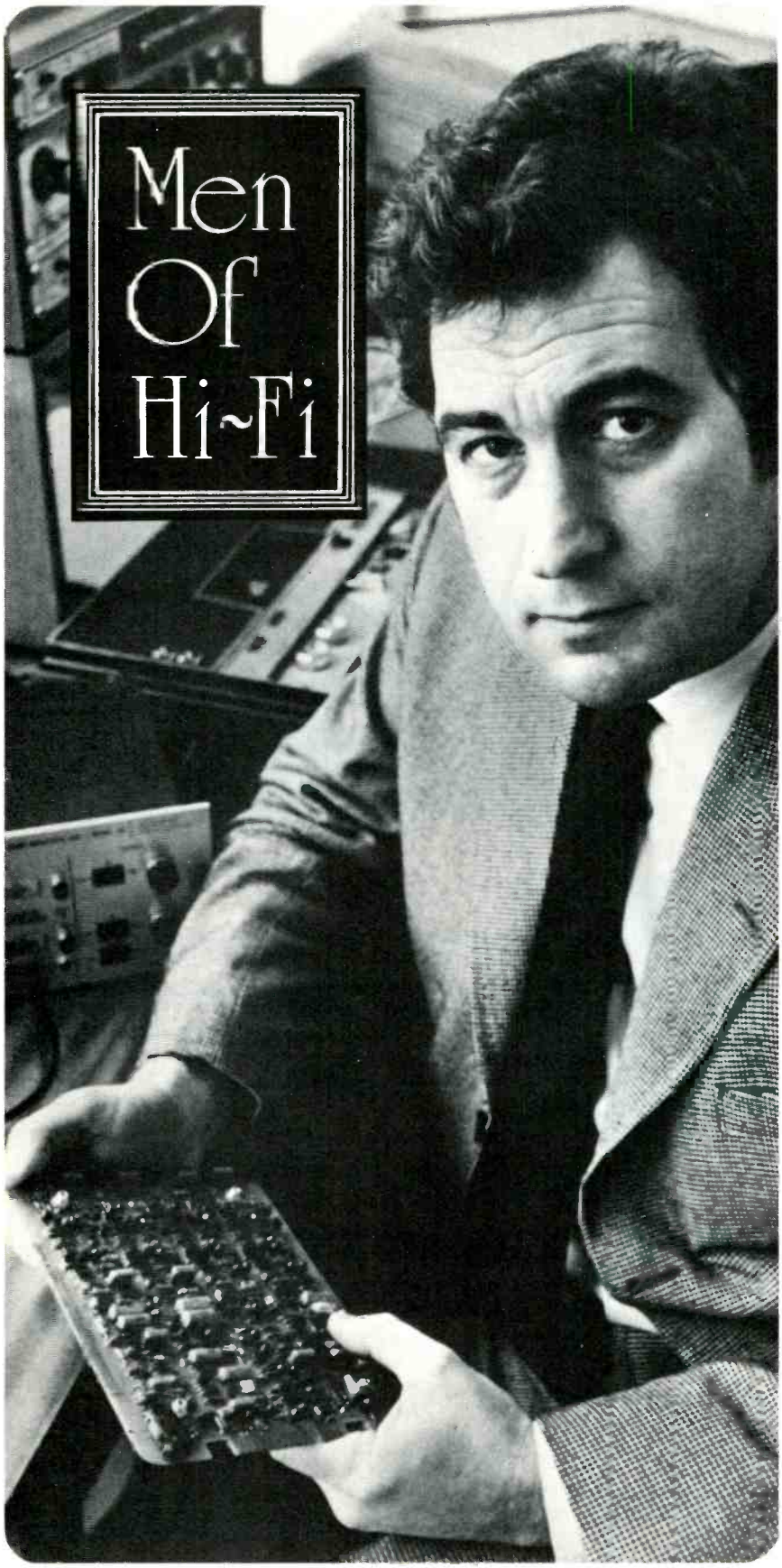

Ray Dolby with an early unit.

Harry Maynard in his program "Men of Hi-Fi" on WNYC interviews Adrian Horne of Dolby Laboratories, London

Maynard: Good evening ladies and gentlemen.
We are going to revisit the Dolby noise reduction system. My guest this evening is Adrian Horne, who is the Licensing Manager for the Dolby Laboratories Incorporated. They are headquartered in London, England. I might add we are also going to play you two demonstration tapes for cassettes, one that is included with the 4760, the 3M machine that incorporates the Dolby circuit, and we are also going to play you an Advent Dolbyized cassette, and we are going to send them out still Dolbyized so you will have a chance to see how they sound with the Dolby characteristic. It seems to me, just a sort of superficial overview, that most manufacturers are using the B-system in cassette recorders. Is that right?

Horne: Certainly that is correct. The cassette has shown itself to be a very interesting product. It had very serious problems when first introduced but, as the major parameters of performance of the cassette machine have improved, it has shown itself to be capable of producing as good quality as almost any other recording medium used in consumer audio.

Maynard: Yes, as a matter of fact when I turn on the Wollensak 4760 and put on a Dolbyized cassette right now, I continually get up to see if it is running. It is so quiet even when compared with a virgin disc or a good reel to reel tape. Why is that so? I think I know the answer, but . . .
Horne: The answer is that with a virgin disc, even new out of the sleeve, there

are going to be some ticks and pops occurring from particles of dust that have been attracted by static electricity. Any tape recorder is bound to produce some sort of noise from the tape unless you have the benefit of noise reduction to minimize this noise but then, even on the lead-in tape with which the cassette is beginning, the noise reduction circuit is working and lowering the level of the signal that comes out, so that you lose the basic hiss that would otherwise be present.

Maynard: I know a lot of our listeners probably know how Dolby equipment works, but I find that even when I am writing articles on it, I have to re-train myself to put this in the simplest understandable terms. What is your favourite current explanation, simple explanation, of how the Dolby system works?

Horne: For the simplest explanation the thing is first of all, I think, to understand clearly what the Dolby circuit is trying to do, and what it is doing is trying to reduce the effect of noise added by the recording process. Any recording process, or for that matter, transmission process, adds noise, but with a slow speed tape with narrow tracks, which is the case on cassettes in particular, the hiss generated by the tape becomes particularly obtrusive when the music is quiet. Now it is quite easy to design an electronic circuit which can take out that sort of quiet hiss, but such a circuit would not be able to differentiate between music and the hiss itself.

Maynard: So it lops off the highs.

Horne: It takes off anything that's there, when it's functioning. Now, to deal with this, we arrange that the music, as it is recorded, has the quiet sections recorded just a little bit louder than they would have been otherwise.

Maynard: That is what you mean when you use the word stretching. Is that it?

Horne: Yes, stretching is the word the professionals use, but we are now using, perhaps an easier word to understand because it has become commonly used with home equipment, the term "encoding", and when a Dolby tape is encoded the quiet high frequency sections, which are most disturbed by the presence of hiss, are made a little bit louder as they go on the tape. When you play back through the Dolby circuit these sections are brought down as the hiss is brought down, and they are brought down to exactly the level they were before they entered the encoding Dolby circuit at the beginning of the whole process. So you get back the original programme material, but you have this hiss missing.

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Maynard: You sort of kick it out the back door. Is that right? How would you describe that kicking it out the back door principle?

Horne: That's technically described as a process of expansion, of making the quiet signals quieter in relationship to the loud signals, and that's why the hiss disappears.

Maynard: Now, other people before Dolby had expansion systems, didn't they?

Horne: Yes indeed.

Maynard: I can remember one person, who will go nameless, but he is quite famous in this business. When I invited Ray Dolby on my programme, he said "Don't have that man on your programme. That whole Dolby process is a fraud. This man is a phoney. It will never work". I found out, right after that, that he asked for the U.S. agency for Dolby equipment.

Horne: Now the Dolby system does have the advantage that it works, and it works because of a very important basic concept which Ray Dolby developed in the middle 1960's. The concept of compression and expansion has . . .

Maynard: It's been around for years.

Horne: It's been around since the 1930's.

Maynard: Well, I remember I had a FM tuner receiver called the "H.H. Scott" and it had, what I guess was a less sophisticated version of what, now, Philips call the DNL system, didn't it. Sort of electronic gate, wasn't it?

Horne: That's right. This was another expansion system, as is the DNL system. The problem with both of these was that neither of them relied on encoding the signal first. The result, therefore, was that when the circuits operated you were bound to lose some of the signal with the noise, and this, we believe, is not as satisfactory an approach as to guarantee the listener that he gets the original programme material back without any degradation.

Maynard: As hi-fi equipment gets better and better, and it seems to be getting better and better with Solid State; it's quieter, its signal to noise ratio is constantly being improved, all forms of distortion in better hi-fi equipment are minimized; it seems to me that this just gives you people a bigger and bigger market, or more reasons for using a Dolby circuit. Is that a fair statement?

Horne: That's a very fair statement. It's an interesting thing that as you take the opportunity by use of the Dolby system to reduce noise, many other deficiencies become apparent which it is possible to remove with good engineering and there is the opportunity then to produce even better equipment. This is a constant process.

Maynard: Well there is another thing that I noticed in the very first records that were Dolbyized in the United States. The name of this record manufacturer will go nameless, but it showed up his record surfaces in a sense. I mean, it's like putting a microscope on a woman's face. Then what was coming through was no longer the high level hiss that is in the master tape, but record surface was beginning to come through. I remember when I interviewed Ray Dolby I brought up this point, and I said "Will this force the record manufacturers to make quieter records". What's your comment on that. I bring the subject up again.

Horne: Well, we believe that that has happened, that recording techniques have improved because of the . . .

Maynard: In the record making . . .

Horne: Record making techniques, disc making techniques, and basic recording techniques also have improved because the blanket of quiet hiss that was present, even with professional recordings, concealed a lot of little errors in technique which, if you like, were unmasked by the use of noise reduction. The result is that recording techniques are vastly improved now. Looking now at the cassette, which is the primary medium with which the B-system is concerned, the companies which have been longest established in producing B-Type cassettes are producing much better cassettes than were available three years ago.

Maynard: Oh yes, and as a matter of fact we are going to demonstrate that in a very few moments, just how good cassettes now sound. And they're getting better and better. I heard that BASF chromium dioxide cassettes with special mechanics, and granted it is an extraordinarily expensive cassette, it still has a fantastic dynamic range.

Horne: It's exceptional and we believe, from our own experiments, that when cassettes of this type are used for duplicating—mass duplicating pre-recorded material—they will probably be, in all respects, better than the equivalent disc.

Maynard: Well now, there are basically two Dolby systems, aren't there? There is the A-system which the professionals, the record companies use for the master tape, isn't that right?

Horne: That is correct, yes.

Maynard: And then there is the B-system which is what the consumer uses when he switches the Dolby circuit on let's say, the 4760, which is the one we are going to play all the demonstration material on this evening. He'll see a Dolby switch, won't he.

Horne: Right, and that actuates a B-circuit.

Maynard: Now will you explain. Go ahead.

Horne: The A-system was the original system developed with the objective of dealing with the most important noise problem, if you like, and that was the noise generated in professional recording. This is a complex system. It divides the programme material into four frequency bands and deals with each individually. As you can imagine, professional equipment built to the highest standards which does something as complex as this is expensive, $740 for a single channel, and a lot more when it was first introduced. Obviously such equipment was not a proposition for the consumer.

Maynard: I have heard it said that the development of solid state electronics made the Dolby system possible. Is that a fair statement? Could it have been done with tubes?

Horne: It could have been done with tubes. Interestingly, some of our first work was done using tubes, but what we now get on to a board which is 9" x 6" took up almost a rackful of equipment; imagine the difference. So, from a practical point of view, I think that the system could not really have been accepted widely if solid state technology were not available.

Maynard: I have also heard it said that the initial resistance to the Dolby was largely due to a misunderstanding of the way it worked. I can remember reading some of the critical questions that were asked. I understand that you have to have a destretcher that gives you a mirror image.

Horne: Right, it's a mirror image process. This is the essential characteristic of the Dolby system, if you like, and it is an encumbrance as well, because it means that if you have recorded a Dolby tape and then want to cut a disc from it, you have to have a Dolby noise reduction unit in the decode mode right next to the cutting lathe and it means that if you make a tape in one country and want to send it to another for cutting, you have to be sure that the company who is going to do the cutting overseas has Dolby equipment, so in the early days this was quite a restriction in getting the system established.

Maynard: Yes, I can remember one critic brought up the question that suppose somebody comes across these recordings in three or four hundred years when they are excavating our civilization and they are stretched and they don't have a destretcher, isn't

this going to be a horrible predicament? I can remember a lot of resistance you ran into among major recording companies. You have enumerated some of this. Weren't there some other resistance to . . .

Horne: There were indeed. There is an interesting psycho-acoustic effect that we had to deal with here which works like this. If you take out hiss the listener, when comparing the same programme material at the same level which has hiss with a Dolby decoded version of the signal which has had the hiss removed, suspects that the high frequency quality of the Dolby treated programme has been degraded, that the highs are missing. This isn't in fact the case and it is quite easy to demonstrate this by adding tape hiss back into the decoded Dolby signal. Then, comparing the two again, (the decoded Dolby signal with the non-Dolby), the high frequencies appear to have come back again. This proves that it is your ear that is confused and not the actual circuit itself.

Maynard: The Dolby system takes advantage of certain, you might say, basic psycho-acoustic phenomena. Would you explain that to our listeners?

Horne: Sure, the most important of these is the concept of masking. If you have a loud signal, as a generalization you can say you will have difficulty in hearing a quiet signal at the same time. However, that's too big a generalization, and the way it works when we describe it more precisely is that if you have got a loud low frequency signal you won't hear quiet low frequency signals, but you may still be able to hear quiet high frequency signals. You know this; that if you are talking to somebody near a jet taking off, there is a lot of low frequency noise as the engines work up, but if you whisper in a high pitched voice it is quite easy for the other person to understand you. Now, in the recording business, you may well have music where there are low frequency sounds—somebody beating a bass drum—and yet no loud high frequencies. In that case, the masking effect is not going to protect you from the high frequency noise that is basically part of the recording process. This is the reason why the Dolby system breaks into four bands in the professional system. The masking will look after noises in its own area in the presence of a loud signal which would switch off the noise reduction circuit, but in a distant area across the audio spectrum the noise reduction circuit must still work, and so must be in a separate frequency band.

Maynard: Dolby is an American, isn't he?

Horne: Ray Dolby is indeed an American.

Maynard: And he worked for Ampex?

Horne: That's right. He lived for quite a long time in the Bay area, and in fact the thing that first took him to England was winning a fellowship to Cambridge University where he took his Ph.D. and did some post-doctoral research back in the late 50's and early 60's.

Maynard: I'm still curious about early resistances to the Dolby system. From where I judged it, and this was as an outsider looking in, and somebody who is vitally interested in anything that will improve hi-fi, there were an awful lot of misunderstandings about Dolby noise reduction that we haven't discussed. I suppose it's that old phenomena—we're down on what we're up on. What were some of the early resistances that Ray ran into when he was trying to convince people, other than the ones that we have already discussed, on the use of the Dolby. I know several recording engineers at several major recording companies were sort of agin it, and now my spies tell me that they insist on the use of the Dolby, the very people who fought it originally.

Horne: The problem is that it seems to be magic, at the first glance flying in the face of the laws every recording engineer has known, that noise is one of the great hazards of recording which you have got to do everything you can to avoid, but that it is inevitable. Suddenly Ray Dolby appears with a big grey box under his arm and says this will take it away. It had happened before. There were five noise reduction systems on the market in 1967.

Maynard: Were they being widely used?

Horne: No. In some cases they were being used by the companies who had invented them and in another were being promoted alongside other audio equipment which had a good reputation and was widely used, made by the same company. But they all had some problem. Either they didn't really work, and that was perhaps the commonest thing, or else they were extravagent in tape, which is no solution really, or else they called for radical changes in recording techniques used in the studio. All of these, of course, are something the studio is going to resist, because it has worked very hard to establish really clear cut and firm recording techniques and practices in order to maintain the standards at the highest possible level. One of the advantages of the A-system, therefore, was that it didn't call for any changes, but it did uncover all sorts of things that just weren't noticeable, that engineers just weren't aware of, before they had the benefit of the noise reduction.

Maynard: Such as, for example.

Horne: There are certain noise modulation effects, that is to say, variations in the apparent level of noise on a tape which were inevitably there, when recording without the Dolby noise reduction system, which it helped remove and which therefore led some engineers to believe that the Dolby recording process was modifying the signal adversely. What you find then, with careful comparison of a Dolby encoded and decoded signal with the original source materials is that, in fact, there has been no degrading, that it's the conventional, or what was the conventional recording technique, without noise reduction, which has been introducing the changes. One of the most thorough checks, one that is most easy to get hold of, if you like, is one that was used by Columbia before they committed themselves in a very large way to use of Dolby noise reduction, here in New York. They hitched together 8 of the original A301 noise reduction units, first of all, one channel in encode and the second channel in decode, and then they encoded and decoded again, and they did this eight times. They then compared the signal that had been in and out and in and out through all these noise reduction systems with a signal that had just come down a wire alongside and they couldn't hear any difference.

Maynard: I think that when we played that last demonstration tape, you had some very interesting comments to make on it. Now we sent it out stretched. That's not the way the consumer would hear it in his home if he had a Dolby system, it is?

Horne: Right.

Maynard: I want to make that very clear.

Horne: Sure. It would sound a little less bright in the quieter passages. You would not notice any difference in the loud passages because, remember, one of the main things about the Dolby circuit is that all the time there is one path that is open, that is just passing the signal through without any modification at all.

Maynard: Well, the Dolby system, the B-system for the cassette, was almost a necessity to put that old statement—necessity is the mother of invention. Because of the high signal to noise ratio of a cassette or . . .

Horne: . . . poor ratio.

Maynard: That's much better, poor signal to noise ratio or higher inherent noise. The tape companies have been working very hard to improve the quality of cassette tape. Most people don't understand that some of the world's best tape is going into a cassette. The problem is not so severe in the reel-to-reel situations, but now I notice that Revox has got a reel-to-reel recorder with Dolby facilities. What other manufacturers are putting Dolby in their reel-to-reel machines on a semi-professional product, a product that a consumer would be apt to buy? I know Tandberg has told me that they are going to be coming out with a Dolby-ized reel-to-reel player. What are some of the other manufacturers?

Horne: Another one is Ferrograph.

Maynard: That's a British company?

Horne: Right. These are the three which are actually under way at present. We are expecting that some of the Japanese manufacturers will as well, but they have universally elected to produce a cassette deck first.

Maynard: I can remember one reel-to-reel manufacturer who said that this tape player was so good—and he will go nameless—was so good that they didn't need the Dolby. What is your reaction to the statement?

Horne: I think we feel that it's a rich man that can throw away 10dB of improvement in signal-to-noise ratio.

Maynard: Yes. What about the dynamic range? What effect does Dolby have on the dynamic range of a recording?

Horne: Effectively, it allows you to increase it because it takes the noise further away from the maximum level that you can get on and so . . .

Maynard: You have more what? What do they call it?

Horn: You have more headroom.

Maynard: More headroom. We will explain that to our listeners.

Horne: It's a very important concept when dealing with cassettes. It is not quite so important if your own recording is done on an open reel recorder running fairly fast, because in that case, if you overstep the mark a little bit, if you record a little too hot, the tape will distort a little bit; more than you would like, but it won't have a really disasterous effect.

Maynard: It won't saturate so quickly, because there is so much more headroom there, is this what you are saying?

Horne: That's right, there is more room available, but you know the cassette tape is very narrow, the oxide on the cassette itself is very thin and this means that if you record too loud, if you put on too much signal, you get really awful distortion, but always you've got down lurking below you this hiss level which you are trying to get away from. With noise reduction you

can take the hiss level away down, 10dB down, equivalent to running the tape ten times as fast and this means that you don't have to be pushing against the ceiling, against the maximum level that will go on the tape, all the time. You can spare a little bit of extra room and the recordings aren't under such risk of overload then.

Maynard: WQXR in New York has been using the Dolby B-system, not the Dolby A-system. As a matter of fact we did an experimental broadcast using the Dolby A, but we didn't send it out stretched, we just used it to Dolbyize the actual recording of the broadcast we made, but we didn't send it out. But QXR has been sending out a Dolbyized signal, isn't that right?

Horne: That's right, and the most interesting thing of this perhaps is that they have, in doing this, demonstrated that a Dolby B-Type broadcast is fully compatible. There is no problem in listening to this if you don't have Dolby equipment at home.

Maynard: You mean it sounds slightly brighter?

Horne: It will sound a little brighter, but it will sound fine. You just won't get any reduction in the level of background FM hiss which, incidentally, is very similar in quality to the hiss you get from a low speed tape, but you know that when WQXR were deciding to go ahead with Dolby broadcasting. . . .

Maynard: Are they Dolbyizing all ot their broadcasts?

Horne: Yes. They are Dolbyizing 100%, and they began to do this five weeks before the announcement, and do you know that they had absolutely no complaints whatsoever in that period of five weeks. Only two of their very many listeners even detected that it was a Dolby broadcast, and this only because once a week they had a one hour programme which was announced as Dolbyized. It was a discussion of hi-fi and in the course of the discussion Dolby broadcasts were put out and a couple of guys, listening to this, noticed that the signal didn't change at the end of the programme. That told them that it was still Dolby, but nobody else noticed.

Maynard: Then let's face it, most hi-fi systems probably need a slight high and boost anyway, wouldn't you say?

Horne: I think that's fair comment.

Maynard: I mean I have a feeling, I can't prove this and it's based on no engineering knowledge at all of these facts, but I think there is probably so much roll-off in the average, both in going out and coming back through the average system that you probably get a slightly improved signal from the listener's standpoint.

Horne: I think it's quite likely. It is certainly true on lower cost equipment, because one of the difficult things in life is to produce a good clean high frequency signal from a low cost speaker. So you can be sure that the majority of listeners, who don't have $500 or $1000 to spend on hi-fi equipment, are actually going to find that the Dolbyized signal is fine.

Maynard: What's your reaction to chromium dioxide?

Horne: We think that this is an excellent development. It does permit an even better performance than can be obtained on most of the iron oxide tape that is available to date. I don't think it is a fair thing at this time to debate whether some of the latest high energy iron oxide tapes are achieving the same benefits but, as compared with the typical iron oxide tapes, the typical high quality tape, even, chromium dioxide as recorded by Advent, will give you maybe 3 or 4 dB better signal-to-noise ratio, and better high frequency

response, so that some of the most exciting music sounds just that little bit more exciting than it did before.

Maynard: You told me about the uses of Dolby noise reduction in motion picture making. Do you want to tell us something about that?

Horne: Sure. This is one of the things we have been getting very excited about over the last year. The system has been used in the movie industry in the way it is used, for instance, in making discs in recording studios, for quite some time, that is to say, in the sound divisions of the film studios they have been making A-type Dolby recordings and processing the audio for the films in A-type form until they got to the point of putting the signal on to the soundtrack. Now we have the opportunity to put an A-type encoded soundtrack right there on the final print of the film and to decode it in the cinema, and this will give the opportunity to get vastly improved sound in the cinema with a significant reduction in noise.

Maynard: I imagine that down the road a piece, as we like to say in America, there are many other potential uses of the Dolby, uses in video systems, perhaps? What are some of the other potential uses?

Horne: Well, any situation where you are transmitting an electronic signal you are going to meet trouble with noise.

Maynard: But most people don't think of noise in connection with video. Explain that one.

Horne: Well, the problem there is lack of definition in greys, and if you think of an action replay and compare it with a news broadcast you understand what noise does to a video picture.

Maynard: So we have that to look forward to.

Horne: That's one thing that we are looking forward to and it will be coming along one of these days.

Maynard: Well good. I want to thank my guest, Adrian Horne. I hope you will come back. Maybe the next time we have him on he'll tell us what is happening to the hi-fi scene in England and also what the state of Dolbyized broadcasts are in England. Are you Dolbyizing any broadcasts in England?

Horne: A little experimental broadcasting has been done.

Maynard: Well, I want to thank my guest this evening. Revisiting the Dolby noise reduction system my guest has been Adrian Horne, Licensing Manager of Dolby Laboratories Incorporated. Thank you Adrian for being on this programme.

Horne: Thank you Harry. I have enjoyed my evening with you.

Canby's Capsules

Ravel: Piano Concerto in G; Concerto for the Left Hand. Philippe Entremont; Phila./Ormandy; Cleveland/Boulez. **Columbia M31426,** stereo, $5.98.
Previn Plays Gershwin. (Rhapsody in Blue; Concerto in F; American in Paris.) London Symph., Previn. **Angel SFO 36810,** stereo, $5.98.

These simultaneously-composed concerti (1930-31) seldom get what they need, an understanding of their Americanized idiom, notably via Gershwin, who met Ravel in the U.S. in 1928. A remarkable affinity! (See below.) Entremont and the two U.S. orchestras do up this aspect much better than classical-minded Europeans, who play the "Gershwin" parts elegantly and out of style.
The perennial boy-wonder (42), born in Berlin, plays piano here and conducts too. Berlin or no, he is good for Gershwin, thanks to long Hollywood experience. The piano is hard, super-brilliant, but the Gershwin is real. Even the *veddy* British orchestra does the New York bit pretty well. Not bad—short of Paul Whiteman, the old original!

Arthur Fiedler/Boston Pops.—Great Children's Favorites. (Peter, Carnival, Young Person's Guide, Nutcracker.) **RCA VCS 7095,** 2 stereo discs, specially priced.

An arch-reissue of reissues—one item goes back to mono days, here reprocessed for stereo. "Peter and the Wolf" (mono) is flat and uninteresting in sound, a bland OK job with Alec Guinnes. "Carnival of the Animals" has the Ogden Nash verses, poorly read by Hugh Downs; the campanion "Young Person's Guide" (Downs too) is better. The familiar "Nutcracker Suite" crackles along merrily.

Handel: Harpsichord Suites Nos. 1-4. Glenn Gould, harpsichord. **Columbia M31512,** stereo, $5.98.

Glenn Gould on the harsichord! (15 years ago I was writing of his "harpsichord-like" touch . . .) As always, he has done a thorough study job of preparation—he plays the instrument for itself, not as a pianist. As always too, his ideas are original and sometimes startling. An absorbing disc.

Dvořak: Symphony No. 8 in G. Hamburg Philharmonic, Mackerras. **Nonesuch H 71262,** stereo, $2.98.

Quite a change from familiar large-scale, super-intense Dvořak readings by such as Bruno Walter! This is almost intimate, relaxed, not very profound (and missing a lot that Walter could bring out), yet entirely enjoyable and nicely styled, the Czech dance/folk element well projected. Sort of high-level Dvořak dinner music.

Rudhyar: Piano Music. (Syntony; Pentagrams, Book III, "The Release"). Michael Sellers, piano. Orion ORS 7285, stereo, $5.98.

Dane Rudhyar, born in Paris, Californian since 1920, is one of those sages, complete with dedicated followers, whose work adorns that sometimes zany state. It's all or nothing. For this ear, the music is vaporous and anachronistic, though "in" right now due to its mysticism and mildly oriental slant. In the midst of the jazzy 20's, Rudhyr found his serious, ultra-Romantic idiom and had stuck to it—passionate, moody, on a vast scale, a bit dissonant but, underneath, mostly just old fashioned harmony. Who knows? If you dig Scriabine and astrology, you'll dig this too. Pianist Sellers copes manfully.

Bartók: Piano Concerto No. 2; Prokofiev: Piano Concerto No. 5. Richter; Orch. de Paris/London Symph. Maazel. **Angel S 36801,** stereo, $5.98.

Amazing, this Sviatoslav Richter! Master of the piano classics, he turns here to that new Russian discovery, "modern" music out of the between-wars period, and does a somewhat unsettling job, not too well focused. The Bartók is bright and maybe too fast, the prominent Bach-like element played down. The Prokofiev sings gorgeously and doesn't sound cluttered—a pianistic miracle. It's the best of the two.

Stravinsky: L'Histoire du Soldat (Suite; Piano Sonata; Three Pieces for String Quartet; Three Pieces for Clarinet solo. Ins. Ens. Guijoan; Parenin Quartet; Soloists. **Musical Heritage Society MHS1365** (1991 Broadway, New York, N.Y. 10023.)

A parallel disc to the complete "L'Historie" with spoken text (MHS 1356), this is a different (Spanish) performance. Pleasant, low-intensity playing, dry enough for authenticity but good in the sound. On side 2, the 1924 Sonata is big; and roomy—excellent playing. The three string pieces (1914) squeak dissonantly as always. The unusual little solo bits for clarinet are superbly done. A good record! The pianist is Pedro Espinosa, the clarinet Julio Pañella, presumably both Spanish.

Domingo Sings Caruso. London Symphony, Nello Santi. **RCA LSC 3251,** stereo, $5.98.

This present-day Mexican tenor sings a batch of works which were sung by the Italian genius—who sang practically everything except, maybe, Siegfried and Brunhilde. Placido Domingo is a gentler, much lighter tenor (more placid?) than the steely voiced Caruso, but he has absorbed the Italian manner very well and he is musical too. All that stereo ambience in the recording—that doesn't sound like Caruso!

Classical Record Reviews

EDWARD TATNALL CANBY

Handel: Music for the Royal Fireworks; Three Concertos. English Chamber Orch., Leppard. **Philips 6500 369,** stereo, $6.98.

Handel: Ballet Music. (Alcina, Ariodonte, Pastor Fido) Academy of Saint Martin-in-the-Fields, Neville Marriner. **Argo ARG 686,** stereo, $5.95.

Handel's orchestral music, if it catches you early enough in the musical game, can infatuate and often does. How many millions have fallen for the well known Water Music! Handel was my favorite when I got my start in records, though in those days he came on 78s and the choice was limited, with plenty of Sir Hamilton Harty and Sir Thomas Beecham, who never played Handel straight. They did symphonic arrangements for large modern orchestra.

The Royal Fireworks Musick (to use a nicer spelling) has never struck me as the equal of the Water Music (to use the same) but it has fine moments and indeed is a sibling work. The English Chamber orchestra presents an up to date styling of the music, briskly played with the proper ornaments, brilliant in the brass, lively in strings and oboes. If there isn't nearly as much of it as in the Water Musick, perhaps it is because the said fireworks prematurely set the place on fire. More likely, Handel used a lot of music out of other collections to supplement the new stuff he composed for the occasion.

More interesting than the Fireworks music on this disc are the three Concertos, with various groupings of solo wind instruments; they seem to have been earlier tries at some of the music in both Fireworks and Water Musick—if those two works are already familiar to you, the Concertos will be most interesting to hear. Same only different.

The body of Handelian orchestral music includes, in addition to the special Fire and Water music and a great many Concerti, some splendid groups of pieces from stage works, including the long Overtures, more properly, Ouvertures (i.e. openings), of the multimovement sort which we today call Suites, beginning with a grandiloquent slow movement and a fast fugue, continuing in a string of dance movements. The Ouvertures are often complemented by other works, ballet music and so on. One of my all-time favorite 78 discs was music from Handel's *Alcina*; here on the imported Argo LP is *Alcina* again, to my great pleasure. The LP, of course, includes many more movements, and the complete Ouverture. I was knocked for a musical loop by its beginning—the finest orchestral rendition of the now-restored "double-dotted" rhythm, with ornamentation, that I have ever heard. You will not be able to keep your seat, so swinging is the pulse of it. The entire *Alcina* side of this disc is first rate.

Side 2 moves on to similar music from *Ariodante*, plus a couple of short bits from *Il Pastor Fido* (Handel himself did plenty of transferring from one work to another). It struck me as less effective, possibly because there are too many successive jaunty fast dance movements. But maybe it was

just because I played this side second, and my ears were already full of good Handel.

Performances: B+, A- Sound: B, B

Handel: **Semele** Vyvyan, Watts, Herbert, James; Saint Anthony Singers, New Symphony Orch. of London, Lewis. **L'Oiseau-Lyre OLS 111-3** (3 discs) synth., stereo, $17.94.

Another, and major, reissue in London's L'Oiseau-Lyre series out of the 1950s, reprocessed for stereo, re-cut and repackaged. *Semele* is not an Italian opera but an English oratorio, one of the few that is based on operatic-style classic texts full of Gods and Godesses and their royal pawns on earth. (Most of the oratorios are concerned with Old Testament stories.) The oratorios were given in theatres, but without scenery; the drama is entirely in the music. Some are true "spectaculars," notably "Isreal in Egypt" and "Messiah" but this one is so much like an Italian opera of the time that, on records, only the English of the text distinguishes it from that category.

You will have quite some fun figuring out the plot, English or no! L'Oiseau-Lyre doesn't include a story-line synopsis. The text is there, to be read, but its highly stylized classical expression is picturesque but not very revealing. No matter at all—the music is superb, and the general drift of occurence is easy enough to follow. The Gods Juno and Jove back different human characters and their squabble is vivid—Jove puts out Juno's altar fire via thunderstorm, and then does it again, just to prove his point; he also runs off with Semele in helicopter style; he converts to an eagle, and just lifts her up and away. She loves it.

As of 1956, this production is reasonably modern, with the proper instrumentation, with harpsichord continuo (Thurston Dart) and small orchestra, and the singers, British except for a very American-sounding Juno, do their trills and elaborations dutifully. But certain anachronisms are noticeable if you are a stickler. No double-dotting in the Overture—unthinkable! (Most listeners won't care.) The sound, like most in this series, is mildly substandard as of today. The synthetic stereo is very gentle and quite unobtrusive. You will soon forget about the recording's age.

Brave, honest London! On every disc in this series the original copyright date is given uncompromisingly. I wish some of our record companies would be as straightforward in their reissues. Over here, if it isn't either

fabulous or legendary, you have to half-pretend it's brand new.

Performance: B+ Sound: C+

Bach: Das Kantatenwerk (Complete Cantatas) Vol. 4: Weinen, Klagen; Meine Seufzer, meine Tränen; Wäre Gott nicht mit uns; Herr Gott, dich loben wir (BWV 12, 13, 14, 16). Soloists, Tölzer Knabenchor, King's College Choir Cambridge, Leonhardt Consort, Gustav Leonhardt. **Telefunken SKW 4/1-2** (two discs), stereo, $11.96.

Well, it had to happen. After all, we recorded the Complete Beethoven Piano Sonatas back in the early 1930s on 78 shellac and, since LP, the urge to get down the Complete this or that, no matter how enormous the task, has never let up. Result—assorted in complete series, there being not enough lifetime available. Haydn Symphonies, the Complete Vivaldi (that would take fifty years at least . . .) and so on. If this coalition group, from several countries, manages to get down all the hundreds of Bach Cantatas under one management, it will be a monument to German-Dutch-English persistence!

Yes, the beginning is good, and up to the latest technical and musical standards for these rapidly changing works—changing, that is, in the manner of their present-day presentation. Gustav Leonhardt, Nikolaus Harnoncourt and David Wilcox, associated with this venture, are leaders in the new all-out "authenticity", the music done as closely as possible in the manner of the original works. Nowadays, it isn't merely an old organ, a harpsichord and maybe a recorder or two (I mean the instrument with the finger holes). Now, we have a complete orchestra of Baroque stringed instruments, subtly different in sound from the modern hepped-up, high-tension strings, plus Baroque flutes, oboes and whole ranks of exotic winds such as oboe da caccia, all in the original non-modernized form, all sounding memorably richer, more reaucous, more colorful, than their bland modern equivalents.

And most of all, we have the old natural trumpets and natural horns without valves. The playing techniques, seemingly impossible only a few years back, have been handily revived and now every difficult note that Bach wrote for these splendid instruments sounds out with never a single finger being moved anywhere. It's all done with the lips, and the overtones.

Boys' voices, and young men's, too. That is at least an approximation of the vocal instruments Bach used. Whether they *sound* like his, we can only guess, since voices do differ.

The four performances in this volume are in the best of taste, the vocal soloists (too many to list), ranging from boy soprano, high male countertenor, to basso, well chosen and the over-all balance of forces beautifully right. Needless to say, all sorts of minor details such as trills, delayed continuo cadence figures, the entire continuo itself, are impeccably right, too, and the tempi are, well—suitable. They fit the music. My only complaint is with the faster ornamental pieces, where an all-too-familiar short, jagged "ha-ha-ha" vocal technique seems to me umpleasant. But who knows? maybe Bach's little boys sang "ha-ha-ha" too, on the difficult lines of fast notes. They have to be produced *somehow*, and present vocal training doesn't help a bit. When I looked at the score—the entire printed music for all the works is included in miniature format—I must admit I had to take back my criticism—any choir that can sing the runs and chordal arpeggios of Cantata 16, the last one here, is to be marvelled at! Bach was forever grousing and groaning as to the inadequacy of his choirs. Yet *look* what the poor kids had to sing.

I would not call any of these performances really exciting. They are smooth, correct, thoughtful, and just a trace on the low-voltage side. There are other German recordings of Bach with more genuine communication, and a reasonable authenticity, too. But then—we Americans always are looking for high voltage. These people, so to speak, let Bach's own scores do the talking, which in the long, long run is probably a good idea.

Performances: B+ Sound: B+

Bach: The Six Brandenburg Concertos. Anthony Newman and Friends. **Columbia M2Q 31398** (two discs), SQ quadraphonic, $6.98.

Imagine it—Bach 16-tracked in quad, with a complement of authentic primitive-type Baroque instruments! That's the Newman-and-Friends approach, with the wholehearted cooperation of Columbia's technical producers. The photos show the performers surrounded by such a forest of mic close-in stands you can scarcely make them out. Practically everybody has his own track, by the looks of it. The sound of the resulting Bach album is thus a mixdown and there could be dozens of *different* mixdowns, with quite dif-

ferent sounds, all made from the "original" master tape. So multi-tracking really comes to the classics!

Anthony Newman is that furiously prolific young organist/harpsichordist who plays anything by Bach and friends for fingers and keyboard faster and more energetically than anyone else, and has very much a mind of his own as to how it should sound. It mostly sounds faster and furiouser, and a lot of people like it, not including the stodgier of our church organists. Serves them right. Mr. Bach. Anthony Newman will have you know, is not a composer to go to sleep by.

Newman as musical director of his own group of young professionals is a new thing. Needless to say, group discipline requires a bit less reckless virtuosity, and Anthony's friends are not forced into eccentricity, give or take a few slightly mannered endings and somewhat odd tempi (the very slow minuet in Number One, for instance).

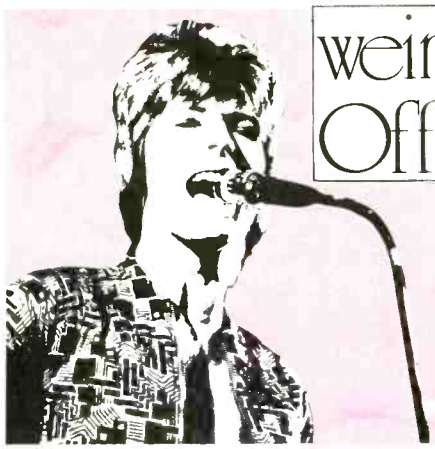
And yet there is, more than Newman probably imagines, a typical American sound to this virtuoso work-out of the six Brandenburgs. One senses, somehow, the American approach to professional performance, via high-discipline virtuoso control rather than long, leisurely and philosophical study. No time! Life moves on. Time costs money, etc, etc. We are anything but plodding when we launch a project costing money and tying up expensive facilities; we Get Things Done, whether it's an advertising campaign, a computerized science project or a performance of music. That's what one hears in these records. High-power youthful efficiency. The sheer virtuosity is enough so that there are no flubs nor any overt clumsiness or haste. The Friends are easily able to keep up with Anthony Newman's prevailingly peppy tempi, even on the old Baroque oboes and recorders that contribute to authenticity. Even so, the slight edge of controlled high tension is always there, the sense that every minute counts. You'll like it or not depending on your own inclinations.

Compare these playings, for instance, with the all-out-authentic Complete Cantata Series performances on Telefunken, if you would hear the contrast. Now if we could just internationalize a bit further, bring the European smoothness of ensemble and totality of correct instrumentation, down to the last instrument, over here; transport at least a bit of the intensity and drive of Newman and Friends over there. That would be Bach indeed!

The quadraphonic sound is really an excellent mixdown—for it can be nothing less than that. There is a curious composite room effect that, while a bit synthetic, is only occasionally false in spatial relationship. (The horns in the First Concerto, for instance, sound close and boxed-in, the other instruments out in the open.) To have Bach's colorful and essentially intimate solo groups spread around is absolutely the height of sonic authenticity, for these were never in any sense "symphonic" pieces for a concert stage. Indeed, this sound is probably nearer the truth, musically, than any live concert of the music likely to be heard in public, at least in this country.

Of course, if you want to argue, Newman can always come right back at you—not one of the Brandenburg Concerti was ever performed at all in Bach's lifetime! Virgin musical territory.

Performances: B+ Sound: A–



weingarten; Off The Record

yeaboooo

Let's play an old party game, *Yeah-Boo.*

David Bowie is a big, big rock-pop star *(yeah!)*. But he has one of the most ordinary voices being recorded today *(boo!)*.

His lyrics are sometimes poetic *(yeah!)*. But more often they are banal or else reach out too far for elusive, obscure mind-pictures *(boo!)*.

David Bowie plays 12-string-guitar, stylophone, kalimba, electric chord organ and whatever else he can put his hands on *(yeah!)*. But he wraps them all in a ribbon of mediocrity *(boo!)*.

He is a kinetic personality, a human supercharger on stage *(yeah!)*. But on records, little of that comes across *(boo!)*.

David Bowie is honest, often telling the world through his songs and interviews exactly where he stands on burning issues of the day *(yeah!)*. But he is a ripoff, also using every platform to turn his self-proclaimed bi-sexuality into a profit-making image *(boo!)*.

He is a Complete Showman, dressing in bizarre costumes and makeup that thrills his audiences *(yeah!)*. But his dynamism and false-face talent can't be seen on vinyl *(boo!)*.

David Bowie writes meaningful songs about the physical and mental rape of war, the beauties of Nature, the mysteries of one-to-one relationships, the "aura of the cosmas" *(yeah!)*. But he destroys as quickly as he builds witty notations that his music "should be . . . made into a prostitute, a parody of itself" *(boo!)*.

He looks like a movie star, a throwback to the days when they were good-looking in the classical sense, and when morality was kept a private belief. But he insists on being offensive, repulsive to the point of parading his tortured soul and crying in one song that he's "a phallus in pigtails" *(boo!)*.

David Bowie is *avant garde (yeah!)*. But his space-age leadership is indicative of how far man can fall *(boo!)*. He has the power to change things and be progressive *(yeah!)*. But he allows RCA to rely on repackaged material, foisting on the public two old Mercury records with nine antique cuts each. **SPACE ODDITY** (Victor, LSP-42813), recorded in 1969, and **THE MAN WHO SOLD THE WORLD** (Victor, LSP-4816), recorded in 1970 *(boo!)*.

David Bowie, because of his massive following, could be almost anything he wants to be *(yeah!)*. But he's become just another cash-hungry pretty face *(boo!)*.

WISHBONE ASH LIVE FROM MEMPHIS (Decca, DL7-1922), lifted from an FM radio broadcast, is aimed at those who prefer their music loud and simple. The electric blues-rock quartet offers three cuts, the 4:48 *Jail Bait*, the 11:34 *The Pilgrim* and the 17:00 *Phoenix*. Love 'em or leave 'em; the choice's yours.

THE EXOTIC GUITARS (Ranwood, R-8104) showcases a smooth, almost playful middle-of-the-road, nothing-spectacular sound. Arrangements seem geared for tea-rooms and the like. High spots include *Whispering, The Shadow of Your Smile, Cold Cold Heart, In the Mood* and *Spanish Harlem,* obviously not tunes looking for a teenybopper audience.

LIFE GOES ON (A&M, SP4367) puts together some new songs and some oldies by Paul Williams, who manages to overcome a nothing voice with good lyrics. All but one of the 10 cuts are his creations; the exception, *That Lucky Old Sun,* is one of the best. Included is his hit *Out in the Country,* one of several items rejoicing in natural wonder and the hope for tomorrow being a better day. It's an upbeat LP, almost an anomaly in today's record marketplace, with the theme summed by a line from the title tune: *You're a fool if you live in the past.*

ELIJAH (United Artists, UAS-5590) is an eight-man outfit, mostly from Los Angeles that get into jazz, big band rock, white soul blues and basic R'n'R. *Mama*, the best tune, contains great trumpet riffs by Tom Bray. The total effect is L.A. rock detouring through Memphis, all fast, high-energy, driving stuff that marks the listener's body move. Of the 10 cuts delivered by the group, which has been together for seven years (almost a longevity record in modern music) half were penned by octet members.

WINDMILLS (A&M, SP4372) thrusts Rick Roberts to the forefront of the country-pop singing field in his first solo outing. The former Flying Burrito Brother is best on *Deliver Me*, a single getting heavy air play, perhaps because Roberts sounds so much like Jose Feliciano on it. The supportive cast is superb, with noteworthy stints by such musicians as Chris Hillman and David Crosby.

HONKY-TONK STARDUST COWBOY (Atco, SD7015) is folk-country-pop by vocalist-tunesmith Jonathan Edwards. There are 13 cuts, eight of which were penned by Edwards, who's popular for reasons I can't comprehend. *Everything* is catchy musically, a sad-happy song lyrically, and *Paper Doll* is an interesting update that the Mills Brothers would disown quickly. The rest is bland, unobtrusive to the extent that you can talk right over it without missing a thing.

MOTHER'S FINEST (RCA Victor, LSP-4790) is a sextet—four blacks and two whites—that offers rock-soul in the Motown mode despite the fact that the group works out of Atlanta. Its roots are in gospel and southern black music and white rock. It seems, however, that something's been honed too finely, for too much of the soul has been replaced by commercial slickness.

THE MASTERPIECE (Ranwood, R-8105) combines classical and pop themes for mass consumption. The 12 tracks by The Charles Randolph Grean Sounde, an electric-company that occasionally needs its batteries charged better, are uneven though usually pleasant. Highlights include the title tune, originally used as the theme for a TV series and later as background music for Olympic Game coverage; *The Ninth*, which springs from the soul of Beethoven; *Gymnopedie*, a steal from Erik Satie; *Amazing Grace, The Theme from 'Star Trek,' Peter and the Wolf* and *Quentin's Theme* (from *Dark Shadows*).

WIND OF CHANGE (A&M, SP4348) finds Peter Frampton attmepting, and failing, to be arty. His voice, which fits easily into the current trend of being impossible to pick out of a crowd, seems to lack real emotion. Ditto his words and music, both of which are slow and complex. Of the 10 cuts, Frampton wrote all but *Jumping Jack Flash*, on which he shows he can do Mick Jagger one worse. For those who still care, Frampton plays at guitars, organ, dulcimer, harmonium and percussion; he's aided ably by Andrew Bown, another one-man band, and a handful of others with dubious talent, including ex-Beatle Ringo Starr.

BANDSTAND (United Artists, UAS-5644) features Family and rock with a variety of rhythmic changes. Overall, however, it's not up to the group's past efforts. The best stuff is when everything's slowed down a bit so the listener can dig the lyrics, which are non-poetic, earthy and interesting.

(Continued from page 23)

All I did, then, was to copy off each speaking voice onto the track of my choice, than reel back and begin again with another voice on another track. Actually, since there were often two voices at a time on each track of the stereo (i.e. two-channel) version, I simply took both off together, channel for channel, and steered the pairs into various tracks on the TEAC. Since I had alternated from side to side in the stereo version, a voice to the right, then one to the left, this worked out just fine in four channels. The sync feature allowed me to bring each track segment in at precisely the instant I wanted it.

We could hardly do a show on speaking voices alone, for more than 50 minutes, so music became a prime consideration and it had to make use of all four channels, one way or another. I'll leave the mixing problem—four channels of music *and* four of voice—to another installment but suffice it to say that I found a way to do this, even without an outside mixer, right on the TEAC. My brightest idea was to use an SQ decoder to feed the four music channels. It worked both for quadraphonic SQ discs and, equally effectively, for standard stereo discs, spread out into four channels. Thus I could use my regular two-channel record player for all the music, starting with two channels—and an unlimited choice of records. A very workable procedure but not without its unexpected pitfalls. To my amazement, I somehow managed to end up with four-channel mono on about one fifth of the 50-minute show! I didn't even notice it, until I became aware that there was a lot of uncalled-for hum, on all four channels, and that the front right channel was low in level and hummed a bit worse than the others. Guess what. You never could.

I spent an entire evening, to two o'clock, trying to figure this one out, and ended up in despair. Nothing worked. The next day I took the entire system apart, unit by unit, testing selectively, and finally found it. One phono channel was dead, right at the source, at the base of the pickup arm! The SQ decoder, with its fancy cross-phasing and divvying-up of signals, had thoroughly disguised this obvious trouble by feeding the remaining signal *and* the open-circuit hum into all of the four-channel outputs. Live and learn! Don't blame SQ. It wasn't designed to decode open circuits. But the very subtlety with which it redistributes the two input signals into four guarantees that any fault that occurs *before* decoding is going to be extremely well disguised in the four-way output. Same with other decoder matrices.

I am aware that for some of our professional readers this is all kindergarten stuff. Those who work in professional recording live with such problems day in and out on a much larger and more awful scale. But I figure that plenty more of our readers who don't happen to frequent the 16-track studios may never have had a chance even to look at those enormous mixing consoles and the huge, fat reels of tape that are common-place in such establishments. The important thing is, a small corner of that audio territory has now extended into home equipment, and I am out to celebrate it. The home semi-pro operation is but a smaller facsimile of the larger one. And, dare I say it, even the pros, God bless 'em, make fool mistakes once in awhile, just like me. We all live in the same audio world. I will retail more of my sync experience in another installment.

(Continued from page 8)

A. If a machine is set for Scotch 203, it will work approximately right with other low-noise tapes. Generally, tape manufacturers try to make tape of a given type competitive with each other. However, one will find some differences with respect to frequency response, distortion, and signal to noise ratio. Sometimes these differences will be measurable but inaudible, and sometimes they may be great enough to be audible. Suitable test equipment is required to test frequency response, signal to noise ratio, and distortion. I doubt that the differences, such as they are, will vary according to tape speed. For Example, if Tape A is 2dB better than Tape B with respect to signal to noise ratio at 7½ ips, Tape A will tend to be about the same amount better at 3¾ ips. I doubt that the Dolby system changes the performance of one tape relative to another.

Buying a tape deck

Q. I am in the process of buying a tape deck. I would like to make full use of all its capabilities, and being a novice in the tape world would appreciate any advice you could give me. Also, indicate any books or articles from which I could derive the necessary information.—(Terry L. Piotrowski, Brook Park, Ohio)

A. Your question is so broad that I can give you only a very general answer. Visit your local audio store(s) and see what books they have on tape recorders. Visit your local library and hunt through back issues of audio and electronic magazines for articles about tape recording. Carefully read the manual that comes with your tape deck.

In purchasing a tape machine, make sure you hear it before you buy it. Take along a phono disc known to be of high quality, and ask to have parts of it copied on tape. Compare the tape playback with the disc; if possible, make it a simultaneous rather than sequential comparison. Keep your ears open for significant difference in frequency response, for pronounced hum and/or hiss, for audible distortion (coarseness or graininess of sound, or a veiled quality), for detectable wow (which causes steady tones, such as those of a piano, to go "sour"); in short, for anything you don't hear on the disc.

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The research begins.

In 1956 a basic research program on musical acoustics was started by Professor Bose.[2] The motivation for this research came from the apparent discrepancy between the acoustical specifications and the audible performance of existing loudspeakers. Musicians were quick to observe the boomy and the shrill sounds produced by loudspeakers for which engineers claimed excellent specifications.

Dr. Bose's research began by making exacting measurements on loudspeakers and setting up experiments to correlate these measurements to aural perception.

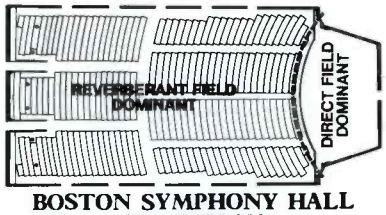
By 1959 it was clear that not only were the existing measurement standards (established 30 years before) incomplete, but worse, they were often misleading. For example, measurements of frequency response and distortion made in anechoic chambers not only fail to indicate what a speaker will do in a room, but speakers with better chamber measurements can actually give inferior performance in the home—and vice versa!

Probing psychoacoustics.

By 1960 it became evident that basic psychoacoustic research was necessary to relate the subjective performance of loudspeakers to objective design parameters. This research was launched and the first major results were reported in November 1964 at a joint meeting of the Audio and Computer groups of the Institute of Electrical and Electronic Engineers held at M.I.T. It was this research that established the validity of the then controversial concepts of multiplicity of full range drivers, speaker equalization, and flat "power" response. It was also shown, with the help of computer simulations of ideal acoustical radiators, that electrostatic, or other types of speakers have no potential performance advantages over properly designed cone speakers—a result that was not known prior to 1964.

Significance of reflected sound established.

At the time of the 1964 meeting, however, little was understood about the spatial properties of speakers. There was some evidence that direct radiating speakers caused shrillness in music but the reasons were not known. From 1964 to 1967 the research concentrated on these spatial problems. With the co-operation of the Boston Symphony Orchestra, measurements were made during live performances to determine characteristics of sound incident upon the listeners. Theoretical studies, verified by experiments, showed that in live performances sound arriving at the listeners' ears from different directions was much more evenly balanced than was the case for loudspeakers in home environments. Experiments then linked this spatial difference to the strident sounds produced by loudspeakers. Then it was discovered that the desirable spatial characteristics could be produced in the home by directing a large percentage of sound away from the listener at precise angles to the rear wall.



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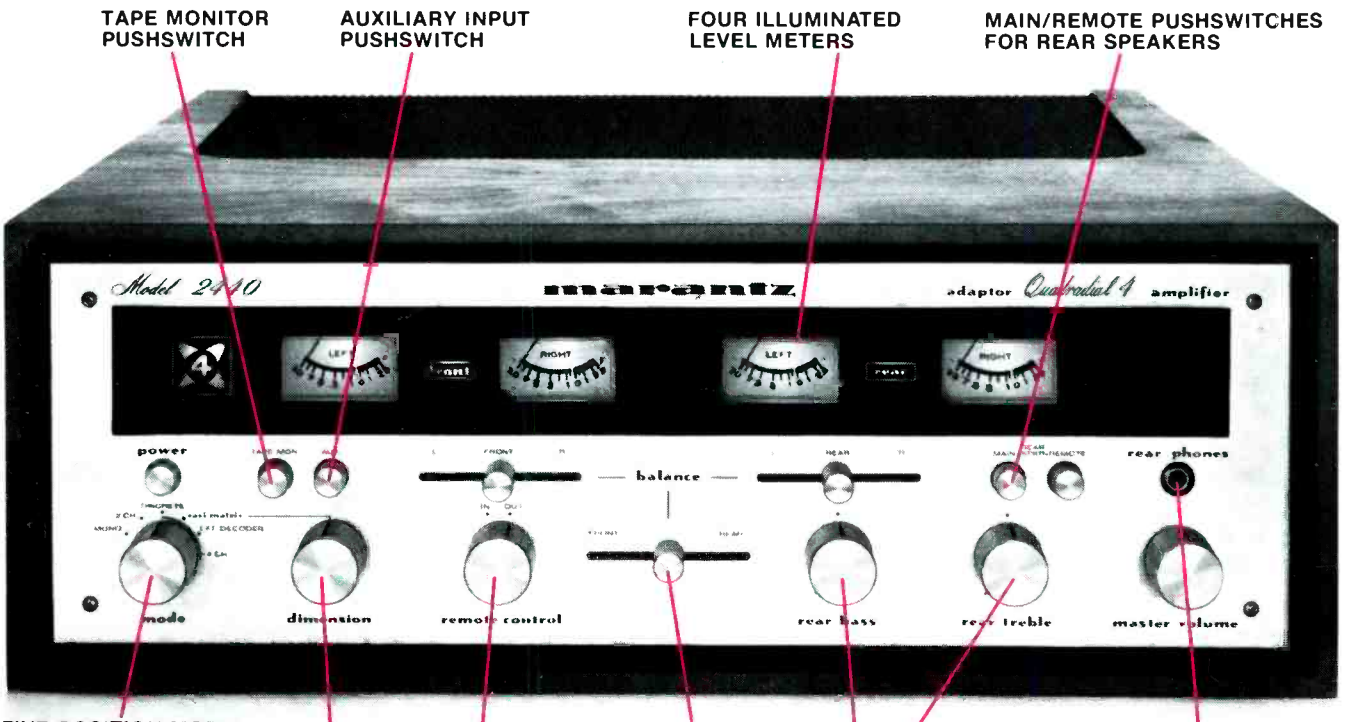

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