CHRISTMAS BUYING GUIDE

Audio

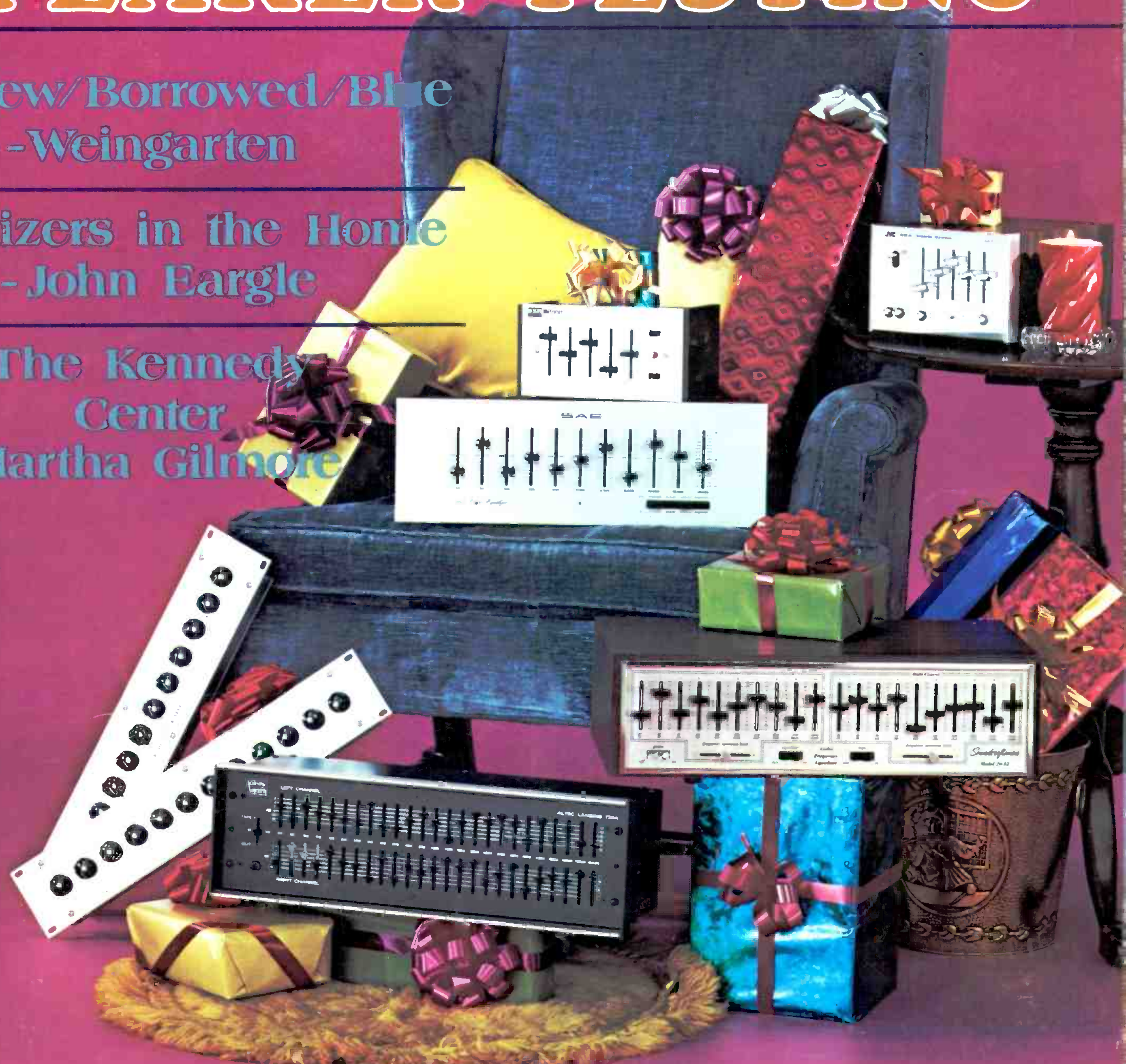
THE AUTHORITATIVE MAGAZINE ABOUT HIGH FIDELITY • NOVEMBER 1973 60¢ ®
23602

BREAKTHROUGH IN SPEAKER TESTING

Old/New/Borrowed/Blue
--Weingarten

Equalizers in the Home
--John Eargle

The Kennedy Center
--Martha Gilmore



Experts agree...

(Left to right) Jerry Fisher, lead vocalist, Blood, Sweat & Tears ■ Bobby Colomby, drums, Blood, Sweat & Tears ■ Walt "Clyde" Frazier, New York Knicks ■ Andy Warhol, movie producer-director ■ Henry Lewis, conductor, New Jersey Symphony

Four-Channel Level Indicator — See what you hear. Make instant adjustments with left/right, front/rear level controls.

electronic trigger relay system is used to protect the speakers from DC leakage or overload.

New and exclusive Power Boosting circuit

When switching from four-channel to two-channel reproduction, power is substantially increased with the new and advanced Power Boosting circuit, as described above. This exclusive circuit is built into both the QX-949 and QX-747 models.

Another plus feature attributable to the Power Boosting circuit is simplified switching from four-channel to two-channel operation. It can be instantly achieved without the usual re-connecting of speaker wires. This, too, is a Pioneer exclusive.

A tuner section the equal of separate components

The FM tuner section of the QX-949 is truly an engineering accomplishment. It incorporates two dual-gate MOS FET's in the front end, plus three ceramic filters and 6-stage limiter's in a monolithic IC in the IF stage. The result is superb sensitivity and selectivity, and excellent signal to noise ratio.

Advanced circuitry includes Dolby adaptor input/output and 4-channel broadcasting multiplex output terminal

In anticipation of the future use of discrete quadraphonic broadcasting, the QX-949 and QX-747 include a quadraphonic multiplex output terminal. Depending on the system finally approved, all that ever will be required is a simple adaptor unit. And speaking of adaptor units, both the QX-949 and QX-747 highlight an input/output for a Dolby noise reduction adaptor unit.

Unique 4-channel level indicator

Regardless which quadraphonic source is in operation, the sound level of each channel can be monitored by viewing the large scope-type level indicator on the top two models. Left and right front/rear controls permit instant adjustment. Indicator sensitivity controls allow for a maximum of —30dB adjustments at any sound level. The level indicator may also be used to view CD-4 channel separation adjustments made with the CD-4 separation controls.

Inputs/Outputs for total versatility

Pioneer has endowed these models with terminals for a wide range of program sources. The only limitation is your own listening interests and your capability to experiment with sound.

Convenient features increase listening enjoyment

Along with the total capability of these receivers, Pioneer has incorporated a wide array of additional, meaningful features. All three instruments include: loudness contour, FM muting, an extra wide tuning dial, two sets of bass/treble controls for front and rear channels, function and mode selector with multi-colored indicator lights. Further refinement is offered with the QX-949's multiplex noise and high/low filters, plus signal strength and center tuning meters in one housing.

Admittedly, these new Pioneer quadraphonic receivers, like fine sports cars or cameras, are not inexpensive. However, they represent the high fidelity industry's most outstanding value. We have built them with the same quality, precision and performance you've come to expect from Pioneer stereo equipment. We offer them to you with the same pride and conviction that has always compelled you to say — "Pioneer, the very best."

QX-949 — $699.95; QX-747 — $599.95; QX-646 — $499.95. Prices include walnut cabinets.

U.S. Pioneer Electronics Corp., 178 Commerce Road, Carlstadt, New Jersey 07072
West: 13300 S. Estrella, Los Angeles 90248 / Midwest: 1500 Greenleaf, Elk Grove Village, Ill. 60007
Canada: S. H. Parker Co.

Specifications

Amplifier	QX-949	QX-747	QX-646
4-ch. RMS power, 8 ohms, 4 channels driven, 20-20KHz	40 watts/ channel	20 watts/ channel	10 watts/ channel (1KHz)
4-ch. IHF	240 watts (8Ω) 380 watts (4Ω)	160 watts (8Ω) 220 watts (4Ω)	80 watts (8Ω) 108 watts (4Ω)
2-ch. RMS power, 8 ohms, both channels driven, 20-20KHz	60 watts/ channel	40 watts/ channel	13 watts/ channel (1KHz)
2-ch. IHF	150 watts (8Ω) 230 watts (4Ω)	120 watts (8Ω) 170 watts (4Ω)	40 watts (8Ω) 54 watts (4Ω)
THD/IM Distortion	0.3% (20-20KHz)	0.5% (20-20KHz)	1% (1KHz)
FM Tuner			
FM Sensitivity (IHF) (the lower the better)	1.8uV	1.9uV	2.2uV
Selectivity (the higher the better)	80dB	60dB	40dB
Capture Ratio (the lower the better)	1dB	1dB	3dB
S/N Ratio (the higher the better)	70dB	70dB	65dB
Inputs			
Phono	2	1	1
Tape Monitor	2 (4-ch.) 2 (2-ch.)	1 (4-ch.) 1 (2-ch.)	1 (4-ch.) 1 (2-ch.)
Dolby adaptor input	1 (4-ch.)	1 (4-ch.)	—
Auxiliary	1	1	1
Outputs			
Speakers	2 (Front) 2 (Rear)	1 (Front) 2 (Rear)	1 (Front) 2 (Rear)
Headset	1 (Front/Rear)	1 (Front/Rear)	1 (Front)
Dolby adaptor output	1 (4-ch.)	1 (4-ch.)	—
Tape Rec.	2 (4-ch.) 2 (2-ch.)	1 (4-ch.) 1 (2-ch.)	1 (4-ch.) 1 (2-ch.)
4-ch. MPX output	1	1	—

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Audio

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FEATURE ARTICLES

EQUIPMENT PROFILES

RECORD REVIEWS

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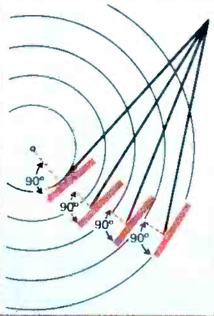
Garrard introduces its new models.

ZERO 100c

ZERO 92

The Zero Tracking Error Tonearm

True tangent tracking geometry. Zero 100c and Zero 92 tonearms.



This season, we have brought out four entirely new units in the Component line, and refined the already famous ZERO 100, now in its third year of production. This unique Zero Tracking Error automatic turntable, which has earned the overwhelming regard of the critics, now becomes the *ZERO 100c*, and includes further advancements; including a built-in, automatic record counter . . . making the ZERO 100c the finest automatic turntable available at any price.

The Garrard policy of pursuing useful technical innovations and resisting "change for the sake of change," has paid off handsomely this year. Most notably, the articulating Zero Tracking Error Tonearm, Garrard's revolutionary patented design, has been incorporated in the ZERO 92, a new model at lower cost than the ZERO 100c. In addition, three other models, the 82, 70 and 62 have been introduced. The entire series, both in styling and features, reflects the ZERO 100c design philosophy.

This year, more than ever, there is a Garrard automatic turntable to suit your specific needs. Your dealer will help you select the model that will best complement your system . . . whether that system is mono, stereo, 4-channel, matrix or discreet.

MODEL 82

MODEL 70

MODEL 62

ZERO 100c
Two speed Automatic Turntable with articulated computer-designed Zero Tracking Error Tonearm. Features: Variable speed ±3%; Illuminated Stroboscope; Built-in automatic record counter; Magnetic anti-skating control; Sliding weight stylus force setting; 15° vertical tracking and cartridge overhang adjustment; Damped Cueing/Pausing in both directions; Patented Synchro-Lab Synchronous Motor. $209.95*

ZERO 92
Three speed Automatic Turntable with articulated Zero Tracking Error Tonearm. Features: Lever type anti-skating adjustment; Sliding weight stylus force setting; 15° vertical tracking and cartridge overhang adjustments; Cueing/Pausing control, Damped in both directions; Patented Synchro-Lab Motor. $169.95*

MODEL 82
Three speed Automatic Turntable with low-mass extruded aluminum tonearm. Features: Lever type sliding weight anti-skating adjustment; Sliding weight stylus force setting; 15° vertical tracking and cartridge overhang adjustments; Cueing/Pausing control, Damped in both directions; Patented Synchro-Lab Motor. $119.95*

MODEL 70
Three speed Automatic Turntable with low-mass aluminum tonearm and fully adjustable stylus pressure setting. Features: Torsion spring anti-skating control; Cueing/Pausing control; 2 point record support; Patented Synchro-Lab Motor. $89.95*

MODEL 62
Three speed Automatic Turntable with low-mass aluminum tonearm, fixed counterweight, and adjustable stylus pressure. Features: Torsion spring anti-skating control; Cueing/Pausing control; 2 point record support; Heavy duty four-pole Induction Surge Motor. $69.95*

*Less base and cartridge

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Mfg. by Plessey Ltd.

GARRARD

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Coming in December

Focus on Microphones
How to Record Live in Two and Four Channels—Jim Gordon

Microphones—The Vital Link in the Recording Chain—David Lane Josephson

Fundamentals of Loudspeaker Design—Michael Lampton and Lee M. Chase

Equipment Profiles Include
Kenwood KR-6340 four-channel receiver ESS Heil amt-1 speaker system

Classical, pop/rock, and jazz record reviews

About the cover: Equalizers, the subject of our editorial focus this month, are becoming increasingly popular as more people come to understand their uses. Good units can make up for deficiencies in response of most any component in the system, and they can correct many difficulties in room acoustics. Equalizers are used by sound reinforcement people to help cure feedback so that the overall level of the system can be increased, and speakers manufacturers use equalizers with specific characteristics to normalize response. All in all, equalizers are one of the most useful tools the audiophile has to change the characteristics of the sound in his listening room.

Audioclinic

Joseph Giovanelli

Musical Instrument Versus Hi Fi Sound

Q. I am planning to construct a bass reflex enclosure with a duct behind the port.

I want to build a system which can handle the sound of a pedal steel guitar and also play recorded music. The loudspeakers I plan to use are designed for musical instrument reproduction. I am interested solely in reproducing rock and jazz; basically, music produced by guitar, bass, drums and organ.

With the help of a graphic equalizer, can I smooth out the response for recorded music?—Dennis Lipster, Bellerose, New York

A. I have not found it possible to make speakers designed for musical instruments produce good sound for high fidelity systems.

Musical instrument speakers are designed to produce certain colorations so that the instruments have a specific sound quality. Therefore, some people do feel that such speakers will be great for reproducing these same sounds. Remember, however, that the sound has already been colored by the nature of the speakers originally producing the sound. It will be colored once again during playback. The quality or alterations of quality, therefore, will be enhanced. This "enhancement" may not be an improvement in quality.

A graphic equalizer will not smooth out speaker resonances and dips. These speaker abberations are much sharper than the equalizer's filters.

I suggest, therefore, that you use two separate sets of speakers: one for live playing, and another for sound reproduction.

Using an Equalizer

Q. The idea of an equalizer working over many different frequency ranges to compensate for room differences fascinates me, but who is to tell me whether I am going to make matters better or worse by twiddling with the controls? My present amplifier, in addition to bass and treble controls, has a contour control, which, believe me, affects the bass. I will go for a month without emphasizing the bass and then decide that things sound thin and go another month the other way.

Do equalizer manufacturers provide advice or test recommendations which will protect me against my own bad musical judgment?—Francis Woodbridge, Boston, Massachusetts

A. An individual's ideas of good musical sound can change from time to time. I do not think, therefore, that you need "protection."

Some manufacturers of equalizers do offer guides for the initial setup and adjustment of an equalizer to compensate for deficiencies in the loudspeaker system and in room acoustics.

We might sometimes want to compensate for deficiencies in the sound of the discs or tapes or to accommodate our own feelings at a given time. Therefore, just make changes in equalization whenever they seem necessary.

Listening to music is a highly subjective experience. There is really no right or wrong way to listen to audio. Listen in accordance with your mood. Forget logic. If you enjoy the results you can achieve with an equalizer, this enjoyment is what counts.

While such equalizers are capable of producing great changes in the quality of sound it is likely that you will only need to make small changes of the setting of any given control to produce a useful enhancement to your enjoyment of music.

It is generally a good idea to record tapes without using the equalizer. The equalizer can then be used during playback of these tapes. This is most true when you first get your equalizer because you will want to experiment with it quite a bit. Once a tape has been recorded with some equalization, it could be difficult to alter the reproduction later on when you have learned more about the uses and abuses to which such equalizers are subject.

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.

KLH is well into its second decade of manufacturing extraordinary high performance loudspeakers that don't cost an extraordinary amount of money. We've kept costs down by making every loudspeaker ourselves. And by selling a staggering number of them.

In short, we've had a lot of practice.

And that's perfect for you.

For now you can own *a pair* of our new Model Thirty-One loudspeakers for just $89.95†. Think of it. Two superb sounding full-range loudspeakers at a price you might consider fair for just one! A pair of Thirty-Ones deliver a truly inordinate amount of sound for their modest size. You can drive them to big listening levels with virtually any decent amplifier or receiver. They're handsome, featuring a new sculptured acoustically transparent foam grille. Rugged. And best of all, incredibly inexpensive. With the money you save, you might even trade-up to a better turntable or receiver, perhaps even get into quadraphonic sound. The Thirty-Ones can help make it happen. A pair is at your KLH dealer now. Listen to them soon. We're sure you'll agree that no one has ever offered you a better value in sound.

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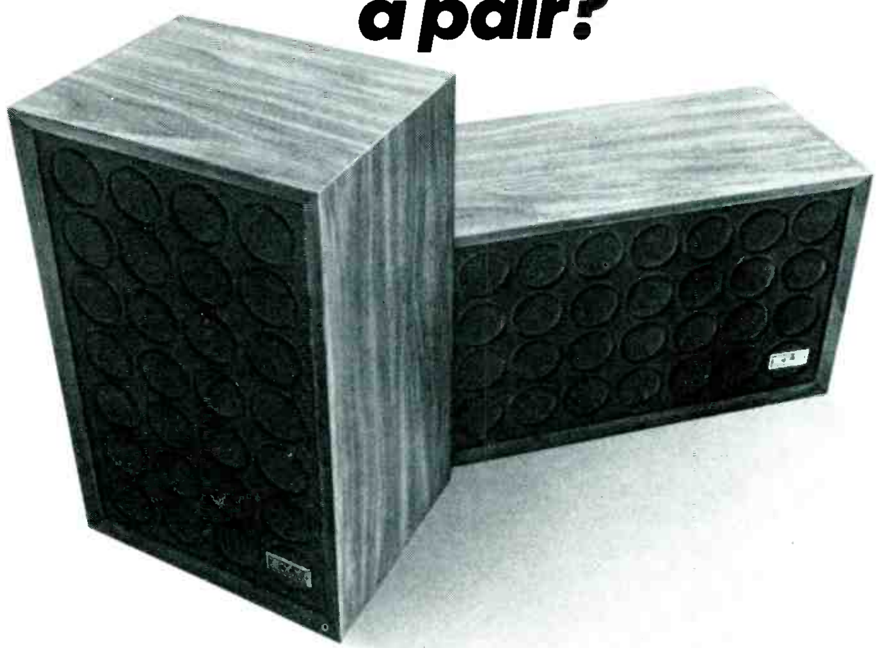
For more technical information, write to KLH Research and Development, 30 Cross Street, Cambridge, Mass. 02139. Or visit your KLH dealer.

What does it take to make an important new loudspeaker and sell it for $89.95† *a pair?*



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Tape Guide

Herman Burstein

Tape Thickness

Dear Mr. Burstein,

I am writing in reference to the first item "Tape Length" which appeared in your Tape Guide section of the April, 1973 issue of AUDIO.

Perhaps by now you have received all sorts of comments to your statement, "For anything like good results, ½ mil tape is generally not recommended." It has been the experience of cassette manufacturers that ½ mil (C-60) cassettes are preferred by knowledgeable audiophiles for two reasons. (1) The magnetic oxide coating is thicker on C-60 tapes than on C-120 and some C-90 tapes. Consequently, saturation and distortion is less of a problem and dynamic range is improved with C-60 tapes. (2) C-60 ½ mil base film is less likely to cause physical and mechanical problems. Usually it winds up better so there is less edge damage and consequently less edge program distortion or dropouts. Statistically, the mechanical jamming rate among cassette manufacturers is far less with C-60 than with C-120 cassettes.

With reliable cassette transports that are properly maintained, "name brand" cassettes rarely cause the tape speed slow down or excessive wow and flutter problems that Mr. Thurwachter mentioned. However, if the torque required to drive a cassette is at the upper limits of the IEC specification and if the transport batteries are not at full strength, these mechanical problems will occur.

John E. Jackson
Manager
BASF Systems

You are completely correct. The state of the art has changed so that, at least for cassette, ½ mil tape, which is used in the C-60 cassettes, does a fine job. In fact, I have found that at least one manufacturer's C-90 and C-120 cassettes, which use tapes even thinner than ½ mil, do a surprisingly good job. My comments about ½ mil tape do not apply to cassettes, where ½ mil and thinner tapes are giving very good performance.

The Tape Guide did not mean to imply that ½ mil tape (C-60) is worse than thinner tapes (C-90 and C-120). It meant that 1½ mil and 1 mil tapes are better than ½ mil tapes.

Matching Microphone Impedances

Q. I recently bought a Sony Mx-12 mixer. The manufacturer suggests that I use low impedance mikes to feed it. I have been using high Z mics with it. Am I doing wrong? Is it important to match the impedance?—Louis Hone, Montreal, Canada

A. I have noticed that transistors do not seem to care what kind of mikes drive them, within reason, of course. However, the use of high Z microphones with circuits designed for low impedance units will result in more mixer noise because its inputs are not properly terminated. I suggest, therefore, that if you are using dynamic microphones, you also use matching transformers to lower their impedance. If your microphones are crystal units, you will lose low frequencies by feeding them into this mixer. This will be the case even when you use a transformer with them. No transformer can help because there is none which can work into the high impedance needed by crystal microphones.

Cassette Head Longevity

Q. What is the usual life expectancy of the record-playback head in a cassette deck? My cassette operates an average of seven hours a day and about 12 hours on weekend days. I have noticed a notch on the face of the head, but I'm not sure if it is a machined notch or due to wear. From the information I have given you, do I have a lot more life left in the head?—Dennis G. Mueller, APO San Francisco

A. In the case of open reel machines, a good conventional head is considered capable of giving 1,000 to 2,000 hours of service. I don't think that a cassette head would give more. So you can judge whether the head in your cassette machine is coming close to the time of replacement. I doubt that the notch you see in the head is a machined notch.

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

Instead of talking about a cassette deck with 3 heads we make one.

The RS-279US.

It has an HPF™ monitor head. So every recording you make will be as sharp and clean as it should be. That's recording insurance. The kind of insurance that great specs alone can't give. Only a monitor head can.

The monitor is more important in cassette than it ever was in reel-to-reel. Because the cassette can drag or jam without warning. And it's prone to recording overload. Which can ruin a potentially great recording if it isn't detected.

The RS-279US also has many other desirable design and convenience features. Like a dual motor system. With a DC motor for the reel-table-drive and our exclusive direct drive DC motor for the capstan. Adjustable Dolby*. Switchable bias for CrO_2 tapes. Solenoid-operated function controls. Locking pause. Memory rewind. And Auto-Stop.

And the specs are just what you'd expect from a deck with those credentials. The signal-to-noise ratio is better than 59dB. Frequency response is from 20-16,000 Hz. And wow and flutter are less than 0.10%.

The RS-279US has the hallmarks of a great cassette deck. Plus one that puts it ahead of other decks. Our patented HPF™ monitor head.

The concept is simple. The execution is precise. The performance is outstanding. The name is Technics.

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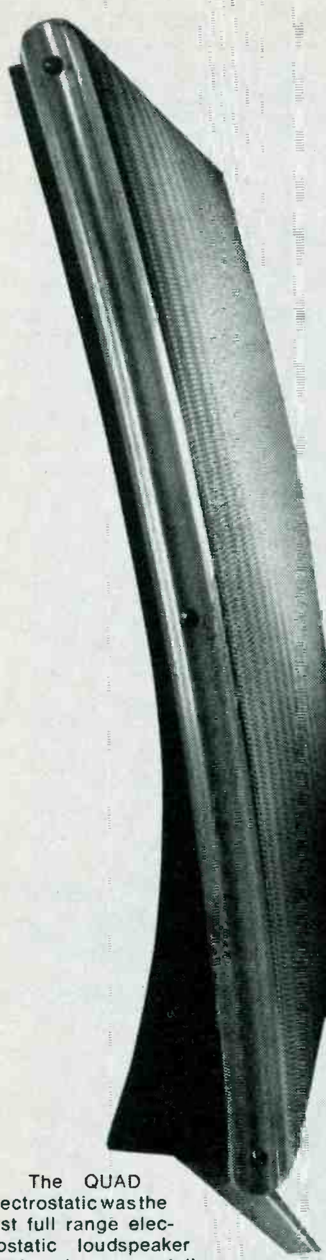


Dear Editor

Shure & CD-4

Dear Sir:

I would like to comment on Edward Canby's most interesting and provocative article on phonograph cartridges in the June issue of AUDIO. Since he has raised several very pertinent questions regarding the future direction of cartridge development, I would like to answer those questions insofar as possible.

Shure's position is that we will provide the best quality cartridge for all record formats that are produced. We will certainly endeavor to satisfy the requirements of the CD-4 system, as well as the matrix and standard stereo. This does not mean, however, that we—or other cartridge manufacturers—can produce a single cartridge that will be the ultimate solution for all systems. It may be that several cartridges will be required, each being the optimum for a given system.

In the case of the V-15 III, our objective was to provide the finest phono cartridge possible for the present-day standard stereo disc. This does not mean that we intend to ignore the CD-4 system or any other system. It simply recognizes the fact that the number of CD-4 discs available today is miniscule compared to the millions of standard stereo discs that have been produced over the past 16 years. Even today, the Schwann catalog of records shows approximately 30K stereo discs and certainly fewer than 30 CD-4 discs. The V-15 III has been optimized to satisfy the requirements of the standard stereo disc.

The V-15 III will track most present-day records at ¾ gram. Cartridges being sold for operation with the CD-4 system are specified at two grams. The design of a cartridge that will play satisfactorily at ¾ gram is significantly different from that which will play at two grams. We feel that the lower tracking force is an extremely important feature of a top-quality stereo cartridge. We have run extensive life tests, which show that the life of a diamond tip increases exponentially as tracking force decreases, as long as the cartridge tracks properly. For cartridges in the price range of the V-15 III, we believe that extending the life of the stylus is a feature we owe to our customers. We could not, therefore, countenance a change in the design of the V-15 III that would require a higher tracking force.

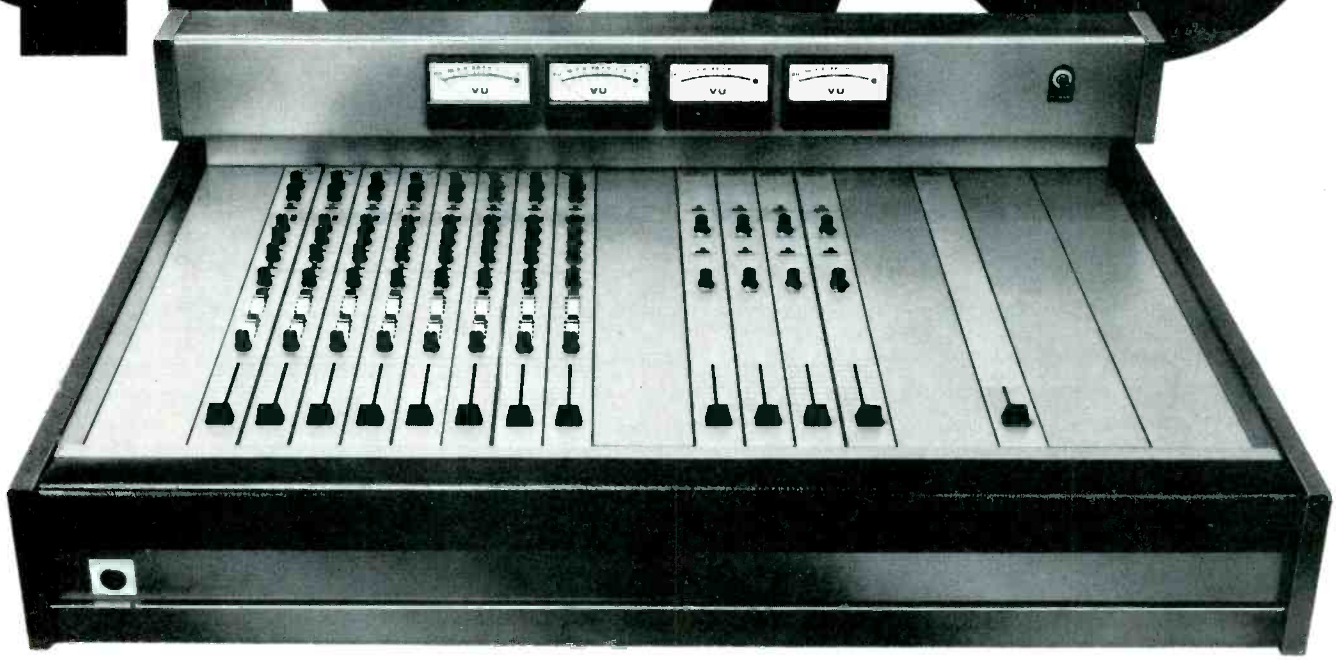
In this article, Mr. Canby indicates that the cartridges designed for the CD-4 system are flat in frequency response out to 45,000 Hz. We have tested all of the CD-4 cartridges that we have been able to find, not only for sale in the United States but in Japan and Europe as well. All of these cartridges have a rise in frequency response above about 15 kHz, with a peak in the 25 to 30 kHz region, approximately 10 dB above the 1 kHz level; however, cartridges with such a frequency response can and do work with the CD-4 decoders that we have used for test purposes. On the other hand, we have found that there are numerous other factors that can affect the ability of the cartridge to work with the CD-4 system; but the response, such as I have just described, is satisfactory.

The frequency response I have described indicates a major resonance in the 25 to 30 kHz region. A flat frequency response out to 45 kHz would require either a major resonance beyond 45 kHz, or a very highly-damped stylus system. Both possibilities would require a dramatically different approach from that of present-day cartridges. Most probably, successful CD-4 cartridges will show a resonance around 30 kHz, with a fairly significant peak. In order to provide proper trackability for these cartridges, a tracking force in the two-gram region is indicated.

One of the problems in developing a cartridge for the CD-4 system is that the system itself is still undergoing development and improvement. In the case of stereo, once the Westrex cutter had been introduced, people produced stereo records; and the phonograph cartridge was designed to satisfy a reasonably fixed objective. In the case of CD-4, there have been numerous improvements in the technique of mastering the records and also in the electronic circuitry for decoding the signal. There also have been changes in the record materials. Designing a cartridge to satisfy the requirements of the CD-4 system, as well as the ear of the trained high-fidelity listener, is not a static task.

We believe that it is necessary to produce a cartridge designed specifically for the CD-4 system. At the

$1890



You pay for what you need

If you're seriously into music or sound reinforcement you want more than hi-fi products can give you. But full professional studio gear costs an arm and a leg, and you pay for a lot of things you may not really need.

That's why there's a TASCAM Model 10. It's an 8-in, 4-out mixing console, and it's just $1890.

With the Model 10 you get what you have to have. Without sacrificing a single necessary function.

Each input module gives you mic and line attenuation, three bands of peak and dip equalization (two with frequency selection), pre- and post-echo send and receive circuitry, pan function, and a unique straight-line fader.

Each of the four submasters has a meter control switch (line/echo), independent monitor level control, echo receive level control, and a straight-line fader. You also get a master gain module and 4″ VU meters with LED peak indicators. Plus pre-wired facilities for up to four additional input modules and other optional accessories including talkback, remote transport control, quad panner, and headphone monitor.

That's what you need and that's what you pay for. Some things, however, you may or may not need, and we leave that choice up to you. For instance, the basic Model 10 is high impedance in and out, but studio line impedances are available optionally. You'll probably want low impedance mic inputs, but you may not need all low impedance line inputs. So we don't make you pay for them. You can order any combination of high and low input/output impedances according to your application.

Details and specs on the Model 10 are available for the asking. At the same time we'll tell you about our new Series 70 Recorder/reproducers.

We've got what you need.

TASCAM CORPORATION
5440 McConnell Avenue
Los Angeles, California 90066

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present state of the art, such a cartridge will be able to perform adequately with standard stereo records; however, we do not believe such a cartridge can approach the ultimate in reproduction of standard stereo records. For such reproduction, we offer the V-15 III. Perhaps, some day in the future, the qualities of these two cartridges may be combined and the ultimate may be offered for both systems simultaneously. Until then, we feel that individual cartridges optimized to satisfy each system should be provided.

James H. Kogen
Vice President
Shure Bros., Inc.
Evanston, Ill.

A New Recruit

Dear sir,

I have been buying your magazine off the newsstand for some time now. I have always thought it was the best. The June and July issues, however, were so good that I was moved to send for a subscription.

The July articles about four-channel by Len Feldman, Ben Bauer, and Harry Maynard really sold me on AUDIO. I have a four-channel system and love it.

Keep up the good job.

Harry L. McDonald
Takoma Pk., Md.

Al Stewart's Instrumentation

Dear sir,

Mr. Canby's review of my album *(Museum of Modern Brass)* just came to my attention. I'm delighted that you felt about it as you did as well as taking the time to write about it in AUDIO.

The instrumentation of the group is 5 trumpets, each also playing flugelhorn and piccolo trumpet where called for in the arrangements. The low horns are tuba, bass trombone and French horn, and the six rhythm are keyboard (piano, organ, harpsichord, celeste, electric piano), fender, two guitars, percussion and drums.

I hope that the next album grooves you as much as this one did.

Thanks for a beautiful article.

Al Stewart
New York, N.Y.

Master Tapes

Dear sir,

In a recent issue of AUDIO in the "Dear Editor" section, I note that Mr. J. E. Cade of Casonic Foundation and Mr. Lee Kuby of Harman-Kardon are looking for prime quality tape dubbings. I have many high quality master tapes available, almost all of which were recorded by myself, at live concerts. Most of the masters were done with the help of the Dolby B system. I use Sony C-500, Neumann U-87, and Vega S-10 condenser mics. I can honestly say that the tapes are extremely good. Most of the performances were done by excellent groups and include a wide variety of music from full symphony to pipe organ (both classical and theatre types) to jazz, etc.

I also am looking for dubbings of first rate material that is technically excellent, and I trade tapes with others in this country who are in my position. We all are disgusted with the commercially available source material, and the only way to really get first-rate stuff is to do it ourselves.

I would be willing to make duplication of some of my tapes for worthy causes or for trade. I would be pleased if you would refer my name to others who might have prime source material available for my use.

Thank you.

Roger Sanders
1578 Austin St.,
Atwater, Calif. 95301

Separate Decoders

Dear sir,

I read with great interest the Leonard Feldman article, "Evolution of Four-Channel Equipment." He makes a number of interesting points, although I take minor exception to certain ones.

My own four-channel interest predates his "Phase One" by several years since I have previously used a rear speaker wired similar to the Dynaco method to improve the sound field. The present system includes separates across the board. AR3a speakers (the LST is planned for the front), Crown International and SWTCo amplifiers, decoders in profusion (Sansui QS-1, EVX-44, Metrotec, JVC-CD4, etc.), 2- and 4-channel tape decks, along with numerous other goodies. All of this tied together through a self-designed and built switch panel. I purchase and try new decoders as they come along. (The Sony SQD-2020 is on order.)

I gather from Mr. Feldman's article that the trend will be toward an "all in one" sort of box with a demise of the separate decoder. I would not wish to see that day arrive.

The receiver has not been built, 4-channel especially, that will match the quality and power of a Crown DC-300,

or for that matter, a SWTCo Universal Tiger. A 20 watts per channel receiver simply will not handle an AR3a.

If the purist (or in my case, HiFi nut) wants the best, separates is the only way to go, and this means separate decoders. This method will permit any change, modification, up-date or what have you without regard to form factor, power requirement, or visual esthetics decreed by the XYL for *her* front room.

Yes, my system looks like Fig. 3 on page 32, only more so, thank goodness. I can add, use, experiment with any decoder in any format, in any size without disrupting in any way the remainder of the system.

I, for one, hope the separate demodulator/decoder is here to stay.

Frank C. Smith
APO San Francisco

From Radio Shack

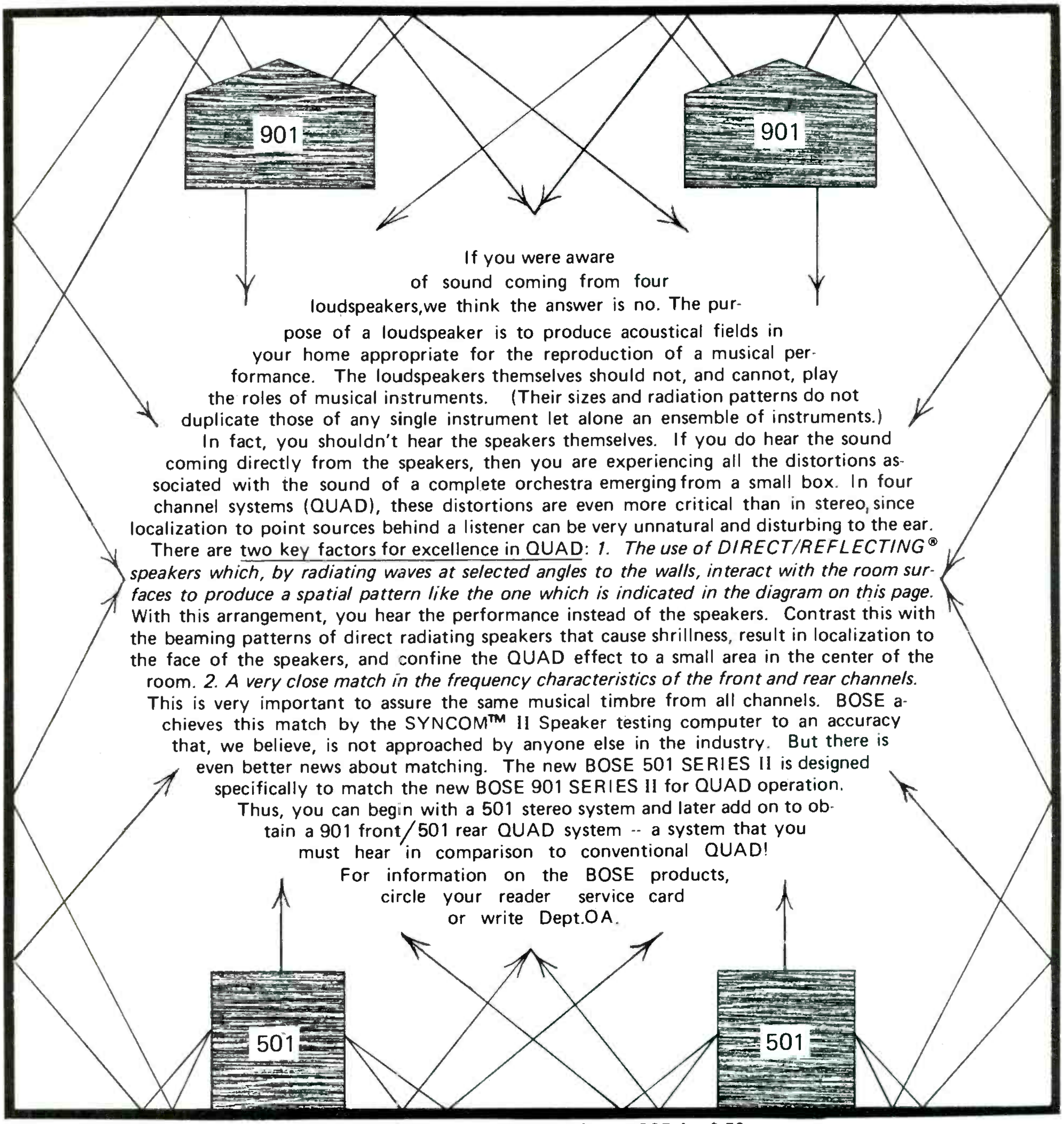
Dear sir,

We are greatly appreciative of the excellent reports on Realistic receivers Len Feldman has written for AUDIO—keep 'em coming! There is just one thing that bugs me: at the end of your STA-120 report and the beginning of your QTA-790 report, you commented adversely upon a little stock paragraph on the inside cover of our operational manuals. I wrote that gem about seven years ago merely to indicate Radio Shack's desire to please people via the sound, the look, the feel, and the reliability of our equipment as opposed to mere specs. I have now rewritten those comments out of fear that the next time you review us your irritation will have reached the point of making a headline (or indeed an entire report) out of my innocent prose. O the awesome power of the press!

Lewis F. Kornfeld, Jr.
President
Radio Shack

*"And if we do have twins, they will **not** be named 'Woofer' and 'Tweeter!'"*

Have you really heard four channel sound?



If you were aware of sound coming from four loudspeakers,we think the answer is no. The purpose of a loudspeaker is to produce acoustical fields in your home appropriate for the reproduction of a musical performance. The loudspeakers themselves should not, and cannot, play the roles of musical instruments. (Their sizes and radiation patterns do not duplicate those of any single instrument let alone an ensemble of instruments.) In fact, you shouldn't hear the speakers themselves. If you do hear the sound coming directly from the speakers, then you are experiencing all the distortions associated with the sound of a complete orchestra emerging from a small box. In four channel systems (QUAD), these distortions are even more critical than in stereo, since localization to point sources behind a listener can be very unnatural and disturbing to the ear. There are two key factors for excellence in QUAD: *1. The use of DIRECT/REFLECTING® speakers which, by radiating waves at selected angles to the walls, interact with the room surfaces to produce a spatial pattern like the one which is indicated in the diagram on this page.* With this arrangement, you hear the performance instead of the speakers. Contrast this with the beaming patterns of direct radiating speakers that cause shrillness, result in localization to the face of the speakers, and confine the QUAD effect to a small area in the center of the room. *2. A very close match in the frequency characteristics of the front and rear channels.* This is very important to assure the same musical timbre from all channels. BOSE achieves this match by the SYNCOM™ II Speaker testing computer to an accuracy that, we believe, is not approached by anyone else in the industry. But there is even better news about matching. The new BOSE 501 SERIES II is designed specifically to match the new BOSE 901 SERIES II for QUAD operation. Thus, you can begin with a 501 stereo system and later add on to obtain a 901 front/501 rear QUAD system -- a system that you must hear in comparison to conventional QUAD! For information on the BOSE products, circle your reader service card or write Dept.OA.

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Behind The Scenes

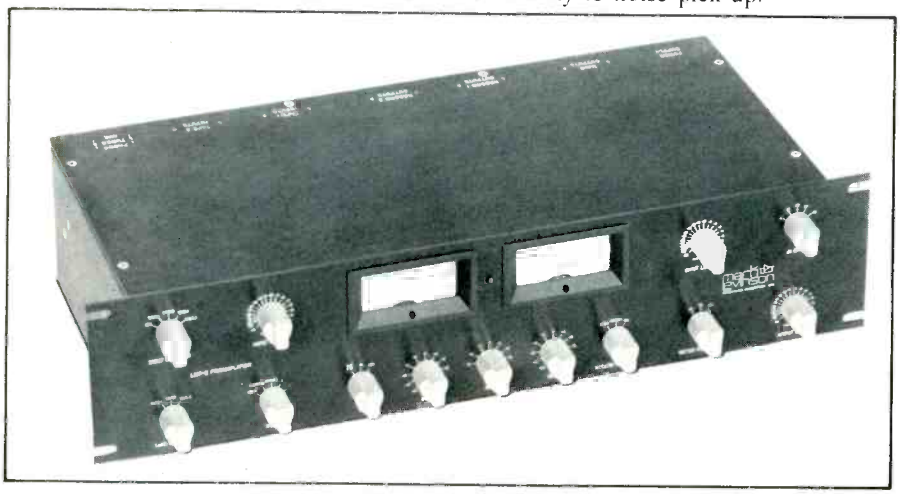
Bert Whyte

IT'S THAT TIME of year again—autumn in New York—and the 46th Audio Engineering Society convention begins its four-day run at the prestigious Waldorf-Astoria. With the general upswing in the recording business, this has encouraged more and more equipment manufacturers to take exhibit space at the convention, so there will be scads of interesting new audio items, which we will report to you in due time.

Time is indeed a problem in dealing with audio products. Far too often a product is announced, or a prototype shown, and by the time you get a unit for evaluation, a year may have passed. As a matter of incidental interest, you may not be aware that electronics manufacturers are currently in a terrible bind for parts. It seems that during the recent recession most parts vendors let their inventory position diminish almost to the vanishing point. Now that things are booming again, the lead time on items such as power transistors, resistors, capacitors, etc. has assumed incredible proportions. You hear horror stories such as 40 weeks for "garden variety" parts, and a year or more wait for specialty items. One manufacturer of high-power amplifiers requires a very fancy capacitor and the vendor of the part is quoting a mere 2½ years delivery! Needless to say, a great deal of intricate "wheeling and dealing" is going on in efforts to circumvent these situations. It is also obvious that the small, highly specialized audio manufacturer, who is usually in a limited capital position, is particularly vulnerable in this parts bind. In spite of all this, most companies seem able to cope with the situation. Fortunately too, the traditionally "venturesome" audio manufacturer has continued his research programs and we see the fruits of all this labor at the engineering conventions. It also appears that the parts shortage has not deterred "people with ideas," from entering the audio business. A case in point is the story of Mark Levinson Audio Systems, a Connecticut-based manufacturer of some very exotic audio products.

I first encountered the company at the 45th AES convention in Los Angeles last May. Sharing a demonstration room with Burwen Laboratories, they were showing their LNP-2 preamplifier which drew attention not only because of its unusual design, but for the rather dazzling specifications which were quoted and the rather breath-taking price of $1750.00! As is usually the case, a brief exposure in a typical demonstration room gives a very superficial evaluation of a product, but what I saw and heard of this preamp intrigued me. I made arrangements to try out one of these units, and for the past several months it has been in daily use in my audio system at home.

Mark Levinson is a very intense, dedicated young engineer, who is by far the most rigidly uncompromising audio purist I have ever met. His company philosophy and his products are a reflection of this attitude. As I have gently pointed out to him, "his way" is not the way to riches. His disdain of component parts that are not of "state of the art" quality is almost monumental. His immaculately wired preamp uses teflon-coated, shielded wire throughout, and one engineer friend of mine saw this, snorted, and said "Hell's Bells! Who needs it? This is aerospace stuff!" Mebbe so . . . but this practice yields crosstalk of minus 95 dB and relative immunity to noise pick-up.



As you can see in the photo of the unit, it is designed for rack-mounting. The chassis is brushed black anodized, and top and bottom plates are secured with stainless steel Allen screws. All lettering and index markings on the front panel are hand-engraved. The satin-finished aluminum knobs are large and easy to handle. The LNP-2 preamp is a modular unit. The military spec. glass-printed mother circuit board has gold-plated input sockets. These mate with six Burwen plug-in epoxy encapsulated UM201 mixing amplifier modules, which are high gain 7mc bandwidth operational amplifiers of extremely low noise . . . 1 microvolt 20Hz to 20kHz. A seventh plug-in module is a Burwen VU306 peak VU detector. There is an eighth input socket which will accept other optional special function modules. As you can see, there are two large Weston VU meters and the meter function is controlled by the VU306 peak detector. Normal VU averaging characteristics are provided in one switch position. In another position, the module gives a 5 microsecond response and will hold peaks for 2 seconds. The switch position marked HF+ shows +13 dB @ 20kHz for slow speed tapes to avoid high frequency saturation. The meters monitor the record output of the unit. The preamp has input provisions for phono, tuner, auxiliary and two tape units. Main output and two tape outputs are provided. Cannon connectors are in parallel with standard phono connectors for tape in and out and amplifier output.

Mark uses a regulated plug-in epoxy encapsulated power supply mounted in a separate chassis to avoid hum pick-up. The unit has the usual input facility switches and mode switches. In addition it has input level controls, which are in essence balance controls, and record output switch so tapes can be made either in mono or stereo. Zero VU levels can be adjusted by a pre-set 700 Hz sine wave calibration tone. On the top right of the preamp is a 0-40 dB gain control switchable in 10 dB steps to allow maximum S/N ratio for any input level. There are three tone controls: 20Hz, +14 to −8dB in 2dB steps; 5kHz, +3 to −3dB in 1dB steps; and 20kHz, +14 to −8dB in 2dB steps. Noise with these controls is typically less than 100 dBm (all controls maximum, less than minus 87 dBm.) Throughout the preamp, resistors are 1% tolerance metal film. Capacitors are

Manufacturers often talk and write about performance specificat ons, 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."

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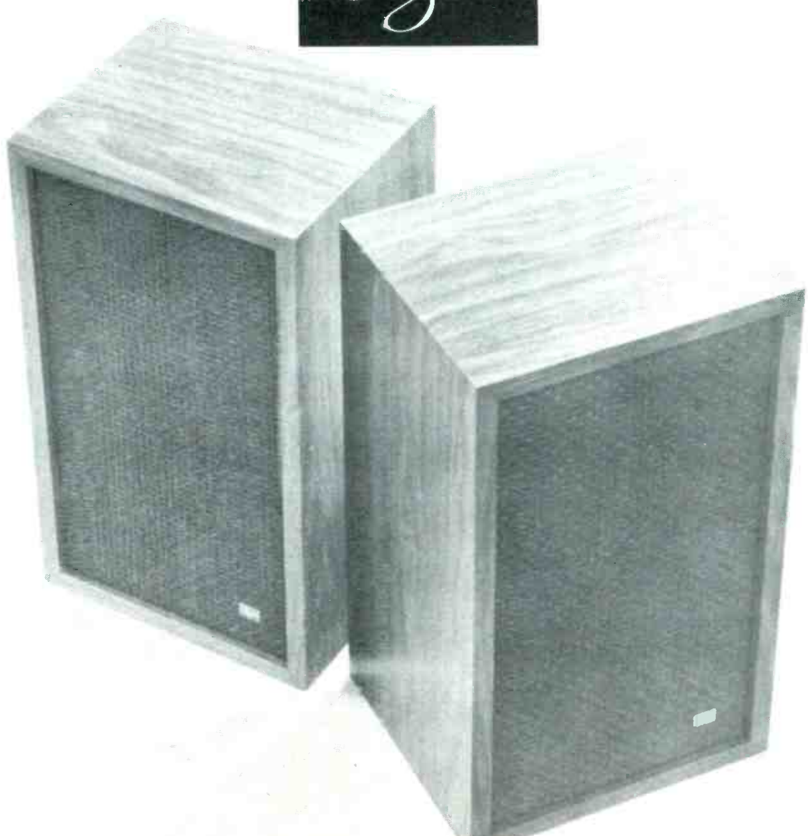


either solid tantalum or 1% tolerance metallized polycarbonate. Potentiometers have conductive plastic elements and teflon-coated shafts. The input level controls and the ganged volume control are calibrated in 1 dB steps from 0 to −30dB and are guaranteed to track within 0.1 dB between channels for virtually identical frequency response and amplitude. On the rear of the preamp is a Cannon connection which is for powering a versatile electronic crossover, which is just about to achieve production status.

For those die-hard advocates of moving coil phono cartridges such as the Ortofon, which have problems with low output, Mark has the JC-1 pre-preamp, a John Curl-design six years in the making, to solve the gain problem with an astounding equivalent input noise of −147 dBm.

As I noted earlier, the specifications on this Mark Levinson preamp were so spectacular, that I wanted a thorough check-out on them. Thus, I had some tests run at a very sophisticated manufacturing facility, where among other things they had a Hewlett-Packard Fourier harmonic spectrum analyzer. On the line inputs to main or record output, the tracing on the graph was practically unwavering showing harmonic distortion below 0.001, and this at odd and even harmonics way on out. The same test on the phono input showed some 0.003 to 0.004 spikes at odd harmonics, but we later learned this test was invalid because the input gain control was set at the 40 dB point, a setting that would almost never be used in any normal circumstances. I next visited the Mark Levinson labs in Connecticut and ran through every test with Mark. He has fine equipment including the well-known Radford low-distortion signal generator, Hewlett-Packard voltmeter and digital voltmeter, scopes, etc.

We checked every standard parameter, and all met or exceeded the claimed specifications. Thus the tracking between pots was verified at 0.1 dB. The frequency response bettered the listed ±3 dB, 0.5 Hz to .5 MHz and ±0.1 dB, 5 Hz to 100 kHz. THD was less than 0.005%, d.c. to 10 kHz, 0.02 at 20 kHz. S/N ratio of the phono measured a fabulous 86 dB below 10 millivolts input at 1 kHz (inputs shorted), and the line measured an incredible minus 134 dB! The RIAA curve was accurate to within 0.4 dB from 20 Hz to 15 kHz. Phono overload was at the lofty figure of 250 millivolts, better by at least 50 millivolts than any other preamp I am familiar with.

Okay . . . so everything checked out with this super unit. The big questions are . . . is any preamp worth this kind of money . . . and what did it sound like? Can any difference be detected between this unit and the lesser-priced preamps on the market?

As far as money is concerned, this is a preamp designed to be used as a laboratory tool; it is a professional instrument in the truest sense of that overworked word. The unit is guaranteed for 5 years, parts and labor free of charge. If your inclinations are to superb specs with maximum repeatability and reliability and your pocketbook can absorb the shock, it certainly can be regarded as an investment. As to the sound, it does one thing superbly well . . . phono and line noise simply are inaudible and cease to be a factor. It sounds measurably cleaner in the phono listening, perhaps because of the high overload characteristics and the high velocities encountered on today's discs. The transient response is razor sharp in line or phono, and the bass is unusually solid and clean. Yes, there are audible differences, subtle to be true, and admittedly something you have to listen for, but if you are one of the puristelite to which such subtleties are important this preamp is unquestionably . . . monetary considerations aside . . . the premier choice.

Editor's Review

THE AUDIO ENGINEERING SOCIETY is celebrating its 25th anniversary this year and its 46th convention was held September 10 through 13 at the Waldorf-Astoria in New York City. Some 14 technical sessions were held, and the New York Section's presentation, "Look What They've Done to My Song, Ma!" was easily the most popular, with more than 750 people attending each of the two presentations. Producers Irving Joel, Al Grundy, and John Woram gave those in attendance a "listen-to and a look at distant past, recent past, and current attempts by the recording industry to capture and create the elusive impact of music." More than 40 selections were played, from a 1904 Victor recording of Sousa's Band, with Herbert Clarke conducting, to current releases by artists such as the Beatles and the Boston Symphony.

Exhibitors took one entire ballroom on the third floor, adjacent to the technical sessions rooms, and most of the fifth floor. One of the most interesting exhibits was the museum of early sound recording equipment, which was gathered by John T. Mullin. Presented for the first time at the 45th Convention, in Los Angeles, the museum contained examples of various stages in the development of recording equipment over the last 80 years.

At the Awards Banquet, C. G. McProud, Audio's former editor and publisher, was the featured speaker. In addition to publishing the letters from Frank Sherry and C. J. LeBel which led to the formation of the Society, McProud also published papers presented at the early New York meetings. The A.E.S. Journal, of course, began publication in January 1953, and through the years Audio has been pleased to be able to reprint many of these important papers. In 1952, McProud became President of the Society.

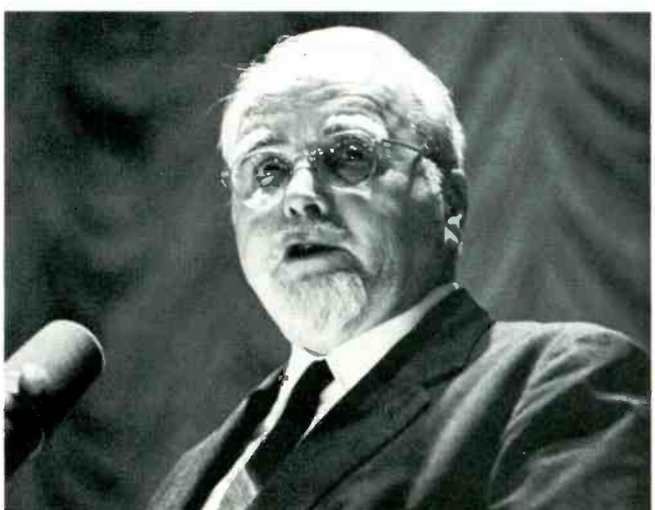
Award recipients in this Silver Anniversary year included Erik R. Madsen, who was presented the Silver Medal, formerly known as the Emile Berliner Award; James White, who received the first Publication Award for his paper, "Mechanical Playback Losses and the Design of Wideband Phonograph Pickups," JAES, Vol. 20, No. 4, and Donald W. Powers, who received the Medal Award, which is given annually to a person who has significantly helped advance the Society.

Honorary Memberships were presented to William S. Bachman, Murray G. Crosby, and Cyril W. Harris. A Fellow Award was presented to Edward Tatnall Canby, Associate Editor of this publication, "for his writing over the years reminding us that music is what the audio industry is all about." Also receiving Fellow Awards were Roy F. Allison, Richard S. Burwen, C. Robert Fine, Irving L. Joel, Arnold Schwartz, and Takeo Shiga.

Expanded Speaker Tests

This month a new name will be found at the end of our speaker system tests, that of Richard C. Heyser. Mr. Heyser is a member of the Editorial Board of the Journal of the Audio Engineering Society, in which several of his papers have appeared. He has been actively involved with test procedures for speakers for many years and his name will be familiar, I'm certain, to most speaker designers. An article by Mr. Heyser, explaining our new test methods, begins on page 20. *E.P.*

Erik Madsen



C. G. McProud

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Pickering has done it again! In 1957—the *first* American-made magnetic stereo cartridge that helped build the industry was a Pickering. Now—in 1973—the *first* American-made discrete, 4-channel cartridge that will change the world's listening is a Pickering. Today, Pickering invites you to enjoy the *best* of the world of your choice.

For the world of STEREO— XV-15/1200E

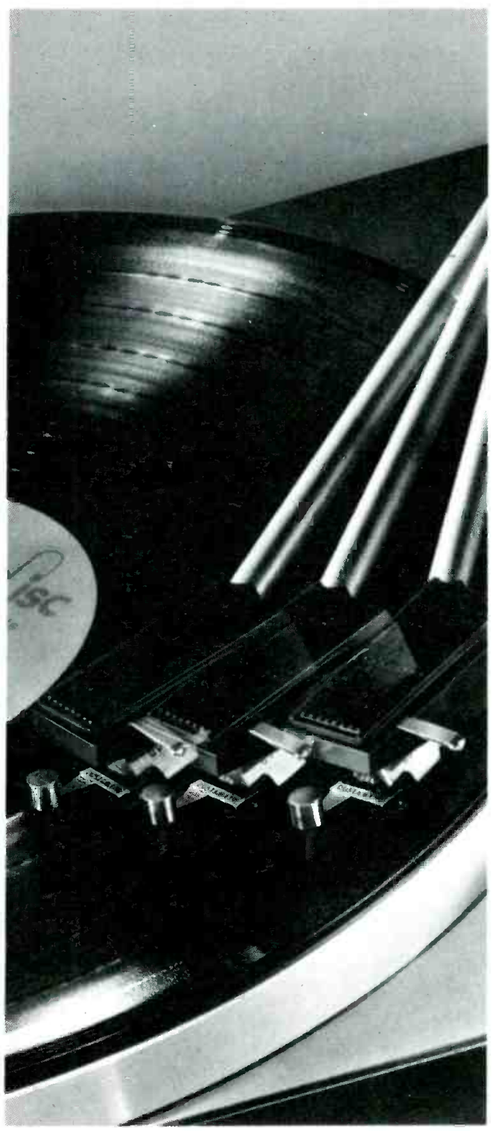
Designed for use with all stereo and four-channel derived compatible systems.

"PRECISION" is the one word that best characterizes the extraordinary quality of the new Pickering XV-15/1200E cartridge, the culmination of Pickering's 25 years in contributing important technological advances to the manufacture of magnetic cartridges. We sincerely feel that the 1200E is the furthest advance achievable today—and perhaps in the foreseeable future—in stereo cartridge design and performance. Its exceptional ability to pick up *all* the material recorded at the lightest possible tracking forces make it totally unique and superior. This cartridge is for the sophisticate—one who possesses components of such superlative quality that the superiority of the XV-15/1200E is a requirement.

And all of Pickering's exhaustive testing shows that the 1200E is superior in the flatness of its frequency response and channel separation in comparison to competitive cartridges.

SPECIFICATIONS

Frequency Response:	10 Hz to 30 kHz
Channel Separation, Nominal:	35 dB
Tracking Force:	3/4 gram, +1/2 gram, −1/4 gram.
Nominal Output:	4.4 mv
Stylus Tip:	0.0002" x 0.0007"



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QUADRAHEDRAL™

Designed and engineered specifically for playback of discrete recordings.

The introduction of the discrete 4-channel system required a completely new cartridge that could not only faithfully reproduce the 20 Hz to 20 kHz AM signals, but also the 30 kHz FM modulated signals. The result is the Pickering UV-15/2400Q discrete 4-channel cartridge, which represents a new level in the state of the art. It consists of a completely redesigned cartridge and a new high performance stylus assembly, the Quadrahedral™, which was specially developed for this application, and features a revolutionary new diamond stylus. The UV-15/2400Q performs in a superior manner by every measurable test, and is capable of satisfying all the technical and aesthetic requirements for playback of all the material recorded on both discrete and stereo disks. Moreover, its stylus is so designed that it not only perfectly reproduces the music recorded, but also reduces record wear.

SPECIFICATIONS

Frequency Response[2]:	10-50,000 Hz
Channel Separation:	35 db
Tracking Force[1]:	1-3 grams
Output[3]:	3.8 mv ±2 dB
Stylus:	Quadrahedral

Notes:
1. Recommended by manufacturer for optimum performance.
2. When the cartridge is terminated in the recommended load of 100K ohms and 100 PF.
3. Output with reference to 5.5 cm/sec record velocity.

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BREAKTHROUGH IN SPEAKER TESTING

Richard C. Heyser

AUDIO is adding several loudspeaker testing procedures in order to provide additional data about speakers. While these tests will be laboratory tests simply because no two listening situations are identical, we have attempted to bring these tests as closely as possible in line with the actual conditions of use. While researchers do not have a uniform opinion about the relative value of some of these tests, these new methods of presentation are a step forward in providing additional information about the properties and characteristics of speakers. The purpose of this article is to introduce these new tests, several of which have previously appeared only in learned journals, and to explore their meaning, as well as to review the other tests which we have been using.

Frequency Response

The frequency response of a speaker is a measurement of a speaker's ability to reproduce constant sound pressure of any pitch component, from lowest to highest, from constant electrical stimulus. It will continue to be our standard practice to plot the relative magnitude of sound pressure for each frequency component.

Frequency response, like that of an electrical network, also has a phase response as well as an amplitude response for each pitch component, and this phase response is associated with "when" a sound arrives at your ears after the application of an electrical signal.

We all use the different "whens" of arrival to distinguish between direct and reflected sound in evaluating the spaciousness of a room and to locate sound sources. These abilities are based on the constant speed of sound, but imagine what would happen if the speed of sound depended on pitch. An instrument's fundamentals and harmonics would all be there, but they wouldn't arrive together as we normally expect. Some speakers do exhibit delays like this, and these are closely associated with phase response.

The exact relationship of phase and amplitude response is quite complicated and still open to final interpretation. However, it can be stated that two speakers with exactly the same amplitude response will not produce the same sound unless they also have the same phase response and that a speaker with a smoother amplitude response than a second will not reproduce more accurate sound unless the phase response is also well behaved. Highly important to a speaker's ability to produce accurate sound, when it has been properly equalized, is that of minimum phase change. A minimum phase change speaker is one which, when all amplitude response variations are removed by conventional resistance, capacitance, and inductance networks, has the minimum possible phase shift over the frequency spectrum. It is then like the proverbial piece of wire in its handling of signals. Conventional tone control equalization for balancing the amplitude response will also automatically balance the phase response for a minimum phase loudspeaker.

We will identify those regions of the frequency spectrum of each tested speaker where non-minimum phase reproduction occurs for direct sound. We must stress that this does not mean that a minimum phase speaker will automatically produce more accurate amplitude response than a non-minimum phase speaker. However, a non-minimum phase speaker will usually exhibit frequency response difficulties which can be associated with time delay effects which, in turn, cannot be corrected with conventional passive equalization.

Basic to our presentation of both amplitude and phase response is a spectrum analyzer, a Probescope Model SS-100, specially modified to become an adjustable bandwidth tracking filter which can be phase locked to any signal from 10 Hz to 100 kHz. The standard test setup uses a 1-in. Hewlett-Packard mic on axis one meter from the speaker being tested. A glide tone is fed to the speaker, and the tracking filter, tuned to the frequency of the glide tone, picks up the direct sound as received by the mic. Since the frequency bandwidth of the tracking filter is narrow and its center frequency changes rapidly to follow the glide tone, only direct sound is passed for measurement because reverberant sound will not have arrived before the filter changes frequency. Thus the amplitude response measured is anechoic. Phase response is obtained in a similar manner using a continuously variable phase shifter which permits either relative or absolute phase measurements.

To take into account the coupling of a speaker and room, without placing undue emphasis on room characteristics, a second measurement of amplitude is made using a wider bandwidth, or time window, so that early reflections from floor, ceiling, and—where appropriate—walls are included. Tests below 100 Hz will not be performed here since the longer wavelengths of those lower frequencies would require inclusion of more room reverberation characteristics than are of interest. The distance for this test will be three meters on axis, one meter above the floor, to approximate the usual listening

position. If listening tests show that off-axis positions are preferred for stereo effects, these speaker arrangements will be used for this test.

The formats of these data is shown in Figs. 1 and 2. The amplitude response, identical to what is usually called the frequency response, will still be plotted in decibels. The phase response is plotted in electrical degrees relative to a pure transmission in which the air path delay from mic to speaker is removed. The convention chosen for measurement of phase shift is that a positive voltage applied to the positive (usually red) speaker terminal will produce an increase in sound pressure and assumes the speaker cone moves toward the listener with this polarity.

Evaluation of the amplitude curve is done in the traditional manner. Sharp peaks of more than 3 dB generally are more obtrusive than dips of the same size, because sounds traveling two slightly different distances can cancel by any amount even to total null at one frequency but cannot reinforce to give an intensity greater than their sum. Such peaks will generally tend to make background noises, such as record pops and tape hiss, stand out more than they should. The peaks indicate resonances and if extreme can actually cause ringing at a discernible high frequency and hangover at lower frequencies.

Sudden sharp dips in amplitude over a relatively narrow frequency range are often due to interference effects of much the same type as those occurring with natural sound in a room. They may be relatively inaudible for direct sound, but other polar angles of radiation may not have the same frequency dip. The effect could then be a lateral shift for these frequencies when you listen for stereo program material in a relatively live room. Such interference effects may not be noticeable in those speakers which depend on room reflection but are to be avoided for speakers which rely heavily on direct sound for stereo or quadraphonic imagery.

The other major effect of amplitude response on reproduction of direct sound—change of timbre—can be estimated by visually smoothing a curve through the average values of response. One rule of thumb is to note the relative response around middle C (262 Hz), two octaves below (65 Hz), and four octaves above (4186 Hz). If the speaker is down more than about 3 dB at 65 Hz, it stands a chance of sounding "thin." The shape of the speaker's low frequency roll off and your pre-amp's tone control curves can indicate whether you can bring this up to a full bodied bass without incurring a bump of more than 3 dB at some intermediate frequency, such as A_2 at 110 Hz.

A look four octaves above middle C to C_8 will indicate whether the principal musical partials of most instruments will be reproduced fully. Difficulties in this range will usually indicate a noticeable change in timbre. If the high end is rolling off, it will be dull, while a rise in response usually betokens brightness. The use of tone control and speaker curves also applies here.

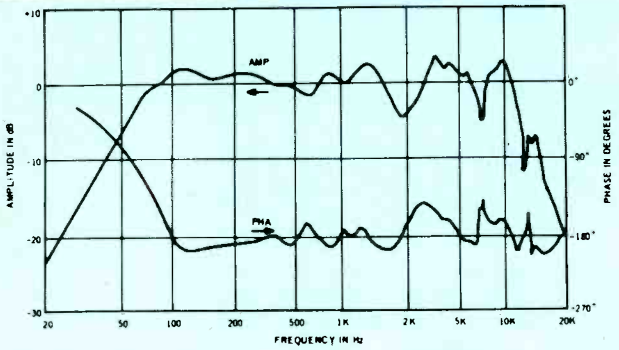


Fig. 1—Anechoic amplitude and phase response.

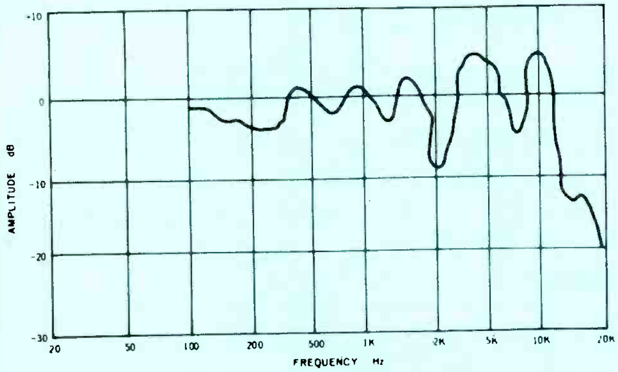


Fig. 2—Amplitude response including early reflections.

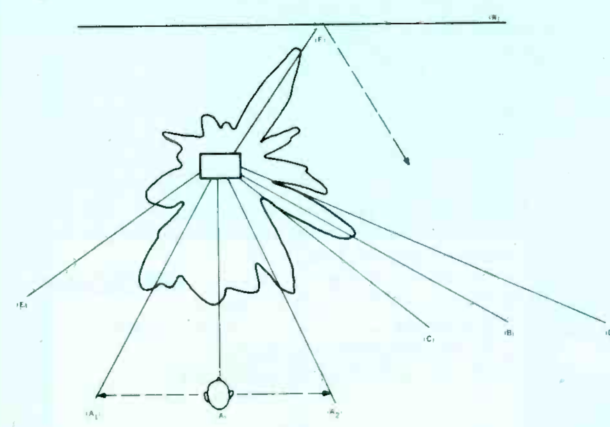


Fig. 3—Polar response.

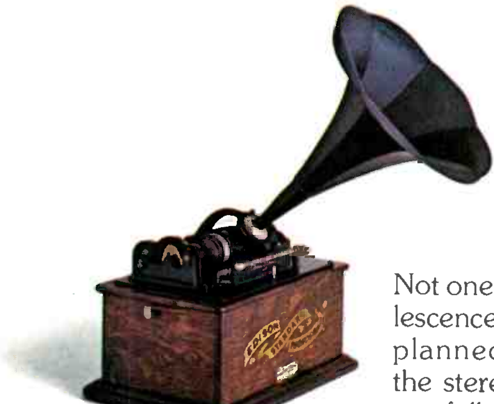
Polar Energy Response

The success of good stereo and quadraphonic imagery depends largely on how much and what quality of sound is radiated at different horizontal angles. Since it is impractical to publish response curves for every possible angle and frequency, a polar plot will be made which, together with the frequency response, can give a reasonable feel for the dispersion you can expect in your listening environment. The basic test setup is much the same as that used for the amplitude and phase response tests except that a specially calibrated motor is used to turn the speaker on its axis and to indicate the relative angle. All fundamental frequencies, from 20 Hz to 20 kHz, are measured with constant input, and the total sound energy in this band is plotted as a continuous function of angle.

The polar plot is made under the assumption that speaker directivity becomes more prominent with increasing frequency. Our plot is made on an equal frequency basis and means that the higher frequency variations show more prominently in this plot. Experiments using both an equal frequency basis and an equal octave basis have shown little significant difference in most speaker polar responses. The choice of an equal frequency basis is made because of its listening relationship with the speaker's reproduction of white noise.

A typical polar plot is shown in Fig. 3, looking down on the speaker from above. The general meaning of this speaker's polar response is that you can expect rather uniform sound anywhere within the dashed line from A_1 to A_2. The polar plot also warns us that there is a strong "finger" of response at position B, where high frequencies are more prominent than at C and D. However, since the overall level at B is about the same as at A, the sound at B is probably well balanced and quite listenable. The sound at E is down overall and because lower frequencies tend toward less directivity, this position's sound will probably be bass heavy.

I bought a Marantz 4 channel receiver because I refuse to be stuck with an electronic antique.



Not one to tolerate obsolescence (planned or unplanned), I considered the stereo vs. 4-channel question carefully, then purchased a Marantz receiver for three compelling reasons.

One. Marantz has Dual Power. This means you get full power of four discrete amplifiers working all the time. When you're listening to regular 2-channel tapes and records you can combine the power of all four channels into the front speakers. This means even if you're not ready to commit yourself to a complete 4-channel system, you can buy Marantz now and when you get the other two speakers just flip a switch. You have 4-channel. Meanwhile, you're not compromising 2-channel because you're getting more than twice the power for super stereo.

Reason number two. Marantz receivers feature the exclusive snap-in snap-out adaptability to any 4-channel matrix decoder. This means that your Marantz stereo will never be made obsolete by any future 4-channel technology because the Marantz snap-in SQ* module is designed to keep up with the changing state of the art. What's more, Marantz receivers have Vari-Matrix—a built-in circuit that will synthesize 4-channel sound from any stereo source (including your stereo records and tapes) and will also decode any matrix encoded 4-channel disc or FM broadcast.

Reason number three. Marantz receivers, from the Model 4230 up, feature built-in Dolby** noise reduction to bring you the quietest FM reception ever. And you can switch the built-in Dolby into your tape deck for noise-free, no-hiss recording from any source. A real Marantz exclusive.

I chose the Marantz Model 4270 because it suits my needs perfectly. It delivers 140 watts continuous power with under 0.3% distortion. And it's literally loaded with features. However, your requirements may be more modest than mine. In which case you can own the Marantz Model 4220 which delivers 40 watts with Dual Power. Or you can go all the way and get the Marantz Model 4300 with 200 watts. It is the very best. Choose from five Marantz 4-channel receivers from $299 to $899.95.

The point to remember is this—whichever model Marantz 4-channel receiver you do buy, you can buy it today without worrying about its being obsolete tomorrow. Look over the Marantz line of superb quality receivers, components and speaker systems at your Marantz dealer. You'll find him listed in the Yellow Pages. Think forward. Think Marantz.

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The polar plot is made without reflected sound, and if your room were anechoic, it would tell you how to balance your system. However, we don't listen in anechoic chambers and here is where your listening room comes into the picture. If you have a hard wall, such as wood paneling or plaster, behind the speaker, as indicated by W, you can expect a strong reflection from the response of the back finger, F. This is fine if you want to use reflected sound to augment stereo imagery, but the polar plot shows that the nonsymmetry of the back lobes will tend to move sound over to the left for this speaker. If you want strong imagery of violins and brightness on the left, use this speaker in front of a hard surface, but don't expect balance on the right channel. By deciding where a speaker will be placed in relation to reflecting surfaces in your listening room, you can spot trends of reproduction and possible trouble areas. There are other considerations in choosing a speaker, but the polar energy response is one of the few you can tie to your listening room.

Harmonic Distortion

We measure harmonic distortion by using a fixed frequency sine wave and plotting the second and third harmonic output as a percentage of electrical drive power. The test signals are the equivalent of pure flute tones with no harmonic structure of their own. The three test frequencies are: E_1 = 41.2 Hz, corresponding to the lowest fundamental normally in musical material and the lowest tone in the usual range of the biggest systems; A_2 = 110 Hz, well up in the musical spectrum and within the usual range of the smaller systems, and A_4 = 440 Hz, A above middle C and a reference pitch generally known while also at or near the crossover frequency in many systems, thus a spot where trouble can easily take place.

The second harmonics are: E_2 = 82.4 Hz, A_3 = 220 Hz, and A_5 = 880 Hz respectively, while the third harmonics are extremely close to their musical fifths: B_2 = 123.5 Hz; E_4 = 330 Hz, and E_6 = 1320 Hz. These tones not only encompass the lowest four octaves where distortion is most prevalent but can be meaningfully related to sounds with a conventional musical basis. The second harmonic distortion is indicative of gap misalignment and field nonuniformity, and third harmonic distortion is tied to a voice coil driving out of the linear region of the gap or otherwise bottoming out. Higher order harmonics are seldom found unless physical deformation occurs, which is usually audible as a buzzing or a similar effect. The use of drive power will give you some idea of how much amplifier you need before the speaker becomes sonically improper for steady signals.

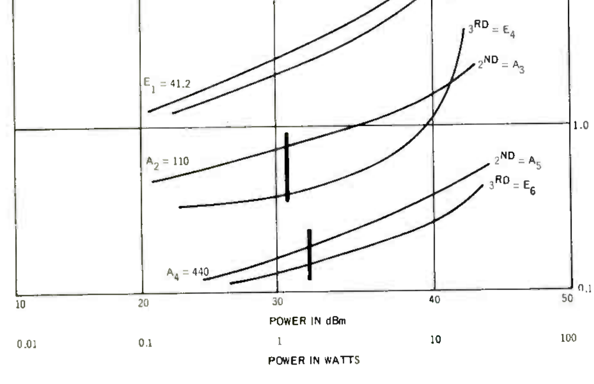


Fig. 4—Harmonic distortion.

Figure 4 is a typical plot for harmonic distortion. The vertical axis is the percentage of distortion of each partial. The horizontal axis is amplifier drive power in both dBm, which is a decibel power ratio above one milliwatt, and its equivalent in watts. Thus one watt is +30 dBm. This power level is not the actual volt-amperes delivered to the speaker, but is the level which a constant voltage amplifier would deliver to a resistor with a value equal to the rated speaker impedance. This is done so as to be more consistent with the rated capabilities of amplifiers.

There are three sets of curves, one for each test frequency. Generally the lowest pitched test tone will have the highest distortion. For the example shown, a one-watt level of the tone A_2 will produce 0.8% A_3 and 0.6% E_4 as additional acoustic outputs. A low organ pedal note of E_1 will at the same drive produce 1.5% E_2 and 2% B_2. Of course the acoustical output at E_1 is less than A_2 at this electrical drive power because, as indicated in Fig. 1, the speaker is rolling off. If you were to use full bass boost available on many pre-amplifiers to bring up the pedal note, you might be able to add 12 dB drive to E_1 relative to A_2. Unfortunately, this would take you from 30 dBm to 42 dBm and the organ pedal note would now have 10% E_2 and 15% B_2 as distortion partials. This note might produce impressive sound pressure in your room but is no longer musically accurate.

The ratio of third-to-second harmonic distortion is a crude estimate of driver capability. The speaker shown is running out of steam at both A_2 and E_1 for power levels above 10 watts as shown by the pulling away of third above second harmonic distortion. A smooth increase of second-harmonic distortion with level is usually a satisfactory indication, but sudden breaks in the curve may indicate non-linear suspension or misalignment of the driver.

Before condemning a speaker for bad distortion, it is necessary to know what sound pressure level (SPL) is actually produced at each fundamental pitch component. One watt into some speakers can be a pleasant level while the same power into another speaker can break both windows and leases. An intensity level of 1 watt per square centimeter corresponds to 160 dB SPL for a plane wave of sound. If one watt of acoustic power were radiated uniformly from a point source, the intensity level one meter away (which is our test distance) would be 109 dB if we approximate the spherical wavefront with a flat wavefront. This is a very high level and above the capability of some speakers.

For distortion SPL comparisons, measurement is made of the speaker power required to produce 90 dB one meter on axis. This is rather loud but within the capability of almost every speaker system and corresponds to an omnidirectional source of about 11 milliwatts or 11 dBm. The electrical power required to produce this level for each fundamental will be shown as bars drawn through the corresponding harmonics, as shown in Fig. 4. This lets you convert from amplifier power level to the sound pressure level in decibels by sliding the curves sideways until the bars line up with each other and lie over the 90 dB SPL value.

You can use these data in several ways. First, the relative distortion produced as you equalize the speaker for flat output from E_1 through A_4 is immediately apparent. Thus for our example a 90 dB level at A_4 now has low distortion down to A_2 but enormous distortion at E_1. Conclusion: If you like true pipe organ sound, you probably should not consider buying this speaker.

The second way you can use these data is to find out how much amplifier power is required to produce the level and quality of sound you prefer. For example, the unequalized speaker of Fig. 4 will show audible distress for single low and mid bass sine waves at about 20 watt level. Composite material with many partials will probably gobble up many times that level before you hear the speaker giving up, so a 60 watt amplifier might bottom out before you note speaker distress at SPL's as high as 100 dB.

Intermodulation Distortion

Speakers also suffer from intermodulation distortion. This occurs when one signal is modified by another because they share the same driver. Intermodulation can occur due to either transfer function nonlinearity, of the same nature as that producing harmonic distortion, or relative motion of the driver causing a Doppler "warbling" of one signal by another.

Since single speakers in a system usually do not cover the entire frequency spectrum, it is not possible to use conventional amplifier practice with tones of 60 and 6000 Hz or any two tones rigidly fixed in frequency. The greatest problem occurs in the bass driver and is the effect of very low frequencies on higher frequencies. Two test tones of equal electrical drive level are used, 41.2 Hz, corresponding to E_1, and either 440 Hz or one half octave below the woofer crossover frequency, whichever is lower. Sidebands about the higher frequency due to 41 Hz are measured and the total sideband energy as a percentage of the energy at the higher frequency is presented at one or more electrical power levels.

An example of what this means is shown in Fig. 5. The signal output in the vicinity of 440 Hz is shown along with the intermodulation products due to 41 Hz. The level at 440 Hz is acoustically measured prior to the addition of 41 Hz and used as reference. Then 41 Hz is added at the same electrical drive level as 440 Hz and the pressure magnitude of each sideband is measured. The total energy in the sidebands is calculated and then presented as a percentage of the unmodulated 440 Hz. This is a one-number power measurement which is not suitable for distinguishing frequency modulation from amplitude modulation, and equal electrical drive power for each frequency is used to provide comparison for cleanness of sound when driven from a "flat" program source.

Certain special cases may arise when other intermodulation tests need to be performed. One example might be the case where an overly compliant woofer may badly wobble in and out of the linear gap region due to subsonic signals from an amplifier when bad record warp exists. While this is not directly the fault of speaker manufacture, it can give sonic coloration and some measure of this is made.

The guidelines for evaluation of distortion measurements are simple: The better speaker will have lower distortion at a given sound pressure level.

Signal Suppression Test

We know that most speakers can handle music and voice at power levels approaching the peak clipping capability of even super power amplifiers, yet if we try a sine wave at what we think these crescendo levels to be, we may char the speaker. We have already outlined two tests using sine waves, harmonic and intermodulation distortion. This third distortion test is intended to disclose how well musical crescendos may be handled by a speaker.

The concept behind this test is that the highest level signals which you normally ask a speaker to reproduce, such as cymbal crashes, traps, and even the human voice, have a high peak-to-average intensity ratio. A measure of a speaker's ability to handle these is made by the amount of intermodulation distortion produced on a moderate signal by a random crescendo with peak-power levels approaching 1000 times (30 dB) the signal to be tested. That may appear to be an unrealistically high ratio but experience on live sounds picked up by a wide range condenser mic shows this ratio is not unusual.

Two test signals are used for this measurement. The first is a flute-type tone with a musical basis, such as 440 Hz. The second is white noise, which treats all frequencies uniformly and is not only reproducible in any laboratory but is a good all-around representation of many sound processes.

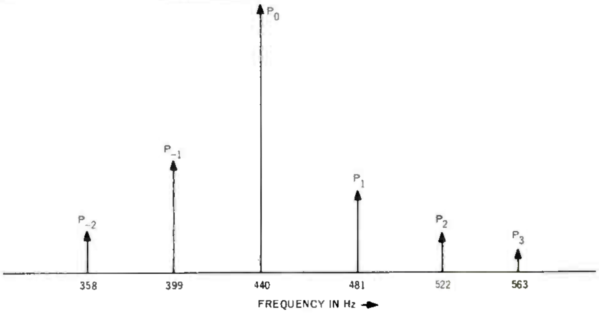
When random noise modulates a tone, it produces sidebands about that tone. The sonic effect is random wobbling of the tone's pitch and amplitude—sort of a combined vibrato and tremulo. What we are trying to measure is how much effect is produced on regular program material by a sonic outburst from an independent signal of higher level. We do this by measuring how much energy in the flute tone is spread into sidebands by the noise burst, by use of a very narrow bandwidth filter before and during the time the noise is applied. The level at which one decibel suppression of the tone occurs in a 1 Hz band is used as the indication of power-handling capability when the average noise is 20 dB higher than the average sine wave power. The peak noise voltage (three sigma)* across the speaker terminals is then used to indicate the amplifier capability to drive the test speaker to this level.

This test is strictly an indication of how inner musical voices are modified by loud random signals and is not a direct measure of the speaker "flatting out" on the loud signals, which is presently determined by looking at the mic pick-up with an oscilloscope.

Transient Response

What we mean by transient response is the ability to produce pressure wavefronts which accurately follow electrical input as a function of time. This is the "clock on the wall" counterpart of the frequency response. Just as the sine wave is the basic signal for determining frequency response, the basic signal for determining transient response is the impulse, a sudden sharp momentary release of energy which should produce a sharp sound ordinarily described as a "crack." A typical transient response of a speaker is shown in Fig. 6.

Figure 7 is a computer-based plot of the time spread of sound intensity derived from the impulse response in Fig. 6. The vertical axis is relative sound intensity in decibels and the horizontal axis is time in milliseconds. This plot shows the actual arrival times of signal energy components relative to the times they should have arrived in order to constitute



$$\% \text{ I.M.} = \frac{\sqrt{(P_{-2})^2 + (P_{-1})^2 + (P_1)^2 + (P_2)^2 + (P_3)^2}}{P_0} \times 100$$

Fig. 5—Method of calculating IM distortion.

perfect reproduction for all components in the frequency span measured. If a woofer woofs or a tweeter tweets at a later time than optimum, this will show as some form of energy spread with time.

A speaker which has perfect reproduction of every signal component in the tested frequency range will have the signal energy hump shown in Fig. 8. This tells us that every signal component, regardless of its pitch, duration, or intensity, arrived at exactly the right time with the correct amplitude and with the correct phase.

However, real world speakers do not have perfect reproduction and differ considerably from one another in transient response. For certain pitch components, a speaker may take a little extra time to get started while responding quickly to others. Instead of a photo finish with all the pitch components arriving at the same time, the race is always won by some and always lost by others regardless of program material. The result is a time delay for some frequencies, which results in a distortion or loss of the "edge" of those sound qualities we associate with real life. (The technical interpretation is somewhat more complicated because some pitch components produce a sound that is equivalent to breaking up into a multiplicity of late arrivals.)

Transient distortion is measured by applying a special signal to the speaker terminals which at one moment in time has all possible pitch components of interest. At a point one meter distant the entire sound spectrum is measured, including all late arrivals, and we clock the total energy in all pitch components at each moment of arrival. This is the energy-time plot of Fig. 7.

If a speaker spreads in time the energy of what should be an impulse, this will show in the measurement. A speaker with internal reflection of improperly mounted or crossed-over drivers will produce a staccato smear in time which will show up as multiple energy humps for the moment when each signal arrives. Quite often, as an example of this, you may see a second bump a millisecond or two after the first arrival for small cabinet-mounted speakers. This is caused by the sound from the back of the cone penetrating into the box, reflecting from the rigid box backwall and coming out through the relatively transparent cone as a late partner to the first direct sound.

To aid you in visualizing how much time smear may exist, we will—when practicable—indicate what portions of the speaker are involved. This is shown in Fig. 7 as the side view of the speaker box with the front of the box at 3 milliseconds, corresponding to the one meter distance, and the rear of the box at the position corresponding to the time it would take sound coming from that spot to reach the microphone.

With this measurement you can begin to sense the sonic effect of a particular speaker's reproduction of transient sounds. The amount of actual time smear for the high pitch components, which give liveliness, is usually small enough so that we can't perceive them as separate entities; all we know is that there is something which separates the reproduced sound of many speakers apart from that live sound.

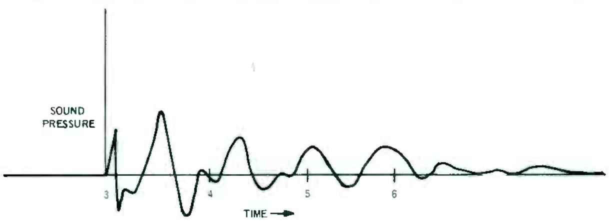


Fig. 6—Impulse response.

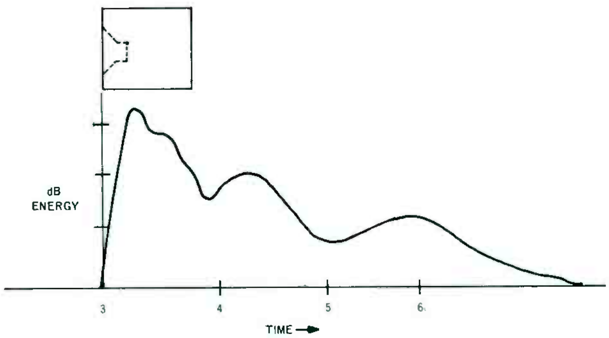


Fig. 7—Time spread of sound intensity based on Fig. 6.

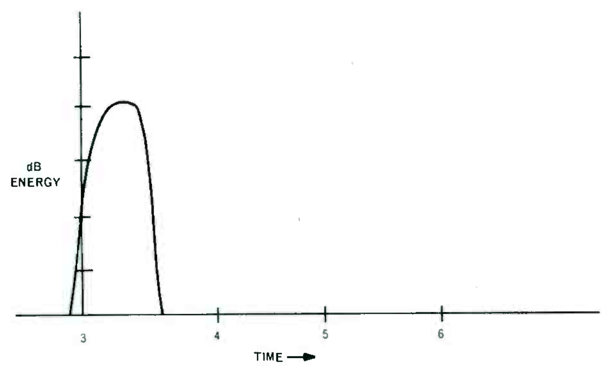


Fig. 8—Time spread for a perfect speaker.

Equipment Notes

As mentioned above, these tests use several sophisticated pieces of research equipment, and since some have no commercial counterpart, a word of explanation is in order. The Probescope SS-100 spectrum analyzer has been modified to include additional capabilities as either a tracking filter or time delay spectrometer (TDS). As a tracking filter, it can be phase locked to any signal from 10 Hz to 100 kHz, and the fundamental, second, third, fourth, and fifth harmonic automatically locked on by preset switching. The design allows its center frequency to be phase locked to $Mf \pm f_0$ where f is the fundamental frequency of any periodic input, M is a selectable integer from 1 to 5, and f_0 is a synthesizer offset frequency on 0.1 Hz steps to 999.9 Hz.

The time delay spectrometer modification was the subject of three AES papers which should be referred to for details. (See "Acoustical Measurements by Time Delay Spectrometry", *J.A.E.S.*, Oct., 1967, Vol. 15, No. 4; and "loudspeaker Phase Characteristics and Time Delay Distortion, Parts 1 & 2," *J.A.E.S.*, Jan. & April, 1969, Vol. 17, Nos. 1 and 2.

The output of the SS-100 occurs at its i.f. frequency of 225 kHz, which is synchronously heterodyned to d.c. in quadrature channels. These are time-weighted in accordance with either a rectangular or a raised cosine multiplication, then processed through sampled integrators. When the TDS mode is used for test, the output of these integrators corresponds to the Fourier transform of the frequency spectrum signal, and this is used for the energy-time plot.

For the polar energy response, the d.c. heterodyned i.f. signals are squared and then integrated for the period of frequency sweep. In the phase locked tracking filter test mode, the output is a matched filter. With a one second gate, this matched filter has a noise bandwidth of 1 Hz and the mean square output is logarithmically calibrated for reading the signal suppression for the speaker test where noise is used.

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The 4 direct-coupled amplifiers each have 22 watts of RMS power at 8Ω, each channel driven. And because they can be strapped together, you get 57 watts RMS per channel at 8Ω, each channel driven, in the 2-channel mode. That's double-power stereo.

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A second nonstandard piece of equipment is a normalizing gain pot, which was made by ganging two precision Daven logarithmic attenuators on the same shaft with a potentiometric switch. A clockwise rotation increases the gain in the transmit channel and decreases the gain in the receive channel by an exactly compensating amount. The test equipment then sees a constant level regardless of the test level. This allows a single setting for 100 per cent level in harmonic distortion, and the tracking filter can plot out distortion on the X-Y recorder at any convenient rate. The full range of the normalizing pot is 32 dB with 2 dB steps and a worst case error of ±0.3 dB.

For speaker impedance testing, a General Radio 1304A oscillator with a 908 dial drive is used as a constant voltage source sweeping 20 Hz to 20 kHz. This is made into an effective constant current with a 5K resistor. The voltage across the speaker is processed by the phase locked spectrum analyzer and displayed on a Moseley X-Y recorder. If more exact and complete impedance measurements are required, a General Radio 1603 Z-Y bridge is used, with measurements beyond 20 kHz normally made with a Hewlett-Packard 200 CD oscillator or a 606A signal generator.

Polar energy is tested by first mounting the test speaker on a special motor-driven tripod with a precision sine-cosine potentiometer mounted on the azimuth drive. The TDS output, a sweeping sine wave, is level set through Hewlett-Packard 350B attenuator, then through the normalizing transmit potentiometer to the power amplifier. A Tektronix 310A oscilloscope is used to monitor the speaker drive at all times. A Hewlett-Packard 1-in. condenser capsule is used for microphone pickup, and its preamplifier output fed to a Hewlett-Packard 450A line-driving amplifier back to the normalizing receive pot. A Ballantine 320 true RMS meter is used as a combined acoustic level calibrator and monitor amplifier to drive the TDS input. The display on the TDS is, in fact, the frequency response of the speaker and this setup is used to check response as a function of polar angle. The frequency response is squared, integrated, and driven to the sine-cosine pot to be split into rectangular coordinate channels. This is returned to the spectrometer and processed for the X-Y recording, which is now in polar format with logarithmic radius.

The frequency response setup is identical to the polar energy setup except that several means of display are used. First, the TDS display is photographed with linear frequency scales for reference. Second, a Hewlett-Packard 130C X-Y oscilloscope is set up to display logarithmic frequency coordinates. Third, a General Radio 1304A oscillator with a dial drive is used to drive logarithmic frequency coordinates on the X-Y recorder and the vertical is a sample and hold output obtained upon coincidence of sweeping frequency and 1304A frequency.

For harmonic distortion measurements, a Heath AG-9A low distortion sine wave oscillator is used to drive the speaker through level setting attenuators and a power amplifier. The Tektronix 310A 'scope is used to monitor voltage across the speaker, while the mic is placed close enough to the speaker to be in the near field and measure the sound pressure in the harmonics prior to far field polar pattern wavefront deformations. To reduce capsule distortion products due to higher SPLs, the capsule is desensitized by capacitive loading prior to amplification.

The normalizing pot keeps the receive level constant independent of speaker power. A Ballantine 320 voltmeter is used as a calibrated amplifier which feeds a Heath HD-1 harmonic distortion analyzer. This is used only as a tunable notch to reduce the fundamental component and increase the dynamic range of the spectrum analyzer. A Hewlett-Packard 130C oscilloscope monitors the analyzer input. The spectrum analyzer is first phase locked to the fundamental and the HD-1 placed in the "all-pass' position. The fundamental component with 1 watt drive is used to normalize the spectrum analyzer to 100 per cent. The HD-1 is then set to "notch" and adjusted to minimize spectrum analyzer reading. Measurement then consists of locking the spectrum analyzer to the desired harmonic and clicking the normalizing attenuator through its 2 dB steps. The X-Y recorder is synchronously stepped with the normalizing potentiometer so that readings can be made quickly.

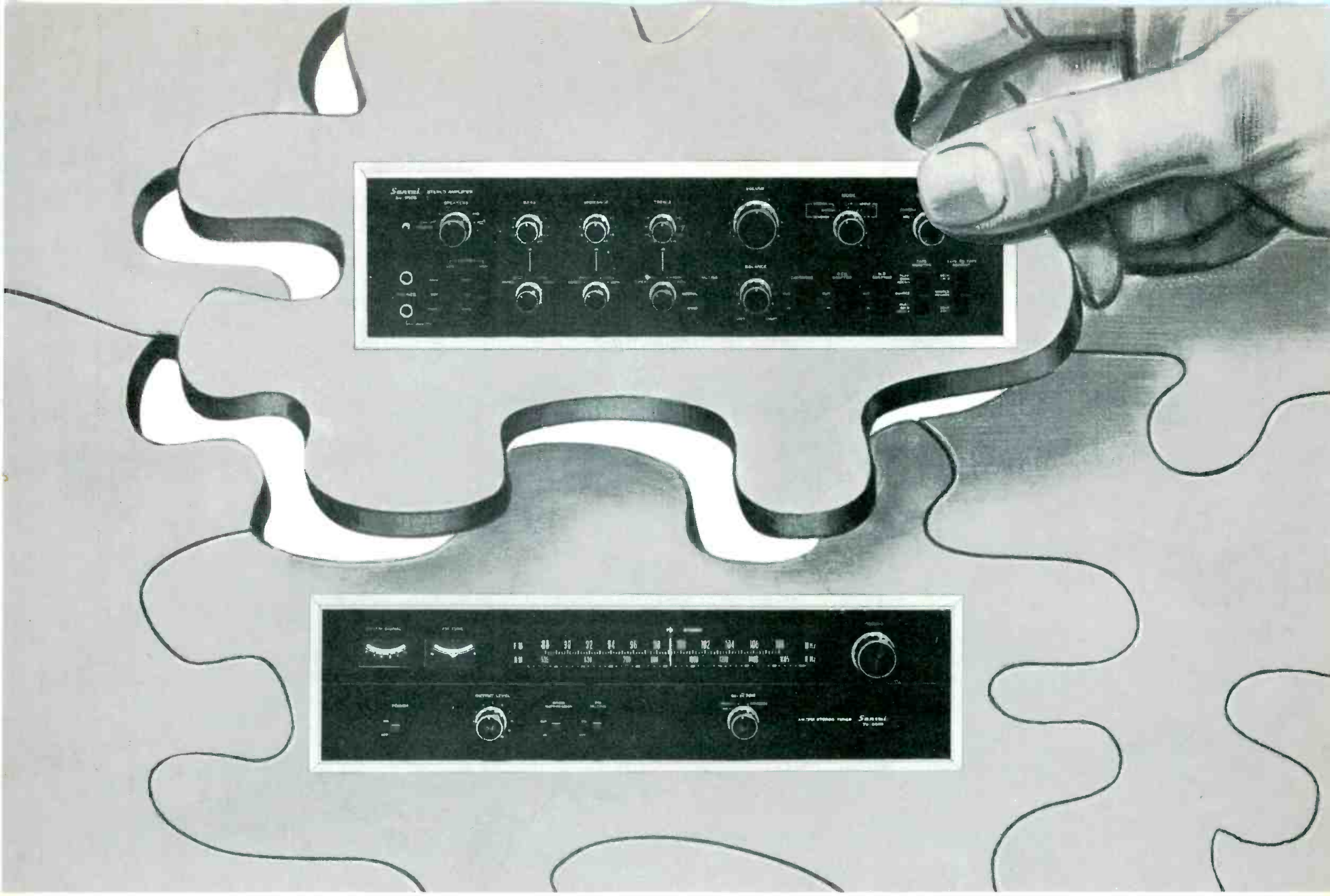
For intermodulation distortion, two sine wave oscillators, the General Radio 1304A and Heath AG-9A, are adjusted to the proper frequencies and have their outputs added in equal ratio and sent through precision attenuators and a power amplifier to the speaker. Mic output is amplified, normalized, and measured by a Hewlett-Packard 300A wave analyzer. The higher tone, which is to be checked for intermodulation by the lower tone, is set to 100% on the analyzer at the lowest practical speaker drive level. It is then tuned to the appropriate sideband and manual readings taken at 2 dB power increments. When all significant sidebands and power level readings have been taken, the data are reduced by use of a Hewlett-Packard Model HP-35 calculator.

The signal suppression setup is similar to that for intermodulation except that a General Radio 1390B noise generator is used with a sine wave oscillator. The normalized microphone output is amplified and preliminary filtering made through the Hewlett-Packard 300A wave analyzer set to the frequency of the tone. This is done to reduce the dynamic range requirements of the subsequent filtering. The i.f. of the 300A (20kHz) is phase locked by the spectrum analyzer which uses a one second gate to implement a matched filter detector. The mean square output of the matched filter is monitored on a meter and sent to a recorder. At the lowest practical drive level, the matched filter is set to 0 dB with the sine wave. The noise is then added at 20 dB higher average level than the sine wave. The normalizing pot is stepped in 2 dB increments until either a 1 dB drop is noted in the matched filter or amplifier clipping occurs. The peak speaker voltage for three sigma noise peaks is then used as the peak amplifier rating needed to produce this 1 dB suppression.

For the time-energy plot, the frequency response is taken by the TDS. This produces one complete spectrum per second. The frequency response is multiplied by Hamming spectrum weighting and sent to a processor which takes the continuous Fourier transform of this weighted spectrum. A control unit selects the proper synthesizer digits to correspond to the appropriate time epoch for each one second spectrum and digitally positions the horizontal axis on an X-Y recorder to correspond to this epoch. The in-phase and quadrature Fourier transform are squared, logarithmically amplified, and used as the recorder Y axis drive. The control unit steps the synthesizer and advances the recorder once per second from starting epoch to final epoch. A maximum of 256 steps may be taken in one record.

Conclusion

Our discussion has concentrated on the laboratory tests because these are reproducible from one time to the next and one facility to another. It is still our policy that final judgment of sound reproduction must come from a critical listening test where human values of perception are strongly dominant. The listening test will therefore continue to be performed as it always has. The reason we perform laboratory tests is to make available to you impartial measurements of how well a speaker does its job and we do this in numerical data form for easy and valid comparison of one speaker with another.



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Bass Equalization in Loudspeakers

Dick Crawford

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Using the nomenclature of Harry F. Olson[1], we can write the motional impedance of a loudspeaker as

(1) $Zem = \frac{(Bl)^2}{Zmt}$

where Zem = motional impedance of loudspeaker in abohms,
B = flux density in air gap, in gausses,
l = length of the conductor in the voice coil, in centimeters, and
Zmt = total mechanical impedance of the mechanical system, in mechanical ohms.

Further, we can write the force exerted upon the loudspeaker cone as

(2) $f = Bli$

where f = force, in dynes
i = current, in abamperes.

Now, suppose I had two loudspeakers, names More and Less. They are identical except that MORE has twice the flux density of LESS. Perhaps the greater flux density is due to a larger magnet. Both MORE and LESS are mounted in infinite baffles. Both speakers are driven at equal power levels by a good stereophonic amplifier. What do the above equations tell us?

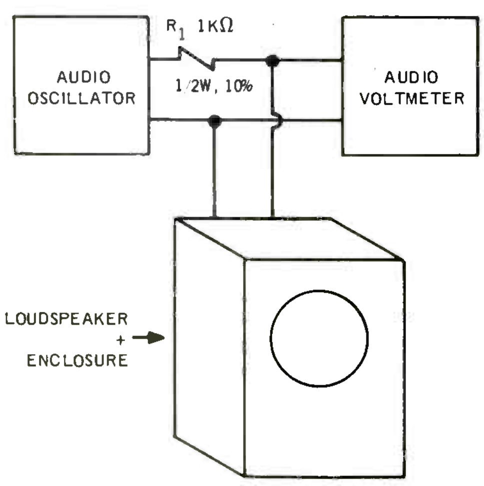


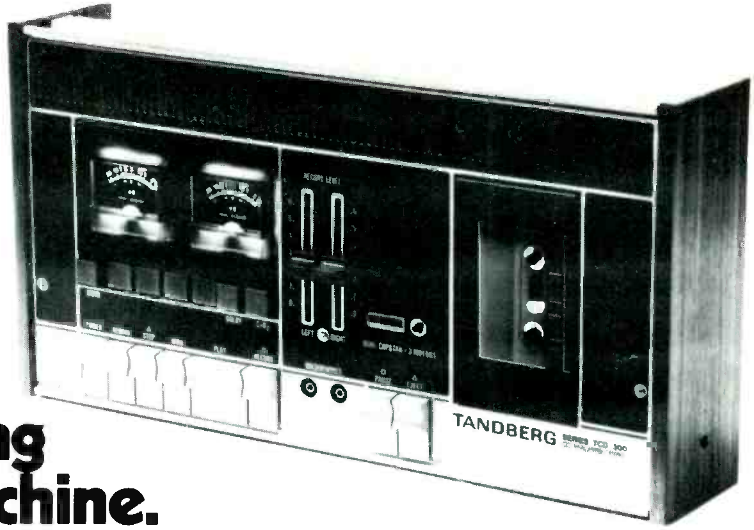
Fig. 1—Loudspeaker impedance test setup.

Obviously, the greater flux density of MORE gives it greater efficiency. How much greater? We can answer this with the aid of equation (2). The sound pressure generated by a loudspeaker is proportional to the force generated by its voice coil. Sound pressure is analogous to electrical voltage in that acoustical power is proportional to the square of sound pressure as electrical power is proportional to the square of the voltage across a resistor. If we double the force in (2), we quadruple the efficiency. Thus if we double the flux density in a loudspeaker while keeping the other factors (including the current flowing in the voice coil) constant, then we quadruple the efficiency. Great! But do we keep the current constant if we change the flux density? Don't we alter the impedance characteristics when we alter the flux density?

In most loudspeakers the impedance in the mid-range frequencies, where efficiency is specified, is dominated by the resistance of the voice coil windings. For woofers, sometimes the dominant impedance is the inductive reactance of the voice coil. This means that most of the electrical power delivered to a loudspeaker gets dissipated in the resistance of the voice coil rather than in acoustical power. This is why most loudspeakers are less than 10 per cent efficient.

Returning to our two loudspeakers MORE and LESS, we see that the resistance of both voice coils is identical, and thus the speaker impedances will be very similar over most of the frequency range. Thus the current in both speakers is nearly identical for equal drive levels. And this means that MORE is almost four times as efficient as LESS in the mid and high frequency ranges.

But what about the lower frequencies? At bass resonance, for example? Surprisingly, MORE is out of luck. Referring to (1), we see that the resonant impedance of a loudspeaker goes up as the square of the flux density. Thus MORE will have four times the electrical impedance at resonance of LESS. This means lower current, less force, less sound pressure, and lower efficiency for MORE at bass resonance. The sound pressure of MORE is one half that of LESS at resonance, and the efficiency is one quarter! Foul play! No wonder low efficiency speaker systems have done so well.



TCD 300

The stereo cassette deck for people who wouldn't own anything but a reel-to-reel machine.

The new ideas we've engineered into the Tandberg TCD 300 may change some of your old ideas about cassette tape decks.

To begin with, the TCD 300 is the world's first three-motor, dual-capstan cassette recorder. A hysteresis synchronous 4-pole capstan drive motor assures smooth, constant speed. The two DC EDDY spooling motors can wind or rewind a 60-minute cassette in 40 seconds flat! And Tandberg's exclusive servo control gives you constant speed, completely avoiding stress on the tape in both wind and rewind. No other cassette deck comes close to handling tape this fast...or with such great stability.

The TCD 300 uses a unique closed-loop tape drive system with two pinch rollers that automatically compensate for slight differences in cassettes. You get inaudible wow and flutter. And you don't have to worry about tape jamming, even with heavily played cassettes.

Now for the specs—and what specs they are! A signal-to-noise ratio of 54 dB *without* the Dolby* circuits in operation. An incredible 62 dB *with* Dolby*. Frequency response of 30-16,000 Hz (DIN) using CrO_2 tape. Maximum wow (WRMS) of 0.15%. It all adds up to the kind of reliability and clean, transparent sound you'd expect from a fine reel-to-reel tape machine.

The specifications for the TCD 300, as with all Tandberg equipment, are guaranteed *minimum* performance standards.

As significant as the specs themselves is the way we achieved them. For instance, the TCD 300 uses a minimum of high frequency pre-emphasis in recording (only 12 dB at 14 kHz with CrO_2 tape). This means a significant increase in dynamic range at the highest frequencies. And an audible improvement in signal/noise as well.

In other words, the TCD 300 does not "buy" its extended frequency response and excellent signal-to-noise ratio with a reduction in dynamic range—which makes the TCD 300 fully capable of recording the true dynamics of a live performance.

Another TCD 300 exclusive—large, illuminated *peak reading* dB meters.

These unique meters show the fully equalized record signal at *all* frequencies, and accurately read the peaks to keep you from getting audible distortion during recording. They allow maximum utilization of the tape, for improved signal/noise.

The CrO_2 tape switch changes record current bias and both record and playback equalization. This gives you full advantage of the special properties of CrO_2 tape. Automatic electronic end stop, one-button record control and built-in microphone preamplifiers add still more control sophistication.

Ask your Tandberg dealer to demonstrate the TCD 300. You'll find it does things the others can't. Because it has things the others don't.

*Dolby is a Trademark of Dolby Laboratories, Inc.

TANDBERG

We're our only competitor.

TANDBERG OF AMERICA, INC. LABRIOLA COURT. ARMONK, N.Y. 10504
A. Allen Pringle, Ltd. Ontario, Canada

Check No. 59 on Reader Service Card

Well, then, why do we want efficiency? For one thing, a more efficient loudspeaker has better damping[2], and thus better transient response and a somewhat smoother frequency response. A high efficiency loudspeaker needs a lower power amplifier. Most component type high fidelity loudspeakers are of the high efficiency type.

So we have a loudspeaker. What can we do if it lacks bass? We can equalize. By equalize I mean bass boost in the amplifier. Bass boost? Does not proper equalization depend upon a complete knowledge of the loudspeaker parameters such as mass, compliance, flux density, et al? Or perhaps an acoustical laboratory with an anechoic chamber, expensive microphones, and so forth? No, I contend that an adequate job of equalization can be carried out just using an audio oscillator, a one kil ohm resistor, an audio voltmeter, and the speaker in its enclosure. Figure 1 shows the test set up.

The first step is to measure the mechanical Q of the loudspeaker. Somewhere in the region from 20 to 200 Hz the loudspeaker will give a peak reading on the voltmeter. This is the resonant frequency, f_0. We also wish to find the two frequencies either side of f_0 where the voltmeter reads 70% of the value at f_0. We call these two frequencies f_1 and f_2. Finally, we wish to determine the minimum impedance of the bass loudspeaker, which is the minimum reading on the voltmeter, and is generally a broad minimum occurring at three to ten times f_0. We call this frequency f_3. What we are interested in here is the ratio of the readings on the voltmeter at f_0 and f_3. Figure 2 shows the impedance plot of a 10-inch woofer in a two cubic foot enclosure illustrating the frequencies and measurements sought. Such a plot can be made, if interested, by assuming that the speaker is at its nominal impedance at 1000 Hz. By setting the oscillator to 1000 Hz and adjusting its output amplitude until the voltmeter reads eight millivolts, then the voltmeter reading in millivolts converts directly to ohms impedance. Then it's a simple matter to note the voltmeter reading as frequency is varied (not touching the oscillator level) and then plotting the readings.

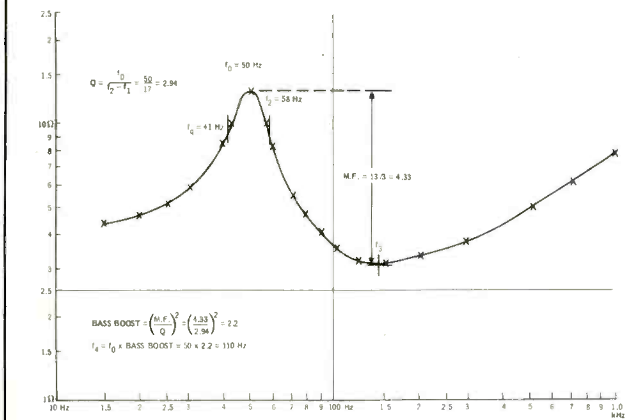
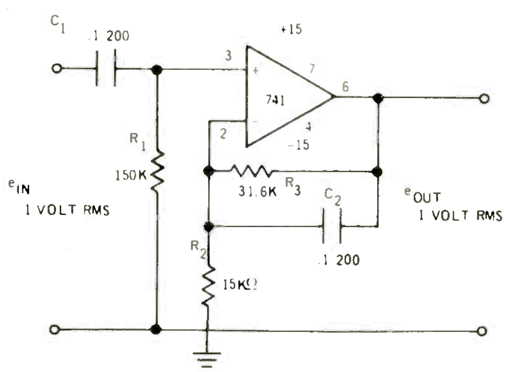


Fig. 2—Impedance plot illustrating measurements.



ALL RESISTORS 1/2W, 10%
GAIN = 0 db AT 1 kHz
SIGNAL CAPABILITY 5 VOLTS RMS
$f_4 = 100 \text{ Hz} = \frac{1}{2\pi R_2 C_2} = \text{BASS BOOST} \times f_0$
$\text{BASS BOOST} = \frac{R_3 + R_2}{R_2}$

Fig. 3—Bass boost circuit.

We are now ready for some simple calculations. First we determine the loudspeaker mechanical Q from

$$(3)\quad Q = \frac{f_0}{f_2 - f_1}$$

Next we determine a number I call the MORE factor. It has no particular meaning to us unless we know a great deal about the design details of the loudspeaker.

$$(4)\quad \text{MORE factor} = \text{M.F.} = \frac{V_0}{V_3}$$

where V_0 = the voltmeter reading at f_0, and
V_3 = the voltmeter reading at f_3.

Now we come to the crux of the matter and determine the amount of bass boost needed to equalize the loudspeaker.

$$(5)\quad \text{Bass Boost} = \left(\frac{\text{M.F.}}{Q}\right)^2$$

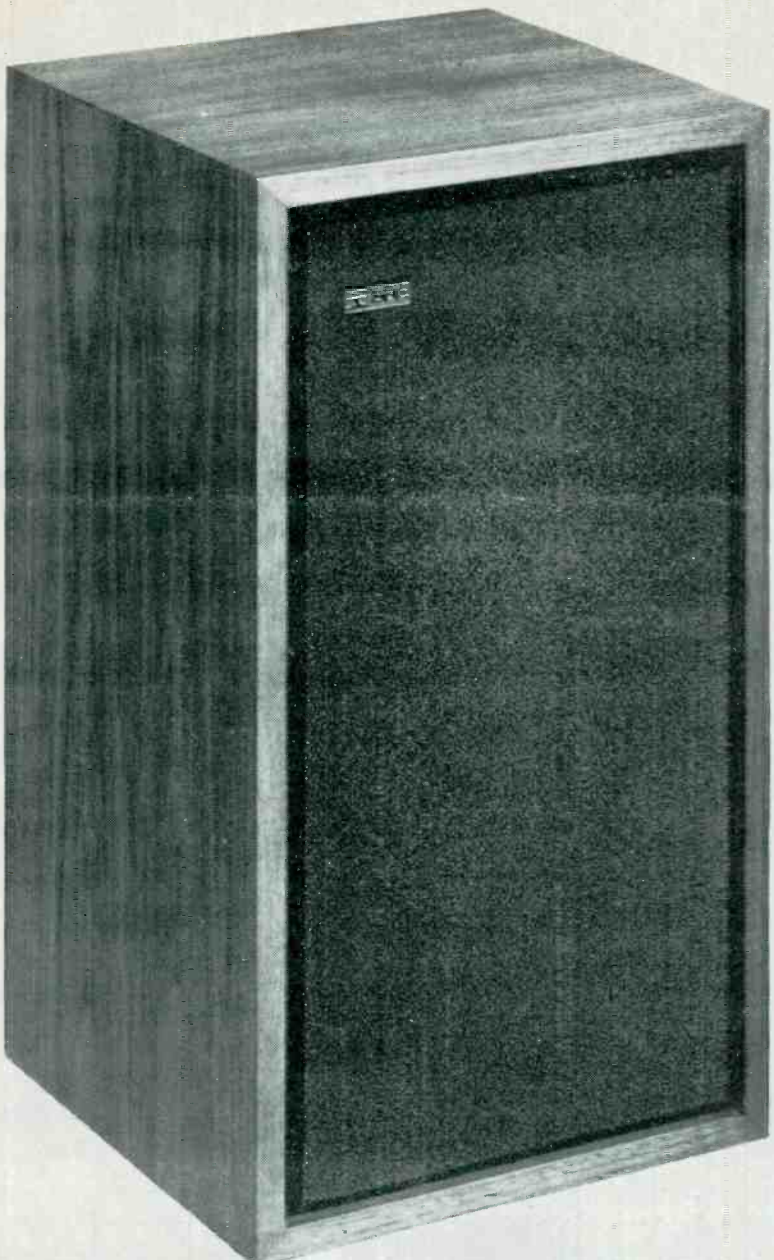
I think it would be wise to explain the above equations. The procedure for determinimg the mechanical Q is not exact, but it is a simplification of a more precise method[3], and is accurate enough for loudspeakers of moderate efficiency. The greater the Q of a loudspeaker, the less electrical power we have to furnish it for a given acoustical output at resonance (under steady state conditions). Alas, the greater the mechanical Q of a loudspeaker, the more poorly damped it will be at resonance, and the poorer the transient response. There is not a great deal that can be done by the reader *to the speaker* to decrease its Q, but we are fortunate in that a speaker with high efficiency will give us more opportunity to electrically damp this resonance[4]. At any rate the bass response is being increased by this mechanical Q, so we have to know the Q in order to calculate the required bass boost.

But for a Q of one or greater there will be a peak in the impedance curve at resonance. The greater the flux density, the higher the impedance peak. The higher the impedance peak, the more bass boost required to equalize bass response. Thus the MORE factor is a measure of the "peakiness" of the impedance characteristic.

Since the MORE factor is an indication of the bass boost required, and the mechanical Q of the loudspeaker is a measure of the bass boost built into the loudspeaker, we see that the actual bass boost required is some function of the MORE factor divided by the Q. Earlier we saw that the bass loss due to greater efficiency was proportional to the square of the relative flux density, thus we have (5) above.

We now know the amount of bass boost required, but we don't know the frequency contour that our bass boost circuit should follow. It the boost is less than twelve decibels at loudspeaker resonance, the single zero, single pole circuit, such as shown in Fig. 3, is adequate. The value of R_2 in Fig. 3 is shown for the loudspeaker of Fig. 2. The bass boost starts at

$$(6)\quad f_4 = (f_0) \times (\text{bass boost})$$



The new ADC-XT 10.

If you believe, as we do, that the ultimate test of any speaker is its ability to produce a true audible analog of the electrical signal fed to it, you'll be very impressed with the new XT 10.

The XT 10 is a two way, three driver, system employing a newly developed ten inch, acoustic suspension woofer with an extremely rigid, light weight cone and a specially treated surround that permit exceptionally linear excursions.

Matching the XT 10's outstanding low frequency performance are two wide dispersion tweeters that extend flat frequency response to the limits of audibility (see accompanying frequency response curve) and significantly improve power handling capacity.

All three drivers are mounted in a beautifully finished, nonresonant, walnut enclosure. And in place of the conventional grille cloth is an elegant new foam grille.

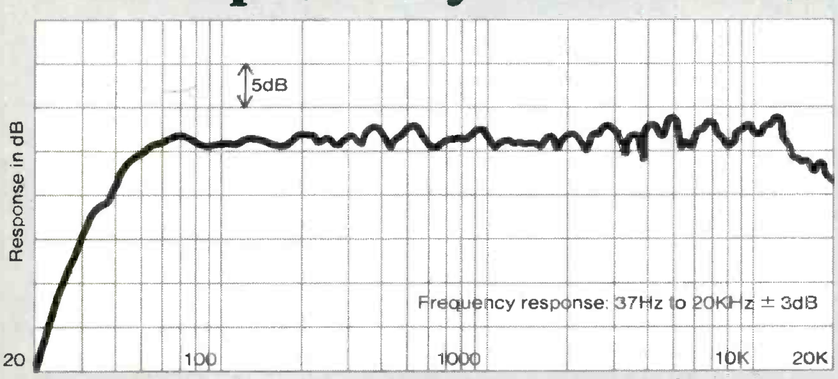
An extraordinarily accurate transducer, the XT 10 is characterized by very flat frequency response, excellent high frequency dispersion and extremely low distortion. Finally, it is distinguished by outstanding transient response assuring exceptional clarity and definition.

As a result, the ADC-XT 10 rivals and in many instances, surpasses the performance of units costing several times as much.

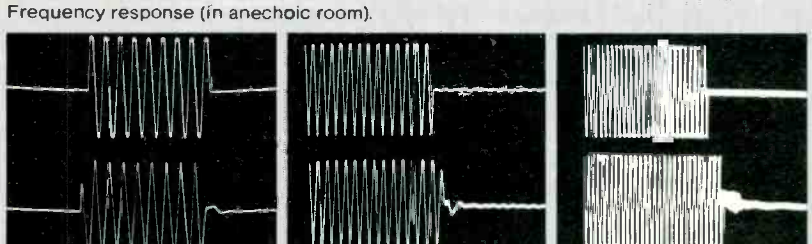
But why not experience for yourself what a truly well behaved speaker sounds like. Audition the XT 10 at your ADC dealer now.

For more detailed information on the ADC-XT 10 write: Audio Dynamics Corporation, Pickett District Road, New Milford, Conn. 06776.

It does precisely what it's told.



Frequency response (in anechoic room).


Tone bursts at 500Hz, 1200Hz, 15,000Hz
Virtually identical waveforms from signal generator above and speaker below demonstrate superior transient response.

ADC Audio Dynamics Corporation

Check No. 9 on Reader Service Card

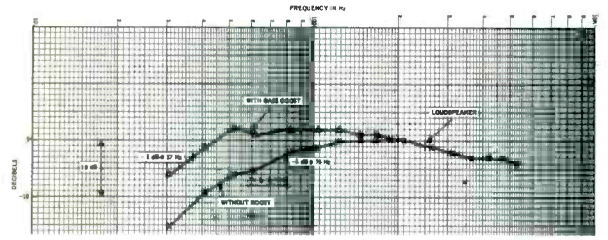


Fig. 4—Frequency response curves.

Theoretically, it is possible to equalize the response of a loudspeaker in the frequency range below its resonance, but I have never had much success in so doing. The slope of the equalization curve below speaker resonance is very steep, and the amount of equalization required very large. The practical problems seem greater than the rewards.

Figure 4 shows the results. The bass boost starts at about 105 Hz, is up about eight decibels at 50 Hz, and reaches a peak of 10 decibels at about 30 Hz. Of course, this represents the transmission thru the entire amplifier and not just the bass boost circuit.

The before and after effects of the frequency response for the loudspeaker speak for themselves. The measurements were taken with a Hewlett-Packard loudness analyzer in my den. Notice that the bass response has been extended for one octave. The falling off in the 400 Hz region is due to the crossover network for this speaker. The response is smooth and lacks large peaks.

Where, say you, is the catch? Yes, there is one. This technique, that is, the equations as given, is valid only for speakers in sealed enclosures. In fact, the only justification for the approximations made in the analyses is the results of Fig. 4! In the case of other enclosure types, it is difficult to assess the degree to which the enclosure modifies the impedance characteristics in the region near resonance. This brings to mind an observation about enclosures. Most enclosures not only add to the bass by additional radiation, but they also lower the electrical impedance in the vicinity of resonance. This latter effect leads to more current flowing in the loudspeaker which means yet more bass. Several examples are the bass reflex, the auxiliary bass radiator (ABR or drone cone), the labyrinth, and the folded horn. All of these increase the amount of bass by increasing, in some manner, the amount of acoustic radiation. This is represented as an additional resistive component in the mechanical impedance of the loudspeaker, and thus (by equation 2) must lower the electrical impedance. As a matter of fact, I have designed enclosures wherein the port of the bass reflex was designed primarily to control the speaker impedance characteristics[5]. I suspect that some of the aperiodic speaker enclosures on the market now are designed with this same goal.

There you have it. A wrong recognized; a cure proposed; proof that it works. Do I guarantee happiness? No, but if your loudspeaker fits the prescription described above, then you might try bass equalization. I *can* guarantee more bass!

References

1. **Olson, Harry F., *Acoustical Engineering*, D. Van Nostrand Company, pp. 124-133.**
2. **Briggs, G.A., *Sound Reproduction*, Wharfedale Wireless Works, 1953, pp. 110-122.**
3. **Jordan, E.J., "Loudspeaker Enclosures," *Wireless World*, January, 1971, pp. 2-6.**
4. **Briggs, G.A., *op. cit.***
5. **Crawford, Dick, "Another Look at Parallel-Connected Speakers," *Audio*, November, 1970, pp. 24, 26.**

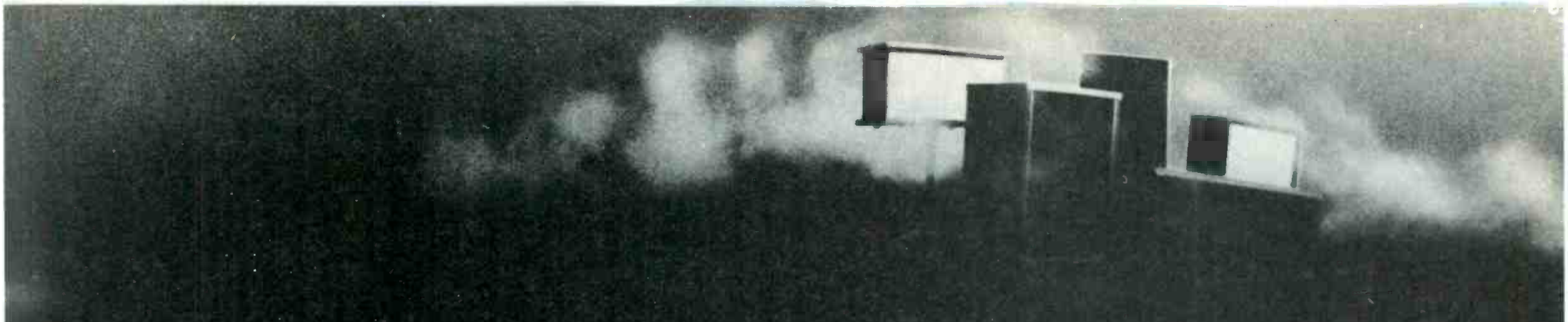
Directory Addenda

SPEEDS (see letter code)

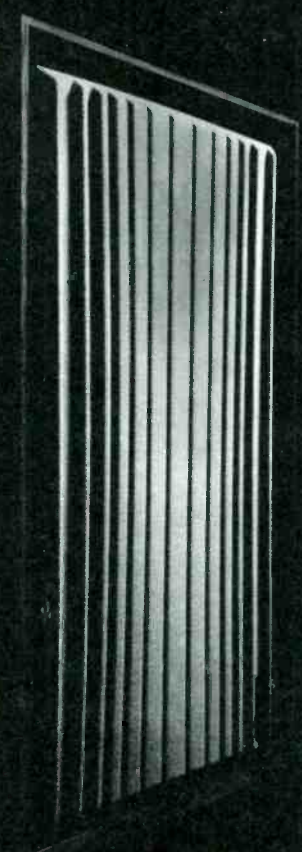
A—33, 45, 78
B—33, 45
C—33 only
D—16, 33, 45, 78
E—16, 33, 45
F—cont. variable

AUTO TURNTABLES MANUFACTURER	TURNTABLES											TONE ARMS												
	MODEL	Speeds (see letter code)	Wow & Flutter at 33⅓, %	Rumble (NAB) dB	Motor type	Platter diameter, in.	Platter weight, lbs.	Drive	Arm mounting provision	Dimensions, W x D x H, in.	Weight, lbs.	MODEL (for separate arms)	Overall length, in.	Pivot-stylus dist., in.	Vertical bearing	Lateral bearing	Stylus force method	Max. tracking error, deg.	Cartridge weight range, gms.	Arm resonance, Hz	Stylus force range, gms.	Weight, if sep., oz.	Price	SPECIAL FEATURES
SONY	PS 5520	B	0.1	43	hys sync	12	2¼	Belt	Integ	17¾ x 15½ x 6⅞	18 lb 11 oz.		11½	8½	Pivot	ball	bal.		4-14		0-3		159.50	Auto lead-in; auto ret., repeat
	PS 2251	B	0.04	58	AC Servo	12	3 lb. 5 oz.	Dir.	Integ	19¼ x 16⅛ x 7¼	33		13½	9⅝	Pivot	ball	bal.		4-17		0-3		349.50	Speed tuning w/built-in stroboscope.
	PS-2251 LA	B	0.04	58	AC Servo	12	3 lb. 5 oz.	Dir.	Mtg. brd.	19¼ x 16⅛ x 7¼	31												299.50	Same as PS-2251.
												PUA 237	13⅜	9⅜	ball	ball				9	0-3		85.00	

MICS MANUFACTURER	MODEL	Directional pattern	Operating principle	Case material	External finish	Impedance, ohms	Frequency response, Hz to kHz, ± ? dB	EIA Sensitivity, dBm	Mic connection	Cable length, ft.	Cable plug type	Dimensions, in.	Weight, oz.	Mounting method	Price	SPECIAL FEATURES
OLSON	EC 100	Card.	Elect.	Alum.	Brshd. gold	low	30-16k ± 1.5	-140	A3S	20	not furn.	8½ x 2½	5	clamp	36.00	
	EO 200	Omni	Elect.	Alum.	Brshd. gold	low	30-16k ± 1.5	-135	A3S	20	not furn.	8½ x 2½	5	clamp	39.60	
	MM-327	Card.	Dyn.	Alum	Brshd. gold	600; 50k	50-15k ± 2	-125	Amph	20	not furn.	7½ x 1⅜	10	clamp	22.98	On-off swit.



What makes Evolution One sound so good are all the speakers which are supposed to sound so much better.



Some honest talk about a new speaker and its non-revolutionary advances.

Is the world ready for a non-revolutionary speaker?

We think the serious listener might be. Behind the development of Evolution One is the same philosophy that has made Sherwood a leading name in receivers.

We've deliberately not sought the sensational breakthroughs.

We put the emphasis on refining technology which currently exists. Refining, perfecting, evolving the state of the art.

Our design engineer.

Great design only comes from great designers.

Which is why our Director of Loudspeaker Design and Research, Charles L. McShane, is an important factor in the development of this new speaker.

He has spent over twenty years in research and design of loudspeakers. With the top manufacturers in the industry. His design credits include some of the best selling acoustic-suspension speakers now on the market (several are considered standards of the industry).

Equally important, he believes, as Sherwood always has, in design simplicity.

No tricks. No gimmicks.

You will find Evolution One is the essence of simplicity.

A two-way loudspeaker system utilizing a 10-inch woofer and a 1.3-inch tweeter. It is an acoustic suspension design.

While the design is fundamentally simple, the execution involves a variety of techniques which cumulatively produce a remarkable sound.

Just how good is it?

You'll be surprised. Especially when you pit it against speakers three and four times higher in price.

It has an extraordinary wide range. Low distortion at *all* frequencies. Wide dispersion. And uniform flat response.

In fact, its low frequency output and distortion are better than any speaker system we know of for home use.

The one revolutionary feature.

We have priced the Evolution One speaker at under $100. When you hear how it sounds, you'll know why we think that it offers the outstanding performance-per-dollar we're famous for.

Write us for complete information, and the list of selected Evolution One loudspeaker dealers.

Sherwood Electronic Laboratories
Loudspeaker Division
4300 N. California
Chicago, Illinois 60618

evolution one

Another best buy from Sherwood

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Price Corrections

On page 80 of the speaker section in the September Directory, the Hartley Concert Master and Holton series speakers were listed at price *per pair*. The prices are for single units.

On page 48 in the manual turntable section, the Thorens TD-215AB and TD-125B turntables had their prices exchanged.

AMPS

MANUFACTURER	MODEL	RMS power/chan., W, 8 ohms	THD at rated power, %	THD at 1 watt, %	IM at rated power, %	IM at 1 watt, %	Power bandwidth, Hz - kHz	Freq. resp. at 1 watt, Hz ± dB	Rated output S/N, phono, dB	Phono sensitivity, mV	Phono overload, mV	Tape head input, mV	High level input, V	Output Z, ohms	Damping factor	Dimensions, w x d x h, in.	Weight, lbs.	Price	SPECIAL FEATURES
OLSON	AM 395	12	0.75	0.4	1.5	0.52	20-28k	20-20k ± 1.8	58	2.0	40	2.8	0.2	4-16	20	11½ x 7¼ x 4¼	12	69.99	
	AM 372	8	1.75	1.5	1.5	1.0	22-25k	20-20k ± 3	55	2.0	45	3.0	0.25	4-16	18	12¼ x 7½ x 3¼	7	39.98	
SONY	TA-1055	23	0.5	0.1	0.5	0.2	10-40k	10-60k ± 3	70	2.0	70		0.25	8	22	16⅛ x 11⅛ x 4¾	13½	169.50	20 + 20 W. at 40-20k; wood cab.; 2 tape mon.; dir. spkr. coupling.
	TA-1150	35	0.2	0.1	0.2	0.1	8-35k	15-80k ± 2	70	2.0	70		0.14	8	100	15¾ x 12½ x 5¾	18¼	249.50	30 + 30 W. at 20-20k; 2 tape mon.; dir. spkr. coupling.
	TA-1130	65	0.1	0.05	0.1	0.05	7-30k	10-100k ± 1	70	1.2	70		0.13	8	100	15¾ x 12⅞ x 5⅞	28¾	399.50	50 + 50 W. at 20-20k; 2 dB-step calib. tone contls.; dir. spkr. coupling.
	(B) TA-3130F	70	0.1	0.05	0.1	0.05	7-30k	10-200k ± 1					1.0	8	200	7⅞ x 12¾ x 5⅞	17¼	249.50	50 + 50 W. at 20-20k; dir. spkr. coupling.
	(B) TA-3200F	110	0.1	0.03	0.1	0.03	5-35k	5-200k ± 1					1.4	8	200	15¾ x 12¾ x 5⅞	28	369.50	100 + 100 W. at 20-20k; ½, ¼ pwr. limit. swit.; dir. spkr. coupling.

PRE-AMPS

MANUFACTURER	MODEL	Frequency response, Hz ± ? dB	Rated output, V	THD at rated output, %	IM at rated output, %	Rated output S/N, phono, dB	Phono sensitivity, mV	Phono overload, mV	Tape-head sens., mV	High-level sens., V	Tape-monitor Z, ohms	Dimensions, W x D x H	Weight, lbs.	Price	SPECIAL FEATURES
OLSON	AM 368	30-20k	250 mv	0.75	0.75	62	2.0	45				4 x 1½ x 2½	1	10.98	
SONY	TA 2000F	10-100k ± 1	1.0	0.03	0.05	73	1.2	300		0.11	10k	15¾ x 12⅞ x 5⅞	19¾	579.50	VU mtrs. made to NAB specs., low noise FET amps.

PHONO CARTRIDGES

Stylus Type
C - Conical
E - Elliptical

MANUFACTURER	MODEL	Frequency response, Hz ± 2 dB	Separation, 1000 Hz, dB	Separation, 10 kHz, dB	Output, mV/cm/sec.	Tracking-force range, gms.	Load resistance, ohms	Stylus type (see letter code)	Stylus radius (radii) mils	Replacement	Weight, gms.	Price	Special Features
OLSON	PC-195	15-25k	30		2.5	1.5-4	47k	E	0.4 x 0.7	User	14	24.98	

SPEAKERS

MANUFACTURER	MODEL	WOOFER			MID-RANGE		TWEETER												
		Diameter, in.	Resonance (in system), Hz	Enclosure type	Diameter, in.	Type	Diameter, in.	Type	Overall freq. resp., Hz to kHz ± ? dB	Ampl. pwr. for avg. room, W	Pwr. handling capacity (RMS cont.)	Crossover frequency (ies), Hz	Impedance, ohms	Enclosure dimensions, W x D x H, in.	Wood finish	Grille material color	Weight, lbs.	Price (per pair?)	SPECIAL FEATURES
MAGITRAN	D560									5	28		8	29⅝ x 23⅝ x 2	Wal.	13 patterns	13	79.95	Flat sound panel; polyplanar, 8-way design.
OHM	D	10	50	Slot. resist. load.			3	Cone	40-16k ± 4	20	75	1700	8	14 x 25 x 8	Wal. or Vinyl	Cloth brn	40	230.00	Phenolic ring surround tweeter.
	E	8	50	Acous.			3	Cone	48-16k ± 4	10	40	1700	8	11½ x 21½ x 7¼	Vinyl wal.	Cloth brn.	20	150.00	Same as above.
	F	12	35	Acous.					33-20k ± 4	50	160	none	4	17¾ x 17¾ x 43½	Wal. or Rose	Cloth brn.	125	800.00	Omnidirectional driver.
OLSON	SS-82	12	48	Acous. susp.	12	Horn	6	Horn	20-30k ± 1	10	60	800; 5000	8	14⅜ x 11¾ x 23⅝	Wal.	Cloth, brn	42	329.98 ea.	3-way.
	SS-72	12	48	Acous. susp.	5	Cone	2½	Cone	25-20k ± 1	10	60	800; 5000	8	14⅜ x 11¾ x 23⅝	Wal.	Cloth brn.	40	249.98 ea.	3-way.
	SS-175	12	58	Acous. susp.	5	Cone	2½ 1¼	Cone spr. twtr.	20-27k ± 1.5	10	50	700; 6000; 12k	8	14¼ x 11½ x 25½	Wal.	Fretwork wood	40	177.98 ea.	4-way.

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SONY	ST-5055	2.2	1.0	70	45	30-15k ±2	35		0.4	0.6	mtr	68	1	yes	16¼ x 11¼ x 4¾	10¾	169.50	FET front-end; linear FM dial scale; wood cab.
	ST-5150	2.0	1.0	70	56	20-15k ±1	40		0.3	0.5	mtr	70	2	yes	15¾ x 13⅝ x 5⅞	15¼	249.50	FET front-end; 75 ohm antenna "F" conn.; linear FM dial scale.
	ST-5130	1.5	1.0	100	60	20-15k ±1	42		0.2	0.3	mtr	75	2	yes	15¾ x 13⅝ x 5⅞	16½	349.50	Same as above plus INS impulse noise suppressor.
OLSON	RA-310	3.5	0.9	3.8	35	50-15k ±3 ±3	37	28	1.6	1.8	mtr	58	1	yes	11½ x 7¼ x 4¼	10	69.99	

HEADPHONES

MANUFACTURER	MODEL	Type	Frequency response, Hz ±? dB	Impedance, ohms	Sensitivity mW input for 100 dBm out	Maximum input, mW	Distortion, %	Cord length, ft.	Weight, oz.	Price	SPECIAL FEATURES
OLSON	PH219	ES	25-19.5k ±3	8	1.2 V.		0.5	10	14	59.98	Coil cord.
	PH220 4-chan.	Dyn.	20-18.5k ±1.8	8	2.0	600	0.32	10	12	48.49	
	PH222	Dyn.	25-18k ±1.5	8	2.5	500	0.38	10	8	24.98	
	PH213	Dyn.	20-20k ±1.5	8	2.0	650	0.3	10	10	42.98	Slide vol. & tone contls. for each earpiece.

CASSETTE RECORDER

MANUFACTURER	MODEL	Cassette	Cartridge; no. of tracks	Type: portable, P; home, H;	Power amp. built in	Rated power output, W	Mode: stereo, S; mono, M	Frequency response, Hz, ±? dB	Wow and flutter, %	S/N, dB	Supply voltage	Channels: 1, 2 or 4	Dimensions, W x D x H, in.	Weight, lbs.	Price	SPECIAL FEATURES
OLSON	RA 959	X		H	no		S	40-12k ±2	0.25	48	117 VAC	2	8¼ x 5⅛ x 16½	8½	89.98	Records; 3-dig. tape ctr.; mic/src. mon.; noise filter.

RECEIVERS

MANUFACTURER	MODEL	AMPLIFIER: RMS Power/chan., W	THD at rated power, %	IM at rated power, %	IM at 1 watt, %	Power bandwidth, Hz-kHz	1-watt freq. resp., Hz ±? dB	Rated output S/N, Phono, dB	Phono sensitivity, mV	Phono overload, mV	TUNER: IHF sensitivity, µV	Capture ratio, dB	Frequency resp., Hz	THD Mono, 100% mod., %	THD stereo, 100% mod., %	Stereo sep., 1000Hz, dB	Tuning indicator	Alt. chan. selectivity, dB	No. of meters	AM band?	Dimensions, w x d x h, in.	Weight, lbs.	Price	SPECIAL FEATURES
SONY	STR-6036A	18	0.8	0.8	0.1	10-25k	30-40k ±2	60	2.5	60	2.2	1.5	30-15k ±1	0.3	0.8	35	mtr	60	1	yes	17⅛ x 13½ x 5¾	19	199.50	15 + 15 W. at 20-20k; wood. cab.; dir. spkr. cplng.
	STR-6046A	22	0.8	0.8	0.1	10-25k	20-40k ±2	60	2.5	60	2.2	1.5	30-15k ±1	0.3	0.8	35	mtr	60	1	yes	17⅛ x 13½ x 5¾	19¾	249.50	20 + 20 W. at 20-20k; wood cab.; dir. spkr. coupling.
	STR-7045	40	0.2	0.2	0.1	15-30k	10-60k ±2	70	1.8	70	2.6	1.5	20-15k ±1	0.2	0.5	38	mtr	70	1	yes	18¼ x 14¾ x 6¼	31	329.50	30 + 30 W. at 20-20k; wood cab.; dir. spkr. coupling.
	STR-7055	45	0.2	0.2	0.1	15-35k	10-70k ±2	70	2.0	70	2	1	20-15k ±1	0.2	0.5	38	mtr	70	1	yes	18¼ x 14¾ x 6¼	33⅓	399.50	35 + 35 W. at 20-20k; wood cab.; dir. spkr. coupling; 2 tape mon.
	STR-7065	70	0.2	0.2	0.1	15-35k	10-70k ±2	72	2.0	70	2	1	20-15k ±1	0.2	0.5	38	mtr	70	2	yes	18¼ x 14¾ x 6¼	33¼	499.50	60 + 60 W. at 20-20k; wood cab.; dir. spkr. coupl.; 2 tape mon.
	STC-7000		0.1	0.1			10-100k ±1	72	2	70	1.7	1	30-15k ±1	0.3	0.5	40	mtr	100	2	yes	18¾ x 13¾ x 5⅞	22⅓	589.50	Pwr. amp not incl.; 2 tape mon.
	SQR-6650 4-chan.	25	0.8	1.0	0.5	10-40k	20-50k ±2	60	2.5	60	2.2	1.5	30-15k ±1	0.3	0.8	35	mtr	70	1	yes	17⅛ x 13½ x 5¾	21½	329.50	8+8+8+8 in 4-ch.; built-in SQ; 4 VU mtrs.; dir. spkr. coupling.
TELEDYNE (OLSON)	RA777	25	0.2	0.75	0.6	10-40k	8-50k	65	2.2	12.0	3.5	2	20-20k	0.5	0.9	35	mtr	65	2	yes	15¼ x 12¾ x 4½	18	269.98	Phase pwr. stereo; dual mtrs.
	RA632 4-chan.	15	0.5	0.85	0.7	15-26k	19-23k	62	2.5	25	2	3	17-20k ±1	0.6	1.0	35	mtr	62	1	yes	18 x 10 x 3½	16	259.98	Built-in decoder; joystick bal.
	RA618	15	0.5	0.85	0.7	15-26k	19-23k	62	2.5	25	2	3	17-20k	0.6	1.0	35	mtr	62	1	yes	18 x 10 x 3½	16	189.98	Phase power stereo.
	RA660 4-chan.	5	0.5	0.9	0.72	20-24k	25-30k	60	2.8	25	3.0	3.5	20-20k	0.75	1.2	30	mtr	62	1	yes	16 x 10 x 3½	14	214.98	Joystick bal.

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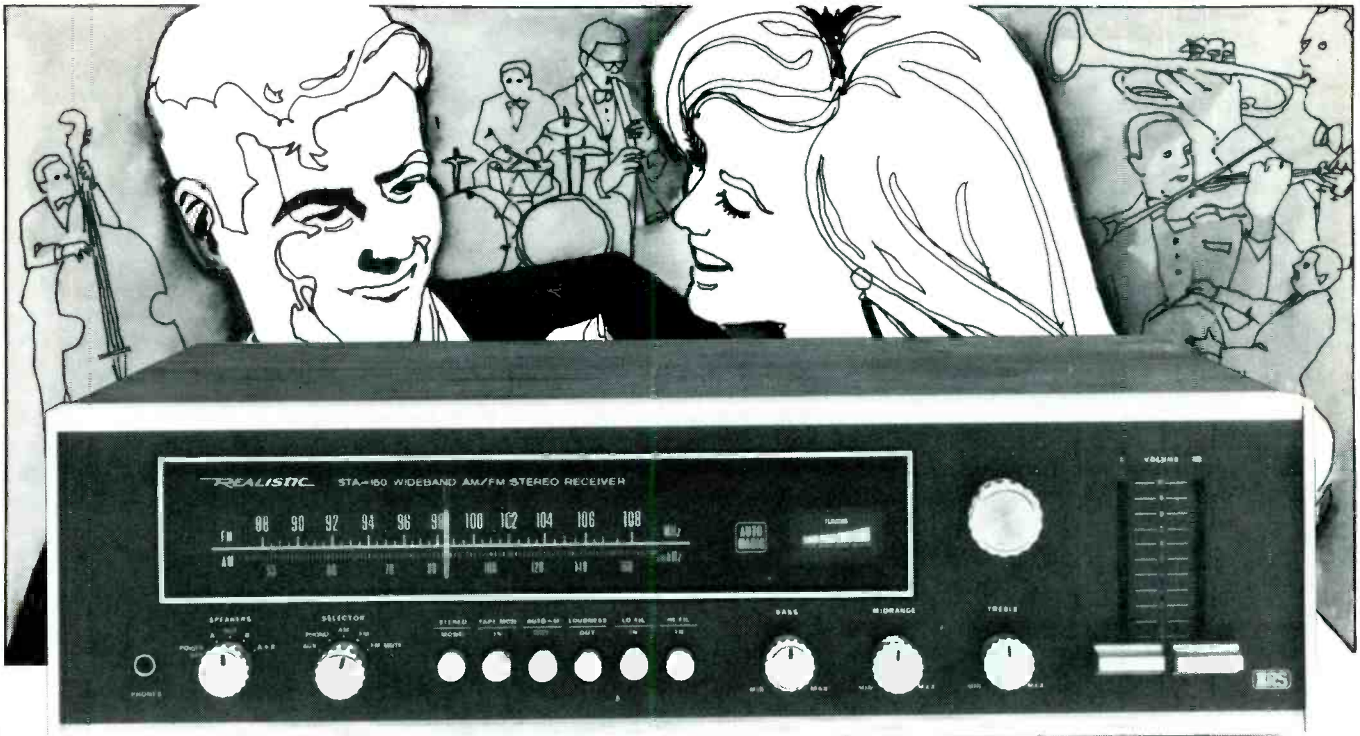

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CASSETTE TAPE RECORDING BIAS

Martin Clifford

In tube and transistor circuits, the word bias means a voltage, generally d.c., applied to some element of an active component to produce a linear output. There are exceptions, of course, most notably in the case of class-C amplifiers functioning as frequency multipliers. However, for audio applications, the role of bias is to help ensure undistorted output from tubes or transistors.

For a component such as a tube, for example, bias in the form of a negative voltage determines the quiescent or operating point Q, as shown in Fig. 1. The graph or transfer characteristic is a plot of grid voltage vs. plate current. This first drawing shows that a bias of -2.5 volts results in a plate current of slightly more than 4 milliamperes. When a signal voltage (Fig. 2) is applied, its effect is to increase and decrease the amount of bias, producing an equivalent variation of plate current. Because the swing is between points A and B, the linear portion of the tube's plate current—grid voltage characteristic, the variation in plate current (the output) is also linear. However, if the bias is incorrect, either too large or too small, the output waveform is distorted. Fig. 3a shows the effect of insufficient negative bias; Fig. 3b excessive bias.

This isn't as far removed from bias for magnetic tape as you might think, for one of the functions of tape recorder bias is to help produce linear output. But there the similarity ends, for tubes and transistors are amplifying devices; magnetic tape is not. Magnetic tape, though, possesses an ability that tubes and transistors do not have—the ability to retain the signal, pending amplification. However, whether this retention is linear or nonlinear depends on the way the tape is biased during recording. It may seem strange that magnetic tape can be biased in a manner reminiscent of tubes and transistors, but not when you consider the way in which tapes are magnetized and demagnetized.

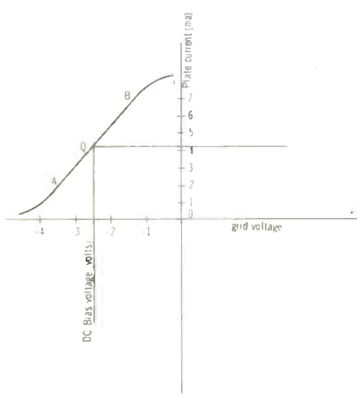

Fig. 1—Grid voltage vs. plate current curve. The d.c. bias voltage determines the operating point, Q.

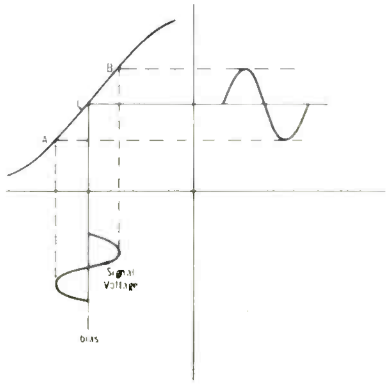

Fig. 2—Because of the presence of d.c. bias, operation is along the linear portion of the characteristic curve.

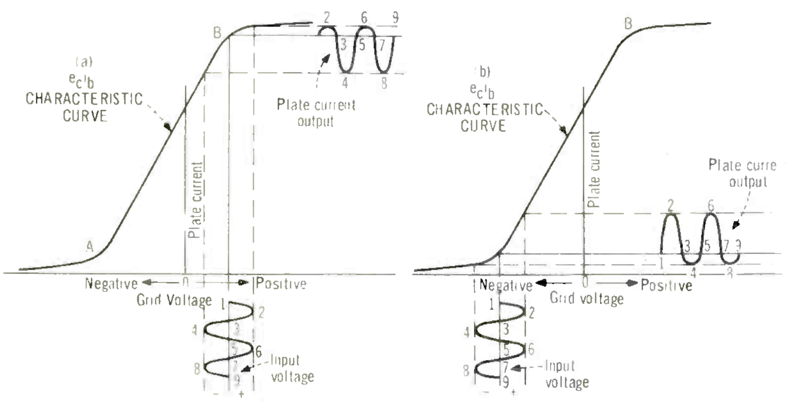

Fig. 3—Distortion occurs when bias is moved in an excessively positive direction (a) and also when it is made excessively negative.

Hysteresis Loops

The magnetic behavior of substances can be graphed, just as it is possible to plot the characteristics of tubes and transistors. The number of available magnetic flux lines or flux density per unit area (represented by the letter B) depends on the permeability of the material. Various substances have different amounts of reluctance to the presence of magnetic lines, much as they also have differing amounts of resistance to the passage of an electric current. A simple example would be a horseshoe magnet with a given magnetic strength, H. The number of magnetic lines of force existing between the adjacent north and south poles of this magnet would depend on the material placed between the poles. For iron there would be more lines of flux; for air, fewer.

A permanent magnet represents a condition in which the magnetizing force, H, is relatively constant. The magnetizing force, however, could be variable, as in the case of an electromagnet, produced by a varying alternating current flowing through a coil. A ferrous substance surrounded by the magnetic field around the coil would become magnetized, first in one direction, and then in the other. The poles of the ferrous substance, possibly a small iron bar, would keep reversing, in step with the frequency of the magnetizing current flowing through the coil. Further, the resulting magnet would also vary in strength, possibly ranging from weak to strong.

Figure 4 is a graph of the behavior of the ferrous material. At first nothing happens when the magnetizing force, H, is increased from 0 to 1, moving to the right along the horizontal axis representing the magnetizing force. This "non-action" can be considered in the same way as applying a force to a stalled heavy object, such as an automobile,

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AKAI America, Ltd., P.O. Box 55055, Los Angeles, California 90055 in an effort to get it moving. There will be no action until the applied force can overcome the inertia of the car. In the same way, the magnetizing force H must overcome the inertia of groups of iron atoms to magnetization. Once the magnetization process starts, though, the flux density, B, of the substance rises rapidly. Note the distance along the H axis from 1 to 2 is about the same as from 0 to 1—that is, each of these distances represents an equivalent amount of magnetizing force. From 0 to 1 nothing happens, yet from 1 to 2 the value of B rises rapidly.

As H is increased, B increases, but not indefinitely. At point C on the graph, any further increases in H will produce only a small increment in B, and so we call this the saturation point. If the graph were to continue beyond point C, it would start to assume a slope parallel to the H axis.

If the magnetizing force is now decreased, the level of the flux density of the material that was magnetized will also decrease but some magnetic flux will remain, even if the magnetizing force H is removed. At point D on the graph, for example, the value of H is zero, but the substance is still partially magnetized. We can, of course, return the material to its original, unmagnetized condition, but only by applying a magnetizing force in the opposite direction. The point at which the graph crosses the -H axis (-1) indicates complete demagnetization, but note that we are now on the -H part of the horizontal axis. If the magnetization is continued, the substance will become more and more magnetized, but the limit will be reached at point A. Here the application of the magnetizing force will not result in much of an increase in the flux lines around the object being magnetized. Again, this is a saturation point.

At point A we can gradually reduce the amount of magnetizing force until it reaches zero. At this juncture, the graph crosses the vertical axis at point E. If we were to stop here, the magnetizing force would once again be zero, but the substance being worked on would still be a magnet—that is, it would be surrounded by its own magnetic lines of flux. This is comparable to the situation that prevailed at point D on the graph, but with one difference. The poles of the substance being magnetized have been transposed.

If we now apply a magnetizing force of +H, similar to that used originally, we will reach point 1 on the graph. The resulting graph looks somewhat like a loop and is called a hysteresis loop. The shape of the loop depends on the kind of material being magnetized.

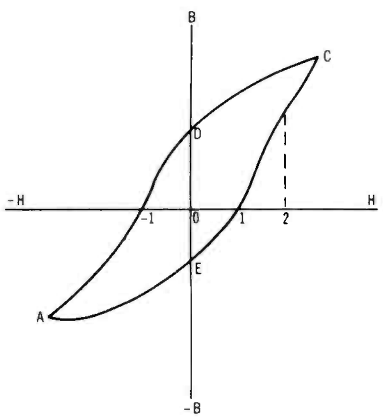

Fig. 4—Graph of the magnetizing and demagnetizing behavior of a ferrous material.

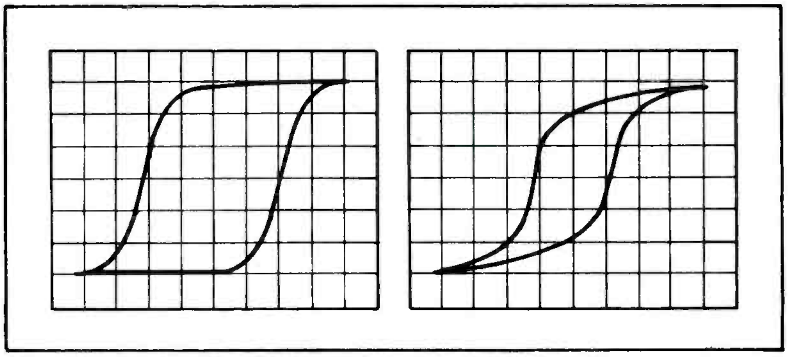

Fig. 5—Conventional hysteresis loop (right); more desirable curve (left).

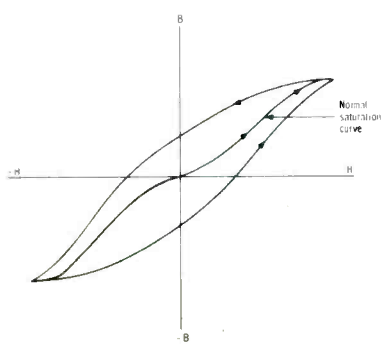

Fig. 6—Saturation or transconduction curve.

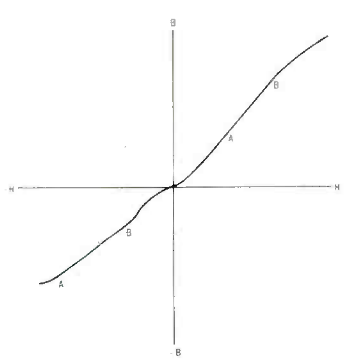

Fig. 7—Saturation curve without the hysteresis loop from which it was derived. A-B and A′-B′ are linear portions.

Shape of the Hysteresis Loop

The hysteresis loop of Fig. 4 is a basic diagram used by engineers to indicate magnetic properties. In general, the closer the loop approximates a square—that is, the greater the area enclosed by the curve—the better this characteristic will be for recording purposes (Fig. 5). The vertical axis of the graph represents retentivity, while the horizontal axis is coercivity. Retentivity accounts for higher output and better low-frequency response; coercivity is responsible for extended high frequencies. Coercive force is the force required to reduce magnetism to zero; it can be regarded as a magnetizing force applied in a negative direction. Retentivity is the magnetic flux that remains in tape after saturation with the magnetizing force returned to zero.

Saturation Curve

When a substance is subjected to a magnetizing force, there is at first a slow increase in the amount of magnetization, followed by a linear rise in which the amount of magnetization is proportional to the magnetizing force. The remainder of the curve becomes nonlinear as magnetic saturation is approached. Known as a normal saturation or transconduction curve (as indicated in Fig. 6), it is derived from the graph of the hysteresis loop.

The normal saturation curve can be drawn without its accompanying hysteresis loop, as in Fig. 7. The lines between

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points A and B and A' and B' are the linear portions of the curve. Note the similarity between this curve and the transfer characteristic shown earlier in Fig. 1. We can now use this curve to show the effect of recording a signal on tape.

In Fig. 8 the normal saturation curve is shown above and below the H axis. If magnetization in the reverse direction has the same force as forward magnetization, the lower half of the curve will be a mirror image of the upper half. Note, in Fig. 8, there is no bias and the only input is that of the signal itself. While the input is a sine wave, the output is a distorted waveform since just the nonlinear portion of the graph is being used. To overcome this condition, bias can be applied to put the operating point on the linear portion of the curve. The curve, however, has two linear sections, one above the H axis and the other below it. The bias could be d.c. and with one polarity would utilize the lower portion of the curve or with the opposite polarity, the upper linear portion. In early tape recorders that is what was done. This kind of biasing technique, however, takes advantage of only one small section of the saturation curve, and as a result, d.c. biased tape recorders had a restricted dynamic range. The modern technique is to use sinusoidal a.c. for bias.

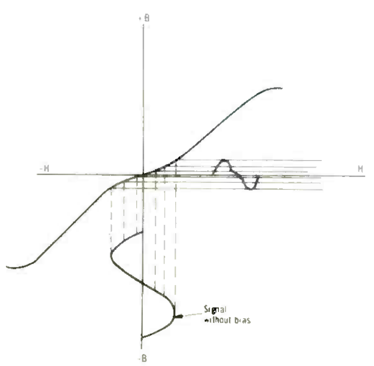

Fig. 8—Saturation curve and applied signal without bias.

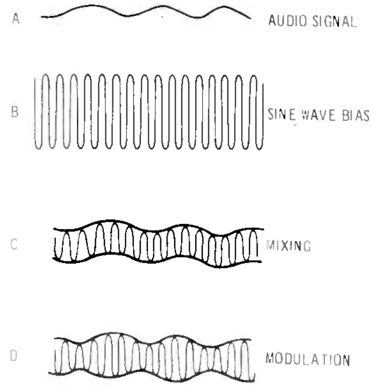

Fig. 9—A.c. bias plus signal is a mixing process, not modulation.

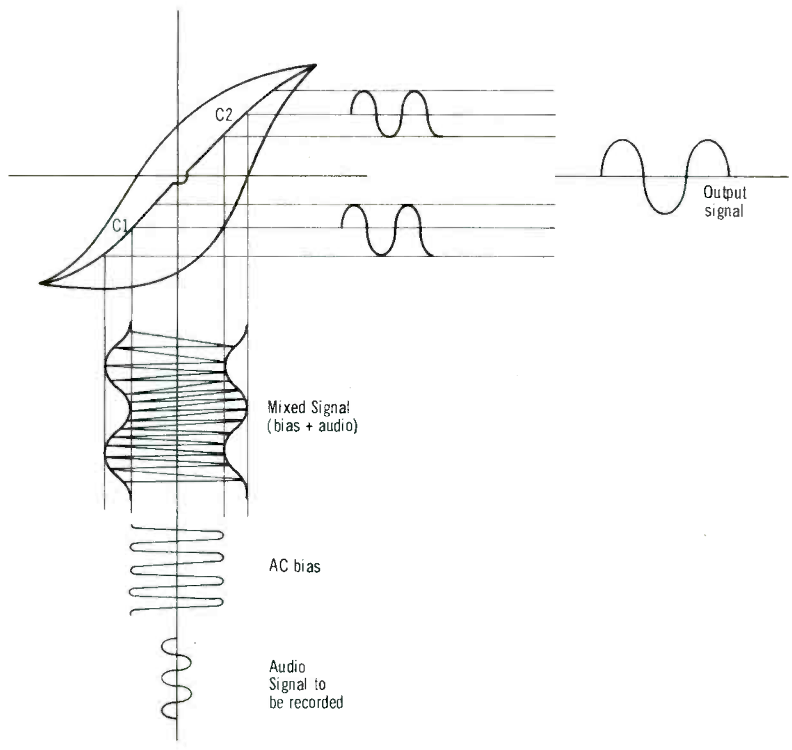

Fig. 10—Effect of a.c. bias is to put signal on linear portions of saturation curve.

Mixing vs Modulation

In broadcasting, the process of loading an audio signal on a sine wave carrier of much higher frequency is called modulation. However, in tape recorders, the audio signal does *not* modulate the bias but mixes with it. Figure 9A shows an audio signal while 9B in the same drawing represents sine wave bias. With mixing the amplitude of the bias remains constant, while in modulation the instantaneous values of the carrier keep changing. However, with either mixing or modulation, if we join the peaks by an imaginary line we will have a graph of the audio signal. Since there are two peaks—a positive and a negative peak for each cycle of bias—the result produces the effect of a duplication of the audio signal.

Biasing Tape

Using sine wave bias instead of d.c. now presents us with a technique for working with both linear portions of the transconduction curve. Figure 10 shows the complete action. Here we have the hysteresis loop and its resultant magnetization curve. The audio signal is mixed with an a.c. bias current and it is this mixture that is applied to the tape during recording. Note that the mixed signal has an upper and lower audio component and that each of these components is a replica of the original audio signal. Our magnetization curve, because of the presence of the a.c. bias, now has two operating points, both of which are centered on the two linear portions of the characteristic. This depends on the amount of bias current which must be such that the audio signal portion of the mixed signal is applied to *both* linear portions of the magnetization curve. Essentially, there are two outputs—one for the lower part of the curve and one for the upper portion. Both combine to supply a single output signal.

Now what about the nonlinear section of the magnetization curve? The bias is being applied to both portions—that above the H axis and that below it. This means there will also be nonlinear outputs. However, these cancel since they are out of phase. The technique is the same as that used to get harmonic cancellation in the output of a pushpull amplifier.

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The a.c. bias, for linear output, must not only be a pure sine wave, but must be evenly distributed around its X axis. This means there must be no d.c. component present in the bias since this would have the effect of pushing the operating point up or down on the magnetization curve, depending on the d.c. polarity.

Linearity of output is also dependent on the lengths of the straight line portions of the magnetization curve, and these, in turn, depend on the way the cassette tape is manufactured. If the straight line portions are small relative to the amplitude of the recording signal, the result will be use of the nonlinear sections of the curve, producing distorted output. If, however, the input audio signal is deliberately restricted to avoid this possibility, then the linear portion may be underutilized, resulting in limited dynamic range.

More About Bias

Bias, then, is a constant high-frequency signal that is mixed with the signal to be recorded. Its prime function is to permit recording a signal on magnetic tape in such a way that the output is distortionless, while at the same time supplying a good dynamic range. But this is by no means the whole story.

The bias frequency is in the supersonic range and is usually somewhere between 30 kHz and 100 kHz, or possibly a bit higher. As a general rule of thumb, cassette recorder manufacturers establish the bias frequency at about five times (or more) than the highest recorded audio frequency to avoid beats between harmonics of the audio signal and the bias.

Frequency response is affected by bias. This means that on fixed bias cassette decks, control of this important factor is out of the hands of the user. Bias is set at the factory by the recorder manufacturers. An examination of existing cassette machines shows there is roughly a 30% plus and minus variation among all cassette recorders in bias level settings for what can be considered "normal" or "zero" bias. These variations in bias, as mentioned earlier, affect a tape's frequency response characteristics.

The ability of a tape to perform properly over a wide range of bias settings is called bias tolerance or bias range. This is one of the factors to look for when buying cassette tapes. Bias range should be as broad as possible. The wider the bias tolerance, the more likely the cassette will perform well in all cassette players, with or without a bias selector switch.

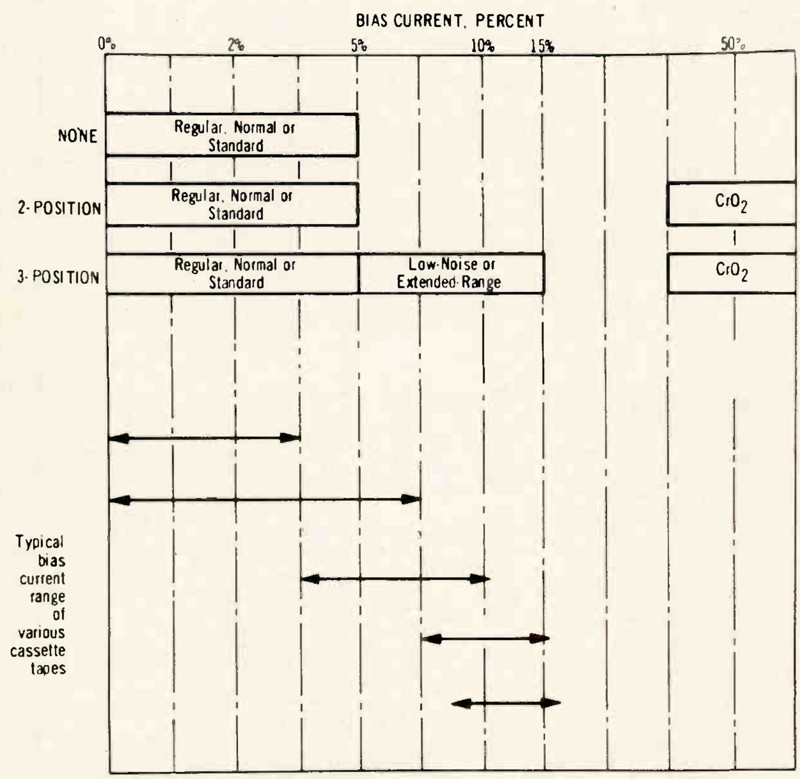

Fig. 11—Bias current ranges of various cassettes.

Bias noise is the major contributor to overall tape noise and hiss. It is present on all tapes, even when no signal is present. Obviously, it should be as low as possible; the ideal is zero.

Some cassette equipment manufacturers calibrate their bias oscillator output with a specific tape in mind. In all tape systems, the noise level (hiss) is also a function of the recorder itself. If low-level signals are recorded at higher levels and then played back at much lower levels, there will be a considerable reduction in hiss. If the equipment has Dolby noise reduction circuitry, the noise level can be diminished even more.

Tapes and Bias Current

The amount of bias current (Fig. 11) required by a cassette tape depends on the manufacturing processes used in making the tape. Inexpensive recorders do not have a bias switch and so the user has no way of varying the bias current. Bias in such recorders is sometimes referred to as "normal" or "standard" or "regular." On a scale of 0 to 100, fixed bias recorders operate with a bias current of 5 percent or less. However, the fact that a recorder uses fixed bias does not mean that all "regular" tapes made by all cassette manufacturers will produce the same results. Correct bias will produce linear output, but only if the properly formulated cassette tape is used with it. As an example, TDK's Super Dynamic and Extra Dynamic tapes can be put in fixed bias recorders, but they are also designed to work well with bias currents as high as 10-15 per cent. Recorders with no bias switch can also use TDK's LN or F-series cassettes.

A more flexible type of cassette recorder is one that has a two-position bias switch. One position is for ferric oxide (FeO) tapes and is generally marked standard, normal, or regular. With the switch in this position, the recorder works in the same way as recorders that do not have a bias switch.

With cassette decks that have a two-position bias switch, the second position is generally marked CrO_2, the chemical symbol for chromium dioxide. These tapes, as the name indicates, use particles of chromium dioxide instead of ferric oxide, as the magnetic particles on tape. While chromium dioxide tapes do represent a forward step to high fidelity since they give a better high-frequency response (or as good as ED), the tape as originally manufactured was excessively abrasive and

(Continued on page 105)

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Christmas

Advent Loudspeaker

The Advent/2 is housed in a high density polyurethane inner shell which is bonded to a white molded thermoplastic outer shell with a silver-gray grille. Said to allow the manufacturer to invest more cost in internal components, this cabinet is lighter and less expensive to produce than a wooden cabinet of equivalent acoustical performance. The system employs an acoustic suspension woofer (with a magnetic structure as massive as the original Advent loudspeaker) and two direct radiator tweeters, claimed to provide maximum dispersion with no interference effects. Resonance is 58 Hz; crossover, 1500 Hz; impedance, 8 ohms; recommended minimum power, 10 W./channel. Measuring $11\frac{1}{2}$ in. x 19 in. x $7\frac{1}{2}$ in. deep, the Advent/2 is available at $58.00.

New TDK Booklet

The *TDK Guide to Better Recordings* is a collection of tips and suggestions on how to make high quality recordings on any cassette deck. Step-by-step pointers show the recordist how to begin and follow through to the finished tape. Also covered are recording levels, reading VU meters, avoiding hiss and distortion, bias settings and noise reduction systems. Free from your local TDK dealer.

Archer Tape Solder from Radio Shack

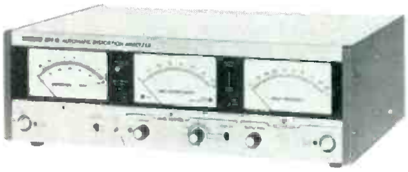
No soldering iron is necessary—just twist your wires together, wrap with Tape Solder and melt it with a match, candle or lighter. Said to be ideal for on-the-spot wiring and repairs, Tape Solder comes in a resealable plastic pouch of 100 pre-cut pieces for 89¢.

Technics Turntable

Panasonic is now producing a line of high quality, high fidelity components—the Technics line. Among these is the SL-1200 direct drive turntable. The turntable has, in effect, one moving part: the outer rotor of the motor and its shaft, of which the platter is an extension. Lacking idlers, belts and gears, the unit is said to rotate at the exact speed required without vibration, wow or flutter. The platter is aluminum diecast, dynamically balanced, weighing 3.86 lbs. with a 13-in. diameter. Speeds are $33\frac{1}{3}$ and 45 rpm; wow/flutter, less than 0.03% W. r.m.s.; rumble, better than -70 dB (DIN B); effective tonearm length, $8\frac{21}{32}$ in.; overhang, $\frac{9}{16}$ in.; minimum tracking force, 0.4 gm. There is also a pitch control with a 5% electrical adjustment, separate for each speed. Price: $269.95.

Buying Guide

Radiometer Distortion Analyzer



Said to be a complete audio performance test set, the BKF10 incorporates a distortion meter, sweepable AF oscillator, amplitude response meter, and a frequency indicator, all of which operate automatically. The unit determines both distortion factor and frequency response while the input signal is swept through four frequency decades from 20-20kHz. Results are continuously displayed on the front panel meters. The distortion meter can be converted to a S/N meter by means of a pushbutton and noise levels are displayed from -80dB to -20dB.

Nortronics Recorder Care Kits

The four new QM series kits are composed of all the essential items for inspection and cleaning of all types of recorders. Model QM-6, for cassette recorders and players, is $9.90. QM-7 is for 8-track cartridge machines, $9.90. QM-8 is designed for reel-to-reel recorders, $9.90. Model AM-9 is especially designed for cleaning all magnetic heads and is priced at $3.35. All kits are complete with detailed instructions for use.

Hartley Speaker Sentry

This self-powered, solid state control utilizes a closed loop feedback circuit to limit the amount of power dissipated in a speaker. Should the power exceed the level you have preset on the control, from 1 to 100 W. rms, the Speaker Sentry automatically reduces the input signal to the amplifier to the desired level. Using only milliwatts of power from your amplifier and reacting much faster than a common fuse, this component is available for $35.00.

Ferrograph Recorder

The Super-Seven is a 3-speed, 10½-in. reel unit offering several options. The recorder is available in 2- and 4-track stereo models with or without an integrated power amp and speakers. With 3 speeds (7½, 3¾, 1⅞ ips), the Super-Seven is the only reel-to-reel machine offering 1⅞ ips with Dolby B noise reduction. An optional high speed unit operates at 15, 7½ and 3¾ ips (Dolby not available for 15 ips) at no extra charge. Solid state with an FET front end, this unit features instant slur-free starts on record and PB, bias adjustment on front deck, variable speed wind/rewind, pushbutton tape/source comparison for each channel, electronic editing, pushbutton bias readings and tape track transfer, mic-line signal mixing, and automatic head demagnetization. Prices: 3-speed deck in walnut case (2 or 4 track), $950; 3-speed deck (2 or 4 track), with amp and speakers, $1000; Dolby unit, $125.

Equalization in the Home

John Eargle*

THE MOST significant advances in home music listening in the last five years have been the advent of quadraphonic sound, the general adoption of B-type Dolby noise reduction, and the "normalization" of loudspeaker/room response through system equalization. While quadraphonics represents a distinct *revolution* in the listening experience, noise reduction and system equalization are *evolutionary*, providing only improvements in what we may call the "transfer function" from studio to listener.

Our increased concern with these improvements stems mainly from the revolution which has been going on in the area of musical values; today, about 90 per cent of recorded product in this country is rock/pop, and virtually *all* of this product has its genesis over loudspeakers in the control room. Thus, noise reduction and equalization can justifiably be sought as ends in their own right.

Quadraphonic sound is happening at every turn, and the 15-year-old mono-stereo controversy is being re-enacted all over again. Noise reduction is being introduced gradually, and in a comparatively orderly fashion. It has long been an important part of the original recording process. A while ago it found its way to the cassette medium—one which was sorely in need of it. It has recently found its way into the production of reel-to-reel tapes, and it can make this medium, in either a stereo or quadraphonic configuration, the superlative one it was meant to be. It has also been introduced into FM broadcasting, and there it promises greater effective coverage for classical music stations.

The evolution of home sound system equalization has been neither orderly nor clear-cut in its direction. First of all, it has been, and will likely continue to remain, a fairly expensive "embellishment" on what is already a good sound system. Many systems, in many good listening rooms, simply do not need specific contouring of the system to the room. On the other hand, a marginal low-powered system *cannot* be equalized effectively at all.

*Altec-Lansing

A problem which has plagued the general adoption of home equalization has been one of adequate instrumentation—and who is to man that instrumentation. Sound level meters are rare; ⅓-octave noise tapes are rarer—and Real-Time Spectrum Analyzers are not only rare, but expensive as well. It seems that the average audiophile is expected to equalize his own system *by ear,* since the number of dealers willing to provide the service is suprisingly low.

Let us now consider in detail the particular goals of equalization, some of the specific hardware available for the purpose, and instrumentation necessary to equalize accurately.

The Goal Of Sound System Equalization

Most professionals consider sound system equalization to be the answer for the audiophile who wants to duplicate in his listening room the acoustics and ambience of the recording studio control room. This is an ambitious goal, and it can, quite honestly, be met only through the use of detailed ⅓-octave equalization. Before this can be done, care must have been taken that the power-handling capabilities of the speakers and amplifier at hand are equal to the demand; both the watts and the ability to *handle* the watts must be duly assessed. It's quite an investment—but one well worth it for the dedicated audiophile.

A second function of equalizers is met by the myriad one-octave devices which are available. These operate in a sense as "super" tone controls—such devices have perhaps nine to

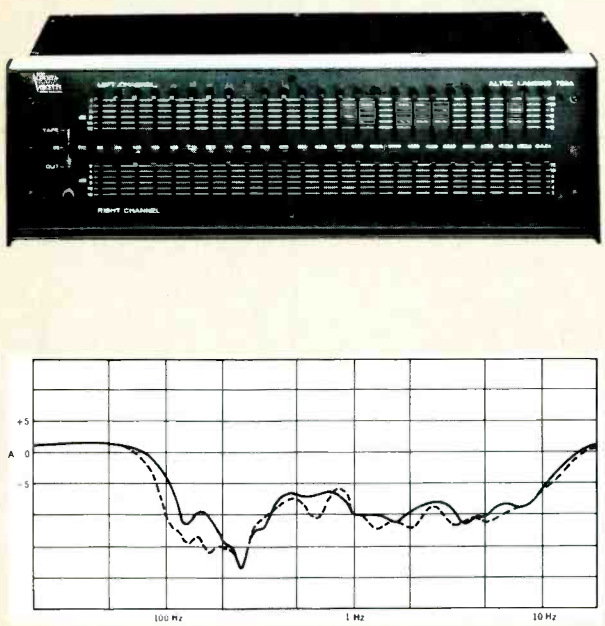


Fig. 1—The Altec Acousta-Voicette one-third octave room response equalizer and two typical electrical equalization curves produced by it.

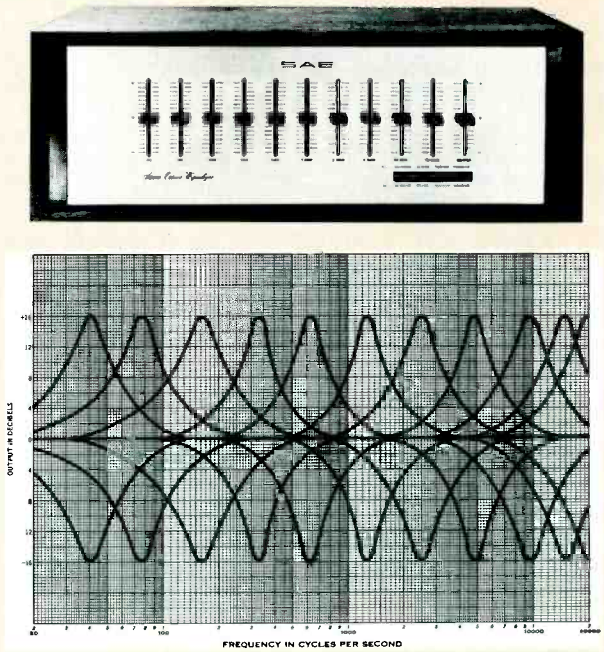


Fig. 2—The SAE MARK VII Stereo Equalizer and its family of curves.

Some of the reasons why other turntables don't perform quite like a Dual.

Because of the wide acceptance and acclaim Dual has earned over the years, especially among audio experts, many Dual features inevitably appear on competitive turntables.

To copy a Dual feature is one thing: to achieve Dual performance and reliability is quite another matter. The true measure of a turntable's quality is not its features alone, but how well the entire unit is designed and manufactured.

Following are just some of the ways in which Duals differ from other automatic turntables.

Gyroscopic gimbal suspension.

The gyroscope is the best known scientific means for supporting a precision instrument that must remain perfectly balanced in all planes of motion. That is why the tonearms of the 1218 and 1229 are suspended in true, twin-ring gimbals.

Every Dual gimbal is hand-assembled and individually checked with gauges especially developed by Dual for this purpose. This assures that the horizontal bearing friction of the 1229 for example, will be no greater than 0.015 gram, and vertical friction no greater than 0.007.

True single-play automatic tonearm.

A turntable of the 1229's caliber is used primarily in its single play mode, so the tonearm is designed to parallel a single record on the platter. For multiple-play, the entire tonearm base is moved up to parallel the tonearm to the center of the stack.

The 1218 tonearm provides the single-play adjustment within the cartridge housing, and the cartridge pivots around the stylus tip to maintain the correct overhang.

Stylus pressure around pivot.

Today's finest cartridges, designed to track at around one gram, have little margin for error. In the 1229, therefore, the tracking pressure scale is calibrated within 0.10 gram from 0 to 1.5 grams.

To maintain perfect balance on every Dual tonearm, stylus pressure is applied internally and around the pivot. This is accomplished by a very long spring coiled around the pivot. Only a small portion of the spring's length is needed to apply the required pressure, thus contributing greatly to the accuracy of the calibrations.

Avoiding sounds that weren't recorded.

The rotor of every Dual motor is dynamically balanced in all planes of motion. Each motor pulley and drive wheel is also individually examined with special instruments to assure perfect concentricity.

Any residual vibration within the motor is isolated from the chassis by a three-point damped suspension. Finally, every assembled Dual chassis is "tuned" to a resonance frequency below 10 Hz.

The best guarantee.

All these precision features and refinements don't mean that a Dual turntable must be handled with undue care. So we're not being rash when we include a full year guarantee covering both parts and labor for every Dual. That's up to four times the guarantee you'll find on other automatic units.

Now, if you'd like to know what several independent test labs say about Dual, we'll send you complete reprints of their reports.

Better yet, just visit your franchised United Audio dealer. You'll see for yourself that only a Dual performs precisely like a Dual.

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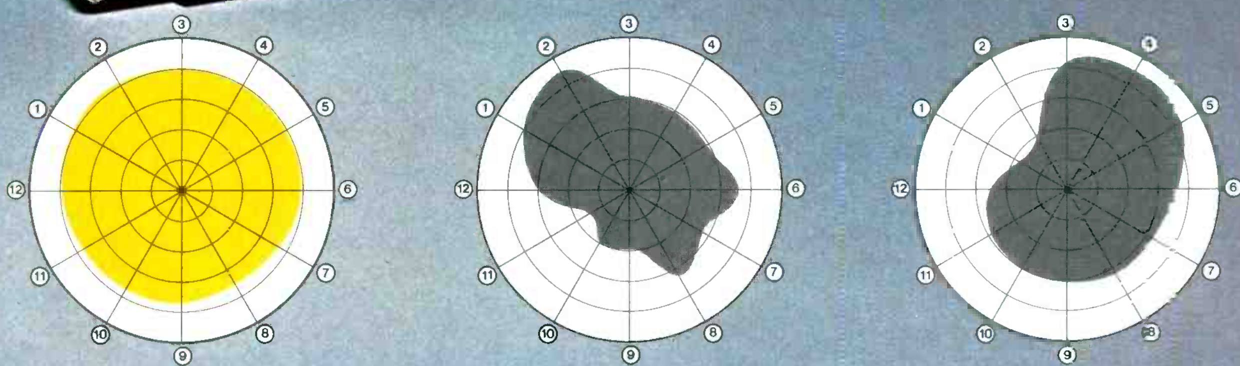
TDK's ED has more of what audiophiles want...



TDK EXTRA DYNAMIC (ED) | Competitor A | Competitor B

extra dynamic performance

If you're an audiophile you know what you want—the best cassette there is. That's why you'll insist on TDK's top-of-the-line EXTRA DYNAMIC (ED). Once you discover ED's superior total performance, you won't settle for anything less than the cassette with more of everything.

EXTRA DYNAMIC offers audiophiles an entirely new dimension in cassette recording fidelity. Its performance characteristics—shown above on TDK's Circle of Tape Performance (see opposite page) — are better balanced and superior to those of any other cassette now on the market, including the two competitive so-called "hi-fi" cassettes also shown.

ED's superior total performance results from use of TDK's exclusive new "Stagnetite"® (stabilized magnetite) coating plus a special binder and proprietary techniques. ED cassettes have the industry's highest MOL (maximum output level), broader dynamic range, extended frequency response, higher signal-to-noise ratio and other characteristics for incomparably fresh, rich and full-bodied sound on *any* recorder, without need for special bias.

Ask your dealer for TDK EXTRA DYNAMIC cassettes when nothing but the very best total performance will do. Once you try ED, you'll wonder why you ever used anything else.

the new dynamic world of

TDK®

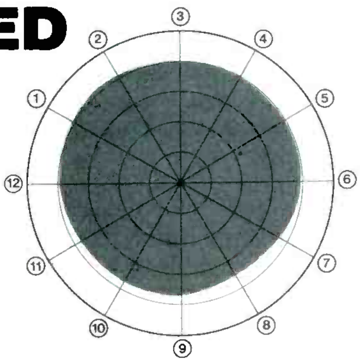
TDK ELECTRONICS CORP.
755 Eastgate Boulevard, Garden City, New York 11530

TDK's EXTRA DYNAMIC (ED), SUPER DYNAMIC (SD) and DYNAMIC (D) cassettes are available in 45, 60, 90, 120 (SD & D) and even 180-minute (D only) lengths, TDK KROM (KR) chromium-dioxide cassettes are available in 60 and 90-minute lengths. At quality sound shops and other fine stores.

more about
TDK's circle of tape performance
....a whole new way to evaluate tape

A tape's ability to provide "real-life" sound reproduction depends not only on its MOL (maximum output level) values and the familiar frequency response characteristics, but also on the value and proper balance of a number of other properties. TDK has arranged the twelve most important tape characteristics on their exclusive CIRCLE of TAPE PERFORMANCE diagrams, shown below. Each of the radii represents one of the twelve factors, and the outer circle represents the ideal, well-balanced characteristics of a "perfect" tape. The closer the characteristics of any cassette tape approach those of the ideal (the larger and more regular the pattern), the better the sound reproduction capabilities of the cassette. The goal is to reach the outer circle. Compare TDK's well-balanced characteristics with those of the two leading so-called "hi-fi" competitive cassettes and a typical conventional tape. Judge for yourself which provides the best characteristics for true high fidelity performance.

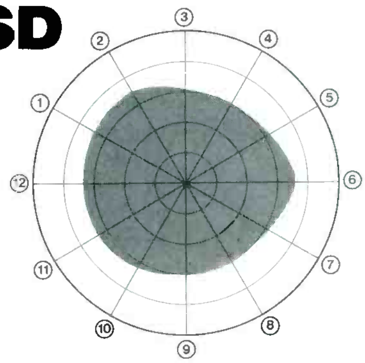
ED



EXTRA DYNAMIC

for the discriminating audiophile, an entirely new dimension in cassette recording fidelity. Vastly superior to any other cassette, with unmatched performance on any deck. 45, 60 and 90-minute lengths.

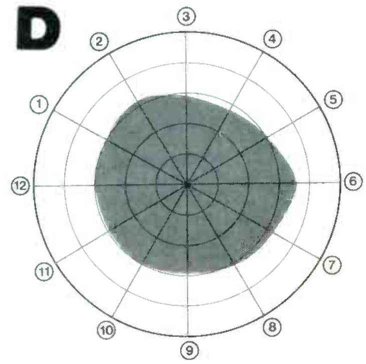
SD



SUPER DYNAMIC

turned the cassette into a true high-fidelity medium. Outstandingly clear, crisp, delicate reproduction of the complex characteristics of "real-life" sound. 45, 60, 90 and 120-minute lengths.

D

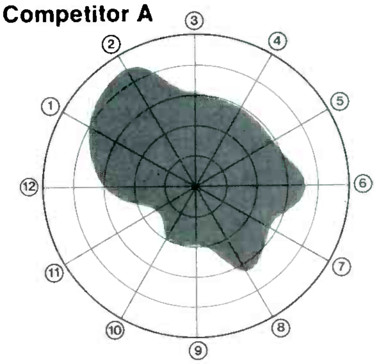


DYNAMIC

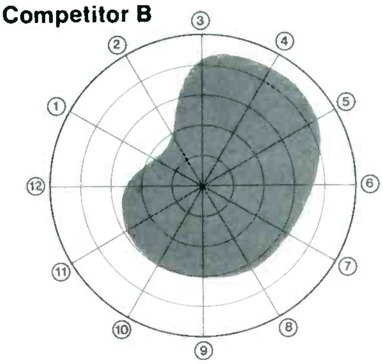
excellent hi-fidelity at moderate prices, with well-balanced performance characteristics superior to most "premium" cassettes. 45, 60, 90, 120 and 180-minute lengths — the world's only 3-hour cassette.

1-MOL @ 333Hz
2-Sensitivity @ 333Hz
3-Sensitivity @ 8kHz
4-Sensitivity @ 12.5kHz
5-MOL @ 8kHz
6-Erasability
7-Bias Noise
8-Print-Through
9-Modulation Noise
10-Output Uniformity
11-Uniformity of Sensitivity
12-Bias Range

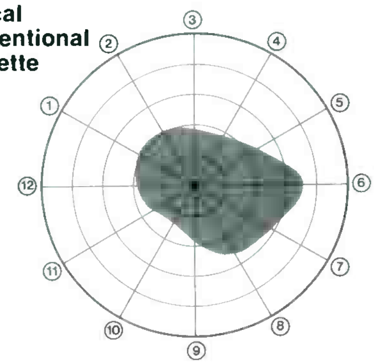
Competitor A



Competitor B



Typical Conventional Cassette



ED'S EXCLUSIVE NEW "STAGNETITE® COATING

TDK EXTRA DYNAMIC is the world's only tape with a magnetic coating of "Stagnetite". The coating consists of microscopically fine particles of stabilized magnetite in a special binder. Magnetite is a material with magnetic properties which make it ideal as a recording medium, except that in its natural state it is not sufficiently stable. TDK discovered a way to permanently stabilize magnetite particles; the result (Stagnetite) is a perfect coating material for magnetic recording tape, contributing to ED's unrivaled "real-life" sound reproduction capabilities.

THE IMPORTANCE OF HIGH MOL

TDK's EXTRA DYNAMIC tape has the highest MOL values of any cassettes on the market today. MOL means maximum output level, and is perhaps the most important single characteristic of a recording tape. MOL is the output signal level resulting from an input signal which produces 5% distortion in the output. A tape with high MOL can be recorded at higher input levels without audible distortion on playback. High MOL lets you faithfully reproduce all the complex transient phenomena, subtle overtones and important harmonics that give the original sound its natural warmth, richness, depth and feeling.

Fig. 3—The 8050A Real Time Analyzer, a device which provides continuous monitoring of sound energy levels in one-third octave bands. The response, which is updated each 30 milliseconds, can be viewed in either *fast* or *slow* modes.

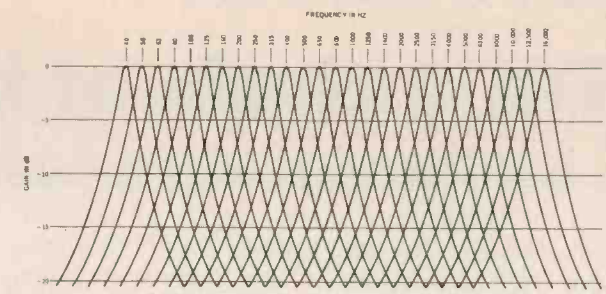


Fig. 4—Filter response curves for the 8050A Analyzer.

eleven vertical slide controls which allow the user to tailor his system by ear. They are indeed useful devices, considering the variety of monitoring conditions between studios and the resultant spectral variations in records.

A typical example of a ⅓-octave equalizing system is shown in Fig. 1. This device, the Altec Model 729 Acousta-Voicette, enables the acoustical contour to be continuously and smoothly manipulated between the frequency extremes of 63 Hz and 12.5 kHz. It is a stereo unit and is normally inserted at the tape-out/monitor-in terminals of a typical stereo preamplifier or receiver. The Model 729 has the normal tape-in/tape-out monitoring facility which provide total flexibility in interfacing this device with a high-quality stereo system.

Typical of a one-octave wide equalizer is the SAE Mark VII Octave Equalizer. This device is available in a stereo model capable of handling the frequency range from 40 Hz to 20 kHz. Another octave-wide device is the Shure Model 610 Equalizer. Whereas the SAE device is a *graphic equalizer,* offering peaking as well as dipping functions for each vertical slide control, the Shure device, like the Altec 729 offers a family of combining-type attenuation-only curves. Figure 2 shows the SAE Mark VII along with a family of typical response curves for the device.

Instrumentation

Real time analysis has greatly simplified the equalization process in both the consumer and professional areas. The Altec Model 8050A Real Time Analyzer is shown in Fig. 3. The device, introduced in 1971, has reduced the cost of real-time analysis to almost one-third of what it had formerly been, and this means that hi-fi dealers as well as professional sound contractors can perform detailed equalization at moderate cost to the consumer as well as moderate investment for themselves. Figure 4 shows the response curves of the individual filter sections which are displayed on the screen of the 8050A.

The Interaction Between The Loudspeaker and Listening Room

A typical high-quality loudspeaker system located in a 20' x 15' x 9' living room may present a pre-equalization response as shown in Fig. 5-A. A pink-noise generator, which provides a random noise signal exhibiting equal energy-per-octave, is applied to the monitor input of the system.

One may be surprised to see such a wide range of response —on the order of 16 dB—but this is typical of many high-quality systems in many rooms. The inverse curve was introduced with the Altec 729 equalizer flat out to 8 kHz, with a 6 dB/octave roll-off above that point. Some kind of controlled high frequency roll-off is desirable to compensate, at least in part, for the fact that most records are themselves mixed and mastered over systems exhibiting a degree of high frequency roll-off. This is a standard situation throughout the industry; what is *not* standard is the precise degree of roll-off.

The 16 dB response variation, once it has been corrected, calls for a 40-to-1 power ratio, and consequent power reserve, between the equalization extremes. Specifically, in order for the left channel of the system of Fig. 5 to produce the same response level at 40 Hz as it does at 250 Hz, it will require *40-times* more power; if 2.5 watts are sufficient at 250 Hz, then 100 will be required at 40 Hz. It has long been observed that the prime problem areas in most equalized systems are the insufficient provision of low frequency power as well as the inability of the loudspeaker to handle such powers. As we have said earlier, only *good* systems can be equalized.

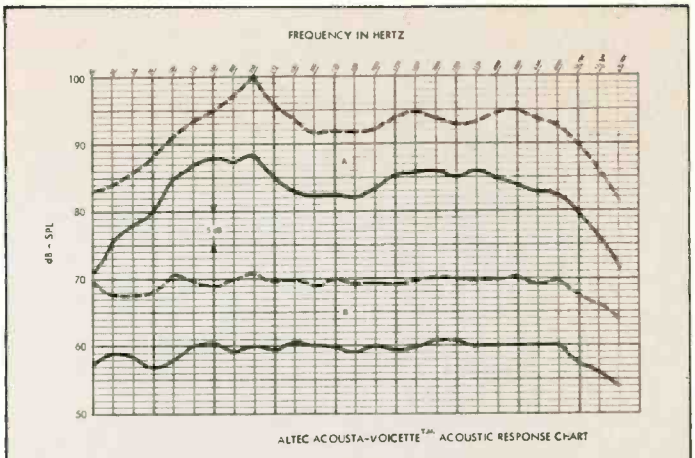


Fig. 5—Typical before and after acoustical response curves for a stereo system in a normal environment. Equalization provided by an Altec 729 Acousta-Voicette monitored by an 8050A Analyzer.

"Pre-Equalized" Loudspeaker Systems

More and more, we are seeing loudspeakers in the marketplace with their own complementary active equalizers. These devices, placed just ahead of the power amplifier, provide fairly broad correction for the most commonly met loudspeaker/room difficulties. The usual problem is shown in Fig. 5; it is the tendency of most room/loudspeaker combinations to exhibit a substantial peak in the 80 to 200 Hz range with a fall-off of bass response below 60 Hz.

The difficulty is largely one of the architectural acoustics; the majority of living rooms are too small to propagate extremely low frequencies as efficiently as the shorter wave

Fig. 6—The Altec "Concept EQ" loudspeaker system.

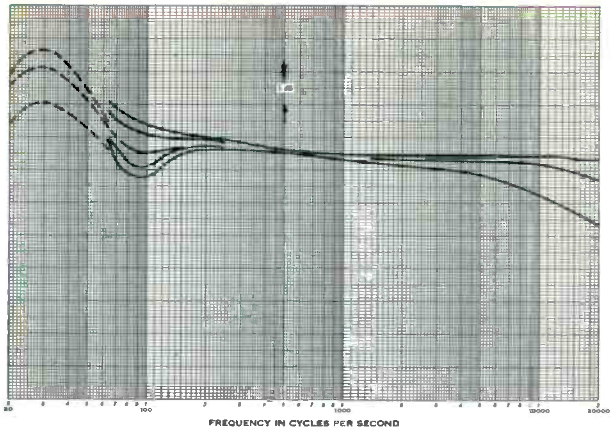


Fig. 7—Electrical response curves typical of the active equalizer portion of the Concept EQ System.

lengths of the mid-bass and lower mid-range regions. The high frequencies are furthermore attenuated due to furniture, carpet, and drapes. The usual sound is described as "thick and muddy," without the "impact of really massive bass." Any loudspeaker designed for flat response in an anechoic chamber will suffer the same fate in such an environment.

One interesting practical solution to this problem has been met by the Altec Concept EQ, shown in Fig. 6. This system is designed basically as a *flat system* in terms of its energy output into a uniformly absorptive environment. It is equipped with a 3-control variable equalizer, whose response curves are shown in Fig. 7. Here we show the flexibility of high frequency tailoring and suppression of an 80 to 150 peak in the solid curves; the dotted curves show the range of extreme low-frequency boost. Actually, the equalizer portion of the Concept EQ system is a welcome adjunct to most wide-range systems, and is separately available at a cost of $125.

Another very well-known system with an integral active equalizer is the Bose 901. Here, the design aim was to provide the electrical equalization necessary for an array of nine loudspeakers to produce a flat spectral output under the specified mounting conditions of eight speakers facing a reflective wall of large dimensions at a distance of about one foot. The Bose equalizer provides a variety of high-frequency tailoring and a "below-40 Hz" cut-off function for alleviating excessive record rumble and other sources of amplifier overload. There is no specific tailoring of the mid-bass response or adjustment to varying room acoustics. Figure 8 shows the range of the Bose equalizer.

Hints for the Audiophile

So far, we haven't been too encouraging. We've told you how *good* sound system equalization is—but we've also told you how expensive it is and how difficult it may be to make it perform properly. The well-to-do audiophile in a large urban area can always purchase an Acousta-Voicette for the sum of $875 from a qualified Altec sound contractor or hi-fi dealer and be assured that the equalizer will be properly adjusted.

On a less ambitious level, he can buy an equalizer, either one-third or one-octave, and equalize it himself by ear—or through the use of any of a number of phonograph discs made for the purpose. Such records date back to early issues of the famous CBS Laboratories Test Record Series, and in recent times the Altec Acousta-Voicing test record has certainly been the best known. This record presents carefully calibrated one-third noise bands covering the range of frequencies which can be adjusted by the Acousta-Voicette. The record is designed to be played back *via* the normal RIAA playback response, and monitored with a Sound Level Meter (SLM). With this device, the sound pressure output from each band is carefully noted and charted. The accuracy of the Acousta-Voicing test disc is ± ¼ dB from 50 Hz to 2000 Hz and ± 1½ dB above 2000 Hz.

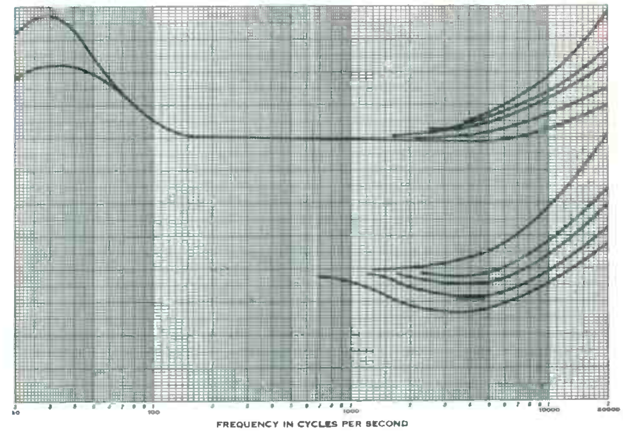


Fig. 8—Electrical response curves of the active equalizer portion of the Bose 901 loudspeaker system.

An audiophile wishing to equalize his own system with this disc should observe the following:

1. Make sure that the SLM is operating in its *flat* mode—the so-called "C" scale.
2. Make sure that the phonograph cartridge is a flat one—and in excellent condition. The better crop of today's cartridges working into good preamps just about guarantee this. If the cartridge is not *flat*, then the resultant equalization will be "biased," so to speak, in favor of the phonograph cartridge, and other input signals, a tape recorder for example, will be reproduced with an improper contour.

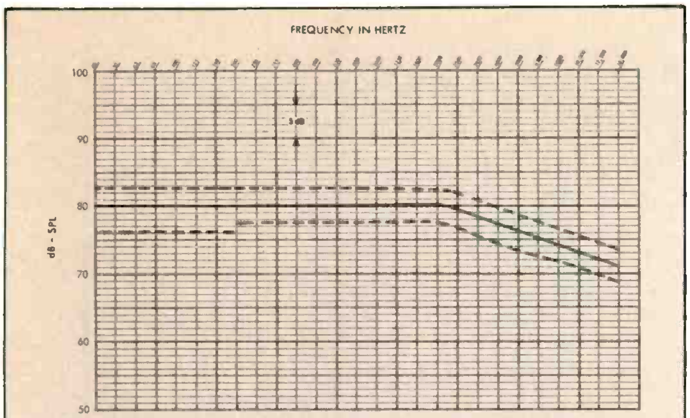


Fig. 9—Optimum acoustical contour for equalization of home systems.

3. Take your time; don't try to equalize too quickly. Adjust a few controls at a time—and then only slightly. Special graph paper is available to facilitate plotting of the curves, and the Altec dealer who can provide the Acousta-Voicette can also provide the disc and the graph paper.

4. Don't try to equalize the system to a *flat* contour. Let it roll off above 2 kHz at about 3 dB-per-octave. This is shown in Fig. 9. A tolerance of ± 2½ dB can usually be maintained over the range from about 200 Hz up to 8 or 9 kHz, if sufficient care is taken. Below 200 Hz, the effects of room resonant modes, with their characteristic peaks and dips, tend to dominate the response. In the region below 200 Hz we simply have to accept dips in the response of perhaps 4 dB; peaks should be held as low as possible. Always perform the equalization with the SLM located at the prime listening position.

Why the Response Should Not Be Flat

At least at the present time, the acoustical response of a playback system, whether in the studio or in the home, should exhibit a rolled off response above 1 or 2 kHz. Let us see why this should be the case by going all the way back to the recording studio and examining the consequences of flat monitoring of recorded product. At this point, the author quotes from a paper given at the AES Convention in Rotterdam, February 1973:

"Another important consideration in equalizing monitor systems is the precise tailoring of the high-frequency response. The question of 'flat *vs.* rolled-off' response has been discussed in some detail, and there is a general consensus among recording engineers that some sort of high frequency roll-off is desirable. The reasons, of course, are obvious; most home playback equipment exhibits substantial high-frequency roll-off at normal listener's positions, and a recording monitored and equalized over a system exhibiting the same kind of roll-off will convey most of the musical values the recording producer had in mind. On the other hand, a recording monitored and equalized on a flat system would surely sound dull and lifeless played over the rolled-off system. The answer to the problem is not to make all systems flat; that would call for a reassessment of present disc equalization standards, not to mention the problems of playback equipment design and obsolescence. Rather, the answer is to be found in standardizing on a degree of roll-off, with reasonable tolerances, which can be met by the manufacturers of home playback machinery and studio monitors alike."[1]

1. J. Eargle: "A Summary of Recording Studio Monitoring Problems" given at the 44th AES Convention in Rotterdam, February 1973.

The 400 millisecond miracle.

Most people seem to take for granted the smooth, effortless way in which a Revox works.

And that is as it should be.

For a great deal of time, effort and sophisticated engineering have gone into translating extremely complex function into lightning quick, responsive operation.

For example, when you press the play button of a Revox, you set in motion a sequence of events that take place with the precision of a rocket launching.

It begins with a gold plated contact strip that moves to close two sections of the transport control circuit board.

Instantaneously, the logic is checked for permissibility. If acceptable, a relay is activated.

Within 15 milliseconds, power is supplied to the pinch roller solenoid, the brake solenoid, the back tension motor, a second relay and, at the same time, the photocell is checked for the presence of tape. If present, Relay One self-holds.

Elapsed time, 25 milliseconds.

At 30 milliseconds, Relay Two closes and puts accelerating tension on the take-up motor.

The logic checks are now complete and power is available to actuate all necessary functions.

From 30 milliseconds to 300 milliseconds, mechanical inertia is being overcome and the motors and solenoids are settling down.

By 300 milliseconds, the brakes have been released, the pinch roller is in contact with the capstan shaft, the tape lifter retracted, the playback muting removed and the motors have come up to operating speed.

At 350 milliseconds power is cut off from Relay Two, which changes over to another set of contacts, releasing the accelerating tension on the take-up motor and completing a circuit through Relay One that, in turn, restores normal tension to the take-up motor.

Total elapsed time, 400 milliseconds. The Revox is now in the play mode.

And it's all happened in a fraction of the time it takes to read this sentence.

The 400 millisecond miracle. **More proof that Revox delivers what all the rest only promise.**

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England: C.E. Hammond & Co., Ltd., Lamb House, Chiswick, London W4 ZPB. Available in Canada.

The Workbench

Heathkit IM-102 Digital Multimeter

MANUFACTURER'S SPECIFICATIONS

D.c. voltmeter: 5 ranges—200 mV, 2V, 20V, 200V, and 1000 V. **Accuracy**: ±0.2%±1 digit with furnished calibrator; ±0.1%±1 digit with lab calibration. Overload protected. **Ohmmeter**: 6 ranges—200 ohms with 1 mA test current; 2000 with 100 μA; 20,000 with 10 μA; 200k with 10 μA; 2.0 megohms with 1 μA; 200 megohms with 100 nanoamps. **A.c. voltmeter**: 5 ranges (same as d.c. voltmeter). **Accuracy**: 0.75% ±1 digit with calibrator from 40 Hz to 10 kHz; increasing to maximum of 1.5%±1 digit on 1000 V range. Overload protected. **D.c. ammeter**: 5 ranges—200 μA, 2 mA, 20 mA, 200 mA, and 2A. **Accuracy**: ±0.5%±1 digit for 2-amp range, better on other ranges. Overload protected to 3 amps. **A.c. ammeter**: 5 ranges (same as d.c. ammeter) **Accuracy**: better than 1.5%±1 digit on all ranges. **Display**: Maximum count, 1999, with overrange indication automatic beyond 1999; polarity indication, automatic "+" or "–" (on d.c. ranges). Numeric display by side-viewing neon glow tubes with integral decimal points. **Dimensions**: 3 in. H x 7 in. W x 7.9 in. D. **Weight**: 8 lbs. **Price**: $229.95.

Anyone who has ever done any servicing or experimenting with either linear or digital IC's will certainly welcome this instrument. Having made hundreds of measurements with the older Heathkit IM-18 vtvm, the writer has been annoyed by the need for switching from "+" to "–" every time the probe was moved from one point to another (almost). The automatic polarity indicator eliminates this requirement and thus speeds up the measurement procedure appreciably. In comparison with the older vtvm—which has given many years of reliable service—the increased accuracy of reading the instrument is noticeable, and especially with solid-state devices, the minimum range of 200 mV is extremely useful. This observer never could see the reason for having a digital instrument until finally putting one into daily use—and now would not be without one. The IM-102 is not inexpensive compared to the IM-18 which is priced at $29.95, but it is a worthwhile investment in any case, and does not require occasional replacement of the ohmmeter battery.

Principle of Operation

The IM-102—and most other digital multimeters, for that matter—combines analog and digital techniques. The basic input range—either 200 mV or 2 V—is the voltage to which all inputs are converted by the range switch. This basic voltage—protected by a pair of diode-connected bipolar transistors—is fed to a linear IC and its output charges a capacitor, which is then discharged at a constant rate. The time required to discharge the capacitor is measured by the number of cycles of the 40,000-Hz clock oscillator that it takes to discharge it. This action takes place every 200 milliseconds, and the number of cycles of the clock that pass during the discharge period are counted, decoded, and displayed. Measurement of resistance is done by passing a specific current through the unknown and measuring the voltage drop across the unknown, so the instrument is still a voltmeter. For a.c. measurements, the input is converted to d.c. by an average-sensing, rms-calibrated converter. Thus the instrument is always a voltmeter, regardless of the quantity it is measuring. This is, of course, true of any vacuum-tube multimeter, and with the except of measuring shunts across the meter movement, this also applies to *any* multimeter. Even then, one could say that the meter movement itself is actually a voltmeter that draws a finite amount of current when making any measurement.

It should be noted here that the input resistance of the IM-102 is considerably higher than in the average vtvm on the two lowest ranges. On the 200 mV range, the input resistance is greater than 100 megohms, and on the 2-volt range it is greater than 1000 megohms, whereas most vtvms have a constant input resistance of 11 megohms. On the three highest ranges, input resistance is 10 megohms, which is approximately the same as with vtvms. Similarly, the test current ranges from 1 mA on the 200-ohm range to only 100 nanoamps on the 20-megohm range. On the a.c. voltage ranges, the input impedance is constant at 1 megohm shunted by 150 pF, and the voltage in the current-measuring modes is only 0.2 volts for both a.c. and d.c.

The main differences between the digital instrument and its counterparts is in the method of displaying the results. In an analog instrument, the display is always on the scale of a meter—usually with a movement sensitivity of 50 microamps for a 20,000-ohms-per-volt instrument or of 200 μA for a 5000-ohms-per-volt model. In the digital instrument, the actual voltage *measurement* is done by analog techniques, and the readout is supplied by display elements—in this case, by neon tubes of the "Nixie" type. Three such tubes are employed, each with full display of numerals from 0 to 9, which accounts for a maximum display of 999. The fourth digit—required to provide a display of 1999—is simply an ordinary neon tube with elements of the same length as the height of the numerals in the display tubes.

Assuming the determination of the number of cycles of the 40-kHz oscillator that pass during the measurement of the discharge time of the integrating capacitor, and repeating this measurement every 200 milliseconds (that is, five times per second), there are 8000 cycles to work with during each measurement period. The actual number of cycles elapsed are counted, fed into buffer-storage units, and then fed to decoder-drivers which actuate the three numerical display tubes. Separate dual flip-flops actuate bi-polar transistors which cause the fourth digit (the "1") to be illuminated, the "over" lamp to light up, or to display the "+" or "–" lamps for d.c. polarity.

The normal display range is 1999, which could be either 199.9 μA, or mV, 1.999 mA or volts, 19.99 mA or volts, 199.9 mA or volts. The maximum d.c. voltage range is 1000; on

dynaco 4-d amp kit

Value—the SCA-80Q is the only 4-D amplifier in kit form and for the same cost as a similar two channel amplifier. From a built-in ce-matrix circuit at the **output** of the amplifier, connect four speakers (such as the very popular DYNACO A-25s). Uncover hidden concert hall ambience in many conventional two channel discs, tapes and FM broadcasts and recreate the original sonics with new 4-D recordings. Or use two speakers now for stereo and add others later. 40 watts RMS per channel, simple assembly, careful engineering, low distortion and superb versatility go together to give traditional DYNACO excellence.

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Also available in Canada from DYNACO OF CANADA, LTD., Montreal, 760, Quebec, Canada

a.c. it is 500; and for the current measuring positions it is 2 amperes—1.999 A plus the "over" light. Operation is quite simple, since there are only two knobs—one controls the function, with positions marked mA and volts/ohms in the d.c. section and V and mA in the a.c. section. The other knob, with twelve positions, is labeled in volts and mA from 1000 to 2, then 200 mV or μA, with six positions labeled from 200 to 20M for ohms. The initial position is the power-off condition. Three banana jacks are mounted on the front panel—red for volts and ohms, black for common, and white for mA. Note that the instrument measures both direct and alternating voltages *and* currents, with the conversion from a.c. to d.c. being done by the a.c. converter circuit board on which are mounted one linear IC, one bi-polar transistor, and one FET, four diodes, and two adjustable controls for calibration.

The power supply, integral with the main circuit board, consists of the transformer (mounted on the rear panel) which feeds 54 volts center tapped to a full-wave rectifier, 12.7 volts center tapped to another full-wave rectifier, and 102 volts to a half-wave rectifier circuit to supply the operating voltage to the display tubes and the neon indicator tubes. The 22 volts d.c. following the rectifiers feeds the collector of a power transistor which is controlled by another transistor which is referenced by two Zener diodes to furnish ± 12 volts to the linear IC's and to most of the transistors in the unit. The 6.75 volts d.c. following the low-voltage rectifiers is fed to a Darlington-connected transistor (all in one package) and referenced by another Zener diode to supply 3.5 volts to the digital IC's. The 102-volt winding is rectified by a single diode to furnish 95 volts to the display tubes. This winding also supplies either a.c. or d.c. at an adjustable 9.0 volts for use in the calibrating procedure. In all, the circuit employs a total of 19 IC's (three of them linear), 18 transistors, six Zener diodes, and 19 diodes of varying characteristics to actuate the three digital display tubes and the four neon lamps which indicate polarity, overrange, and the "1" of the digital display.

Construction

The layout of the instrument is interesting in its simplicity. The range switch consists of an eleven-wafer switch which is designed for printed-circuit board use, and which is first disassembled to "straddle" the a.c. converter circuit board, then installed on the main circuit board and its 25 contacts soldered in place. Several other connections are made to the switch by wires and by components. This arrangement puts the a.c. converter circuit board some two inches to the rear of the front panel, with a number of other connections making a sturdy mounting. The four-wafer function switch has 24 contacts which solder similarly to the circuit board, and which is entirely in front of the converter board.

The circuit boards are glass epoxy with foil connections on both sides, and with appropriate "solder-through" points. The DIP IC's mount on Molex connectors which are first soldered in place in strips of seven or eight and then the connecting backbone is broken off, using a "tool" furnished for the purpose. The three linear IC's are housed in the familiar TO-99 case, and they mount in a series of female connectors which accept the pins of the IC in the same manner as a tube socket. Most of the bi-polar transistors simply solder to the foil, in the usual way for installing transistors. Two dual transistors, each with six pins, mount in the connectors as used for the linear IC's. The three digital display tubes mount in sockets which are soldered to the circuit board, and the neon single tubes for the "1" and the overrange indicator are also soldered to the circuit board, being positioned by a plastic light shield which holds them in the proper locations. The + and – indicator lights also mount in the plastic shield.

The various indicators are visible through the smoky plastic front panel window with the designations visible as illuminated to indicate the +, –, and "over." A pressure sensitive light shield is furnished to provide a black background behind the display tubes.

On the whole, the instrument goes together with usual Heathkit ease. The rear panel is screened with a space for the Heath label which is put on to cover the lettering for the line voltage for which the instrument is *not* wired, leaving the line voltage for which it *is* wired visible. Fuses mount on the side panel to protect the line voltage supply (¼ amp) and for the voltage-measuring circuits (¼ amp) and the current-measuring circuit (3 amps).

The a.c. line cord is a three-wire assembly with the usual three-terminal plug on one end and a female receptacle on the other which plugs into the male connector on the rear panel. The housing consists of a top cover and a bottom cover which are held in place by the side trim strips. The handle, with its plastic grip, is detented to hold it in any of three positions—for carrying or for a tilted position on the workbench.

Calibration

While the instrument may be calibrated using laboratory equipment, the average constructor will use the d.c. calibrator furnished with the instrument. This device is a small circuit board on which are mounted a 1.35-volt mercury cell, three fixed resistors, and two adjustable ones (one is factory set). This device provides an accurate source of 0.2 volts which is used to calibrate the 200 mV range of the unit. Connecting one lead from the calibrator to the 3.5-volt test point on the instrument permits the adjustment of the variable resistor to provide an accurate 2.0 volts which is used to calibrate the 2-volt full-scale position.

The a.c. calibrator circuit is built directly into the instrument and permits accurate adjustment of the a.c. circuits, after first making an adjustment to provide an indicated 9.0 volts d.c. with the calibrator switch in the d.c. position. Possibly hard to explain but simple to do.

We assembled the instrument in about 10 hours with no problems attributable to Heath, and only one attributable to ourselves—we connected the black "common" lead to where the "hot" red lead should be and vice versa, resulting in some odd indications until we found the trouble and corrected it. After that, the unit worked just as expected. While the specifications seem to indicate that the a.c. response is somewhat limited in frequency response, we compared the voltages indicated with those indicated on a Heathkit a.c. VTVM, model IM-38. Practically the same indications were observed at any frequency up to 100,000 Hz on both instruments, and both coincided with the output indications on the IM-72 audio generator. It would probably be desirable to make a complete check on any individual instrument to make sure that this performance is duplicated, but it was a pleasant surprise to find such an agreement throughout the audio spectrum in spite of the specifications. Maybe we were just lucky, but that is what we found.

The digital multimeter is a real joy to use when working on circuits which employ both positive and negative polarities as is common with IC circuits, and being able to read voltage to as low as 1 mV is most helpful in almost any transistor circuits. The IM-102 is an exceptionally useful instrument, and after living with one for a few days, the user would never give it up for the older analog instruments. The addition of current-measuring capability to the usual voltage-measuring qualities of the average multimeter makes it an important instrument for any workshop or laboratory. Try it—you'll like it!

C. G. McProud

THE 800+ IS.

The world's most advanced multichannel receiver is a production reality. It is available in your area now, or it will be soon.

The Harman/Kardon 800+ multichannel receiver is equipped with built-in CD-4 circuitry. Newer, more compact, more efficient circuitry than standard industry use.

It is also equipped with built-in matrix circuitry. Also newer, more compact, and more efficient.

This means that the 800+ is able to play all mono, stereo, and quad systems now. There is nothing you have to add. No accessories to buy.

If you're interested in power, you'll be delighted and astonished to learn that the 800+ is rated at a remarkable 22 watts RMS per channel quad, 50 watts RMS per channel stereo.

Because unlike most four channel receivers, the 800+ is equipped with a bridging circuit that allows you to transfer all the power to 2 speakers when you want to play stereo.

A unique phase shift network is Harman/Kardon's answer to those who would like to play their stereo records through four speakers for an enhanced stereo effect.

And lastly, the 800+ is another from a long line of Harman/Kardon ultra wide bandwidth receivers.

So its phase linearity and square wave response match the matchless lab results of other Harman/Kardon products.

But important as bench test numbers are to verify performance, what really matters in the end is sound.

Because if you have great numbers but you don't have great sound, then the receiver is a fraud.

And, that, the 800+ is not.

HARMAN/KARDON

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Check No. 28 on Reader Service Card

Why We Believe the Advent 201 is the Most Satisfying Tape Machine of Any Kind You Can Buy.

In 1970, Advent decided to do what no manufacturer of tape equipment was doing: to develop cassette equipment that was not only convenient and fun to use but capable of making and playing recordings that would be fully comparable to the best open-reel tapes and LP records. Accordingly, we became the first, and for quite a while the only, manufacturer to apply such crucial innovations as the Dolby System of noise reduction and DuPont's chromium-dioxide tape to cassette recording. While developing our high-performance cassette equipment, we also held demonstrations of what was possible in cassette recording for the public, press, and other manufacturers, and lobbied for Dolbyized pre-recorded cassettes from the major labels.

The major product to come out of that process was the Advent 201 cassette deck.

The 201, one of the most highly and explicitly praised products in the history of audio products, has been on the market for two years now. It has literally dozens of competitors claiming equivalent or better performance.

But we believe it to be not only as good in every way as more recent and far more expensive cassette machines, but to be as satisfying for the most critical home-recording purposes as any tape machine of any kind. Here are some questions and answers to help define that satisfaction:

Why Is The 201 Such A Simple Machine?

Because we wanted it not just to be capable of making excellent recordings but to make it easy for the listener to obtain its full performance time after time, recording after recording. Most tape recorders of all kinds and all prices don't make it easy for the user to get best results every time or at all, and many are made needlessly complex to operate because of too many marginal "features" that were assumed necessary to make them attractive (or competitive with other machines) in an audio showroom.

It's important to point out, we think, that Advent products are designed with far more thought to satisfying people after they buy than to what might tempt them to buy in the first place. The 201 has no knob or slider or gauge or indicator light that isn't a useful feature rather than a sales feature. But everything conducive to highest-quality recordings and long-term enjoyment is there.

Why Does The Machine Look So Different From Most Others?

Because it *is* different, and far more rugged and reliable than most. It has evolved from a transport that has been in heavy and hard use for years in schools, libraries, and other audio-visual applications, and it is likely to last and maintain its mechanical performance far longer than most cassette machines on the market. It also provides facilities such as automatic shut-off and complete mechanical disengagement at the end of a cassette or in the event of a jammed cassette—with the latter preventing tape spillage that makes an otherwise salvageable cassette a hopeless snarl of tape. And it enables you to shuttle from one mode of tape motion to another without having to press the Stop button in between. As a trade for our configuration, you have to hold onto the Rewind-Forward lever while you use it, but its action is so fast that we have had vanishingly few complaints from customers about it.

Why Does The 201 Have A Single VU Meter Instead of Two?

Because that proved, after consideration of all possible approaches, to be best—combining precision and simplicity. One of the troubles with using two VU meters in home recording is that they tend to lead the user to adjust them to read the same on both channels. In reality, though, the material on the two channels is usually different, and the meters *shouldn't* read equally. Two meters also produce a tendency to correct for overload or under-recording by adjusting only the channel whose meter showed too high or low a level. But if the channels were balanced properly in the first place, this puts them out of balance.

The 201's single VU meter, unique in cassette equipment, scans both stereo channels and instantaneously registers the louder peak on either at a given moment. The listener first uses the meter, which can also be switched to read either channel individually, to set channel balance with a pair of Input Level controls. Once balance is set, the meter is set to scan both channels, and final recording level is set or changed with a single Master Level Control that operates on both channels—

leaving the balance undisturbed. This sequence provides far more accurate level-setting than is possible with the overwhelming majority of tape machines of all kinds.

Not only does the 201's meter read instantaneous peaks (by far the most accurate indicator of possible overload), but its action is compensated to indicate the exact point of tape saturation at all frequencies. On rock music in particular, overload is most likely to occur and be heard at high frequencies, and most level-indicators on tape recorders of all kinds don't register full high-frequency content.

We know of no metering system more advanced or effective than the 201's. Most not only aren't as accurate, but tend to mislead the user.

Has The 201 Been Changed?

Yes and no. We have made Volkswagen-style changes as we have gone along, including the change of our original meter for better indication of high frequencies, but the changes were mainly in the direction of making use of the machine still easier and more precise. They would be hard to hear on most musical material, and we made them mainly because it seemed the responsible thing for a manufacturer to do.

Why Is The 201 Fairly Small?

Because its design consciously avoids needless gadgetry that might make it bigger, and also avoids what you might call "packaging air" in order to make a product look like there's more in it. We don't think we have the right to make something that takes up far more of your living space than it has to (or whose chrome shines in the dark) to get you to buy it.

Why Does It Cost Less Than Machines Claiming Equivalent Performance?

Again, because needless gadgetry is *not* there. And because we made the lucky decision to manufacture it in this country, avoiding the price rises that have resulted on imported products because of the fluctuation of the dollar *vs.* foreign currencies.

Why Did We Pick These Questions?

Because every manufacturer attempts to direct your attention in advertising. We want to direct it toward the realities that we feel genuinely determine whether something is enjoyable or not, because what we see on other products—including the confusing variety of super-expensive cassette machines now being publicized—tells us that we give far more attention to those realities than most other manufacturers.

Ours isn't the only good cassette machine in the world, but there is none likely to satisfy you more in the long run.

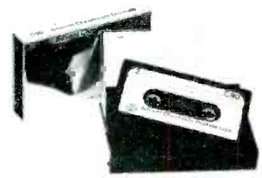
If you would like more information on the 201, including its reviews and a list of Advent dealers where you can hear it, please send us the coupon.

Thank you.

About Advent Chromium-Dioxide Cassettes:

While we were developing the first high-performance cassette equipment, we became convinced that DuPont's chromium-dioxide tape formulation was crucial for optimum recordings, and began to put it in cassettes and market it on our own. Advent Chromium-Dioxide tapes are made to live up to the quality of the tape they enclose. If one ever jams, we will either replace it or, if you prefer, do our best to transfer a valued recording to another cassette.

Advent Chromium-Dioxide tapes cost no more than other premium-grade cassettes. We think you will find them a bargain.



Advent Corporation,
195 Albany St., Cambridge, Mass. 02139

Gentlemen:

Please send me information on the Advent 201, along with a list of your dealers.

Name________________

Address________________

City________________

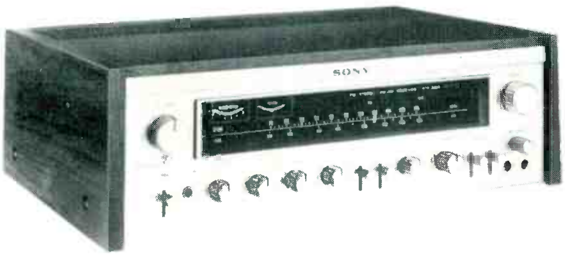
State________ Zip________

The Advent 201

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

Equipment Profiles

Sony Model STR-7065 Stereo FM/AM Receiver



MANUFACTURER'S SPECIFICATIONS

FM Section. IHF Sensitivity: 2.0 μV. **S/N**: 70 dB. **THD** (Mono): 0.2%; (Stereo) 0.5%. **IHF Selectivity**: 70 dB. **Capture Ratio**: 1.0 dB. **AM Suppression**: 56 dB. **Image Rejection**: 70 dB. **IF Rejection**: 100 dB. **Spurious Rejection**: 90 dB. **Frequency Response**: 20 Hz to 15 kHz, ±1 dB. **Stereo Separation**: Better than 38 dB at 400 Hz. **19 kHz, 38 kHz Rejection**: 40 dB. **SCA Suppression**: 55 dB.

AM Section. IHF Sensitivity: 30 μV (external antenna). **S/N**: 50 dB at 50 mV/M. **THD**: 0.8%. **Image Rejection**: 50 dB. **IF Rejection**: 40 dB.

Amplifier Section. Continuous Power Output: 60 watts/channel, 8 ohm loads, 20Hz-20,000Hz; 70 watts/channel, at 1 kHz, 8 ohm loads, both channels driven. **Rated THD**: 0.2%. **Rated IM**: 0.2%. **IHF Power Bandwidth**: 15 Hz-35 kHz. **Damping Factor**: 50, at 8 ohms. **Frequency Response**: Phono: RIAA ±1 dB; MIC: 100 Hz-10 kHz, +0, −3 dB; **High Level Inputs**: 10 Hz-70 kHz, +0, −3 dB. **Input Sensitivity for Rated Output**: Phono, 2 mV. Mic, 1.0 mV; High Level Inputs, 150 mV. **Power Amp Input**: 1.0 V. **Hum and Noise Level**: (all referenced to rated input and rated output) Phono, 72 dB; Mic, 65 dB; high level inputs, 90 dB. **Power Amp Input**: 110 dB. **Tone Control Range**: Bass: ±10 dB @ 100 Hz; Treble: ±10 dB @ 10 kHz. **High Filter**: 12 dB/octave above 9 kHz. **Low Filter**: 12 dB/octave below 50 Hz.

General Specifications. Power Consumption: 180 watts. **Dimensions**: 18¼ in. w. x 6-3/16 in. h. x 14¾ in. d. **Weight**: 33½ lbs. **Price**: $499.50.

This top-of-the-line stereo receiver from Sony should help to maintain that company's well-earned reputation for elegance in design, both internally and visually. The massive gold-colored panel, set back and framed by the side panels of the included walnut finished cabinet makes the STR-7065 eminently suitable for "instant use" on a shelf or table top. Removal of the cabinet discloses a complete metal enclosure rather than the exposed wiring of the chassis so commonly encountered with competitive units that come "complete with cabinet." Not only does this feature make sense for those of us who want to custom-mount a receiver behind a panel in existing furniture, but the extra internal cover provides shielding of low-level input circuits which might otherwise be subject to hum induction from other nearby components.

Fig. 1—Rear panel.

As for the front panel itself, the photo of the complete unit shows an orderly and carefully thought out arrangement of controls and switches surrounding a blacked-out dial scale area which, itself, is over 12 inches long. With power applied and selector switch set to all but radio functions, subdued green illumination of the dial area occurs and red program source indication appears at the upper portion of this area. When FM is selected, full dial illumination takes place, and both the signal-strength and center-of-channel tuning meters are brightly lit. In the AM mode, only the signal strength meter remains illuminated. At the left of the dial scale, a massive dual concentric knob/lever combination serves to adjust volume and balance, while a matching single knob at the extreme right is used for tuning stations in what is probably the smoothest flywheel action we have yet encountered.

Along the lower portion of the panel are a lever-type power switch, stereo headphone jack, speaker selector switch (as many as three pairs of speaker systems can be connected to the STR-7065, with one or two pairs activated at any one time by this switch), dual concentric friction-loaded bass and treble controls, filter selector switch, mode switch (with full facilities for stereo, reverse, L+R, right or left only to both channels), program source selector and a microphone mixing and level control, located directly above a piar of microphone input jacks. In addition, there are lever-type switches for activating loudness and FM muting circuits and for selecting tape monitoring facilities for *two* separate tape inputs. In addition to their normal monitoring use, these tape inputs and outputs can be used for "dubbing" or printing from one tape recorder to the other, or vice versa, depending upon the setting of the program selector switch.

The rear panel, shown in Fig. 1, has the usual provisions for external program input sources plus the two sets of tape in-tape out jacks previously referred to. A standard DIN socket parallels the tape 1 inputs and outputs. Antenna terminals are provided for either 75 ohm or 300 ohm balanced antenna connections and there is a terminal for an external AM antenna as well, should the self-contained pivotable ferrite bar antenna prove to be inadequate for distant AM signal reception. Preamp out and main-amp input jacks are also included, which permit separate use of the preamplifier (to feed other power amplifiers—as in bi-amp or tri-amp electronic crossover arrangements) and power amplifier. The usual "jumpers" are absent from these jacks, since a separate slide switch is used to "make" or "break" this circuit interruption point. This thoughtful addition makes the circuit-interruption feature more useful, since the "preamp out" jacks are available for feeding programs to other amplifiers even when the amplifier of the STR-7065 is in use. Normally, the jumpers usually used to complete such circuits would prevent this additional usage. Three sets of well-separated speaker terminals, two switched and one unswitched AC receptacle, and a separate ground terminal complete the back panel layout.

A view of the internal wiring of the chassis is shown in Fig. 2, and while at first glance the amount of harness wiring from module to module seems fairly great, we had no trouble identifying the various major circuits, which are well labelled for servicing, if required.

The sealed FM tuner section (front-end) uses junction FET's in both the r.f. and mixer stages, while the i.f. amplifier section uses permanently aligned ceramic filters and a high gain IC for limiting. The AM section has triple tuned ceramic filters as well, and a single IC circuit which includes an AGC circuit. The amplifier section uses differential amplifiers and incorporates balanced positive and negative power supplies which permits direct coupled (output capacitorless) connection to the speaker terminals. The FM multiplex section includes an FET for high impedance isolation between the ratio detector and the input to a single IC stereo decoder circuit.

In all, the STR-7065 contains 5 IC's, 4 FET's, 49 bipolar transistors and 31 diodes—quite a handful of active devices for a single package!

Laboratory Measurements

FM performance measurements are shown in Fig. 3. IHF sensitivity measured 2.3 μV, which is not significantly worse than the 2.0 μV claimed by the manufacturer. Ultimate S/N reached 70 dB, as claimed, for all input signal strengths above about 80 μV. Mono THD measured 0.18%—a bit better than the 0.2% claimed, while stereo THD measured just a bit over the claimed 0.5% at mid-band frequencies. 50 dB S/N was reached with a signal input of only 2.9 μ V. Muting action was positive and instantaneous, occurring at a signal input level of about 8 μV. In view of the excellent quieting characteristics observed, this parameter might better have been set at about 5 μV and, while no external adjustment is provided for the customer, potentiometer RT-201, which we located easily on the included schematic, could be trimmed to readjust the muting threshold if this is important to the user.

Stereo threshold occurs at an input of 4.5 μV, just exactly where we felt it should with a receiver of this quality, and the transition is smooth and positive. Stereo separation, shown in Fig. 4, reached 38 dB at mid-band, as claimed, falling off to about 28 dB at 50 Hz and about 20 dB at 10 kHz. Mono THD was below 0.5% at all frequencies from about 60 Hz to 7 kHz and barely reached 1.0% at 15 kHz. Stereo THD remained well below 1.0% from 50 Hz to over 2 kHz, above which "beats" between the internal 19 kHz and the test frequencies tended to produce high readings on our distortion analyzer.

Amplifier Measurements

If the tuner section of the STR-7065 were categorized as basically meeting its excellent specifications, we'd have to rate the amplifier as one that exceeds its claims by far. As shown in Fig. 5, THD reached the manufacturer's rated (and very low) value of 0.2% at an incredible 85 watts per channel. Remember, that Sony rates the amplifier at 70 watts mid-band, per channel and, even more conservatively, at 60 watts/channel for all frequencies from 20 Hz to 20,000 Hz! At all power levels below 60 watts, THD measured well below 0.15%, while IM distortion measured under 0.1% for all power levels up to 45 watts, rising to the rated 0.2% at 60 watts and remaining at less than 1.0% even at 65 watts per channel and higher.

Even if we consider the nominal output rating of this receiver to be 70 watts per channel (its mid-band rating), power bandwidth exceeds manufacturer's claims, extending from 12 Hz to nearly 60 kHz, as shown in Fig. 6. Distortion versus frequency for 60 watt and 30 watt levels per channel is plotted in Fig. 7 and, even at 20 Hz, THD measured less than 0.3% for full power output (60 watts) and well below 0.2% for 30 watts of output power per channel.

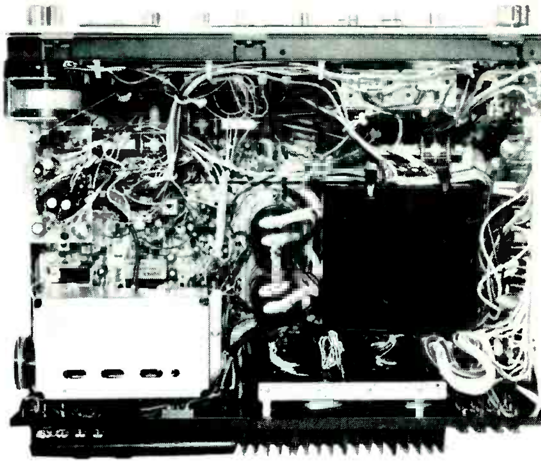


Fig. 2—Internal chassis view.

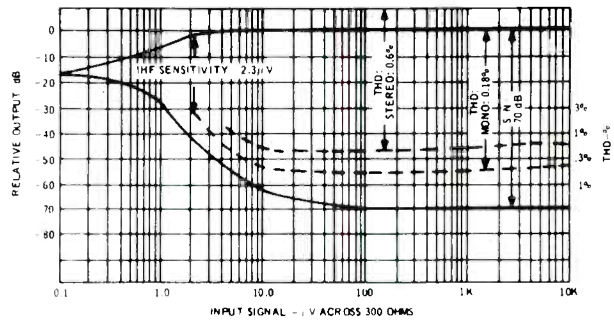


Fig. 3—FM performance characteristics.

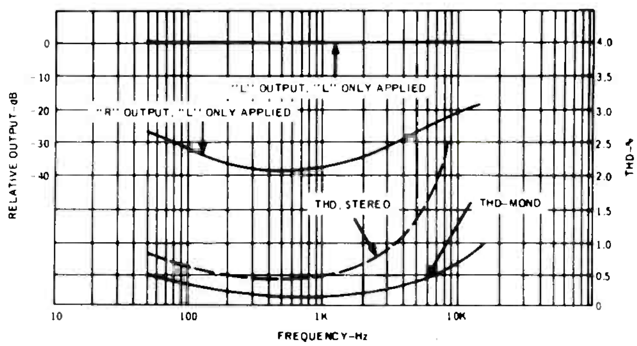


Fig. 4—Separation and distortion characteristics vs. frequency.

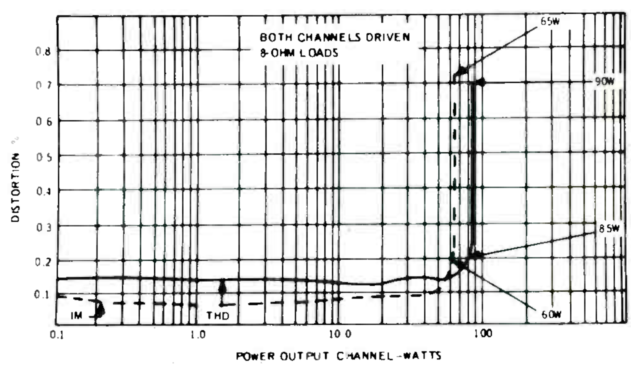


Fig. 5—Harmonic and IM distortion characteristics.

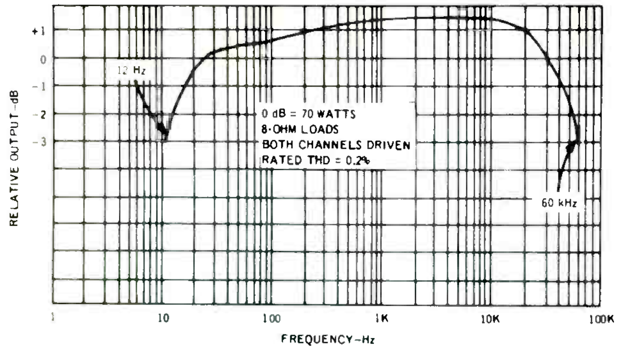


Fig. 6—Power bandwidth.

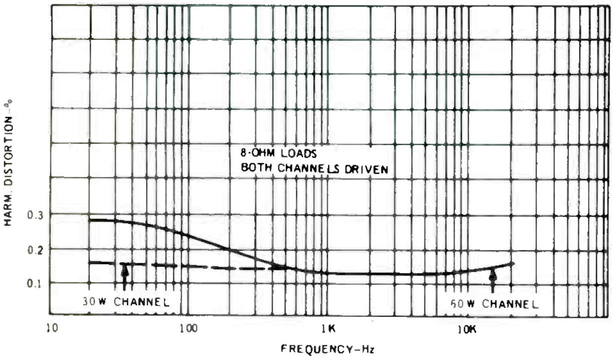


Fig. 7—Distortion vs. frequency.

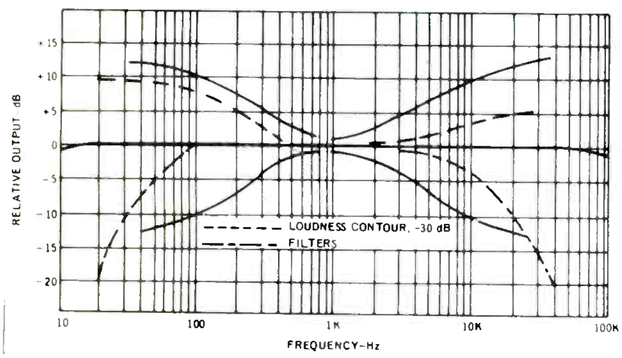


Fig. 8—Tone control, loudness and filter characteristics.

Tone control, loudness and filter characteristics of the STR-7065 are plotted in Fig. 8, and all conform nicely to manufacturer's claims. The use of 12 dB/octave low and high frequency filters, while requiring a few more component parts than the more commonly used 6 dB/octave types, clearly shows up advantageously when plotted against the tone control range as in Fig. 8. High degrees of attenuation at low, rumble frequencies and high "record scratch" frequencies become possible without materially affecting more important "musical" frequencies—as would be the case if tone controls or less steep cutting filters were used to correct for such problems.

Additional Measurements

Measurements not shown graphically include: capture ratio, which measured just under 1.0 dB at 1000 μV; FM alternate channel selectivity, which measured 68 dB at the same signal input level; AM suppression, which measured 58 dB; and spurious response rejection, which turned out to be higher than our 100 dB instrument capability. Hum and noise on phono (referenced to 3 mV input) read 75 dB—better than claimed by Sony, while the same parameter measured for the high level inputs was about 80 dB.

Listening Tests

The Sony STR-7065 served as our "listening set" for nearly a month (we rotate receivers and amplifiers regularly, using them for casual as well as concentrated listening for varying periods of time, depending upon backlog of sets to be tested). Largely because of its ease of handling and its excellent control features, we were unusually reluctant to displace it in favor of the next set ready to undergo our listening tests. It performed flawlessly during that long period and, a hasty check of a few FM and power measurements made before we re-packed it indicated that it was as good as the day we turned it on. Calibration of the FM band is just about perfect, and there was no evidence of drift. AM performance was better than average for our location, and the FM band managed to pull in fifty-two usuable signals, of which about 28 were stereo stations. The measured high alternate channel selectivity was obvious in our listening tests and, with our outdoor antenna properly oriented, we were able to get a few adjacent channels (only 200 kHz apart) with listenable quality.

The best thing that can be said about the amplifier section of the STR-7065 is that like all good amplifier designs, we were never conscious of its being there—it responded well at all listening levels, drove high and low efficiency speaker systems with equal ease and produced all the clean, audio power demanded by our varied listening situations. The microphone input feature will find favor with recording enthusiasts who can use it, instead of going directly into their tape recorder mic inputs. In this way, tonal deficiencies of your microphone (or even your voice) can be "sweetened up" just like the professionals do by simply connecting from the output of the "preamp out" jacks to the high level input of your recorder. This trick cannot be accomplished by feeding from the conventional "tape out" jacks—another virtue of the unique out-in arrangement provided on the Sony STR-7065.

Leonard Feldman

AKAI GXC-46D Cassette Recorder

MANUFACTURER'S SPECIFICATIONS:

Frequency Response: 30 to 18 kHz (50 to 15 kHz ±4 dB) with CrO_2; 30 to 16 kHz (50 to 13 kHz ±4 dB) with LN. **Wow and Flutter**: less than 0.12%. **Signal-to-Noise**: Better than 50 dB; 58 dB with Dolby. **Erase**: 70 dB. **Outputs**: Line, 0.775 V; DIN, 0.4 V; Headphone, 30 mV. **Motor**: Hysteresis synchronous outer-rotor type. **Dimensions**: 16 in. w. x 11½ in. d. x 5 in. h. **Price**: $319.95.

AKAI has long had an enviable reputation for top-quality open-reel recorders—in fact, they were the first, or *one* of the

What makes the NIKKO 8080 the surprise sellthrough of the year?

Today's quality-oriented consumer may not know electronics from a technical point of view. But he *does* understand quality. And value.

And when you can offer him a quality AM / FM receiver that combines both high-end features and a middle-range pricetag—you can predict his response.

The Nikko 8080 offers, among other things, a feature previously found only in such high-end components as the Macintosh C28: a two-tapedeck dubbing system that gives you two sets of stereo tapedeck inputs and outputs, with switching that allows you to dub from left deck to right, and from right deck to left. The 8080 also protects your speakers with a special Nikko-designed three-stage circuit breaker.

Furthermore, it is powered by both a modest pricetag and 45-45 watts of RMS power at 8 ohms.

The specs, the price, your own ears and your sales experience can tell you that the Nikko 8080 is more than just an exceptional receiver. It is an exceptional sales performer.

So get over to Booth 508 and take a look at the Nikko 8080, as well as the rest of the Nikko action-provoking line, including the Nikko 7070 and the brilliant top-of-the-line Nikko 9090.

Who knows—with a receiver featuring two-tapedeck dubbing, you might even be able to sell two tapedecks!

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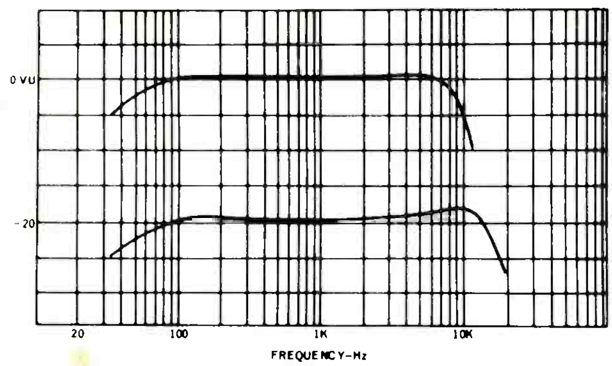


Fig. 1—Record-replay response with TDK KROM-O_2 tape.

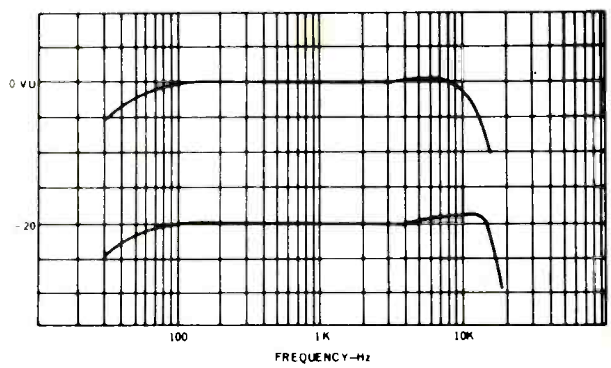


Fig. 2—Record-replay response with Maxell UD tape.

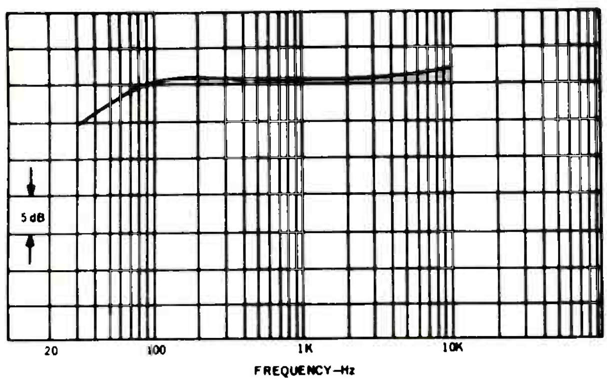


Fig. 3—Playback response from standard tape.

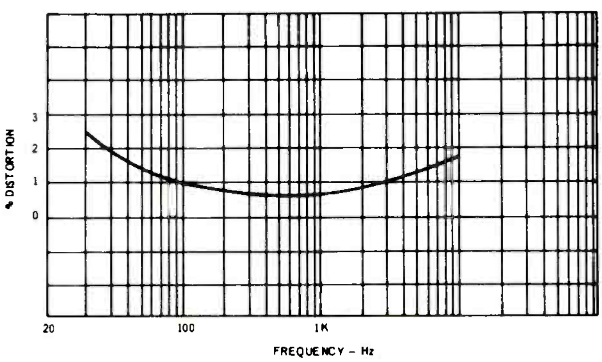


Fig. 5—Distortion vs. frequency.

first, to use cross-field technique. And so it is only natural that their featured entry in the cassette market would be a high quality machine using a Dolby system. Model GXC-46D uses an ADR distortion reduction system, said to eliminate almost all high frequency distortion above 8 kHz. The styling is fairly conventional with piano keys for tape control and the now almost standard slide units for input and output functions. Reading from left to right, the key switches are as follows: RECORD, REVERSE, STOP, PLAY, and FAST FORWARD. Next comes three pushbuttons for PAUSE, EJECT, and power ON-OFF. To the right of the recessed cassette holder are switches for limiter and tape selector (CrO_2 and Low-Noise) and the four slide controls—two for input level and two for output. At the top left on an angled panel is the Dolby switch with an indicator light and at the right are the two VU meters. The microphone and headphone jacks are located at the front near the AKAI nameplate and the other input and output connections (including DIN) are all at the rear. Incidentally, the limiter circuit is described as an "over-level suppressor" and it is recommended for use when recording from microphones at close range.

Circuit Details

The circuit of the 46 is fairly straightforward using 39 transistors, 39 diodes and 2 IC's. Figure 6 shows the input arrangement as it appears in the playback mode. Note that there is an RC roll-off network as well as an NFB equalizing loop. Two transistors plus a diode are used in each channel for the limiter circuit. Bias frequency is 61 kHz and the oscillator is a push-pull type employing an auto-transformer. No fewer than 16 transistors are used in the Dolby circuit—one reason for the extra cost involved.

Measurements

Figure 1 shows the record-replay response with TDK KROM-O_2 tape taken at 0 VU and –20 VU. The 3 dB point is about 16 kHz. Very similar results were obtained with Maxell UD Low-Noise tape, as can be seen from Fig. 2. As a matter of interest, two other tapes were tried—Maxell LN and TDK ED. The former had a rise of 1.7 dB at 10 kHz with a 3 dB point at 15.5 kHz, the latter having the same 3 dB point, but with a rise of 1 dB at 10 kHz. The Dolby system was checked but there were no significant frequency deviations. Figure 3 shows the response from a standard tape and Fig. 4

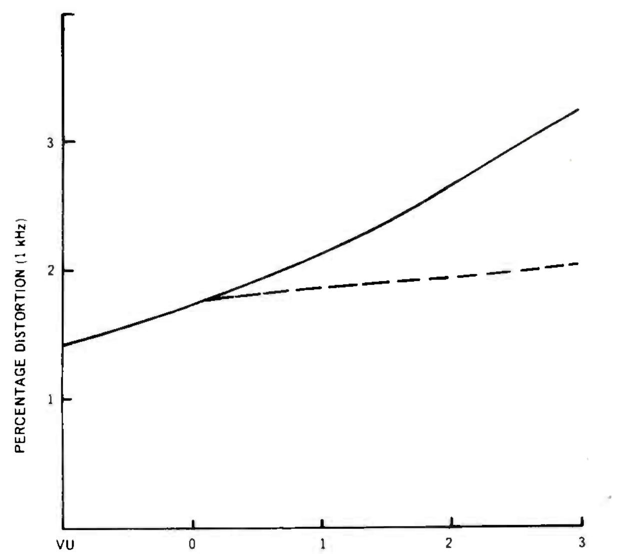
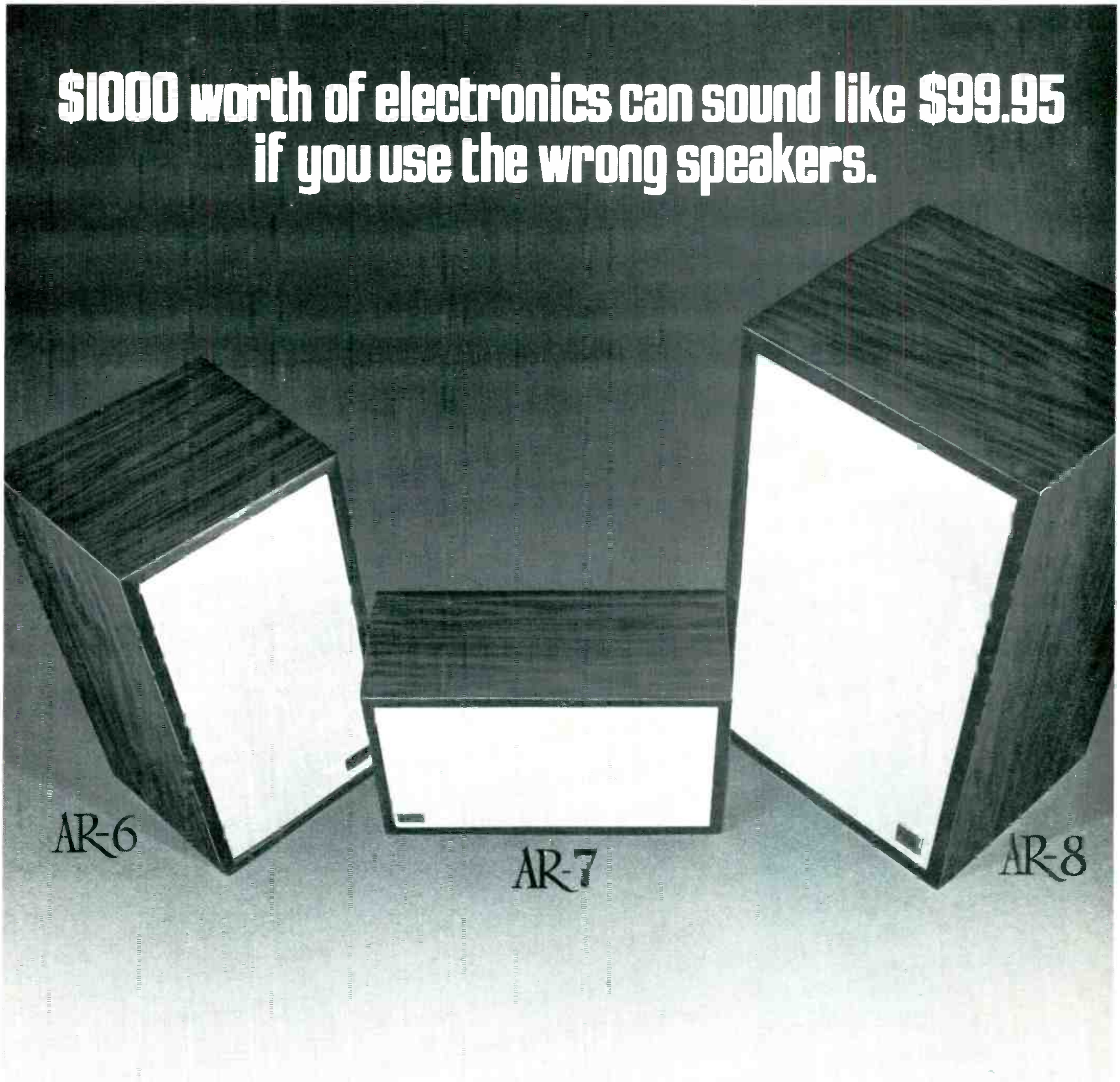


Fig. 4—THD at 1 kHz. Broken line shows the effect of the limiter.



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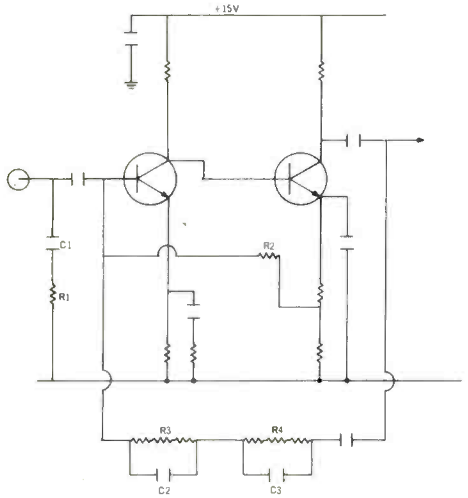

Fig. 6—Input circuit as switched for playback. R1 and C1 form a passive roll-off network; R2 supplies d.c. stabilizing; and R3, R4, C2, C3 comprise the NFB equalizing loop.

indicates the distortion at 1 kHz up to +3 dB on the VU meter. The broken line shows the effect of the OLS limiter circuit. Distortion vs. frequency can be seen in Fig. 5. Output at 0 VU input was 750 mV with CrO_2 tape and just under 700 mV with LN tapes. Input for 0 VU was 45 mV.

Signal-to-noise (unweighted) was 51 dB, increasing to 58 dB with Dolby, which is excellent. Wow and flutter came out exactly as specified at 0.12% (DIN). Tape speed was just under 1% fast and average rewind time for a C-60 cassette was 57 seconds.

Listening Tests

The GXC-46D was very easy to use: The key switches were positive without needing excessive pressure and the pause button worked without fuss. I find it an advantage to have the pause button positioned away from the bank of piano keys, as there is less chance of pushing the wrong key when in a hurry! As can be seen from the graph, the OLS limiter circuit can reduce overload distortion on high input signals although it should only be used if absolutely necessary. Summing up: the AKAI GXC-46D must be numbered among the top half-a-dozen cassette recorders and can be recommended without reservation. *G.W.T.*

RTR 280 DR Speaker System

MANUFACTURER'S SPECIFICATIONS

Drivers: Four 10-in. bass, six 2½-in. tweeters. **Crossover Frequency**: 3500 Hz. **Recommended Amplifier Power**: 15 to 100 watts RMS per channel. **Frequency Response**: 22 to 18,500 Hz. **Impedance**: 8 ohms, nominal. **Weight**: 95 lbs. **Dimensions:** 16½ in. W × 39 in. H × 16½ in. D. **Price**: $299.00

The RTR 280DR is a column speaker which uses a total of ten transducers. A 10-in. extended range woofer is centrally mounted on three of the four vertical sides with a 2½-in. tweeter above and another below each woofer. On the very bottom of the free-standing enclosure, a slot-loaded low bass woofer completes the column and radiates uniformly at floor level. The fourth vertical side is painted flat black and has terminals and controls mounted in a recessed cavity. The enclosure is attractively finished in walnut and black and is definitely a speaker you would not choose to hide in a corner or out of sight for either cosmetic or acoustic reasons.

A toggle switch labelled "Normal" and "Bi-amp" is provided to allow this system to be driven by either one amplifier for full range sound or a frequency splitting bi-amplification system. Two sets of binding posts serve as woofer and tweeter connections when the toggle switch is placed in the Bi-amp position. In the "Normal" position, the woofer binding posts, also marked "Normal," serve to drive the complete system. A tweeter gain potentiometer and a resettable tweeter protective circuit breaker complete the back controls. In fairness to RTR engineering, the controls and terminology are well labelled and reasonably placed, but the purchaser is on his own from the standpoint of hookup information. A supplementary description of recommended hookup is something which is needed and we hope this is a temporary manufacturer's oversight. The use of good quality insulated terminals is commendable. Connection can be made without tools using spade lugs, tip jacks, or stripped wire of any reasonable size. This eliminates the fear of short circuiting poorly connected stranded wire if the speaker is periodically moved for cleaning purposes.

The lack of hookup instructions together with the choice of terminal configuration could be an expensive trap for the unwary Bi-amp user. In the "Bi-amp" position the two sets of terminals are electrically isolated, the woofer and tweeter each having a black and red terminal, but when the mode switch is set to "Normal," both black terminals are tied together. If the amplifiers used for bi-amplification have a common ground, it is possible to wire the speakers out of phase (such as is commonplace for 12 dB per octave crossovers) and get normal sound when the speaker is in the "Bi-amp" position. If the switch is then flipped to "Normal," one of the power amplifiers will look into a short circuit and possibly be damaged. If this speaker is used for bi-amplification, we recommend exercise of caution in hookup.

Technical Measurements

The stated impedance of the 280DR is 8 ohms nominal. Our measurements indicate that the impedance should be considered to be slightly above 4 ohms. Figure 1 is the impedance for "Normal" configuration with the two extremes of tweeter control position. Figure 2 is a plot for the Bi-amp mode with the tweeter impedance given at the two extremes of adjustment. This speaker should not be paralleled for drive from most transistor amplifiers. In view of the higher amplifier demands of this speaker, the heaviest gauge hookup wire should be used that is practical and consistent with decor.

The anechoic frequency response obtained one meter directly in front of the speaker is shown in Fig. 3 for the "Normal" switch position and the tweeter level control set to the mid position. The amplitude response is ±5 dB from 40 Hz to 14 kHz. The response is non-minimum phase only near the acoustic crossover frequency of 2 kHz. The phase slope indicates the acoustic position of the woofer is about 6 inches behind the tweeter.

The "Bi-amp" response of woofer and tweeter considered separately is shown for pressure amplitude only in Fig. 4. The range of control for the tweeter is +7 dB in the maximum position to –5dB in the minimum position referenced to the halfway position of the potentiometer on the rear of the cabinet. The tweeter control changes the electrical damping causing some response irregularities below 4 kHz at control positions less than maximum. If this speaker is connected for bi-amplification, we recommend using the maximum tweeter position and reducing the gain in the tweeter control of the amplifier.

The frequency response deteriorates off-axis and shows interference dips at 45° due to an equal contribution of sound from the identical front and side drivers. Progressing around to 90°, the response again smooths to a similar form to that of Fig. 3.

The energy-time plot of the first millisecond of direct sound for all components from 20 Hz to 20 kHz is shown in Fig. 5. This is the amount of time spread which an impulsive sound undergoes when reproduced through the 280DR. Because the measurement is performed at a distance of one meter in front of the grille cloth, the first arrival is due to the tweeters and comes at around 3.2 milliseconds. The impulse response is within 20 dB of its peak value for 0.25 milliseconds after the first arrival and within 30 dB for the first millisecond. No significant energy remains beyond 1.25 milliseconds of first arrival indicating a desirable lack of internal structure reverberation.

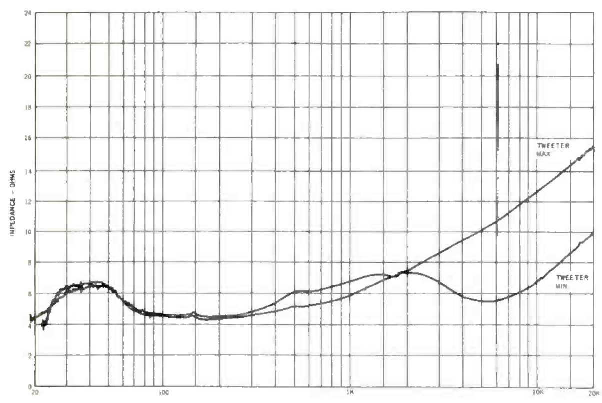

Fig. 1—Impedance for normal operation and extreme position of the tweeter control.

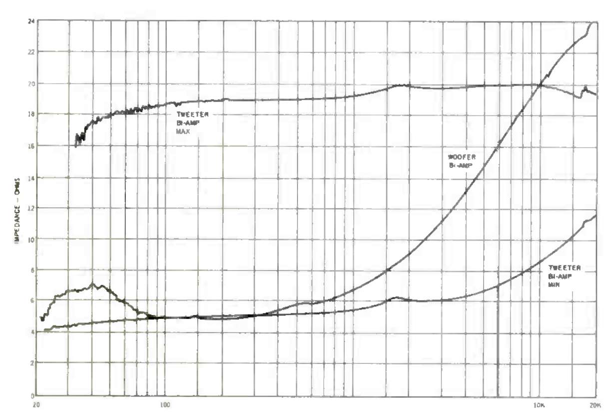

Fig. 2 Impedance for bi-amp operation using woofer alone or tweeter alone with extreme positions of tweeter control.

The 280DR is intended for free-standing use in a room. In order to evaluate the technical performance under these conditions the speaker was placed on a rug surface in a room with a hard plaster ceiling slightly over 8 feet above the floor. The microphone was placed one meter above the floor (slightly over three feet) and three meters (about nine feet ten inches) in front of the speaker. An energy-time measurement indicated that the first 2 milliseconds of sound arrival contained the majority of direct and floor reflected sound and that the ceiling contribution was perhaps 5 dB less than the floor reflection and somewhat less than later scatter arrivals from other portions of the room. Frequency response measurements were taken for both the first 2 milliseconds of arrival and the first 6 milliseconds of arrival which would include ceiling reflection. There was no substantial change in the character of the spectrum for these two time-gated frequency responses. Figures 6 and 7 show the frequency response of the first 6 milliseconds of arrival for two azimuth positions at 3 meters. The zero degree curve is the on-axis response and corresponds to sitting directly

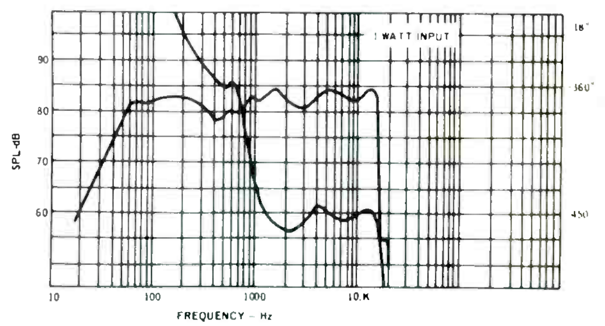

Fig. 3—Anechoic frequency response including amplitude and phase measured one meter on axis with one watt input.

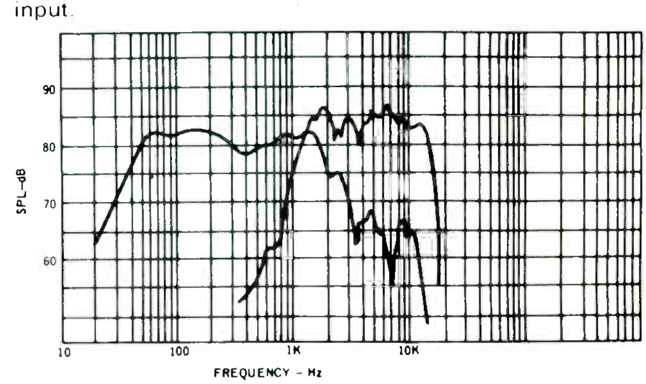

Fig. 4—Anechoic pressure amplitude response for the bi-amp mode with woofer alone and tweeter alone.

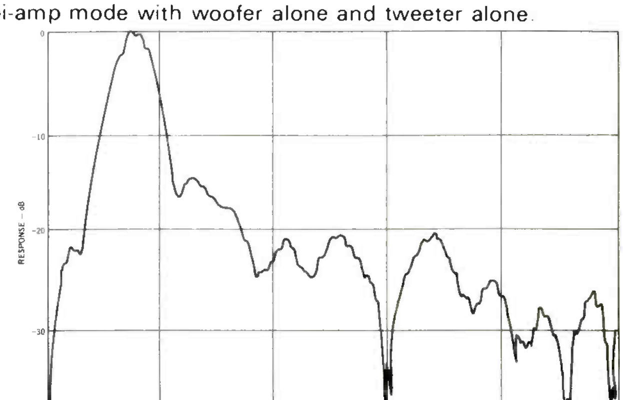

Fig. 5—Energy-time response measured one meter on axis.

in front of the speaker. The second measurement is made for a 30° off-axis position corresponding to the left channel of a stereo installation with a 60° separation angle. The data is not continued below 100 Hz because of the six millisecond time window used for this measurement. A general dip in response is noted from about 2 kHz to about 7 kHz with a top end brightness peak in the vicinity of 10 kHz then a drop off above 15 kHz. The tweeter control was placed in the same position as for the anechoic measurement of Fig. 3. Because of the

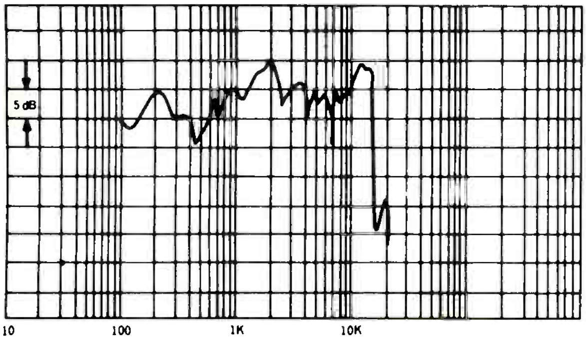

Fig. 6—Frequency response for the first six milliseconds of direct sound including floor and ceiling contributions measured three meters on axis.

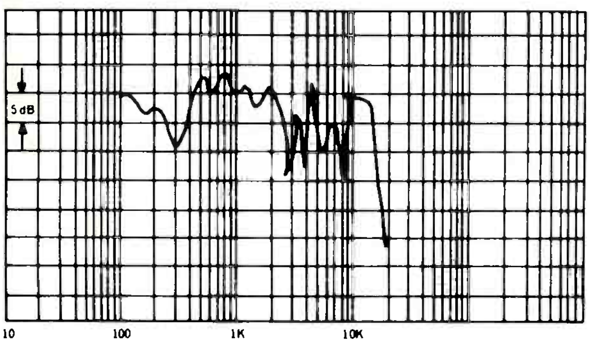

Fig. 7—Frequency response for first six milliseconds of direct sound including floor and ceiling contributions measured three meters at 30° off axis.

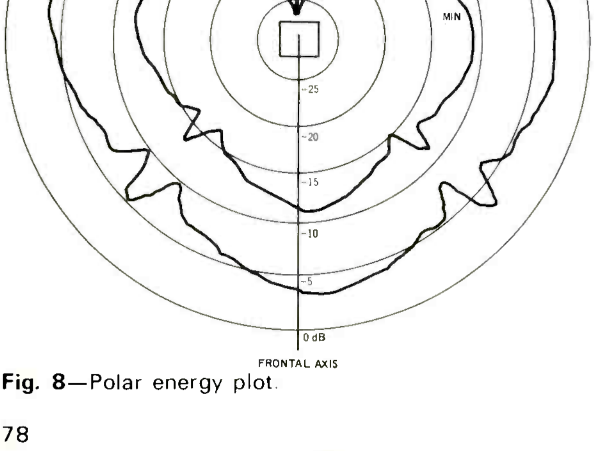

Fig. 8—Polar energy plot.

radiation from three sides of the enclosure, the 280DR contributes a substantial amount of room reflected sound in any normal listening situation. Thus room coloration problems must be anticipated. The general dip in the treble region is found at all azimuth radiation angles.

The polar-energy plot is shown in Fig. 8. This is the total energy in the 20 Hz to 20 kHz range as a function of angle. The view is that of looking down on the speaker, and this measurement is made anechoically for the first two milliseconds of arrival. The plot shows the two extreme positions of the tweeter control. There is a very clear symmetry of the direct frontal and side axis as one would expect but which is not found near the 45° positions. If these speakers are positioned in a usual stereo configuration such that the front of the speaker is directly perpendicular to the line of centers joining them, the polar fingers at 45°, together with the interference-prone frequency response at this angle, will give good stereo localization only over a narrow range of seating positions when the speakers are farther apart than 60°. The implication of this polar measurement is that you should rotate the speakers toward the listening area in order to preserve localization. The broad dispersion of sound implies that a substantial stereo effect can be expected due to room reflection.

The 280DR is stated by the manufacturer as being moderately efficient and an amplifier power of 15 watt to 100 watt is recommended. Our measurements indicate that a one watt electrical input produces a sound pressure level of 82 dB one meter on axis at 1 kHz. Even adding the contribution of the other two major axes, this must rank as a speaker which demands a lot of power. Even if you are not a hard rock enthusiast, you could readily run an amplifier into peak clipping in a moderately draped listening area if it has less than a 50 watt rating. Our experience in measuring distortion, however, makes us recommend the use of speaker fuses if a high power amplifier is used.

The harmonic distortion on the 280DR is extremely low. A flute tone E_1 (41.2 Hz) at 20 watts input produced 1 percent E_2 (second harmonic) and 1 percent A_2 (third harmonic). The critical mid bass remained below 0.4 percent at this same level. It was not until a power level of 100 watts at 41.2 Hz that the bass drivers became non-linear as indicated by the ratio of odd to even harmonic distortion. The sound pressure level measurement of Fig. 3 is for one of the three equal axes of radiation. The sound pressure level of 90 dB shown in Fig. 9 is calculated by adding 5 dB to take into account the contribution of all speakers in a reverberant environment. Our undoing occurred during the testing at the 100 watt level. Even though the tone is applied for about 5 seconds duration for each component, we managed to burn out one of the woofers during test. The fault rests solely with us since the lack of sonic distortion lulled us into testing at high power. The lesson, however, is clear. Because you need a truly high power amplifier to get high sound levels, we strongly recommend fusing the speaker lines with a fast blow fuse rated no larger than 5 amps. The power level of 100 watts shown on the harmonic distortion plot is that which would be delivered to an 8 ohm resistor. Investigation of the impedance plot shows that we were in fact delivering close to 200 watts of heating power to the 280DR at maximum test level.

Intermodulation distortion was determined by using E_1 and A_4 at equal power ratios and measuring the modulation sidebands on A_4. The relative order of the sidebands indicated that the effect was more nearly due to frequency modulation than amplitude modulation. With this type of drive, a 25 watt E_1 and a 25 watt A_4 produce a peak drive that demands the services of a 100 watt rated amplifier. At this level the intermodulation distortion is 2.4 per cent and is composed primarily of 481 Hz, 399 Hz, and 358 Hz. Intermodulation is more prevalent

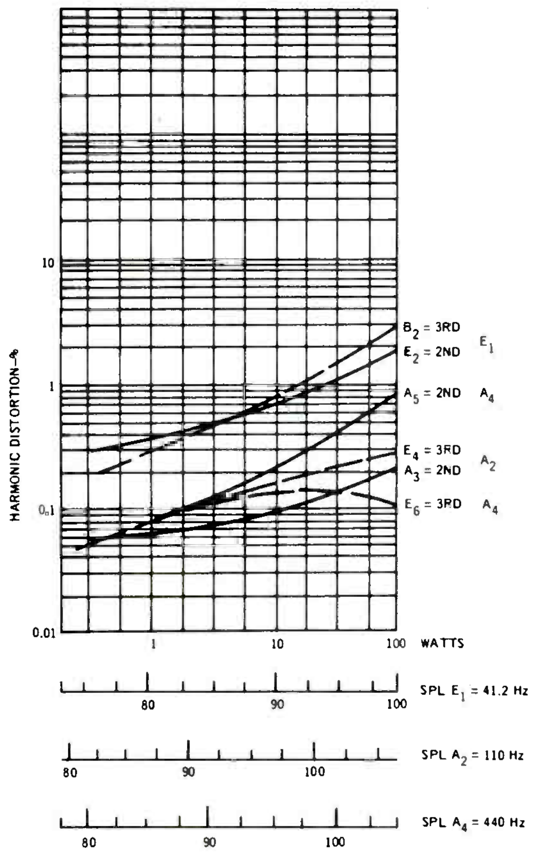

Fig. 9—Harmonic distortion of flute-type tones E_1, A_2, and A_4 as a function of driver power in watts and SPL one meter on axis.

than harmonic distortion, remaining at nearly 0.5 per cent at one watt input, corresponding to a quarter watt each of E_1 and A_4.

For the signal suppression test, 440 Hz and 3500 Hz were used with white noise mixed at an average level 20 dB higher than the tones. No signal suppression of these equivalent inner musical voices was noted when the white noise was added, even up to a noise peak voltage of 80 volts across the speaker terminals. The 280DR can handle high peak-to-average crescendos up to the capability of the most powerful amplifier without compression of inner voices.

Listening Tests

Several room positions were tried and the most listenable location was flush against a hard wall and symmetrically located on either side of a projecting fireplace. Presumably a bookshelf would serve the same acoustic purpose. In other room locations, the illusion was one of listening to more localized loudspeakers, though quite good ones. Even in the best wall position, the sound has good stereo spread but the stereo localization is not as good, since a phantom center image is not really well defined and the extreme left and right sound images are more sharply localized. The flush wall position was found to help fill in the phantom center channel.

The sound is that of slightly suppressed mid to high frequencies with a modest top end peak which accentuates a few voice sibilants. The extreme top end which might give instrumental sheen seems down somewhat, particularly when a disc such as the sparkling *Shostakovich Symphony No. 15* (RCA ARD-1-0014) was played. Any high frequency tone control which simply boosts the frequencies above 1 kHz would not help this, because extreme high frequencies will start spitting before the 5 kHz region is raised sufficiently. A mid-band equalizer would be more effective if your personal choice is for stronger mid frequencies.

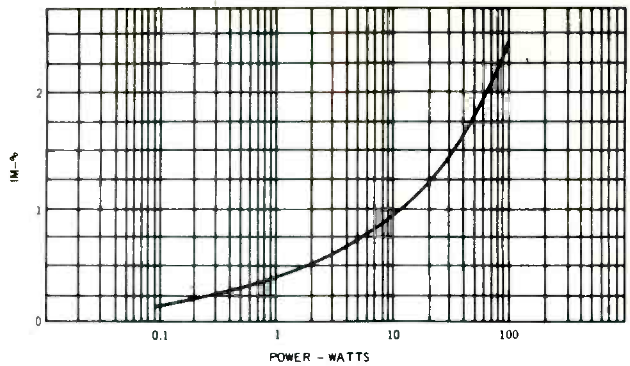

Fig. 10—Intermodulation distortion using 41 Hz and 440 Hz mixed 1:1.

The 280DR has a smooth, solid bass. In moderate size rooms, the low bass is definitely present but not obtrusive. If you have any turntable rumble, this speaker will let you know should you carelessly add bass boost.

This speaker is well suited for the reproduction of massed orchestral music where absolute pinpoint localization is not altogether important, though this can be improved by rotating the speakers toward the listening area. However, the cosmetic effect of this position for these attractive enclosures leaves something to be desired. The manufacturer advises that if the units are to be placed more than 8 or 10 feet apart, a corner position is to be preferred with rotation towards the center.

Classic organ music, on the other hand, can be reproduced with great accuracy at high levels. Hard rock music which places a great demand on the 1 to 5 kHz range was not reproduced to my complete satisfaction. For example, the Cat Stevens selection, on *Sheffield Vol.II*, seemed to lack punch when played at the levels one usually likes to hear such pieces. In any event, the best performance can only be obtained from the RTR 280DR by using amplifiers which are able to drive 50 or more clean watts into 4 ohms.

Overall, the speaker should be considered as very good and the $299 price tag is quite reasonable for this level of performance. For best reproduction, these speakers need to be used with high quality components and they may lead you into buying more than just a pair of speakers.

Richard C. Heyser

Check No. 73 on Reader Service Card

Editor's Note

This is the first in a new series of speaker system reviews. While these test methods are not new, since they have appeared previously in engineering journals, they are new to these pages and should generally be compared only with the reviews following in this series. A full explanation of the test procedures used begins on page 20.

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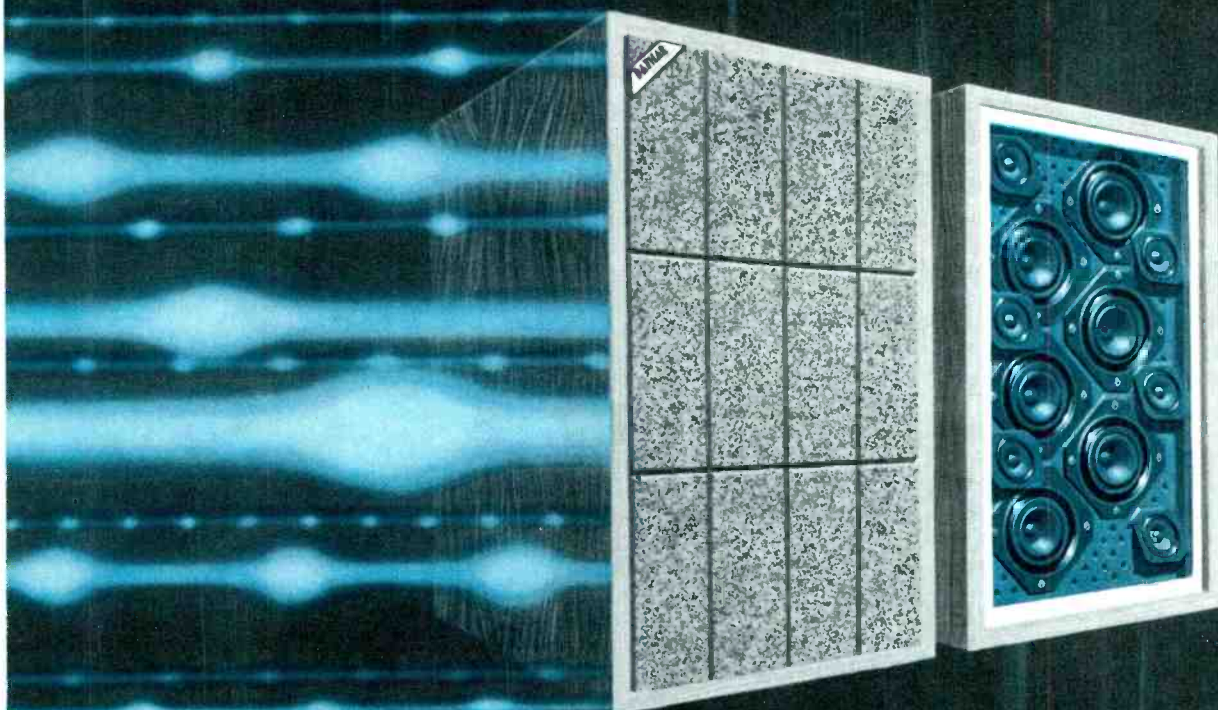
Martha Sanders Gilmore

The Kennedy Center

THE BEST THING the Kennedy Center on the Potomac has going for it are its superb acoustics, which performers and critics alike warmly praise, though the building has also been acclaimed for its beauty. The structure takes shape in a majestic rectangular slab of white Carrara marble, some 3700 tons cut to specification and donated by the government of Italy. The marble is the largest of the gifts the Center received from foreign countries. The Kennedy Center sits on a 17-acre tract of land, a classic Greek temple in stark contrast to the tangled wilderness of Theodore Roose-



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velt Island near the opposite bank of the Potomac. Architect Edward Durell Stone said of the site: "It is one of the most exciting and glorious settings for a public building in the world."

From atop its expansive roof. the Jefferson. Lincoln, and Washington Memorials loom historically in its panoramic view. And underneath its roof are housed three separate theaters: the Concert Hall, the Opera House, and the Eisenhower Theater, separated by a Hall of Nations and a Hall of States, colorfully blazoned with their respective flags.

Although ground was broken on December 2, 1964 for the $68 million structure, which seats 6500 persons, construction did not begin until 1966. A succession of American Presidents had a hand in its formation. On September 2, 1958, President Eisenhower signed the National Cultural Act into law. President Kennedy signed amending legislation extending the deadline of fund raising for three years, to give "full recognition [to] the place of the artist." After Kennedy's assasination, President Johnson signed into law a bipartisan measure designating the National Cultural Center the only official memorial in the nation's capital to the late President Kennedy, renaming it the John F. Kennedy Center for the Performing Arts.

The person responsible for the remarkable acoustics of the Center is Dr. Cyril Manton Harris, who holds dual professorships at Columbia University while serving as a consultant in the acoustics field. Harris, a "fireball of energy" according to his June 17, 1972 profile in *The New Yorker,* maintains a rigorous schedule at Columbia, wasting not a moment's time out of his beautifully organized schedule which is as firmly packed as canned sardines. Prof. Harris' regimentation is necessary to carry out his duties teaching acoustics in both the School of Architecture, where he also teaches a course on the legal and technical aspects of noise control with Prof. Albert J. Rosenthal, and the Department of Electrical Engineering and Computer Sciences.

Harris received his doctorate in physics from M.I.T., studying under Prof. Philip McCord Morse. The author of numerous scholarly articles in the acoustical field, Harris is editor of *The Handbook of Noise Control,* published in 1957, and has compiled a *Dictionary of Architecture and Construction,* published this year. Having always been interested in electronics, Harris is the co-inventor of a talking typewriter. In view of Dr. Harris' auditory accomplishments, it may not surprise you to learn that he has such exceptionally acute hearing that he has to wear earplugs to get a good night's sleep.

Cyril Harris has served as an acoustical consultant for years and is presently working as an architectural-acoustics consultant specializing in large auditoriums. He planned the acoustics for Powell Hall in St. Louis and we have him to thank for the acoustic design of the new 3850-seat Metropolitan Opera House at Lincoln Center. It was in this capacity that he collaborated with architect Edward Durell Stone in the design of the three magnificent performing halls at the John F. Kennedy Center for the Performing Arts in Washington, D.C.

The Center's first use and grand, glittering opening in the Opera House on September 8, 1971 was attended by members of the Kennedy family and other carefully coiffed celebrities. They heard the world premier of Leonard Bernstein's *Mass,* commissioned specifically for the occasion—a controversial work to launch a controversial Center.

The Center's resident orchestra, the

National Symphony, conducted by Antal Dorati, opened the Concert Hall on September 9th, while the Eisenhower Theater threw open its doors October 18th with Ibsen's *Doll's House*, starring Claire Bloom.

Dance was one of the strongpoints of the inaugural season of the American Ballet Theater. The Kennedy Center's resident company, the Alvin Ailey Company, and companies came in from all over the world to dance on the Opera House's highly praised stage. In addition, there were 87 concerts by 22 major world orchestras; 46 concerts of jazz, folk, and rock; a House of Sounds Jazz Festival and American College Jazz Festival; 34 recitals by world-famous individual musicians, and 36 weeks of theater.

The Kennedy Center is young and a point in its favor is that it has fostered healthy competition among Washington area theaters in getting suburbanites into the city and away from TV. And despite the vitriol spouted concerning Center tactics and the occasional caustic reviews of individual performances, the commentary on the Center's acoustics have been virtually free from attack.

Music critic of *The New York Times*, Harold C. Schonberg, who attended a rehearsal before the opening, commented with enthusiasm upon the orchestral sound of the National Symphony in the nearly empty Concert Hall. "The sound was reverberant and full, with a stunning bass quality and unusual 'presence.' The various choirs of the orchestra stood clearly apart from each other, but there was a voluptuous mesh. Indeed, there was no feeling of listening to music in an empty hall. The sound was 'tight' and echoless, without the feeling of being in a barn that is experienced at so many rehearsals in unoccupied auditoriums. There even seemed to be no loss in quality under the balcony overhangs."

Washington Post music critic Paul Hume cited the Concert Hall acoustics as "a modern miracle" and praised the hall's "clear, balanced, live sound."

Martin Feinstein said exuberantly: "We have been blessed! We haven't touched the halls since they've been opened. Audiences are happy. The critics are happy, and more important, the artists are happy. Every artist I have talked to has raved about the acoustics in the Concert Hall—Artur Rubenstein, Isaac Stern, Beverly Sills, Dorati, Normandy—all praise the acoustics, and they *are* remarkable. The same is true in the Opera House. Even for a straight play. Ingrid Bergman was very happy with the Opera House in spite of the fact that it is a big house for a straight play. The New York City Opera came down here and they were just bubbling over about the acoustics in the Opera House. And the same thing is true in the Eisenhower Theater. Cyril Harris has batted 1000, which is unheard of," Feinstein laughed.

There have been, however, a few minor grievances by some performers concerning the difficulty of hearing onstage, especially in *fortissimo* sections, and another *Washington Post* critic, Alan Kriegsman, insists the Concert Hall doesn't live up to "its paradigm in Boston." Paul Hume recently commented on the audible transmission of coughs and whispers and those Concert Hall doors which close with a bit of a bang when people simply must get up during a performance. (The doors reportedly have been since worked on.) This writer has noted a certain shrillness in sound quality as though the hall is almost *too* sensitive. Noticeable also is a tendency for the percussion instruments—except for the piano—to override and sonically smother their fellow instruments so that (at jazz concerts in particular) it is often necessary to place a pad or shield in close proximity to the drums.

But, for the most part, these are minor flaws, and there is talk of recording in the Center's halls for all their clear, lively, well-balanced sound. Dr. Cyril Harris summarized: "It came out exactly as we planned it."

Harris actually began work on the project as early as 1965 in close consultation with the architect and engineers, thereby getting the jump on problems and preventing them by superimposing acoustical principles upon Stone's design from the very outset. Harris says: "Acoustics is a science. Applied acoustics is both science and art—the application of experience to the science . . ."

Dr. Harris encountered very special problems in the acoustical design of a Center for the Performing Arts beset by the traffic noise of a neighboring parkway and in the direct flight path down the Potomac River of low-flying jets coming in for a landing at nearby National Airport, directly downstream from the Kennedy Center. Helicopters at times hover about the Center like gigantic mechanical bumblebees. Harris notes the Center "posed some unusual and severe problems in acoustical design because of exceedingly high peaks in the background noise level." It was therefore crucial to insulate the Center from all extraneous noise sources.

Dr. Harris describes the Center's construction as a "box-within-a-box" wherein the three auditoriums are insulated from noise by individual supporting columns completely independent of the columns supporting the outer framework of the Center. This tatic also protects the theaters from noise of facilities such as kitchens and cafeterias directly over them. In most cases, Harris implemented solid 6-in. high-density concrete block double-walls separated by a 2-in. airspace filled with low-density fiberglass laid on load-bearing cork, and used sound-rated doors. In each instance, noise-rated doors are used for auditorium entrances and each auditorium is enclosed by corridors at each audience level to prevent noise from pedestrian traffic in and out of it. Described as "sound locks," the theaters have acoustically treated ceilings, their walls are covered with 2-in. thick absorptive acoustical board faced with carpeting, and their floors are covered with carpeting.

Separating each of the auditoriums are the Hall of Nations and the Hall of States, two enormous halls through which ticket-holders pass to reach the individual theaters. Forty feet wide and 63 feet high, the halls run all the way from the front of the auditoriums to backstage. At intermission, theatergoers gather in an additional hall of gargantuan proportions, the Grand Foyer, one of the largest rooms in the world. An awe-inspiring promenade 600 feet long, 40 feet wide and 63 feet high, the Grand Foyer flows down the entire length of the Center in front of the three auditoriums with its west side flanking the river. Along the west wall is the 7-ft., 3000 lb. monumental bronze head of the late President Kennedy sculpted by Robert Berks. The Grand Foyer creates another potential noise problem in that the audience from one performance often stands around in it chatting while another theater is in operation. Air traffic noise is also a hazard in the Grand Foyer. Therefore special sound considerations were required such as carpet on the floor underlayment, acoustical plaster on the ceiling, and a total of 40 sound-absorptive panels on the walls. The side of the Grand Foyer overlooking the Potomac is glazed and large acoustic double-window units seal out air traffic noise as well as providing thermal insulation. Both panes of glass in each unit are "mounted with a resilient seal so that there is no solid connection between the glass and the surrounding frame."

The noise from the air-conditioning system was a factor in Harris' overall acoustical plan and by consulting with architect Stone and the engineers in the early stages of construction, a noise level of no higher than NC-20 was insured throughout the stages and auditoriums, and all transformers and mechanical units were strategically placed to the advantage of noise control. Cyril Harris lists other noise-control measures as " . . . specifications which limited the noise output of potentially objectional noise sources, and the appropriate use of floating slab constructions, inertia blocks, resilient mounts, flexible connectors, duct lining, damping materials, and sound traps, as required. Where noise from piping was a potential problem, flexible connectors and resilient hangers were used. Finally, where space requirements were such that it was necessary to locate a quiet area under a mechanical equipment room, a resiliently hung ceiling was used in that quiet area."

The Concert Hall, the largest of the Center's auditoriums seating 2,759 persons, is a rectangle and is similar in shape to some of the finest concert halls in the world such as the Concertgebouw in Amsterdam, the Musikvereinsaal in Vienna, and Boston's own Symphony Hall. Because of the decorative embellishments of gargoyles and cherubs, indicative of the time when these halls were built, they provide excellent acoustical diffusion. A problem at the Kennedy Center was to achieve a persuasive acoustical design compatible with the architectural concepts of Mr. Stone, that would perform the same function. In keeping with the period, Harris used no clouds or other modern devices.

Splayed wood panels, ¾-in. thick and extending from ceiling to floor along the side walls are one such element of diffusion. Projecting about 30 in. from the wall surface, they provide ample diffusion at low frequencies. To facilitate diffusion at higher frequencies, Harris used a lapstrake construction in fabricating the splays whereby each vertical wood board overlaps the one adjacent to it so that varying widths are exposed. The panels are attached to a solid wall 6-in. thick with about a 1-in. airspace filled with a fiberglass blanket. A solid plaster wall surface 3 ft., 11 in. wide separates each of the panels into which are set the side entrance doors to the hall, intentionally recessed 6 in. from the edges of the side wall splays to create additional diffusion.

Harris prefers his ceilings to be thoroughly broken up. The 52-ft. high ceiling of the Concert Hall is coffered and comprised of a multiplicity of hexagons about 1 ft. in depth. Set within them are stepped hexagonal surfaces of varying sizes centered around a small perforated metal hexagonal surface. Some are diffusers of the air-conditioning system, others are backed with solid plaster to prevent unnecessary acoustical absorption. Moreover, some 292 spherical balls intervene to further diffuse the sound and are interspersed throughout the ceiling for diffusion at high frequencies together with 11 large crystal chandeliers given by the government of Norway. Because of their unique tier design, the chandeliers diffuse the sound in several frequency ranges. To prevent bass frequencies from being soaked up, the ceiling is extremely heavy. A concrete plank above it insulates the Concert Hall from the kitchen and restaurant facilities overhead.

A very shallow balcony overhang obviates a reduction in sound level underneath it. A series of 1-in. thick plaster panels on metal lath comprise the balcony facias. Arranged in groups of three, they form splayed surfaces to contribute to sound diffusion.

The hardwood floor consists of red oak on the stage floor and white oak nailed on plywood in the seating areas. Harris explained: "Wooden floors cost more, but you know how it is in a great hall. You can literally feel the music through your feet." Identical chairs are used in the three auditoriums, carefully scrutinized and chosen for their acoustical properties by Dr. Harris. A minimum of carpeting covers the aisles and crossover at the rear of the hall. In order to select carpeting which possessed the desired sound absorptive characteristics, Harris utilized an impedance tube measurement technique, choosing the carpet "on the basis of its sound absorption versus frequency characteristics, being lower than the other samples tested at high frequencies." After carrying out comprehensive comparitive tests of various carpets in his laboratory, Harris chose a 70% wool, 30% nylon carpet with a cut pile of about 0.16 in. in height laid on concrete for all the theaters in contrast with the carpet in the exterior foyers where high sound absorption is a prime requisite.

The Concert Hall stage is surrounded by splayed surfaces similar to those on the side walls but varying slightly in dimension, thereby making it possible for the players onstage to better hear one another. The over 4,000 pipes of an Aeolian-Skinner organ dominate the upper rear of the stage but can be closed off from view.

The Kennedy Center's borsch-red Opera House is the central theater and the most attractive of the three, playing host to musical comedy and ballet as well as to grand opera for which it was primarily intended. With a seating capacity of 2,319, the Opera House is in the shape of a horseshoe and it was the intention of architect Edward Durell Stone to achieve as much intimacy as possible for both performers and audience. This was accomplished. There is absolutely no bad seat in the entire house. Sightlines to one of the largest stages in the world—the space behind the curtain surpasses the auditorium itself—are uniformly excellent.

Adjoining convex-shaped cylindrical surfaces form the rear and side walls of the Opera House, separated one from the other by ornamental recesses. On the sides, these convex surfaces are constructed of 1-in. plaster on metal lath backed by 6-in. solid block which follows the convex shape. A 1-in. airspace lies between the plaster and the block. The rear walls are of a similar design but are constructed of preformed curved ¾-in. wood paneling fixed to solid block. A fiberglass blanket is inserted into the intervening 1-in. airspace.

The center of the Opera House's ceiling is recessed and is of a 27-ft. radius broken up by 4 stepped surfaces tilted convexly downward. Mounted therein is a splendid starburst crystal chandelier given by the government of Austria which diffuses the sound at high frequencies. Convex diffusing surfaces radiate outward from the center of the ceiling, widening as they reach the outer edge. It is composed of plaster on metal lath and is of a minimum thickness of 1 in.

On the facias of the box tiers, curved panels bowed outward diffuse the sound waves and are formed of ¾-in. plaster on metal lath. The floor, which slopes about 7 degrees, is fully covered with a low-pile carpeting laid on concrete. Because the hall is to be used for speaking as well as singing, a lower reverberation time was required than for traditional grand opera.

The Eisenhower Theater for drama seats 1,142 persons and is the smallest of the three completed theaters. Contiguous triangular splays which extend from floor to ceiling form the rear and side walls and are made of ¾-in. East Indian Laurel veneer panels mounted on 6-in. solid-block walls. Again fiberglass fills a 1-in. intervening airspace. Each splay projects about 18 ins. into the theater and each side of the triangular splays is approximately nine feet in width.

A box tier and balcony have facias consisting of a series of vertical bars. Lighting units for the stage lie behind the grill and behind these lighting units are fiberglass blankets. The soffits of the tiers are formed of 1-in. plaster on metal lath.

The ceiling is spanned by convex-shaped surfaces from one wall to the other. It is resiliently hung from the slab overhead and is of 1-in. plaster on metal lath. The floor, which slopes about 8 degrees, is fully carpeted with the same carpet that is used in the Concert Hall. It is interesting to note that in the ⅔ full theater Sargent Shriver fired a small cannon whose decay was recorded and analyzed by Dr. Harris two days before the official opening of the Eisenhower Theater.

I have attempted here to sketch out the tremendously detailed and complex acoustical plan Dr. Cyril Harris implemented in the Kennedy Center for the Performing Arts. In preparing this non-technical blow-by-blow description, I am deeply grateful to the mastermind himself, Dr. Cyril Harris, who kindly permitted me to use his article "Acoustical Design of the John F. Kennedy Center for the Performing Arts" which appeared in the *Journal Of The Acoustical Society Of America,* Vol. 51, Number 4 (Part 1) 1972. It is thoroughly informative and readable and is absolutely indispensable to this piece. Readers who are interested in additional statistics such as reverberation time charts, tables, and architectural plans would enjoy reading his article in its entirety.

Audio ETC

Edward Tatnall Canby

There is no opera house effect more wearing upon the psyche than what I like to call the Wagnerian hush. It comes somewhere in the middle of one of those vast five-hour music dramas and you must be *there* to appreciate it. After hours of massed togetherness in the dark, crowded house, there comes a long *decrescendo*. The music goes down and *down*, until time and sound are suspended and only a thread of continuity, a few faint notes, breaks into the long, pregnant pauses. Nobody breathes. It's awful. Don't think that John Cage discovered the musical silence.

Of course, these moments are but the distant prelude to some vast sonic climax, a veritable Krakatoa of music, which will arrive, say, an hour and a half later. It's all calculated—a stupendous dynamic range—and Wagner spreads it out over unthinkable lengths. He knows exactly where he is going, though. And you will go with him whether you want to or no. Many an opera fan, overwhelmed, goes soundly asleep. It's an easy way out—you might think. Not a bit. Hours later, you wake up with a violent start, your hair absolutely on end. You've heard every note and you're just in time to be flattened by the monster climax. Asleep or awake, you can't resist, and no use trying. That is, in the opera house.

On records, Wagner is a problem. Just try the Wagnerian hush in your living room. Down goes the volume, lower and lower, right on schedule, say, the beginning of side 7. Slower and slower. Long pauses. *Churn, churn, churn!* That's your turntable, relentlessly pulsing its 33⅓. *Ssssr, ssssr.* Tiny residue of tape hiss after Dolby, brutally exposed. Then BEEP! BLAAST! Your neighbor cuts in with his auto horn. It's in the wrong key. A roaring crescendo of drums? Nope, just a hopped up Pontiac out on the street. Faint shrieks of agony—Brünnhilde immolated? The kids outdoors, playing gangster. Kerplunk. The refrig went off. Throb, throb. The air conditioner or, maybe, the furnace, according to season. And at this moment, of course, the phone rings.

Meanwhile, back in the opera, a French horn gives a faint burp, once . . . twice. Or was that a distant diesel locomotive? Not easy to tell. Poor Wagner! A thousand petty distractions, all reeking of *now*, hopelessly entangle his calculated silences in the rapid-fire sounds of our own age. A wholly different time sense. It's a problem common to much classical recording but never more dramatic—or non-dramatic—than in Wagner, whose musical pace is that of the eons, glacier-like, inevitable, and who demands and gets total attention. Again, in the opera house. Where else? That was all he knew.

So why do we have whole albums of Wagner on LP? Pure human cussedness. And imagination. If we really want to, we *can* wrench ourselves back into that atmosphere and hear the slow silences, in spite of interference. And our recording engineers, too, can do vital things to aid the musical translation we must have in order to remove Wagner from opera house to living room. That's recording technique. Its specialty is *not* being literal.

With all this as background, you will marvel with me at the bravado of Philips. This big Dutch record company has been recording whole Wagner operas, one after the other, right in the opera house at live performances. Crazy. We need every bit of flexibility that modern recording technique can devise if we are to make a workable Wagner translation and to do such an enormous, risky, expensive job other than via the recording session would seem corporate suicide. In most other Wagner recordings of recent times, the live productions are followed by separate sessions for the recording. In Wagner, these enterprises are almost beyond belief. The entire production, refashioned for the recorded result, is laid out in some vast hall, the artists spread everywhere, on the floor, in the balconies, backstage, surrounded by seas of cable, hundreds of pieces of equipment; alternative takes are taken *ad infinitum*, until each segment is precisely right. The continuity is as likely to start with the final scene and end with the overture as the other way around. A vast and complex ingenuity (and more and more like film production), all in the service of musical translation. From the live opera to the recorded opera! Every bit is justified, as we hear the Wagnerian drama unfold at home in a situation totally inconceivable to Wagner himself.

I am trying valiantly, you see, to tip you off on the momentousness of Philips' achievement in taking down Wagner whole and live from the stage performance—and making it work, right in the original Bayreuth opera house that Wagner himself built a century ago for his own music. Well, you mutter again, isn't *that* a literal hi-fi reproduction, if ever there was one? The horse's mouth! Nope. It is still a *translation*. Philips is successful because they take this for granted, even though the live and the recorded versions are the very same performance.

What Philips has in mind is to capture as much as possible of the human quality of a living performance, before an audience on a stage, while providing those necessary adjustments, via recording technique, which make the translation acceptable in living room terms. That's a tall order, though they had a lot going for them in the special circumstances of the Bayreuth Festival. So many things can go wrong in a live recording. No corrections—a mistake is a mistake—unthinkable in a recording that is to be heard again and again. A limited possibility for joining parts of live performances—they seldom match. The mood is different. The weather changes, and the humidity. Even the pitch. So do stage movements, and hence mic balance. Singers sing louder one night than on another. The embattled engineers can't do a thing; they must take what comes. A ghastly risk.

Miraculously, little of all this shows up in Philips' astonishingly smooth and natural productions. Mistakes? Virtually none. Very few of those minor mishaps, that usually abound in live recordings. One must assume that these seasoned productions were done over and over again and honed to razor precision. Bayreuth runs a heavy schedule and is the mother-house for the entire living Wagner tradition. Its singers, top pros, are unlikely to fall into states of nerves in the face of a "simulcast" for the live audience out in front and for posterity via the mics. The conductor of the new "Ring" series, all twenty-odd hours of it, is Karl Böhm, another veteran pro who keeps things in hand down to the last detail. One might—if one were Philips—take a risk on these people. One did.

What of the effect of the live audience? Musically, it should enhance the impact of the singers. The excitement of such a performance is a two-way thing, a vibrant emotional circuit between performers and around audience. That is what we miss in many dramatic recordings done without an audience. Can't be helped, and we do get fine music even so. But—if we could translate the audience feel, without the audience disadvantage (most of them are noisy), it would be fine.

Can we? Too often an exciting live performance makes an anticlimactic recording, even when the audience behaves itself acoustically. Tense, hysterical, full of nerves, uneven, and often unbelievably replete with glaring mistakes, wholly unnoticed in the glory of the actual occasion. When you chop off half the circuit and toss the result, like a leg off the musical body, out into the living room, you are changing the entire musical substance—*it is no longer the same performance.*

A recorded live performance, then, must be extraordinarily well controlled, perhaps even to the point of non-incandescence. The Philips Wagner is precisely that. Yes, one does sense the audience, indirectly, though it remains astonishingly silent. But the singers have that audience before them, and the strength and purpose can be heard in the music, ever so clearly. But there are no nerves—almost none. All is discipline, a maximum energy transfer into pure musical expression.

Whether these performances "took off" *in the actual opera house*, I could not say. I wasn't there. That is another matter altogether—a different performance, if you will.

If the audience is supernaturally quiet, what of the opera staging and the acoustics, as we hear them? I'll have to take my hat off to Philips' seasoned wisdom in this area. They understand, even the Wagnerian hush. They make a *recording* that works as a recording, a true translation of the musical intent. It isn't at all what you hear from the audience.

What Philips does is, of course, to put us on the stage itself, not in the audience. So that we perceive everything in carefully exaggerated close-up impact, to carry us through in the tough living-room situation. The singers are no more than a dozen feet away, right before us. Every note, in the dry, warm acoustics of the house itself, is ultra-clear, every syllable precise. The big orchestra is spread out behind the singers, not in front and below, as it is heard by the audience, but in a wide stereo spread—much wider, again, than the spread heard from that fabled "best seat in the house." The acoustics are indeed dry, as in most proper opera houses. But not lifeless. Far from it. I have seldom heard strings so realistically projected in recording. Top-notch mic placement.

I will admit that there are some debits. All is well when the gods and heroes and heroines are doing their long tête-á-têtes, musical conversations person to person. Or when one of them launches into a half hour synopsis of previous events. (The "Ring" cycle is well known for its endless catching up on what has happened before, and before that.) Here, the close-up vividness of the singing makes it easy to follow the dramatic sense, especially with the aid of the complete text and translation. You begin to understand that these long passages aren't really so bad. One up on most opera goers! They have to guess, if their German isn't so good.

But Wagner's characters are curiously contradictory, half god, half man, at one moment fallible and human, at another suddenly rearing forth as symbolic figures of timeless dimension. When this happens, it is not comfortable, nor right, to be so close. Bad to feel the angry Wotan's every breath, hear his teeth click. Wagner meant these great people to stand off at a distance in a stage world of their own and that is how they are heard in the opera house.

Luckily, the Wagner orchestra rescues us. Always the direct protagonist of the voice, it rushes in to cover the too-closeness whenever the great climaxes come along. Philips knows better than to play *it* down in the balance. The orchestral stereo is fully enveloping and beautifully projected. So the climaxes are climactic, and you'll love 'em.

If I were to make hours of AB tests, I think I'd favor by a small hair the Philips competition, made by the other system. Notably the Von Karajan recordings for Angel and Deutsche Grammophon. They project a smoother, more even dramatic continuity. Greater control of the ultimate sound is the answer—via the specially set up recording session. (And what a paradox, that these recordings are put together in bits and pieces!) Von Karajan himself has a lot to do with it, an expertly dramatic conductor and a man who knows recording and respects it.

The Philips live-recorded Wagner is inevitably a bit uneven. Remarkable that it is not worse. At times we seem to lose contact with that stage production and the music drags. (But was the live audience impatient? An interesting question.) I do love the warm, dry Philips sound, Wagner's own acoustic. But, on records, I found Von Karajan's big "concert hall liveness" thrilling, even though like no opera house in existence. Why should it be? This is a recording.

So take your choice. But don't ever think that a live recording is a literal reproduction of *any* original. Not even a simultaneous and identical one. It is still a *recording*, for better or worse, and that's how it sinks or swims.

Sherwood's Forest

Sherwood L. Weingarten

I'M GETTING remarried! Maybe it's just November, with its biting wind, that lashes at our illusions and makes us confront reality. Perhaps there's enough stamina left to whip the fatigue, the enormous weight of time, that buries dreams.

Over four years ago, I wedded myself to this column, which promised its own brand of love, experimentation, vitality. The column was faithful; I cheated. Somewhere along the line, I traded romance for traditionalism, wandered from imagination to dullness. Worst of all, I let myself become bored—jaded by listening to, and commenting on, too many recordings marketed by money-managers instead of musicians.

So I wrote about things *others* found interesting, eating up valuable space with bland commentary or playful puns. No more. I've declared my independence, which enables me to return to the starting point, the wedding point; only the original, the fresh, the exciting will gain my ear. And if that leaves out Mantovani or Donny Osmond or a host of others, so be it.

To commemorate the event, sort of a second time, let's begin with a ceremonial cliche—something old, something new, something borrowed, something blue.

The old is **THE BEST OF MARLENE DIETRICH** (Columbia, C 32245). Dietrich is an original, one-of-a-kind creature abhorred by advocates of Women's Lib. Her nasal, tremble-filled voice offers sultry sex in a manner that will bemuse and interest as long as chemistry between genders exists.

Charm seeps from the LP, which is introduced by Noel Coward—another unique show biz dinosaur—via clever drawing room verse. But the show belongs to Dietrich, whether she's stealing from Fats Waller *(Honeysuckle Rose)* or Edith Piaf *(La Vie En Rose)* or Cole Porter *(The Laziest Gal in Town)*.

Style, some would term it; others would label it class. Either way, it's the kind of thing that makes each listener feel as if she's singing just for him.

Falling in Love Again, for instance, is a *tour de force* created from a song whose limits ordinarily are all too obvious; *The Boys in the Backroom can't* be done effectively by anyone else; *I Wish You Love must* increase the rate of your heartbeat, and *Lili Marlene* is proof that memory can be pure.

Old in years, yes. But these reissues are as perfect now as the refurbished Pieta.

Stepping from the past to the future, we find a new LP from a young performer destined for superstardom, **MICHAEL FRANKS** (Brut, 6005). He's funky, poetic and incredibly honest.

The genre is folk-rock, a good deal of it vastly softer than the heavy metal sound that's regaining popularity, but even buffs of the latter will pay homage to Franks' talent if they give him a chance. His melodies tend to be simple, though it's evident he's done his homework in jazz and the classics; his lyrics are poignant, lovely excursions into a stream of emotionalism. As for his voice, it carries enough impact to enable him to compete with the likes of Carole King, Roberta Flack—or even latter-day Dylan.

It would be criminal, furthermore, to fail to mention his instrumental abilities: acoustic guitar, banjo, and mandolin almost seem as if they were created for him to use as an aid to his music.

Best of the ten cuts on the LP, distributed by Buddah, is *Three Today,* a masterwork that sharply contrasts—in words and melody—the disillusionments of adult life with the innocent joys of childhood. Additionally, it pinpoints how parents can gain new insights and hope through the actions of their offspring.

Little Sparrow, another joy, is a paean to life and love and natural wonders, contrasting frailties and strengths. And *Can't Seem to Shake This Rock and Roll,* which is getting heavy airplay, alludes to the classics and jazz and is a personal statement of where the artist is at.

The album favorably compares with two others from a couple of years back, one the debut of a Pete Segger disciple, Don MacLean, the other the first LP by a virtually unknown songsmith, Carole King.

Segment three of our ceremonial offering consists of **THE NAKED APE** (Playboy, PB 125), an original soundtrack LP from a film "borrowed" from the Desmond Morris book of the same name. Spotted with both sardonic humor and serious historical perspective, the vinyl is one of those rare examples of a recording that whets your appetitie and makes you want to see the movie.

The score is by ***Jimmy Webb*** and includes four new vocals (which *he* sings), in addition to satirical version of *You Brought a New Kind of Love to Me,* a gospel-screecher (*Jesus Loves Me*) and an excerpt from a Bach classic.

Naked Ape Theme (Fingerpainting) is one of the Webb creations, an excellent, moody piece that probably will win an Oscar if a superstar does a cover version. But the best moments are found on *Survival Rag,* a funny but biting tune sung by director-screenwriter ***Donald Driver.***

It's the kind of album that surprises because it truly entertains—and lets you think as well, if you choose.

Finally, something blue is available on Mercury's **NO MORE, NO LESS** (SRM 1-666), with a dozen tracks taped by an exciting quartet, ***Blue Ash.***

Most of the music is original, with nine of the songs penned by Frank Secich, bass guitarist for the group, and Bill "Cupid" Bartolin, lead guitarist; a tenth was written by Jim Kendzor, Blue Ash's lead vocalist and rhythm guitarist.

Although there is some repetition, there's enough hard rock variety to keep any fan happy. Witness, for example, *Just Another Game,* a superlative, multi-tempoed view of life today, slapping at those who do what they *think* is necessary when it really isn't; *Smash My Guitar,* a fascinating look at emotions, particularly those of a rock performer; *All I Want,* good old-fashioned rock 'n' roll, and *Wasting My Time,* which has won a large amount of DeeJay favor.

Each of the musicians has passages that merit raves (including drummer David Evans, the only group member not credited with songwriting skills). And together they can do novel wonders with hackneyed things such as Bob Dylan's *Dusty Old Fairgrounds* or a Lennon-McCartney clinker *Anytime at All.*

Blue Ash does its damnedest to chase away the blues; it succeeds.

RICHARD NIXON: A FANTASY (Buddah, 1600) finds ***David Frye*** satirizing the President's plights with

Watergate, taking the Man From Whittier from involvement with the bugging incident to incarceration in Folsom Prison and his subsequent execution. Frye, the foremost mimic of Nixon's voice, slightly exaggerates Tricky Dicky's woes. As when Nixon-Frye talks to the American people shortly after learning of the magnitude of the scandal. Says he: "Today I have regretfully been forced to accept the resignation of 1,541 of the finest public servants it has been my privilege to know." No matter which side of the political fence you're on, listen—and laugh.

DAVID CLAYTON THOMAS (RCA, APL 1-0173), former lead singer of Blood, Sweat & Tears, goes it alone, sort of. He's actually backed by a group even bigger than B,S & T—but he's billed as a single now. His "debut" LP, which combines rock, blues and country, ranges from great (Lennon-McCartney's *Can't Buy Me Love*) to good (Hoyt Axton's *Sweet Fantasy,* despite the slick, gimmicky arrangement) to horrible (*Hernando's Hideaway*). Mostly, though, he's a man with star quality—particularly when his voice is in counterpoint with the brass section. *Alimony* could be a sleeper hit, country-rock at its best. Thomas should stick to singing, though; the three tunes he penned are only mediocre.

BECK-BOGERT-APPICE (Columbia, EQ 32140) is one of the best quadraphonic discs so far, the nearly perfect vehicle to envelop you in sound. It's fashionable for critics to knock supergroups (like the late, lamented Blind Faith), usually commenting on the difficulties of ego clashes, and the pattern has been continued in some rock journals with B-B-A; problem is that the group deserves better treatment, for this recording will be played long after its components have split. Best of the nine cut are *Black Cat Moan,* a heavy, heavy sound; Stevie Wonder's *Superstitious,* replete with tribal rhythms, and Don Nix's *Sweet Sweet Surrender.*

RAINBOW (MCA, 2103) resembles a "best of" LP in that it anthologizes ***Neil Diamond*** hits, 11 of them. The difference here is that no original Diamond creations are present; all the tunes were written by others. Nonetheless, for those who enjoy the singer's folky style, this could be a real money-saver. The lineup includes *Everybody's Talkin, Both Sides Now, Until It's Time for You to Go, Suzanne, Mr.*

Bojangles, I Think It's Gonna Rain Today and *He Ain't Heavy, He's My Brother*.

GLUGGO (Vertigo, VEL-1015), a recording distributed by Phonogram, the new name for the Mercury cluster, features a group that can do it hard or soft, bluesy or countrified, dry or with humor. It's together-rock, basically, with easily understood lyrics. There are nine cuts by the ***Spencer Davis Group,*** all except the traditional *Trouble in Mind* penned by a member of the quintet. Highlights are *Alone; Today, Gluggo, Tomorrow the World,* a great vocal-less rocker showing the synthesizer's scope at its best, and *Mr. Operator*, a smooth, harmonious rock special.

MINSTREL IN FLIGHT (Kama Sutra, SKBS 2069) is a good LP with lots of variety (though the emphasis is on hard rock). ***Roger Cook*** is the star, and he composed all but two of the ten tunes. You can find fragments of slow material, country and lots of moralizing. Cook's voice is rough 'n' tumble, a sharp contrast to his lyrics, which sound as if they stem from a flower child who retains hope that the Haight-Ashbury syndrome isn't gone forever. Best numbers on the record, distributed by Buddah, are *Eating Peaches in the Sun, Carry On, Sad Stoned* and an anti-war, anti-Establishment treatise reminiscent of some early Country Joe stuff, *The Power of Your Big Brother*.

LIVE AND LET DIE (United Artists, UA-LA 100-G) is an original soundtrack LP distinguished by the presence of the chartbusting title tune, a song performed by ***Paul McCartney*** and his backup group, ***Wings.*** The tune, written by Paul and his wife Linda, can be heard on virtually every pop radio station. The *James Bond Theme* also is reprised here, more than adquately. The rest, by ***George Martin,*** is regular movie garbage—except for the traditional *Just a Closer Walk With Thee*, an updated version to be sure.

HEAVY TRAFFIC (Fantasy, 9436) is the sound track from an X-rated full-length cartoon. Even if that category irritates you, the music should soothe. Best are the replays. ***Sergio Mendes & Brasil '66*** doing *Scarborough Fair*, the ***Isley Bros.*** and *Twist and Shout*, the ***Dave Brubeck Quartet*** performing *Take Five*, and ***Chuck Berry*** with the classic *Maybelline*. Other material features Mel Saunders toying with an original score by Ray Shanklin and Ed Bogas. At worst, worth a few spins!

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JAY L BUTLER, Publisher

Classical Reviews

Edward Tatnall Canby

E. Power Biggs-Bach Organ Favorites, Vol. 5. Flentrop organ, Busch-Reisinger Museum, Harvard. **Columbia MQ 31424**, SQ, $6.98.

I played this quadraphonic disc late last summer on the latest "3-chip" SQ logic decoder, especially installed in my system at the time. The results were, I must admit, impressive. The new decoder is a clear improvement in the continuing sophistication of the matrixing system.

The biggest fault of any matrix arrangement, with or without logic, is a variable overlap of signal in the room-sound aspect of the recording which tends to create a curious standing-wave "hump" of sound overhead, in the middle, a four-way mono component that does *not* belong there and, for a careful ear, is a real distraction and distortion. In the earliest matrix decoding this effect was unpleasantly noticeable. With increasing sophistication, first in straight matrix circuitry, then with the extra aid of logic, that central hump of sound has, so to speak, been gradually reduced, flattened and spread out, and the over-all quadraphonic effect has been correspondingly improved.

I still can hear some of it via this latest decoding from CBS, though its presence depends in part on which recording you play. But it has definitely been reduced to a new "low" and the sound in four channels is correspondingly much better. Even in older SQ-type records. No logic "pumping," audible jumps from back to front and the like, either. In this big organ recording, the sound is dramatically good, perhaps because of the nature of organ sound in a reverberant space, already so gloriously mixed-up that a sonic "hump" would have trouble maintaining itself!

Without any question, the RCA-type Quadradisc ("discrete") can do a still better job, sound for sound, in this particular facet of quadraphonic reproduction. There simply is no argument on that score. There *is* no hump. The reverb is reproduced naturally as a real space. That superiority is at a multiple price which we are still all of us evaluating—secondary problems of expense, equipment availability, broadcasting, disc cutting at slow speed, and the direct problems of lowered levels, necessary tonal adjustments, the residue of distortion and so on. But so long as the "discrete" disc can give us *humpless* four-way sound, and so long as the matrix disc decoders continue to improve in their subtlety, the matrix-discrete arguments will go happily forward. More power to them.

(Biggs? He is always at his best when he has a really good organ to play. This modern instrument is his own, at home base; he plays it with gusto and appreciation. Good Bach, well registered and beautifully recorded.)

Performance: B   Sound: B-

Beethoven's Greatest Hits. (Ode to Joy, parts of Fifth Symphony, Moonlight Sonata, etcetc.) Assorted CBS orchestras, soloists . . . **Columbia MQ 32056**, SQ, $6.95.

The point to be made concerning this potpourri of reissues in SQ is that quadraphonic recordings—any system—can be constructed very nicely out of older catalogue items going back a good many years. Columbia, if I am right, has been doing all its classical in 8-track for umpteen years and presumably other majors have too, at least on this side of the Atlantic ditch. A four-way mix-down, brand new in effect, can be made just as readily as the conventional two-way mix-down. That is what we have here, from the Philharmonic, the Philadelphia (pre-RCA), Philippe Entremont, the Morman Tabernacle Choir. It's not a Beethoven disc for dedicated Beethoven listeners but it is an excellent example, which happens to be in the SQ matrix format, of the kind of new-type recording which can be made from thousands and thousands of older tapes which were not specifically intended for quadraphonic sound.

The only question, I think, is—do these constitute "reprocessed" quadraphonic? Not to my opinion. The "reprocessed" stereo disc is a mono original, one channel, which has been made into two, a mix-UP. No pun intended;

some of them are excellent. This SQ disc is simply a new mix-DOWN. There are dozens of them and soon will be hundreds.

Brahms: The Complete String Quartets (Op. 51, Nos. 1,2; Op. 67). The Cleveland Quartet. **RCA VCS 7102,** 2 discs, stereo, $11.96.

It had been a long time since I had heard these three quartets—they have not been very stylish in recent years. But now, with the supposed "Romantic revival," they are back and, of course, high time if we are to have any music at all for plain old string quartet, unamplified! But I find them, for my somewhat ancient ear, very strange performances of familiar music. Definitely, of a new generation with a new point of view.

The Brahms chamber music is tough stuff, extremely strong minded, rigorous, compact, dedicated, and nowhere more than in the quartets. They were far more modern, at the time, than was then conceded—especially by the Wagnerian school of German music, which disapproved of virtually any music that made use of traditional formats and structures. As Brahms had it, the great shadow of Beethoven, looming ominously, spurred him to ever greater intensity. The great performances of the early 20th century maintained this tradition as a matter of course. I very well remember these quartets as the scratchiest, hardest-worked pieces in the repertory—the strings seemed almost hoarse with the sheer effort of projection and I always felt that Brahms had outdone the medium itself—these were symphonies, concerti, at least in their intensity, trying to get through the small voices of the quartet.

Now what? The Cleveland Quartet is young, long haired, bearded, and like many younger people, honest in their convictions; they have worked out their own feelings about this music and to heck with traditional ways of play. That guarantees interest. Instead of that rigorous, almost hard intensity I remember, here we find what I can best call a gentle approach. *Gentle*—for Brahms! Crazy. The man was possessed of a demon, a puritan conscience, to drive him forward; his marvelous sense for melody was the foil that kept drama alive. And yet these people play him gently. No better word for it.

Not really good for Brahms. There is no long line, no sustained shape; all is expressive, pulsating, emotional non-drive. It is a Baroque sound in Romantic guise, the melodies almost lost in their accompaniments, the counterpoints unemphasized when two melodies play at once—which is often and should be emphatic in any 19th century music. And the rigorous climaxes, the returns of major ideas, are treated in pleasantly casual fashion, rather than as great fulfillments of high-level formal construction. Nope—this isn't the old Brahms. It's a sort of flower-child version.

A criticism? Only in that some aspects of the music are unrealized. The solo melodies are very seldom given the prominence they need. The first violin, always the leader, is almost apologetically modest. The super-intense moments, not set off by the melodic parts, aren't really intense, and so on. My feeling is that the very honesty of these interpretations is both their best quality and their main fault. Most young quartet players slavishly imitate the Budapest Quartet (or the local conservatory faculty quartet—which usually has done the same) and so acquire a technically correct interpretation that sounds right and is pure fake—until they grow into it for themselves. I think this is the better way, by far.

The fact is, though, that these young people haven't really found Brahms yet. When they do, they'll be terrific. In their next recording.

Performance: B- Sound: B-

Liszt: Mountain Symphony; Malediction for Piano and Orch.; La Lugbre Gondola. Alfred Brendel, piano; Vienna Symphony, Gielen; Music for Westchester Symphony Orch., Landau. **Vox Turnabout TV-S 34518,** stereo, $2.98.

Vox's Turnabout series, the low-priced offering, is an intelligently produced series combining relevant recordings that are both old and new. The piano solo about the lugubrious gondola here, for instance, is simulated stereo, the rest "real" stereo—I wouldn't have noticed the difference. The excellent Austrian pianist Alfred Brendel is the musical binding force along with old man Liszt himself, represented here in early, middle and late music.

The big symphonic poem subtitled *Ce qu'on entend sur la Montagne* (What one hears on the mountain) remains a sprawling mood work of a sort still too corny sounding for our sophisticated ears, though it was—for the revolutionary ears of 1848—undoubtedly quite sensational. I'd say that the Westchester-based orchestra under Landau does a remarkably good job with it, all things considered. The *Malediction,* very rarely heard music, is another of those lugubrious Liszt pieces that are often his best—it isn't exactly easy listening, either, but makes its dismal points in the gloomiest fashion. The funereal gondola is a late Liszt piano piece, one of those that now appears as advanced experiment in atonality. Extraordinary for its day and once again it marks Liszt as the first of the German modernists, far ahead of the much later Richard Strauss in harmonic terms.

Performances: A- Sound: B-

Liszt: Piano Concertos (No. 1 in E Flat; No. 2 in A). Ivan Davis; Royal Philharmonic, Edward Downes. **London SPC 21081,** stereo, $5.98.

London's Phase Four recording—no connection with quadraphonic—is well known for liberal microphoning for advanced effects. Here, the projection of the piano solo is *very* liberal, at the expense of the orchestra. OK; so Liszt was a pianist and so is our star, Ivan Davis. Even so, the music is not well served by being treated as solo piano music, close-up. Even though, admittedly, you can also hear the orchestra.

Davis is a fantastic technician and a solid musician. Thus his Lisztian pyrotechnics are just that, tossed off as though they were no problem at all, which indeed they aren't. But the whole thing is a bit on the cool side (in an old fashioned sense). An excellent and workmanlike set of performances, impeccable, but never magical. Somehow, Liszt himself must have thought they *were* magical. Otherwise he could not have composed such floridly Romantic stuff! Some performers can still make the stuff sound like magic, but it isn't easy these days.

The first of the concerti is the familiar *Triangle,* played to death a generation ago and recently given a healthy amount of rest. The second, like the "other" Tchaikovsky concerto (and part of a third), is less familiar because less immediate in appeal. This one is built on an often-repeated series of chords that tend to drive you nuts after awhile. Davis does commendable things in postponing that particular happening. He doesn't try to say—see, listen, there's that set of chords again! Too many pianists do.

Mr. Downes and the orchestra do a good job but the focus is on the piano, especially in the second of the two works.

Performances: B-   Sound: B-

William Mayer: Brass Quintet; Miniatures; Two News Items; Khartoum. Dominick Argento: Letters from Composers. Catherine Rowe, sop., Vern Sutton, ten., Jeffrey Van, guitar; Iowa Brass Quintet et al. **CRI CD 291,** stereo, $5.95.

CRI (Composers Recordings, Inc.) continues to pour out its LPs of contemporary music, far beyond any quantity we can review short of dropping Bach, Beethoven and Brahms for ever. So I sample one every so often—it's always interesting. But I end up hearing double, mostly. Never know what's coming next, nor what sort of musical bedfellows will be plunged together on the one LP. CRI runs a prepaid operation, so to speak, managed largely by composers and musicians themselves, financed by major foundations, and thus nobody has to be "commercial" if he doesn't want to. Sometimes this is good. Sometimes it means you can ignore your audience. Is that good? A question.

This disc, like many, is both difficult and interesting. For one thing, it's funny. William Mayer is a (relatively) conservative composer who has a real quirk for offbeat humor, even if its inspiration can be traced, say, to Stravinsky's *Histoire du Soldat* way back in 1918. The Brass Quintet is a very spunky piece that spits in your face the instant you put it on. Rather nice. The six Miniatures are for spunky soprano, who squeaks, sings, sputters and talks her way through satirical little texts à la Dorothy Parker. One of the *News Items* is entitled "Hastily Formed Contemporary Music Ensemble Reveals Origins." That's Mayer for you. Not exactly of the new neo-Romantic generation.

Is it the name which makes me sense an Italianate intensity in Dominick Argento's settings of actual letters by such diverse composers as Chopin, Mozart, Debussy, Puccini? Very lyric, for the tenor, and passionate too. Excellent guitar accompaniment. But I was somehow confused to hear Chopin, Mozart, then Debussy all "speaking the same language"; it didn't seem quite convincing. Not even for Puccini. I kept hearing Mr. Argento, even when he quoted a bit of actual Schubert in Schubert's letter. The seven letters take up the whole of side 2, with Mayer occupying side 1.

Performances: B- Sound: B-

Handel's Overtures. English Chamber Orch., Leppard. **Philips 6599 053,** stereo, $6.98.

Imagine it—all these weird Handel names. You've heard the Overture to "Messiah" no doubt and maybe "Israel in Egypt"; you might know a few Handel opera names too—"Alcina," perhaps. But here we have a raft of total unknowns, and I'll omit the quotes just to get them down more easily: Lotario, Admeto, Orlando, Poro, Partenope, Ottone! Every overture is the take-off point for an evening-long opera and there are plenty of others available, in case they want to make a Volume 2, or 3.

Superb music. Needless to say. The trouble with Handel has always been that he wrote too much, and people wanted to hear "Messiah" or the Water Musick. So, like some bumper wheat crop, the rest of Handel has been stored away unused. These overtures are mostly what we later on have called Baroque suites, a splendid, stately introduction with the well-known dotted rhythm, *ta-dum, ta-dum,* followed by fast music and very often several additional dances, slow and fast, no doubt to get the people seated and ready for serious matters on the stage. The English Chamber Orchestra has achieved 95 percent spontaneity in playing the dotted rhythm the way it must be played—short, snappy—instead of as it is written down. Double dotting, we often call it. They really do the job as though it were taken for granted, where most orchestras still sound surprised and annoyed, not really believing their conductors who tell them, don't play it the way you see it on the page, play it *this* way.

Better play one side at a time. It wasn't Handel's intention to line these overtures up in a row, one after the other, after all.

Performances: B+ Sound: B+

(Continued from page 46)
had a pronounced wearing effect on cassette heads. Chromium dioxide tapes also require about 40%–50% additional bias current.

The most sophisticated cassette recorder-players have a three-position switch. In addition to "regular" and "CrO_2" positions, there is a third position for "low noise" or "extended range" cassettes, such as TDK's ED or SD cassettes. While these tapes, as mentioned earlier, can be used with the bias switch set to the "regular" position, on cassette recorder players having a 3-position switch, it is preferable to set the bias switch to its "low noise" position to take advantage of the higher bias current provided.

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Ordinarily, equalization is standard on cassette tape decks. For regular and premium-grade tapes, it's there during both recording and playback. The playback conforms closely to the NAB standard for 7½ ips open-reel tapes and because of this, cassettes recorded on one machine can usually be played back on any other cassette recorder with no significant differences in equalization characteristics.

With chromium dioxide tapes you may have to be a bit more careful. Each manufacturer has his own standards for equalization and bias changeover. While the bias selector switch also changes the equalization, there is no machine-to-machine standard and so the safest procedure is to record and playback on the same machine.

Which Tape To Use

With the proliferation of cassette tapes and adjustable bias controls on cassette recorder players, there is an excellent opportunity for confusion. The choice, however, is quite simple. If the recorder has a CrO_2 bias position, use this only when playing CrO_2 tapes. If the recorder has either fixed bias or a three-position switch, you can use cassette tapes such as TDK's ED or SD with the bias switch positioned to low noise or extended range. It is important to remember to record and playback at the same bias level. Æ

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