the authoritative magazine about high fidelity

AUDIO

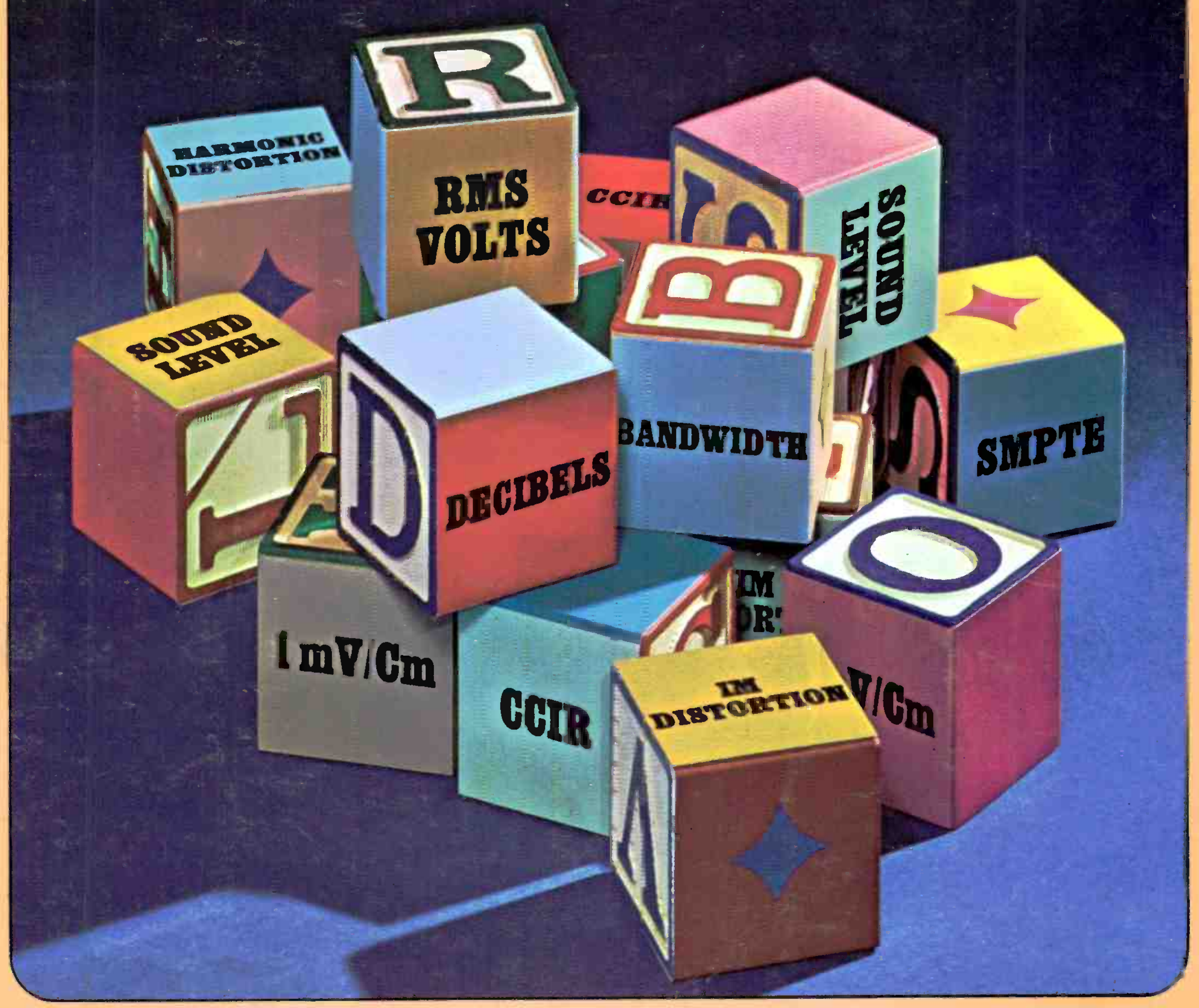
STEREO EQUIPMENT & RECORD REVIEWS

JULY 1969 60¢

The Technical Quality of Records

Historical Stereo Music Reviews

AUDIO MEASUREMENTS: Methods & Instruments



Scott introduces AM high fidelity

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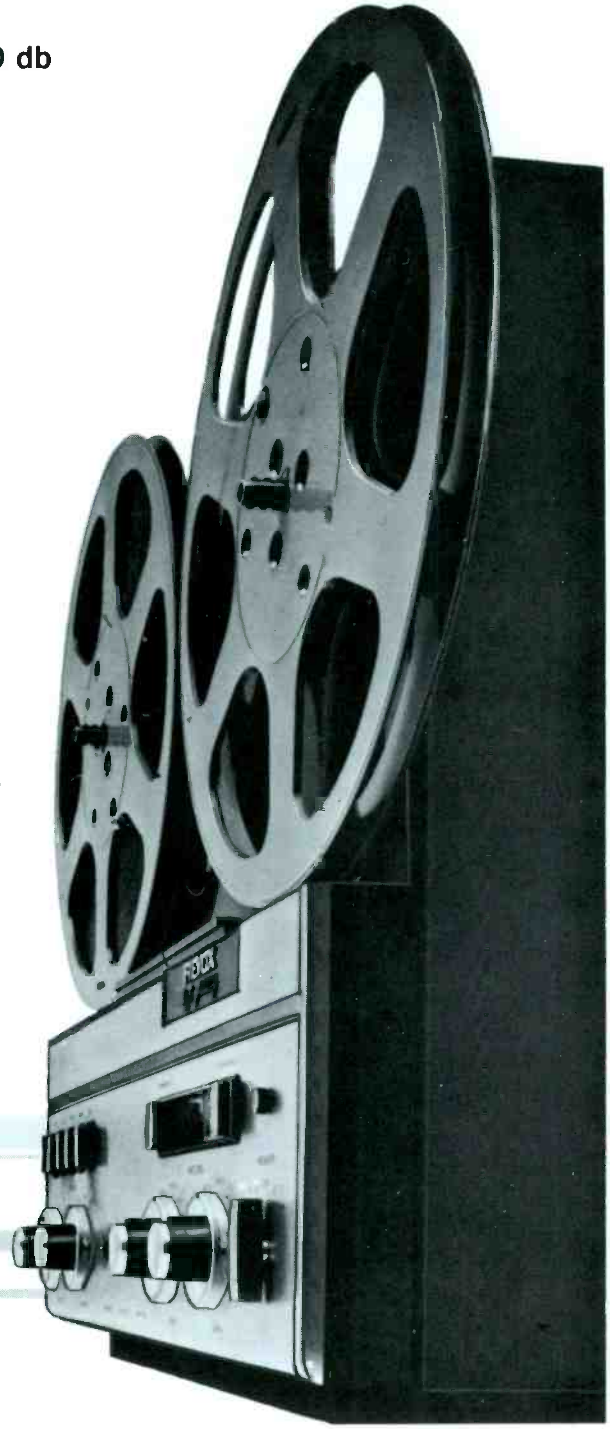

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July 1969 Vol. 53, No. 7

AUDIO

Successor to RADIO, Est. 1917

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Audio Measurements: Methods and Instruments

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RECORD/TAPE REVIEWS

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Acoustic Research AR-3a speaker systems are important professional tools to composer/arranger Don Ellis.

Don Ellis creates music that ranges from the ancient sitar to a novel four-valve quarter-tone trumpet specially made for him. His work is well exemplified by **Electric Bath** (Columbia 9585), which was Album of the Year (1968) in **Down Beat**, placed second in **Playboy**'s annual poll, and third in **Melody Maker;** the record was also nominated for a Grammy Award.

Mr. Ellis' high-fidelity system in his studio consists of an AR turntable, a Bogen-Lenco B62 turntable, an AR amplifier, a JBL 600 amplifier, a Koss Pro 600A headset, Revox and Crown tape recorders, and a pair of AR-3a speaker systems.

Mr. Ellis advises AR that the turntables, amplifiers, and tape recorders are all capable of highest-quality reproduction, so that making comparisons of different tapes and records can be done dependably with any of them. However, he finds that only AR-3a speaker systems are accurate enough to use in his work.

AR

Acoustic Research Inc.

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Overseas Inquiries: Write to **AR International** at above address

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Coming in August 1969

Focus on Commercial Sound — Articles on microphones, amplifiers, and speaker systems for commercial sound applications.

Primer on Sound Level Meters, Pt. 2—Bernard Katz continues his primer on SLMs by exploring how data are interpreted.

The Composite Stereo FM Signal — The 17 paragraphs listed under section 73.322 of the FCC rules that launched stereo FM are examined by Leonard Feldman.

PLUS:
Equipment Profiles, Record and Tape Reviews, Audioclinic, Tape Guide, and other regular departments.

ABOUT THE COVER:

Some measurement terms mentioned in this issue, which focuses on audio measurement methods and instruments, are printed on faces of alphabet blocks. See articles starting on page 22.

Audioclinic

If you have a problem or question on audio, write to Mr. Joseph Giovanelli at AUDIO, 134 North Thirteenth Street, Philadelphia, Pa. 19107.

JOSEPH GIOVANELLI

Bass Boost & Speaker Damage

Q. I am confused with treble and bass settings on my receiver. I have read that too much of an increase in bass is harmful for speaker systems. Is this true? What would you consider a safe setting for bass on the plus side? I am now using a setting of normal bass and a —3 treble. Is this a good setting? However, does a minus treble setting increase bass? — Frank E. Scirocco, Jersey City, N. J.

A. Because most of the power output of an audio amplifier is used to produce bass, it is especially important that the woofer is capable of handling as high a percentage of total amplifier power as possible. This is even more important when the bass control is advanced.

The factors which determine tone control settings, therefore, have little to do with the speaker's ability to handle bass, except for the case in which the woofer is capable of handling, say, only ten watts of power and its associated amplifier is capable of supplying 50 watts. Under such circumstances, the bass might need to be cut somewhat, especially if you plan to run the equipment at high volume levels. When the speaker system is able to handle anything which the power amplifier can supply, factors such as room acoustics and your taste become important in determining just how the bass and treble controls should be set.

If your room is highly reflective or if your tweeter is quite "hot," you might very well want to cut back on the treble. It is a matter of judgment. The action of the treble control does not influence the amount of bass you have present in your loudspeaker. It affects the overall sound balance between highs and lows. Further, adding bass does not result in a reduction of treble response.

Your equipment is for your own enjoyment. Set the controls where you find that the sound is pleasing to your ear. There is no "right" setting for them. It really does not matter if the sound you like would not have been heard in the original recording session. Tone controls are placed on amplifiers to be used.

Installing Shielded Ignition Cable

Q. How do you install ignition cable? —Earle Stevens, Patterson, N. J.

A. If you are using shielded ignition wire, ground the shield to as many places on the engine body as is convenient. When using such cable, we are attempting to suppress ignition interference to FM sets or mobile communications equipment. If the shield is grounded at one end only, the remaining shield length can become inductive. Therefore, it will do little to shield the radiation.

Also, keep the runs of such wire to as short a length as possible. Try to avoid having the lines as multiples of a quarter wavelength at the frequency of interest.

Defective Headphones?

Q. I have had two sets of headphones, each of which failed after a short time Why?—Leonides O. Florin, Miami, Fla.

A. It is possible that you have been unlucky enough to obtain two defective sets of phones.

However, phones are delicate items, and they can be damaged by overloading them. If you play the phones really loud, loud enough to damage your ears, you will probably ruin most pairs of phones within a very short time. If you use them for quiet listening, however, you are not damaging them.

Here is the exception. When you switch from "tuner" to "phono," is there a loud transient click in your speaker or phones? If there is, the peak energy of such a click may be the cause of headphone damage. I used the switching to "phono" as an example. Any transient can damage headphones. Do your controls work smoothly or is one of them dirty, and, therefore, noisy? The transient clicks and pops brought about by such noisy controls may damage headphones.

Antennas & Portable Radios

Q. My radio receiver is battery operated. What type of outdoor antenna would you recommend for both FM and shortwave? We are located right outside of the metropolitan New York City area. I live in a one-story dwelling.— Roy W. Hoffman, North Bergen, N. J.

A. I do not recommend that you add much in the way of an antenna for the shortwave portion of the receiver. If you do, you will have lots of what we call "birdies" on your hands. These are whistles created by overloaded circuits and the introduction of image responses. As good as your radio may be, or any radio fitting this general descrip-

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tion, not go enough expect to with the built have some of not, then try ad length and see what
tuned circuits are just
Even the FM might lem if you have a good loca reception. I would put up a this radio, but would not consid a Yagi.

Receiver Sensitivity

Q. I am using a stereo cartridge rated at .08 mV output. Because this does not match the receiver's 2.5 mV input sensitivity, would this have any detremental effect on my phonograph's playback capability?

What would happen if a 3.0 mV cartridge or even higher were connected to the receiver's 2.5 mV phono input jack? Would the cartridge's higher output overdrive the phono input and cause playback distortion?

My tape deck preamplifiers also put out 1.2 V at maximum output into the receiver's 150-mV tape monitor jack. Is there much significance to matching each source's output precisely to the input sensitivity of the stage to which it is connected?—E. T., APO San Francisco, Calif.

A. If your cartridge has only 0.8 mV output and if your amplifier requires 2.5 mV to drive it to full output power, then your amplifier cannot be so driven with your cartridge. Furthermore, this will result in a reduced signal-to-noise ratio. You will either have to replace the cartridge or you will have to think in terms of a different receiver or in terms of a low-gain preamplifier ahead of the receiver's phonograph input.

Because the 3.0 mV output of a cartridge is so close to the 2.5 mV sensitivity of your phono input, the circuitry should not be overloaded. If it were, the receiver design would be poor indeed—at least in terms of the phonograph circuit. You might run into trouble if you use a cartridge having 6 to 8 mV output. That signal level might overload the front end of the preamplifier section, ahead of the volume control.

The case of your tape deck is something different. While your monitor will accept as little as 150 mV of signal, chances are that this input is at the volume control. Therefore, your tape machine will cause no trouble because all you need to do is turn down the volume. You may find that most of the action of the control takes place near the bottom end, but you can learn to control that.

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There's a lot more enjoyment coming your way from the brand new Pioneer OUTPERFORMERS. We are introducing an exciting array of all new products; compacts, tapedecks, stereo receivers, tuners, amplifiers, speaker systems, turntables and headphones that will delight even the most discriminating listener.

Illustrated here is the brand new SX-440 Stereo Receiver. Pleasing in every detail, a smartly styled midnight black front panel with 3-dimens on subdued illumination graces the esthetic handcrafted cabinet. Its FET front-end provides excellent selectivity and delivers clear, interference-free reception. Frequency response is 20 — 70 kHz; inputs; magnetic phono, tape monitor and auxiliary. Outstanding sensitivity. Music power is a solid 40 watts (IHF) with stereo channel separation at better than 60 db (phono).

Priced at only $189.95, the Pioneer SX-440 is an ideal component for the budget minded or the audiophile. You'll discover qualities of sound you never knew existed with the full line of OUTPERFORMERS which only Pioneer can bring you.

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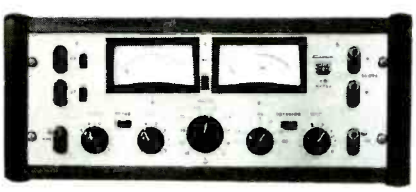
NEW IM ANALYZER

ADVANCES STATE OF THE ART

Extended measuring range and high-speed readings are the outstanding features of a unique new Intermodulation Distortion Analyzer introduced by Crown International recently. The American firm is known for its line of Crown precision professional tape recorders.

This analyzer was developed to meet the production line requirements of the Crown DC300 lab standard amplifier. The first need was for accurate measuring capability through 0.01%. This analyzer guarantees a residual IM level of less than 0.005%, with seven full-scale ranges from 100% to 0.1%.



The second requirement was for an instrument simple enough to be operated by production-line personnel and rapid enough to make sequential readings across the entire power band. The Crown analyzer meets the challenge by reducing measuring time from minutes per reading to just seconds. This is accomplished by a "tracking" function, using two meters and a ganged input/output gain control. The input level is set using the calibrate meter, and distortion is immediately read on the percentage distortion meter. Successive readings at 5db increments take under five seconds each. The entire operation is completed in less than one minute.

Solid state construction, utilizing FETs, makes the Crown analyzer highly stable and uniquely compact, measuring 7x19x7 inches. Rack mount list price is $595. Write for spec sheet to CROWN, Dept. A-7, Box 1000, Elkhart, Indiana, 46514.

Check No. 8 on Reader Service Card

What's New In Audio

Indoor/Outdoor Speaker

Electro-Voice's new Musicaster 1A and IIA portable speaker systems retain the bass reflex-type enclosures of previous Musicaster models, but incorporate improved weatherproofing: a ½" "Acoustifoam" barrier sandwiched between the silicon-treated 12" diameter speaker and the front grille. The new material is said to increase internal damping, thereby improving the system's bass performance. In addition,

the Musicaster's lightweight polyester enclosure has been restyled.

Nominal impedance of both Musicasters is 8 ohms. Frequency response of the Model IA is 80 to 10,000 Hz; Model IIA is 80 to 16,000 Hz. Both have power-handling capacities of 30 watts of program material and 60 watts peak. Weighing 30 lbs., they are priced under $100.00.

Check No. 22 on Reader Service Card

Stereo Reverb Unit

A new reverberation unit for use with stereo or mono systems has been introduced by Gibbs Special Products Corp., a subsidiary of Hammond Corp.

Featuring a 10-watt solid-state amplifier designed for reverberation purposes, distortion is said to be under 3% at 1000 Hz. Both input and output impedances are 8 ohms. Front-panel controls include tone, volume, and reverberation %, plus on-off switches for reverberation and for power. The rear panel has terminals for connecting amplifier leads and for an auxiliary reverberation speaker. $70.00.

Check No. 23 on Reader Service Card

Video Tape Recorder

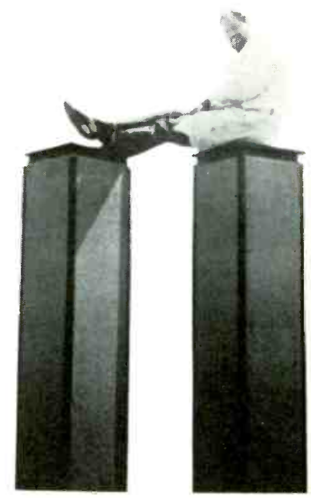
The new Sony Corporation of America Model EV-320 video tape recorder features electronic editing, which allows sequences from the source to be inserted into a prerecorded master tape by pushbutton control. The inserted portion, in either color or monochrome, is said to be practically indiscernible from the original tape. Another feature of the recorder is that it does not require an external sync generator for editing or replay. $4900.

Check No. 24 on Reader Service Card

Man-Size Speaker

Epicure Products, Inc. introduces its Model 1000 "Tower," a 6½-ft. high by 18-in. square speaker system.

The company has incorporated four of its standard non-directional modules, in an eight-cu.-ft. acoustic suspension-type sealed enclosure, with one



module on each of the "Tower's" four faces. According to the manufacturer, the speaker system produces a spherical sound field from 20 to 15,000 Hz ±3 dB. Minimum power requirement is 20 watts; maximum power handling capacity is 250 watts (rms) continuous.

Check No. 26 on Reader Service Card

Cassette & Cartridge News

- Robins Industries has a host of new cassette and eight-track cartridge accessories, including bulk erasers and tape-head demagnetizers for both formats, cassette splicers, storage cabinets, and carrying cases.
- Ampex Stereo Tapes' prerecorded stereo cassette catalog lists more than 1500 selections from 64 record labels. It is issued separately from the company's standard catalog due to the growth of the cassette library. Added recently are the Golden Records library of children's stories and fairy tales on cassettes, which hold up to eight minutes of material on each side ($1.98).
- Superscope Inc., exclusive U.S. distributor of Sony tape recorders, has formed a new recording division to produce and market under its own label pre-recorded stereo cassettes, 8-track cartridge tapes, and reel-to-reel tapes.
- Panasonic plans to introduce a cassette adaptor pack which will enable cassettes to be played in all Panasonic eight-track car stereo units.

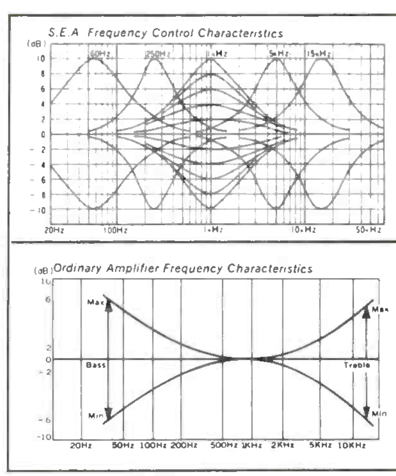
Unique "S.E.A." Sound Effect Amplifier tone control system of models 5001 and 5003 eliminates conventional bass and treble controls. Provides individual control of the five different frequencies that comprise the total tonal spectrum; 60, 250, 1000, 5000 and 15000 Hz.

In introducing the striking all solid state 60 watt 5001 and 140 watt 5003 AM/FM Multiplex Stereo Tuner Amplifiers, JVC brings the stereo fan a new dimension in stereo enjoyment—the complete control of sound effects.

This exciting innovation is made possible through the incorporation of a built-in Sound Effect Amplifier (S.E.A.), a versatile component that divides the audio range into five different frequencies. It enables the 5001 and 5003 to be tailored to the acoustical characteristics of any room, or to match the sound characteristics of any cartridge or speaker system, functions that were once reserved for expensive studio equipment. But even without the built-in S.E.A. system, the 5001 and 5003 would be outstanding values. They offer improved standards in FM sensitivity and selectivity by utilizing the latest FET circuitry with four IF limiters in the frontend of the 5001 and five in the 5003. They both deliver a wide 20 to 20,000Hz power bandwidth while holding distortion down to less than 1%. They feature completely automatic stereo switching with a separation figure of better than 35dB. They allow two speaker systems to be used either independently or simultaneously. Indicative of their unchallenged performance is their refined styling. All controls are arranged for convenient operation. The attractive black window remains black when the power is off, but reveals both dial scales and tuning meter when the power is on. For the creative stereo fan, the JVC 5001 and 5003 are unquestionably the finest medium and high powered receivers available today.

How the SEA System Works

Glance at the two charts appearing on this page. In looking at the ordinary amplifier frequency characteristics where only bass and treble tone controls are provided, you can see how response in all frequency ranges at the low and high levels is clipped off. Compare this chart with the one showing the SEA frequency response characteristics, and the difference is obvious. No clipping occurs in the SEA system. It offers full control of sound in 60, 250, 1,000, 5,000 and 15,000Hz frequency ranges from −10 to +10db. For the first time ever, you have the power to determine the kind of sound you want to hear.



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JVC

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BEHIND THE SCENES

BERT WHYTE

The Technical Quality of Records

The phonograph record has been with us now for over 70 years, and in spite of the incursions of the various tape formats it remains the principal source of selective music for home entertainment. Over the years the basic methods of record manufacturing have undergone various improvements, and today's records have benefitted greatly from many new and highly sophisticated technologies. The phonograph record, as the handmaiden of high fidelity, however, has been praised and damned with equal fervor for its faults and virtues. A great body of information concerning records has been built up, some of which is fact and a high proportion of which is sheer fancy (or fantasy).

The performance charactertics of disc recordings are something quite ephemeral for the average audiophile. As a general rule, he exaggerates both the positive and negative aspects of the disc as seen from his limited technical horizon. He feels he can certainly distinguish a good from a bad recording, but his subjective evaluation is often colored by his involvement in the purely musical aspects, which blunts his perception of technical factors. It is his privilege to enjoy the music. That is what records are all about. Be he wouldn't be an audiophile and own high-quality component equipment if he wasn't interested in the technical quality of the recording. Surrounded on all sides by critics and "experts," who inundate him with opinions which are more folklore than fact, he ascribes qualities to recordings which simply do not exist. Of course, one must hasten to add that the quality of his equipment and his acoustic environment profoundly affect what he hears.

Lately there has been a spate of letters in the hi-fi press relating to alleged technical shortcomings of records, some of which is fully warranted and some of which is quite unfounded. It would seem a propitious time to discuss certain technical aspects and manufacturing techniques of current commercial stereo discs.

Record Noise

There would seem to be little question that the most common complaint leveled at the stereo disc is "record noise." This encompasses the whole annoying gamut of "ticks, pops, crackles, and swishes," as well as residual tape noise and extraneous hums and other low-frequency noise components. It is important to note that these defects are not inherent in the product. With the exception of tape noise, which can be controlled with the Dolby system, the other noises are the result of improper quality control, decreased processing time, and (to a certain extent) economic factors.

The "tick, pops, et al" can also be electrostatic in origin, or caused by various forms of dirt attracted to the record because of the static charge. The various anti-static devices and chemicals are too well-known to require discussion here. Suffice to say that some authorities question the efficacy of these products or, at best, consider them very transitory in their action. Some phono cartridge manufacturers still contend that the chemical products gum up the record grooves. A few years ago, one manufacturer stated that even without the use of the chemicals, a waxy deposit would build up on the stylus after a few dozen playbacks. To remove it, he said, one should use a fine camel's hair brush dipped in isopropyl or caprylic alcohol. If the chemicals were used, he considered such cleaning mandatory after every six playbacks.

You have all opened factory-sealed records and, upon withdrawing the record from it's shuck, found it covered with tiny shreds of paper, lint and other assorted dirt, due to electrostatic attraction. Now this is not a plug, but you may have noted that when you open an RCA Victor record the surfaces are usually free of such dirt or, at the most, there are a few specks. This is because they make their records with a special compound that is anti-static. The usual record compound consists of polyvinyl chloride, carbon black, and lead stearate, which acts as an inhibitor to prevent the formation of hydrochloric acid during the pressing process. RCA adds a further chemical called "Catenac," whose molecules occupy the interstices between the long-chain vinyl molecules. If it were possible to "dissolve" the normal components of the disc you would find the "Catenac" distributed like a skein or network, which would be anti-static.

What floored me, however, is that I was under the impression that RCA's advertised "Miracle Surface" was an exclusive process. Now I learn that Dow Chemical will supply their vinyl powder with "Catenac" to any company for an extra penny per pound! You can press approximately 2⅓ records per pound of vinyl, figuring about 5 ounces for the actual dics and 2 ounces of disposable "flash." This works out to less than half a cent per record. I can see where a half cent per disc would be significant in a million-seller pop recording. But it would seem that in these days of Dolby noise-reduction, other manufacturers would spend that extra half cent on their classical products to ensure that static noises wouldn't intrude.

One of the least known types of record noise is a low-frequency sound called "mold grain" by the professional, and often mistaken for rumble in the recording by audiophiles and some pros who should know better. The master lacquer is cut on machines that are built on a massive, Gibralter-like scale, where the chances of impressing audible rumble on a recording are quite remote. The final record part, which will become the stamper, is nickel-plated in the electroplating bath. The plating builds up smoothly on the recorded side, but on the back of the stamper the metallic crystals build in random fashion so that at the conclusion of the electroplating process the back is quite rough and uneven. The back must be ground down smoothly so as to make intimate contact with the die in the press. During this grinding operation many very tiny discrete bumps or nodules are impressed on the recorded grooves. If the record is held obliquely to a point source of light the record appears to have an "orange peel" look which is termed "mold grain." This mold grain is noticeable on almost all pressings, in greater or lesser degree.

If you have a speaker system with good low-frequency response, the more severe cases of mold grain will sound like rumble. It is interesting to observe that mold-grain noise falls off at the inner diameters of a record, as there are fewer disturbances passing the stylus per unit time at the inner as opposed to the outer diameters. Mold grain is also the reason why the many test records that feature a "silent groove" to test your record player for rumble are not very accurate. The only sure way to use an unmodulated groove to test for rumble is to have several minutes of the groove cut on a lacquer, using a good cutter, say, a Neumann or Scully lathe. The lacquer is, of course,

IF YOU REALLY VALUE YOUR RECORDS

DON'T UNDERRATE THE GRAM!

(. . . a commentary on the critical role of tracking forces in evaluating trackability and trackability claims)

TRACKABILITY:

The "secret" of High Trackability is to enable the stylus tip to follow the hyper-complex record groove up to and beyond the theoretical cutting limits of modern recordings—not only at select and discrete frequencies, but across the entire audible spectrum—and at *light tracking forces that are below both the threshold of audible record wear and excessive stylus tip wear.*

The key parameter is *"AT LIGHT TRACKING FORCES!"*

A general rule covering trackability is: the higher the tracking force, the greater the ability of the stylus to stay in the groove. Unfortunately, at higher forces you are trading trackability for *trouble*. At a glance, the difference between ¾ gram and 1, 1½, or 2 grams may not appear significant. You could not possibly detect the difference by touch. *But your record can! And so can the stylus!*

TRACKING FORCES:

Perhaps it will help your visualization of the forces involved to translate "grams" to actual pounds per square inch of pressure on the record groove. For example, using ¾ gram of force as a reference (with a .2 mil x .7 mil radius elliptical stylus) means that 60,000 lbs. (30 tons) per square inch is the resultant pressure on the groove walls. At one gram, this increases to 66,000 lbs. per square inch, an increase of *three tons* per square inch—and at 1½ grams, the force rises to 75,000 lbs. per square inch, an increase of *7½ tons* per square inch. At two grams, or 83,000 lbs. per square inch, *11½ tons* per square inch have been added over the ¾ gram force. At 2½ grams, or 88,000 lbs. per square inch, a whopping *14 tons* per square inch have been added!

The table below indicates the tracking force in grams and pounds, ranging from ¾ gram to 2½ grams—plus their respective resultant pressures in pounds per square inch.

TRACKING FORCE		GROOVE WALL PRESSURE
GRAMS	POUNDS	POUNDS PER SQUARE INCH
		(See Note No. 1)
¾	.0017	60,000
1	.0022	66,000 +10% (over ¾ gram)
1½	.0033	75,000 +25% (over ¾ gram)
2	.0044	83,000 +38% (over ¾ gram)
2½	.0055	88,000 +47% (over ¾ gram)

SPECIAL NOTE:

The Shure V-15 Type II "Super-Track" Cartridge is capable of tracking the majority of records at ¾ gram; however state-of-the-art advances in the recording industry have brought about a growing number of records which require 1 gram tracking force in order to fully capture the expanded dynamic range of the recorded material. (¾ gram tracking requires not only a *cartridge* capable of effectively tracking at ¾ gram, but also a high quality manual *arm* [such as the Shure-SME] or a high quality automatic turntable *arm* capable of tracking at ¾ gram.)

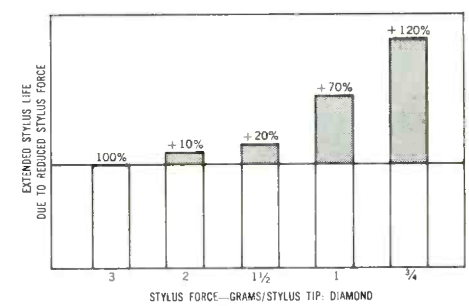
TESTS:

Our tests, and the tests of many independent authorities (see Note No. 2), have indicated two main points:

A. At tracking forces over 2 or 2½ grams, vinylite record wear is dramatically increased. Much of the "high fidelity" is shaved off of the record groove walls at both high and low ends *after a relatively few playings.*

B. At tracking forces over 1½ grams, *stylus wear is increased to a marked degree.* When the stylus is worn, the chisel-like edges not only damage the record grooves—but tracing distortion over 3000 Hz by a worn stylus on a brand new record is so gross that many instrumental sounds become a burlesque of themselves. Also, styli replacements are required much more frequently. *The chart below indicates how stylus tip life increased exponentially between 1½ and ¾ grams*—and this substantial increase in stylus life significantly extends the life of your records.

RELATIVE AVERAGE TIP LIFE VS. TRACKING FORCE



No cartridge that we have tested (and we have repeatedly tested random off-the-dealer-shelf samples of all makes and many models of cartridges) can equal the Shure V-15 Type II in fulfilling all of the requirements of a High Trackability cartridge—both *initially* and after *prolonged* testing, especially at *record-and-stylus saving low tracking forces.* In fact, our next-to-best cartridges—the lower cost M91 Series—are comparable to, or superior to, any other cartridge tested in meeting all these trackability requirements, regardless of price.

NOTES:

1. From calculations for an elliptical stylus with .2 mil x .7 mil radius contact points, using the Hertzian equation for indentors.
2. See HiFi/Stereo Review, October 1968; High Fidelity, November 1968; Shure has conducted over 10,000 hours of wear tests.

SHURE

V-15 TYPE II

SUPER-TRACK HIGH FIDELITY PHONOGRAPH CARTRIDGE

Write: Shure Brothers, Inc., 222 Hartrey Avenue, Evanston, Illinois 60204 unprocessed, and as such cannot have any mold grain. The big trick here is to find someone or some company that will cut such a lacquer for you.

Warpage

A pet peeve of many music lovers seems to be record warpage. There are three kinds of warpage that can afflict the vinyl pressing and degrade it's performance. "Dish" warpage is the case where the record is shaped like a shallow bowl and appears to be due to minute differences in the press die and stamper thickness tolerances from outer to inner diameter. If a "dish" warped record is played by itself on a turntable or record changer back-to-back, then slippage may result due to insufficient friction. "Saddle" warpage is where the record is actually bowed along one diameter, and is almost always due to improper storage in warehouse, store, or home, or to warped paper components used in record packaging. "Saddle" warpage can cause record slippage as well as a once-around "wow" in pitch. "Pinch" warpage results from improper removal of the record from the press. If the record is still warm, it can be easily twisted by the edge by the press operator, resulting in a permanent set at the edge. The obvious cure for this would be to remove the record from the press at a lower temperature, or in some fashion ensure more careful handling of the record at this critical point. Pinch warpage is unquestionably the most annoying of the three types of warpage. In extreme cases it can cause a lightweight tone arm to leave the record altogether; in moderate degree it can cause an unpleasant once-around "wobble" in pitch.

Although not as common as it once was, spindle hole eccentricity—the off-center record otherwise known as a "swinger" — still can be a cause of tracking troubles and other problems. Although a stamper may be accurately centered to begin with, wear and tear in actual use may result in it's shifting to one side. NAB specifications call for a spindle hole concentricity within .005 inches of the recorded groove spiral. As long as these tolerances are maintained the effect on most music is negligible. However, on sustained organ or piano passages, an alert listener might hear some wow at an inner diameter.

There was a notion current some years ago (and may still be for all I know) that a thicker record gave better high-frequency response than a thinner one. Wishful thinkers often cited European records as being thicker and that this also meant better surfaces. Both ideas are pure hokum. The only thing a thicker record may do for you is get you into trouble if you use certain record changers, though it is conceivable that thicker records could withstand stresses caused by improper album storage better than thinner records and, therefore, be less susceptible to this cause of warpage. Record manufacturers should follow the RIAA recommendation of .075 inches, ±.010.

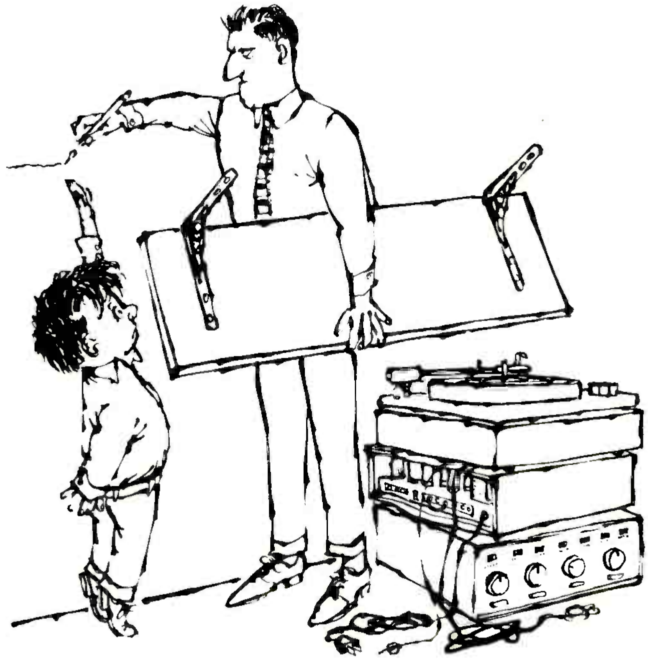
Transformeritis

A professional audio engineer who is a good friend of mine says I am always accusing him of being cynical. I tell him this is because he is forever reminding me that the audio business is full of folklore and that many of the most cherished ideas of the legions of self-appointed "experts" verge on fantasy. He paraphrases the late Sir Winston by saying that "never have so many known so little."

"Take the latest notion that is making the rounds," said my friend. The "experts" have decided that transformers are for the birds; that no self-respecting audio system should tolerate these obsolete devices. Any iron is anathema to them and they mumble learnedly of hysteresis effect, phase shifts, etc. They claim their radar-sharp ears can easily discern the difference between sound reproduced through transformers and direct-coupled transistor output stages. "Whoa," I said, "I'm not getting involved in that argument." "Neither am I," said my friend, "but I want to show that some of their statements are pretty far-fetched by revealing to them what happens to a recording before they get the finished disc and play it back on their 100% Simon-pure solid-state stereo system." Just take a little trip from microphone to cutting lathe. First stop is the recording console where the preamps, combining network, booster amplifier and program amplifier contributed six transformers. Then on to the tape recorder where the input and output adds two more transformers. The remix console has six transformers divided between input, booster, and program amplifiers, with another two possible if a Pultec or other type of equalizer were used. The two-track record and playback add another two transformers. Finally, the lacquer transfer channel adds two transformers for the program amplifier, two for the correlator and two for the power amplifier. A grand total of 24 horrible lumps of iron degrading their recording."

I said that I understood that many of these stages were now transistorized. "True," he observed, "many studios have installed solid-state consoles, and other transistorized gear, but there still are plenty of transformers around.

Remember, too, that many of the finest recordings of the past few years, that have been lavishly praised by our experts, have been made with all transformers in the recording chain. Now I am not trying to make a case for the use of transformers," my engineer friend noted, "I just get a bit tired of all this folklore and these people with their intractable opinions." Amen. Æ



Check No. 13 on Reader Service Card

HISTORICAL STEREO

Edward Tatnall Canby

EVERY COIN has its other side. Back in our March issue ("It's a Gamble!" p. 66) I remarked rather loudly that musical comparisons on records were "hard work" and the best policy was to avoid them. Find a good version, play straight through it and forget all the others. Well . . . sometimes. And sometimes not.

If you look at it differently (as I am now), then record comparisons can be great! And now they are taking on an added new dimension. We have entered the era of the stereo reissue.

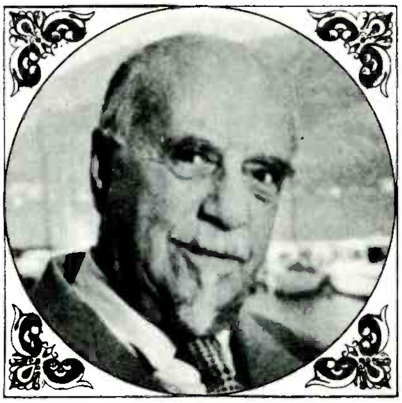
It was just ten years ago that the first batch of stereo discs hit the market (after that abortive start in December of 1958). Now, at last, these earlier stereo recordings are returning in force, updated with the latest improvements. They have a double value, quite aside from the price. First, stereo being still the most recent major upheaval in the disc field, they are wholly modern as no older mono or even simulated-stereo recording can ever hope to be. Moreover, they are actually in large part *brand new,* since they share with the new releases those refinements in disc mastering and processing that have so dramatically improved stereo in these ten years. Only the original tapes are old. And the musical performances, of course. That's where music history comes in.

I had Brahms on my mind (Serkin and the First Piano Concerto) when I made the remark about comparisons in March. I meant comparisons-in-detail, A-B phrase by phrase, the way record reviewers must sometimes do it. That is never easy. Now Brahms is again on my mind as I think on slightly different lines, of the sort of comparison that comes easily, by memory alone. If you get to know one performance really by heart, then how different any other can be! It hits you, without an effort at all. You couldn't miss.

This time I have on my turntable the Brahms Second Symphony and the Academic Festival Overture, as conducted by Sir Thomas Beecham on a Seraphim stereo reissue (S. 60083). What is so astonishing about this record is that, though Sir Thomas has been a'mouldering in his grave these many years, ten to one you couldn't possibly tell this from new material. The old man's ghost is more potent than he ever was himself.

Now this is odd, because with the technical differences in fi between new and old reduced virtually to the esoteric, what's left on these stereo reissues is *the music.* It stands out. And at last we can make historical comparisons on par, in sonic equality. No more "antique" sound to confuse the issue. As we move further away from 1959, this aspect is going to grow more and more interesting.

Sir Thomas Beecham was never a man for the musical background. Behind that shrewd old face with its elegant pointed beard and quizzical smile was a character of musical steel, if an eccentric one. Every recording of his has punch and precision. Plenty are oddball, or simply dated; out of his own time, not ours. He dominated classical recording all the way from the early electrical



era until stereo, for which he cannily saved himself before taking off for parts unknown. His performances have a classic quality, the distillation of a lifetime of music going back to 1905 when his conducting first came into prominence. Some sixty years of history are packed into the modern sound of those last recordings. It is something to hear.

Oh, so you think you couldn't tell the difference? Not so. All you need is a bit of listening.

True, back in 78 days with no more than two or three versions of most works available we bought just one, and played it until we knew it cold to the last note, not to mention every scratch and all the side breaks. (Agonizing in a concert to hear those breaks *not* happen.) In contrast, the concert goer never hears any performance more than once. Quite a difference. But LP changed that. You could acquire, cheaply, a "repeat" in a different version, and you often did. Get the new model. And so you perhaps began to catch onto the idea that—even for you—there could be more than one way to skin a musical cat. You heard it with your own little ears.

Like cars, you buy your versions mostly consecutively, one after the other. But unlike cars, the old records usually stay in operation. And get played. Amortize the cost; the more plays you get, the less the expense, yes? So comparison becomes almost involuntary. You can't help making them.

Naturally if you haven't the habit of listening to Brahms you can't tell him from Beethoven, nor one Brahms version from the next. Why should you? It's like Fords and Chevrolets; unless you study their personalities every day (make, model and year) you can't tell one from another, nor sometimes even the rear from the front. (That's why they put those red lights in back, some women have been known to mutter.) Observation counts, by eye or by ear. Observation is education. Wanna know all about recorded music? Play it.

Beecham didn't like Brahms, and said so. He was a crusty old bird, if humorous; British as they come, he nevertheless was partial to all things French, and decidedly anti-Teutonic. World War I period. He was an Impressionist, if a sturdy one; he played plenty of Debussy, Delius, even Berlioz, Massenet, Gounod, Bizet. For him, Brahms was just another of those heavyweight late-Romantic Germans, all turgid, fussy fugues and counterpoint. He had the sense, of course, to know when to stop in this sort of opinion (though it was by no means uncommon early in the century). And the Second Symphony was one work he would often play, the only Brahms Symphony he recorded—twice. The first time was in 1936. The second is very much alive on our Seraphim reissue.

So—listen. The playing is beautifully polished and conscientious, for Beecham never made the mistake of underrating an important work. But how *different,* how dated! His tempi are astonishingly slow by present

(Continued on page 16)

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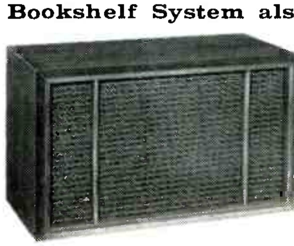

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Tape Guide

HERMAN BURSTEIN

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

Lubricated Tape

Q. Most of the tapes I buy do not indicate whether they have a built-in lubricant. I would like to go the economy route on my tapes, but not if it will cause my recording equipment to wear out more quickly. My questions are: How important is the lubricant in recording tape? Are the tapes I am referring to good quality tapes? Will these tapes help prolong the life of my tape recording equipment? — Andrew Kalafut, Lubbock, Texas

A. The lubricant is all-important in order to minimize wear of the tape heads, which can be quite expensive to replace. At the same time, the tape should not contain excessive lubricant, for this may permit slippage between the tape and the pressure roller and capstan, resulting in wow and inaccurate tape speed. When you go to cheap tapes you take an increasing chance of getting one with an improper amount of lubricant.

Converting to Four Tracks

*Q. I have a *** tape recorder and would like to change it so that it can erase, record, and play back four tracks in line—that is where four tracks are recorded on one side of the tape, and on the other side you can not record. What would I have to do besides buy new record, erase, and playback heads to make this work with my machine?*— Don Simons, Northridge, Calif.

A. I am afraid I am not clear as to what you want to do, because you speak of recording on one side of the tape. Any and every tape machine records only on one side of the tape. Let me assume that what you want to achieve is conventional 4-track recording. Now the question arises, are you interested in mono or stereo? Inasmuch as you make no reference to stereo, let me further assume that you are interested in recording four tracks of mono on the tape. As you realize, your first task is to equip the machine with new heads, namely quarter-track in place of half-track heads. Next, you will have to install a switching arrangement in your record amplifier and in your playback amplifier permitting you to alternate between the upper gaps of each head (tracks 1 and 4) and the lower gaps of each head (tracks 3 and 2).

Taping TV Sound

Q. I am interested in taping TV sound, but have not had too much success. One way I tried was to splice into the audio output transformer. Another way was to connect to the speaker terminals. Both ways resulted in a fuzzy sound or intercarrier buzz. What is the right way? — Edward Durben, Little Ferry, N. J.

A. The quality of sound you get depends in good part on the quality of your TV set. If the design of the set makes for minimum intercarrier buzz, and if the set is properly aligned, then you can get good TV sound. But if not, then you simply can't, and wherever you take off the sound and whatever else you might do, the buzz will still be there. Further keep in mind that some buzz is transmitted by the TV station, so that no matter what you do you can't get away from it. Apart from the question of buzz, you are apt to get better TV sound at the volume control than at the secondary of the output transformer.

Refurbishing a Vintage Machine

*Q. I own a *** tape recorder, which I bought about 12 years ago. This is a professional machine with deck and separate amplifiers. It has worked well all these years, but now it distorts quite a bit on recordling, although playback is still very good. I suspect the record head is worn out. I realize there have been many advances in electronics and tape recorders over the last few years, but my machine represents a sizeable investment, and I would like to keep it going as long as possible. Do you have any suggestions on how to check the record head, and where to get a replacement if it is worn out? Also, are there any things that can be done to modernize the unit? I have had trouble with the pressure pad system. With four pads acting on the tape it sometimes causes a slow-down. (There are four heads—two erase, one playback, and one record). As I write this, I think that what I am really asking is: Do you think this vintage machine, even though it costs over $800, is worth fixing?*—H. D. Sarge, Huntingdon Valley, Pa.

A. While a worn record head is a possible cause of distortion in recording, other factors are just as likely or more likely to be the cause, such as a faulty capacitor or resistor in the recording circuit, distortion or reduced amplitude of the bias current, misadjustment of the record-level indicator (resulting in excessive recording level), and soon. It seems that a visit to an authorized service shop is indicated. Write to the manufacturer for information as to the authorized service shop nearest you. You can also get information on replacement heads from him. Another source of information on replacement heads is Nortronics, which makes an extensive line of such heads.

I really can't advise you on whether to invest an appreciable sum in bringing your tape machine up to par. As you recognize, there have been many improvements over the years, and you have to judge for yourself whether you want to postpone taking advantage of these improvements for another several years, such as the ability to obtain as good or better performance on a quarter-track basis as formerly obtained on a half-track basis; or to obtain about as good performance at 3.75 ips as formerly obtained at 7.5 ips.

HISTORICAL STEREO

(Continued from page 14)

standards. A Beecham trait, also common in older days. The big tunes, the colorful harmonies, the great dramatic climaxes, these come through splendidly, for he liked them. But during the equally important segments that are, indeed, all themes, counterpoint, and complex development, we seem to hear Sir T. mumbling to himself; just between you and me we could skip all this; but let's get on with it. He does. Yet with incredible skill he manages to make it *sound* pedantic.

As for that lesser and amiable piece, the Academic Festival Overture (a *very* German work, to be sure), Beecham's version is plain outrageous, a grisly parody, all schlimy with schmalz, dripping with unctuousness and German beer. German student songs, my eye! (the piece is full of them). Lucky I know a dozen or so other versions for comparison; or I might think Brahms really meant it this way.

That's what you can hear in this great historical stereo, and in many another of the sort, Beecham and others. Any old ear can hear the differences. Æ

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Noise-Reduction System. This exclusive Sony circuit automatically reduces the gain of the playback amplifier during quiet passages of the recorded material which is when background noise and tape hiss is most predominant. Sony "SNR" provides the purest playback of all recorded tapes—automatically.

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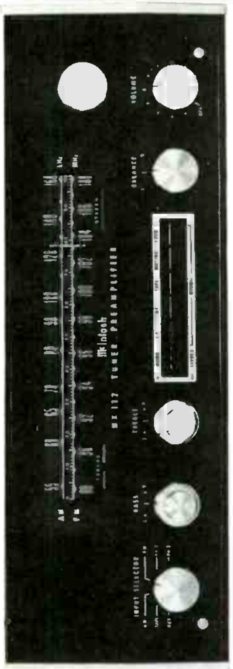


Letters

FM Alignment

• Is there some reason why you did not describe alignment of the detector and r.f. stages by use of a harmonic or intermodulation distortion analyzer in your recent articles on FM Alignment?

Although my experience is somewhat limited, I have found that the use of a distortion analyzer yields the best results in terms of minimum distortion and therefore maximum fidelity. This seems to be especially true when aligning high-quality tuners (or receivers) which have a number of adjustments in the r.f. stage. After all, both of us will probably agree that with today's super-sensitive receivers (tuners) it is much better to sacrifice some peak voltage for a cleaner modulating waveform. Furthermore, in theory at least, alignment of the detector stage can best be achieved through the use of a distortion analyzer.

Granted, this technique necessitates the use of a distortion analyzer, a high-quality sine wave generator and a FM generator capable of accepting outside modulation. Nevertheless, any technician who specializes in high-fidelity servicing will certainly have the first two pieces of equipment and should be seriously thinking about the latter. Then, too, any technically minded "audiophile" will own the analyzer and generator and be feverishly looking for a "good buy" on the FM generator.

RONALD N. TOMMASINI
Garden Grove, Calif.

The use of a distortion analyzer in alignment of the i.f. and detector sections of an FM tuner is a valid approach, and one which is becoming increasingly popular. In inexperienced hands, however, this approach can prove to be disastrous. The final distortion reading (in this case, the sum of distortion and noise) is based upon a 100% output reference which is first set up by calibraion. It is possible to rotate all the slugs in the i.f. transformers for a really low "minimum" of "distortion" while all the novice is really doing is de-tuning everything so that the overall gain *and* audio *recovery are really upset. Under these conditions, the user may think he has achieved a distortion of, say .05% when all he has actually done is reduce the output (by severe alignment) by 10 or more dB.*

A compromise approach would be to do the entire alignment by the more conventional sweep/S curve approach and then *check distortion, perhaps just touching up the i.f. coils, especially the primary and secondary of the ratio-detector (or discriminator) for optimum or lowest distortion. Even then, reference output should be re-checked to make sure it has not been attenuated in the process.—Ed.*

Sinatra Discography

• I read with interest your review of "The Music of Alec Wilder" in the Feb. 1969 issue of AUDIO. You mentioned the set of three 12-inch 78's issued by Columbia, and said you thought it was the only time Sinatra led an orchestra on records. This same recording was also issued a good many years ago on a Columbia 12-inch LP (CL 884) with the reverse side containing the numbers by the Alec Wilder Octet listed for the Odyssey record which you reviewed.

WILLIAM C. RICHTER
Palo Alto, Calif.

• Regarding your review of the album of Alec Wilder conducted by Frank Sinatra, there is another album on which Sinatra conducts an orchestra: Reprise R9-6045, "Frank Sinatra Conducts Music from Pictuers and Plays." It was recorded in September, 1962, and is still available.

STEVE KELLER
Cedar Rapids, Iowa

Price Correction

• In the February 1969 issue, Monitor MCSC 2128 is listed as being priced at $4.79. This record is one of Monitor's 2000 series and lists at $2.50. What is really interesting about the record [*Piano Music of Mendelssohn,* Anton Kuerti], is that: one, it is a recording of a solo piano by a professional recording engineer who is also a professional pianist, David Hancock; and two, it is one of a handful of commercially available records made with the Cambridge wide-range ribbon microphones, and little or no "gimmicking" or doctoring of the recorded sound. In this era of spiked sound, the disc is extremely interesting.

KARL C. THOMAS
State College, Pa.

• Your report on the Ampex Model 1461 [AUDIO, April 1969] machine was very good. Let me correct one item, though: You list the unit at $485, while it is priced at only $429.

JOHN PAGLIONE
Littleton, Colo.

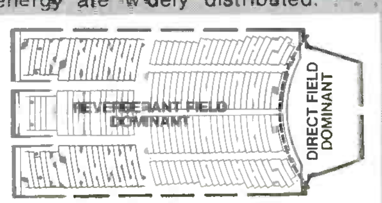
BOSE puts you in the REVERBERANT FIELD

If you have heard the BOSE 901 Direct/Reflecting™ speaker system, or if you have read the reviews, you already know that the 901 is the longest step forward in speaker design in perhaps two decades. Since the superiority of the 901 (covered by patents issued and pending) derives from an *interrelated group of advances*, each depending on the others for its full potential, we hope you will be interested in a fuller explanation than is possible in a single issue. This discussion is one of a series on the theoretical and technological basis of the performance of the BOSE 901.

We've mentioned previously that the "spatial property of the sourc incident on a listener is a parameter ranking in importance with the frequency spectrum of the incident energy for the subjective appreciation of music."* By 'spatial property', we mean the directions from which the sound arrives at the listener — not the directions in which the sound leaves the speaker.

Yet though it is as important as frequency response, spatial property has played little part in the design of speakers prior to the 901. Measurements of a speaker, on-axis in an anechoic environment, deliberately avoid spatial property ('room effects') because in order to measure spatial characteristics, the speaker and the room must be considered as a system. No way was previously known to distinguish the contribution of the speaker from that of the room.

In a room, "the Sound Pressure Level drops off as the distance from the source increases until the direct field becomes smaller than the reverberant field. Beyond this point, the intensity is independent of distance and its variation with room position is a function only of the standing wave pattern in the room." This becomes significant for loudspeaker design "when we examine the sound field in concert halls and find that for virtually all seats, the reverberant field is dominant. Even for a large hall such as Symphony Hall in Boston, the reverberant field equals the direct field at about 19 feet from the source." In the reverberant field, "since the energy in this field arrives at any point via reflections from the surfaces of the room, the angles of incidence of the arriving sound energy are widely distributed. . . .



BOSTON SYMPHONY HALL
FLOOR PLAN

Conventional speaker design however results in the dominance of the direct field from the loudspeakers with the consequent localization of stereo sound in two points and the noticeable lack of fullness or openness of the reproduced sound."*

How The 901 Incorporates These Findings

The use of the Direct/Reflecting technique in the 901, with only 11% direct sound, is designed to simulate the concert hall experience by placing the listening area in the reverberant field, rather than the direct field. The stereophonic experience of the listener is uniform throughout the room. The speakers vanish as point sources — even to a listener directly in front of one speaker. Instead, they project the image of the musical performance across the entire wall behind the speakers.

These spatial characteristics are combined with three other essential advances to produce the full range of benefits offered by the 901. They will be the subjects of other issues. Meanwhile, if you'd like to hear what spatial property means, ask your franchised BOSE dealer for an A – B comparison of the 901 with the best conventional speakers he carries, regardless of size or price.

You can hear the difference now.

***From 'ON THE DESIGN, MEASUREMENT AND EVALUATION OF LOUDSPEAKERS', Dr. A. G. Bose, a paper presented at the 1968 convention of the Audio Engineering Society. Copies of the complete paper are available from the Bose Corp. for fifty cents.**

THE BOSE® CORP.
EAST NATICK INDUSTRIAL PARK
NATICK, MASSACHUSETTS 01760

Check No. 19 on Reader Service Card

EDITOR'S REVIEW

Winners

Everything's coming up Columbia Records. Almost, anyway, according to awards made by the *Schwann Catalog* for favorite 1968 recordings of its readers. Here are the winners:

Classical (2): R. Strauss-Elektra-Nilsson, Resnik, Georg Solti and the Vienna Philharmonic, London Records, and The Glory of Gabrieli—E. Power Biggs—Columbia Records.

Popular: Bookends—Simon and Garfunkel—Columbia Records.

Musical Show: Hair—RCA Records.

Folk: John Wesley Harding — Bob Dylan — Columbia Records.

Country & Western: At Folsom Prison—Johnny Cash—Columbia Records.

Electronic Music: Switched-On Bach—Carlos—Columbia Records.

Fifteen FM radio stations were named winners in the fifth annual competition for Major Edwin H. Armstrong Awards. CHUM of Toronto, Ontario, Canada captured two first-place awards, one in the news category, and a second in the educational category. Other commercial stations receiving awards were: WNCN, New York City, for its musical entry; WFBM, Indianapolis, Ind., for its community service entry. Non-commercial FM stations winning top awards were: WUHY, Philadelphia, Pa., for its musical entry; WAMU, Washington, D. C., for its educational entry; WHA, University of Wisconsin, Madison, Wis., for its news entry; WBUR, Boston University, Boston, Mass., for its community service entry.

Runner-up awards were issued to: (Commercial stations) WQXR, New York City, musical programming; WLIB, New York City, educational programming; KMET, Los Angeles, Calif. and KPLX, San Jose, Calif., community service programming; KNX, Los Angeles, Calif., news programming. (Non-commercial stations) WRVR, New York City, musical programming and community service; WGBH, Boston, Mass., educational; WUHY, Philadelphia, Pa. and KPFK, N. Hollywood, Calif., for community service; and WMAQ, Chicago, Ill., for news programming.

. . . and Sinners

Last March we reported the use of the specification, IHF ±1 dB, by some manufacturers. Since then, the Institute of High Fidelity issued a resolution in which it urged non-member and member manufacturers and importers of power amplifiers and/or receivers to state power ratings as set forth in its standard, IHF-A-201, though any other rating could be used additionally. It was further resolved that manufacturers and importers discontinue using the IHF initials when a non-IHF standard is used, including such tolerance as "±x dB." Also, IHF-sponsored Hi-Fi Show rules were amended so that IHF power ratings must be displayed with prominence and in type size equal to that used for other ratings. In effect, the IHF appears to be pressing for "equal treatment," while condoning the use of multiple ratings.

Video Cartridge

A color video tape recorder for home use that employs a cartridge or magazine was introduced by the Sony Corporation in Japan, it was reported. Features of the recorder, which is not yet on the market, include pushbutton loading and unloading of the cartridge, two sound tracks, and direct connection capability to a conventional TV receiver for playback purposes.

In the Gutter

An industry magazine's advertisement made us chuckle a while back. It was a two-page-spread ad for STEEL Magazine that announced it was changing its binding method from side stitch to saddle stitch (which AUDIO also employs). It pictured how part of a girl's face was distorted with side-stitch binding due to the center portion being "lost" in the "gutter." (The photo simulated one that is spread across two pages; the "gutter" is the space along the inside margins of facing pages.) The headline of the ad was: "Another nice girl lost in the gutter," while the copy observed that words printed across facing pages could have letters lost in the gutter area due to the use of side-stitch binding of a magazine. (The word, "fidelity," for example, could appear as "fidity" to the reader.) Another nice attribute of saddle-stitched magazines that was pointed out was that the magazine stays open without holding it down with your hands.

As a result of the above, saddle-stitched magazines are easier to read. We hope that this answers the questions of readers who inquire why AUDIO uses this method of binding.

A. P. S.

PHOTOGRAPH BY FRANZ EDSON

Words are inherently limited in stimulating the emotions aroused by music. This is especially so in describing how high fidelity components perform.

With cartridges, for example, we speak of flat frequency response, high compliance, low mass, stereo separation. Words like these enlighten the technically minded. But they do little or nothing for those who seek only the sheer pleasure of listening.

We kept both aspects in mind when developing the XV-15 series of cartridges. We made the technical measurements. And we listened.

We listened especially for the ability of these cartridges to reproduce the entire range of every instrument. With no loss of power. In the case of strings, this meant a cartridge that could recreate the exact nuances that distinguish a violin from a viola. A mandolin from a lute. A cello in its lower register from a double bass in its higher register.

We call this achievement "100% string power."

When you play your records with an XV-15, you won't be concerned with even that simple phrase.

Instead, you'll just feel and enjoy the renewed experience of what high fidelity is really all about.

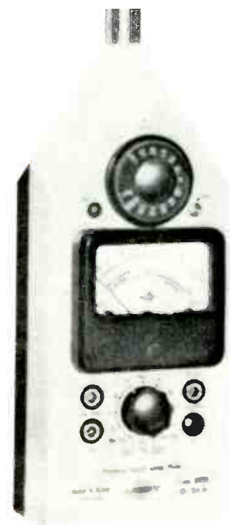
PICKERING

THE NEW PICKERING XV-15/750E.
PREMIER MODEL OF THE XV-15 SERIES. TRACKS AT ½ TO 1 GRAM. DYNAMIC COUPLING FACTOR OF 750 FOR USE IN FINEST TONEARMS. $60.00. OTHER XV-15 CARTRIDGES FROM $29.95. PICKERING & CO., PLAINVIEW, L.I., N.Y.

A Primer on Sound Level Meters

BERNARD KATZ*

Part I: Introduction to Sound Level Meter Construction



THE SOUND LEVEL METER is an instrument to measure sound, as implied by its name. There is a good deal more that can be said, such as: Does the meter really measure the acoustical energy? How accurate is the measurement? How does the meter reading relate to what we hear? What else can be measured with a Sound Level Meter?

All Sound Level Meters have at least three components. The first is the input transducer, or microphone. It converts sound pressure fluctuations into an electrical signal proportional to the sound signal's amplitude. The next item in the chain is an amplifier that takes this rather weak signal and magnifies it sufficiently so that it can drive an indicating device. Figure 1 shows this chain of components, while Fig. 2 illustrates a more detailed block diagram. You cannot take any microphone and hook it up to an amplifier/meter and read the sound pressure level, however. Sound pressure is a very carefully defined quantity, which we will examine.

The key to sound level measurements is the transducer, or microphone. Ideally, you would like to have a microphone that has: 1) flat frequency response, 2) excellent stability, 3) excellent linearity, 4) very low distortion, 5) good conversion efficiency, 6) easy calibration, 7)

*B & K Instruments, Inc., Cleveland, Ohio

TABLE OF SOUND LEVEL METER TERMS

COMPONENT	FUNCTION
Microphone	Generates an electrical signal proportional to sound pressure and waveform (frequency characteristics). The microphone consists of a thin metallic diaphragm mounted close to a rigid backplate. Diaphragm and backplate are electrically insulated from each other and function as the electrodes of a simple capacitor. The capacitor is charged by a polarizing voltage.
Impedance Translator	The low capacitance of the microphone requires a high input impedance and an impedance translator is therefore introduced between microphone and input amplifier. Typically, this circuit has a gain of 0.8 dB. Input impedance, 4 giga ohms, output impedance, 25 ohms.
Amplifier	Increases the magnitude of a signal. The amplification (or gain) may be stated in terms of a multiplier (× 10, × 100, × 3.16, etc.) or as a logarithmic function (20 dB, 40 dB, 10 dB, etc.).
Attenuator	Decreases the amplitude of a signal. The attenuation (or loss) may be stated in terms of a multiplier (× 0.1, × 0.01, × 0.316, etc. or as a logarithmic function (−20 dB, −40 dB, −10 dB, etc.).
Meter	Indicates the timer-averaged magnitude of a signal by means of a scale and pointer arrangement (all instantaneous values of a signal are continuously integrated over some finite time interval such as 0.3 or 1.0 sec.).
Filter, Octave-Band	Separates signals on the basis of their frequency in Hertz (Hz). It introduces relatively small insertion loss to signals in the frequency band and relatively large loss to signals of other frequencies. The bandwidth of an octave-band filter is defined as 0.707 times the center frequency of the filter. The band limits are 1.414 and 0.707 times the center frequency.
Weighting Network, Sound Level	Alters the frequency response of a Sound Level Meter by a prescribed amount for comparison purposes. The weighting networks are labeled A, B, C.
Reference Stabilized Oscillator	Internal signal source that is highly amplitude-stabilized for calibrating the internal voltage gain of the Sound Level Meter.

conformance to published standards, 8) rugged construction, and 9) known and detailed parameters. The closest we have come to the forego-ing is the "Precision Condenser Microphone."[1] This condenser microphone comes complete with its own "birth certificate" giving its name, serial number, and individual calibrations of frequency response.

There are two drawbacks to the use of condenser microphones: (1) They require a diaphragm d.c. polarization voltage of 200 volts. (2) They are high-impedance devices requiring extremely high-input-impedance translators.[2]

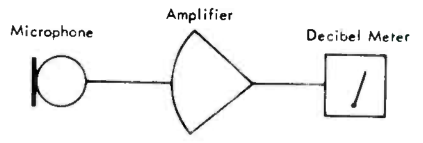
There are other microphone types that can be used for sound level meters. The development of ceramic elements has reached the point where fairly stable ceramic microphone elements are being manufactured, for example. They can be constructed at lower cost, and may be used directly with long cables, and they do not require polarization voltage. On the minus side, ceramic microphones cannot be made at the same close tolerances as condenser microphones and are somewhat vibration-sensitive, so they are used to meet less exacting requirements. A frequency-response curve and certificate of calibration may also accompany the ceramic-transducer-constructed sound level meter.

The second component of the Sound Level Meter—the amplifier—is usually divided into two segments. There are several reasons for this: (1) the signal amplification needed is more than can be achieved practically with one amplifier; and (2) various filters and weighting networks can be placed between the two amplifiers.

What are *weighting networks?* To answer this, let us look at a family of curves called Equal Loudness Contours (Fig. 3). Although the response of the human ear depends on many other characteristics besides frequency, the modern Sound Level Meter usually contains weighting networks similar to the human ear's frequency response. The curves in Fig. 3 indicate the sensitivity of the average ear to pure tones at various sound level intensities versus frequency. The weighting network filters (A, B, C shown in Fig. 4) correspond to the ear's sensitivity at various loudness contours, 40 phons (A scale), 70 phons (B scale), flat (C scale).

In practice, the simplest physical measurement of sounds is the overall sound pressure level. A "flat" measurement of this sort tells nothing about the frequency distribution, nor gives any indication of the human perception of the signal. The use of the internationally standard-

Fig. 1—A Sound Level Meter with a simplified block diagram.



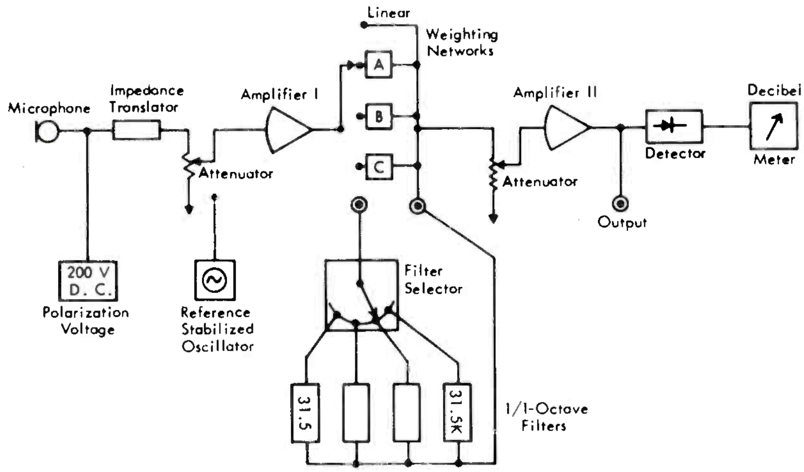
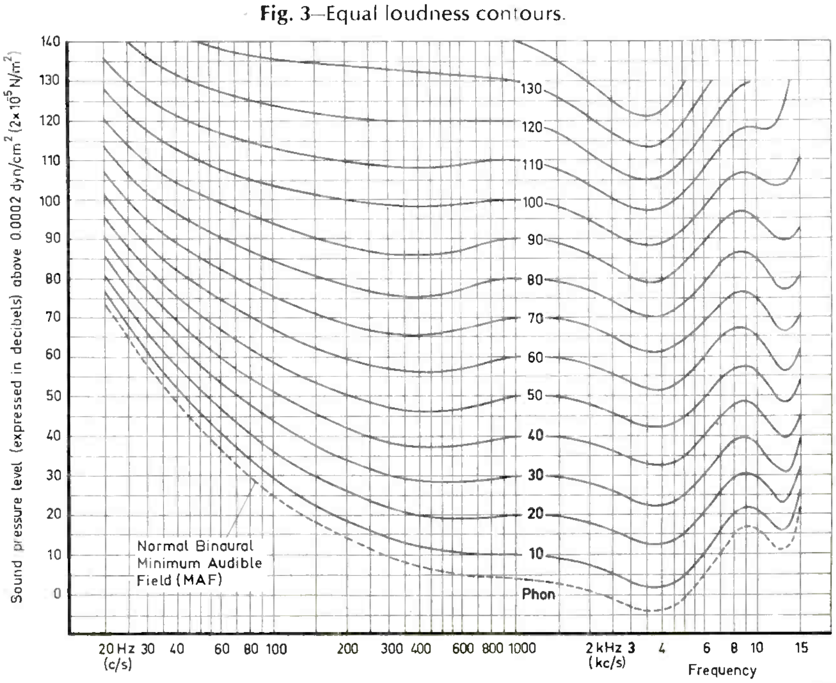


Fig. 2—Block diagram of a typical Sound Level Meter.

Fig. 3—Equal loudness contours.



[1] Precision condenser microphones have a 20-year performance history with the National Bureau of Standards.

[2] Typical values for field effect transistor input impedance translators (FET followers) are 4 giga-ohms to 25 ohms (a 160,000,000: 1 ratio).

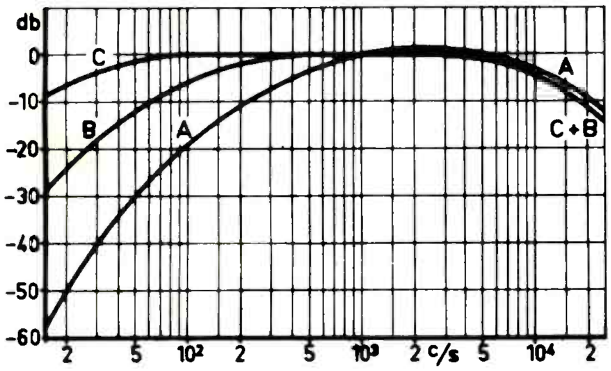


Fig. 4—Response of weighting networks.

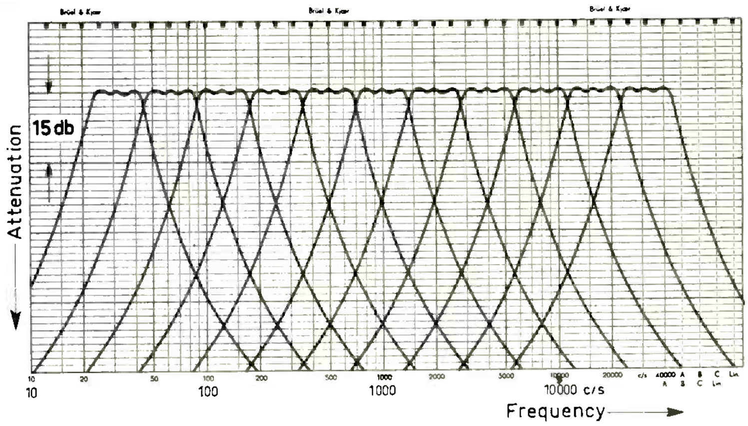


Fig. 5—Set of filter characteristics for one-octave filters.

ized weighting networks (A, B, C) is an attempt to provide a rough handle of the loudness value on certain classes of noises. It has been determined that an approximate noise-rating number can be obtained when the A-weighting curve is used. The measurement, though a rough approximation, has the advantage of simplicity and speed.

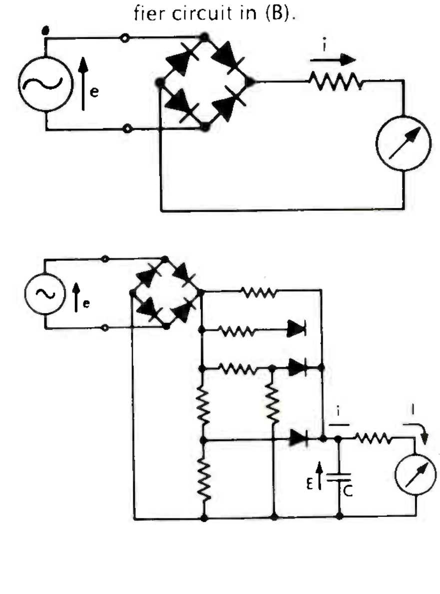
In recent years the trend has been to use one-octave filters (see Fig. 5) for several important reasons. A wide-band measurement of complex sounds, even though weighted, does not indicate what the frequency components of the noise or sounds are. It merely shows the overall sound level. In order to do any analysis, you must break the signal into segments, indicating what frequency bands are causing the disturbances. This process operates much as does the human ear. The ear is able to segregate complex sounds into various contiguous band-pass groups. This ability, though not fully understood, is a function of the cochlea located in the inner ear.

Another important reason for the use of filters is that all actual or proposed standards on noise risk criteria, loudness, and perceived noise levels specify at least one-octave measurements. The signal level of each of the bands is then summed according to various techniques producing a single value rating.

Again, it is important to note that a weighted or wideband measurement usually produces limited results. A one-octave analysis is often required, not only for signal analyses but to improve the signal-to-noise ratio when measuring weak sounds. Another important use for filters is to flatten the frequency response of sound systems. Here, we feed wideband pink noise[3] into the speaker system and then make the frequency-response measurements in one-octave bands at various test locations.

The last segment of the Sound Level Meter is the readout. Ideally, one would simply average-rectify the signal, using the rectified current to drive the meter (Fig. 6A). If all sounds were pure tones, this rectified signal driving a RMS-corrected meter would suffice. Unfortunately, sounds are seldom pure. Machinery noises, speech, and music generate random non-periodic signals. The simple average-detected signal driving an RMS-calibrated meter works just fine for known periodic functions (that is, sine waves), but gives poor results when the signal is non-periodic or random.

Fig. 6—Schematic diagram of "average" rectifier is shown in (A); an "RMS" rectifier circuit in (B).



To eliminate these detection errors, an RMS rectifier (within its dynamic range) actually measures the energy value of the signal regardless of the signal form,[4] as shown in Fig. 6B. The meter now will read the sound pressure level without errors induced by the characteristics of the signal's wave shape.

We now have presented a basic view of the Sound Level Meter. At the input, we have a transducer (microphone) with well defined characteristics. The amplifier is designed to give high gain with low noise, permitting the use of weighting networks and filters. Finally, the meter and its detector circuit indicate the RMS value of the amplified signal. Thus, the basic Sound Level Meter is complete and should be capable of performing an effective job of measuring.

[3]A noise that is weighted so that there is a 3 dB/octave slope, the level at 200 Hz is 3 dB down from the level at 100 Hz. (constant energy per octave).

[4]There is naturally a limitation to any electronic device; modern RMS detectors have a crest factor capability of 10 to 1, or better. This crest factor will handle just about any known signal one will encounter.

CONTINUED NEXT MONTH

"The finest loudspeakers I've ever listened to, regardless of size, type or price."

That's how Ronald M. Benrey, electronics editor of Popular Science, described a pair of **Rectilinear III** speaker systems in the May 1968 issue of his magazine, in an article on "The Stereo System I Wish I Owned."

Mr. Benrey went on to justify his ranking of the **Rectilinear III**'s:

"They produce beautiful bass tones without boom, accurate midrange tones without a trace of coloration, and crystal-clear treble tones without a hint of harshness. And they do it at any volume, including 'window-rattling' sound levels."

Of course, one expert's opinion may differ considerably from another's. But here's what Julian D. Hirsch wrote in the "Equipment Test Reports" of Stereo Review, December 1967:

"The **Rectilinear III** ranks as one of the most natural-sounding speaker systems I have ever used in my home. Over a period of several months, we have had the opportunity to compare it with a number of other speakers. We have found speakers that can outpoint the **Rectilinear III** on any individual characteristics—frequency range, smoothness, distortion, efficiency, dispersion, or transient response. However ... none of the speakers combine *all* of these properties in such desirable proportions as the **Rectilinear III.**"

Summing up his test report, Mr. Hirsch concluded: "In our opinion, we have never heard better sound reproduction in our home, from any speaker of any size or price."

Of course, both Mr. Benrey and Mr. Hirsch write for the readers of popular, large-circulation magazines. But here's what Larry Zide wrote for the more specialized audience of The American Record Guide ("Sound Ideas" column, October 1968):

"The transient response of the speaker is superb... the overall quality is extreme in its fidelity to 'live' music. The bass is solid and firm, the midrange is clear and neutral, and highs are bell-like in their cleanliness.

"It all comes down to this: there are only a handful of speakers that I find completely satisfactory... I have had these **Rectilinear III** units for a month now. Lately I have found myself listening to them just for the pleasure of it. They are among the very best speakers on the market today."

Of course, all of the opinions above appeared in publications that accept advertising. But here's what Buyer's Guide magazine wrote in their August 1968 issue, just in case you're more inclined to trust a consumer review without ads:

"**Rectilinear III**... has had tremendous impact on the hi-fi industry... This speaker's virtue is the fact that it is the first and only full-range dynamic speaker system that possesses sound quality which is directly comparable to electrostatic speakers.

"... Flute and violin concertos as well as string quartet were reproduced with honest clarity... Piano and organ music were effortlessly reproduced in a manner that suggested the instruments were being performed live. Jazz and rock music were unpretentious and true sounding..."

To such unanimity from such varied sources we need only add the dimensions and price of the **Rectilinear III:** 35" by 18" by 12" deep, $279.00 in oiled walnut.

(For further information, see your audio dealer or write directly to Rectilinear Research Corporation, 30 Main Street, Brooklyn, N.Y. 11201.)

Rectilinear III

Check No. 25 on Reader Service Card

A New Use for Intermodulation Tests

NORMAN CROWHURST

Selection of specific pairs of frequencies will permit the determination of various kinds of distortion not found by simple harmonic or conventional IM distortion methods.

Measuring distortion has always presented a variety of problems. Back in the days when fidelity meant extent of the frequency range, in both directions, the part played by harmonic distortion was identified as inconsequential, provided it was less than 5 per cent! This was verified by checking how little distortion could be detected, when it was alternately added and removed, using a single-tone signal.

Quickly after that, enthusiasts discovered that forms of distortion from equipment measuring less than 5 per cent could spoil reproduction. This was when intermodulation distortion first achieved notoriety.

Meanwhile, the talking picture business (as it was known then) had introduced the SMPE test for its own reasons. Harmonic distortion is difficult to measure, from almost any recorded medium, but especially from film. The overall gain, from recording through processing to playback, can change, without causing distortion *per se*. But the distortion meter sees this gain change as distortion. And speed fluctuations that might not matter as flutter or wow, can also show on the meter as distortion.

Added to this was the fact that the most prominent form of distortion that beset film recording was the kind their engineers went after detecting: that which occurs due to a variation of gain around the large envelope of a low-frequency wave.

The fact that the SMPE was useful for its particular test purpose led to trying it for other purposes, for some of which it was also useful. Amplifiers with inferior output transformers are likely to cause it. But there are other forms of distortion that do not coincide with the occurrence of the SMPE form, and which that test would not detect.

Meanwhile, directed to detecting the more common form of distortion, the CCIF method was devised in European countries. This uses two higher frequencies and then you look (or listen) for the buzz, the difference frequency between them, as a distortion product. As many writers, including myself, have repeatedly pointed out, this test only detects asymmetrical distortion — the same kind of transfer nonlinearity that produces second harmonic of a single test frequency.

That this difference-frequency product is related to the practical effects on reproduction, more definitely than is harmonic distortion, can easily be demonstrated. But the fact remains that, using say 7000 and 8000 Hz as test frequencies, and looking for 1000 Hz as the distortion product, only discovers the equivalent of second-harmonic curvature.

Intermodulation Testing Discarded

With the advent of feedback and push-pull amplifiers, this kind of curvature, if not nonexistent, is much less serious than some other forms. This is why, after giving the various known forms of test a workout under practical conditions, the people who specify amplifier and receiver test methods have reverted to harmonic distortion as the more practical to use.

But before this happened, Emory Cook, of binaural record fame, devised a test for detecting distortion in record-playing equipment that used the CCIF method a little differently, and usefully for his purpose. He applied one of the test tones as a steady note, and keyed the other to correspond with the Morse code for N (— •).

These test tones differed by 1000 Hz. He then keyed a 1000-Hz tone with the code for A (• —), so arranged that the two codes interlaced exactly (Fig. 1). In using the test, you ignored the higher frequency sounds, which changed, so as to apply the test at different frequencies, and concentrated your attention on the 1000-Hz tone.

The 1000-Hz reference tone was applied at a level that, if the intermod on playback was exactly 2 per cent, you would hear a steady-sounding 1000-Hz tone, because the interlaced effects would have exactly the same level. If the A signal predominated, the distortion was less than 2 per cent, if the N signal did, it was more.

As the major form of distortion was likely to be the equivalent of second harmonic, due to incorrect tracking or a side force on the pickup, this test served its purpose well.

One reason for needing a test of this kind, as opposed to a simple harmonic test, remains. This is especially true for measuring the performance of a tape recorder, in both the record and playback functions. If you try to measure distortion by harmonic measurement, any fluctuation of speed or amplitude will appear as out-of-balance, and show up erroneously as harmonic distortion.

The difference-frequency method is ideal for this purpose, if its limitations could be overcome. This is why we decided to take a second look at this possibility. The first step was to analyze mathematically the products of various orders of distortion.

We really want to check mid-band distortion, so we'll assume the test signals are 1000 and 1100 Hz. Curvature that would produce second-harmonic distortion will produce the second harmonics of these two frequencies, 2000 and 2200 Hz, along with the sum and difference frequencies, 2100 and 100 Hz.

The 100 Hz is used to detect the distortion, because it is easier to separate from the original frequencies.

Now suppose there is symmetrical distortion of the lowest order, that would produce third harmonic of a single tone. This would produce the third harmonics, 3000 and 3300 Hz, of the original frequencies, which we will designate f_1 and f_2, to show derivation of other product frequencies. It will also generate two difference frequencies, $2f_1 - f_2$ and $2f_2 - f_1$, which are 900 and 1200 Hz, and two sum frequencies, $2f_1 + f_2$ and $f_1 + 2f_2$, which are 3100 and 3200 Hz.

The difference frequencies are difficult to separate from the original frequencies, and the sum frequencies are almost identical with the harmonics. The method has no advantage over harmonic measurement, using this choice of frequencies.

Next suppose that asymmetrical distortion includes fourth harmonic as well as second. In addition to the components listed for second, the distortion will contain two fourth harmonics, 4000 and 4400 Hz, three difference frequencies, $3f_1 - f_2$, $2f_2 - 2f_1$, and $3f_2 - f_1$, which are 1900, 2000, and 2300 Hz, and three sum frequencies, $3f_1 + f_2$, $2f_1 + 2f_2$ and $f_1 + 3f_2$, which are 4100, 4200 and 4300 Hz.

Here one of the difference frequencies is relatively easy to separate, being twice the frequency used to detect the presence of pure second-harmonic curvature. The others are close to the other harmonic products, and difficult to separate.

Finally, suppose that symmetrical distortion produces the next order, which would yield third and fifth harmonics from a single frequency. This would produce in addition to those listed for the lowest order symmetrical, the fifth harmonics, 5000 and 5500 Hz, along with four difference frequencies, $4f_1 - f_2$, $3f_1 - 2f_2$, $3f_2 - 2f_1$, and $4f_2 - f_1$, which are 2900, 800, 1300, and 3400 Hz, and four sum frequencies, $4f_1 + f_2$, $3f_1 + 2f_2$, $2f_1 + 3f_2$ and $f_1 + 4f_2$, which are 5100, 5200, 5300, and 5400 Hz.

Again, these difference frequencies are difficult to separate from the original frequencies, and the sum frequencies are close to the simple harmonics.

But why should the test frequencies used be restricted to those used to give the convenient detection frequency for first-order asymmetrical distortion? By changing our test frequencies, the difference products for various orders can be moved about.

A New Method Added

Based on this premise, we decided to use, as a detection frequency, 250 Hz. This was chosen, rather than a frequency as low as 100 Hz, to get further away from low-frequency roll-off, and into a region of good audibility (for aural detection).

For the lower test frequency, we decided to use 1500 Hz, with whatever higher frequency would yield 250 Hz as one of the difference products for each particular order of distortion. This avoids any direct octave relationship, gives good spacing to enable the detection frequency to be separated from the test frequencies, and yet measures the distortion at frequencies that are representatively mid-band.

We have tabulated the results, to show sets of test frequencies for detecting each of the four distortion products. For each set of test frequencies, we have listed all the dis-

Table of Product Frequencies for Various Distortion Components
Two-Frequency Input (CCIF-Type)

Test Frequencies	Second Harmonic Group Diff.	Harm.	Sum	Third Harmonic Group Diff.	Harm.	Sum	Fourth Harmonic Group Diff.	Harm.	Sum	Fifth Harmonic Group Diff.	Harm.	Sum
1500	**250**	3000	3250	1250	4500	4750	500	6000	6250	1000	7500	7750
1750		3500		2000	5250	5000	2750	7000	6500	2250	8750	8000
							3750		6750	4250		8250
										5500		8500
1500	1250	3000	4250	**250**	4500	5750	2500	6000	7250	1000	7500	8750
2750		5500		4000	8250	7000	1750	11000	8500	5250	13750	10000
							6750		9750	3250		11250
										9500		12500
1500	125	300	3125	1375	4500	4625	**250**	6000	6125	1250	7500	7625
1625		3250		1750	4875	4750	2875	6500	6250	1875	8125	7750
							3375		6375	4375		7875
										5000		8000
1500	625	3000	3625	875	4500	5125	1250	6000	6625	**250**	7500	8125
2125		4250		2750	6375	5750	2375	8500	7250	3375	10625	8750
							4875		7875	3875		9375
										7000		10000

Fig. 1—The component signals for the A-N code test, introduced by Emory Cook (see *J. A.E.S.*, Vol. 2, No. 1, page 50, Jan. 1954).

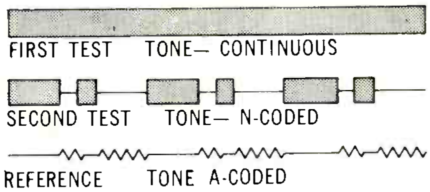


Fig. 2—Basic test setup for applying this method to detect other orders of distortion.

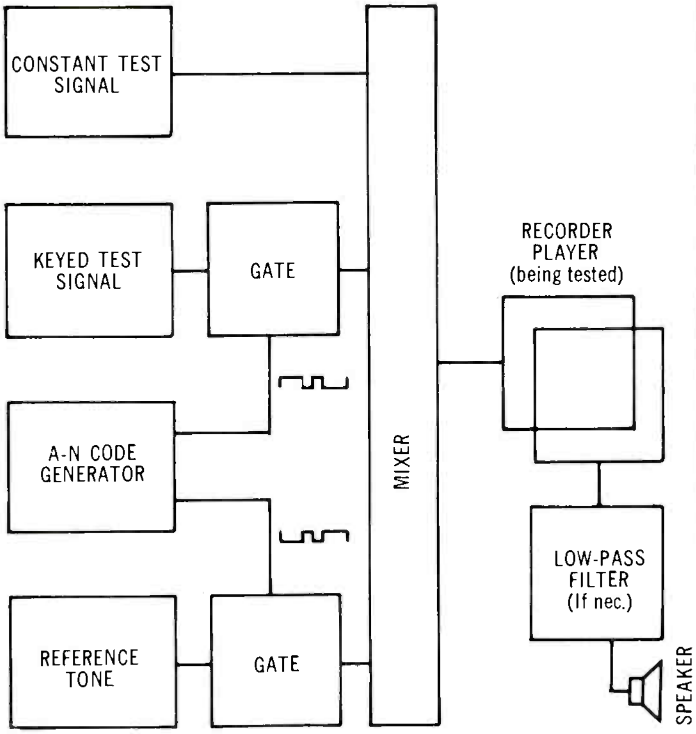
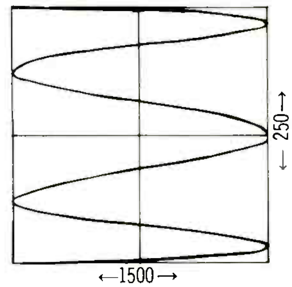
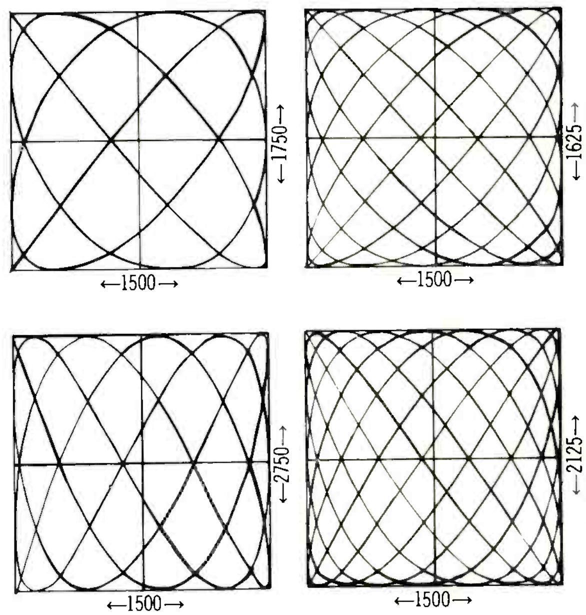


Fig. 3—The Lissajous patterns needed to secure correct frequency ratios for proper detection of the various distortion orders. The numbers along the bottom and sides indicate the frequencies in those directions to produce the steady pattern indicated.





tortion products of the combination. In each case, the higher order includes the frequencies from the lower order of the same kind (which are not listed, to avoid unnecessary duplication).

This means the symmetrical fifth curvature will generate those listed for third, as well, and the asymmetrical fourth will generate those listed for second, as well. However, the frequencies associated with the lower order may undergo phase reversal or cancellation at certain levels of measurement, if both orders of distortion are present together.

To make the tests meaningful, a 250-Hz signal is generated as a reference and, borrowing from Cook's method, this reference tone is keyed with A-code, while the second test tone is keyed with the N-code. To obtain an exact reading of various orders of distortion, the reference signal can be varied in amplitude by means of a calibrated attenuator, indicating equivalent percentage directly, when the setting is nulled to yield an apparently steady tone, without either A or N code predominating.

There may be slight clicks due to phase shift of the 250-Hz tone heard at the keying moments, but these will not be audibly related to the tone for which you are listening. They will sound like keying clicks (even if they are electronically generated).

Figure 2 shows the complete setup in block schematic form. For low orders of distortion, such that the 250-Hz level would be very much lower than that of the test tones, a steep roll-off filter can reduce the level of higher-frequency output products, after playback, to low enough level not to interfere with listening to the 250-Hz tone.

To ensure that the code signal disappears when null is achieved, the distortion product for which you are listening must have a frequency identical to the reference tone. Only a small error in test frequency relationship, particularly for the higher order measurements, will rapidly shift the frequency, so the code is audible as a change in pitch.

If all the frequencies change in step, as by a variation in recorder speed, either during recording or playback, this will not affect the distortion products and the reference frequencies being identical, because the same frequency ratios will prevail.

Calibration Procedure

A relatively simple way to set up the correct frequencies, using fine frequency adjustment, is to employ Lissajous figures to relate the reference tone to the lower test tone, and to relate the upper test tone to the lower test tone. Figure 3 shows the complete set of Lissajous figures for the purpose.

Frequency should be adjusted so these patterns hold absolutely steady on the oscilloscope screen. Finding the more complicated ones may re-

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quire some practice. The easiest way to identify the patterns is by noting carefully three things about each:

(1) counting the rows of crossings across the pattern, vertically and horizontally;

(2) checking that the two "loose ends" are at either left or right side, or at opposite corners; but not at the top or bottom;

(3) noting the slope of the line parts that cross near the center of the pattern.

A little more explanation of the patterns will help understand this procedure. With 1500 Hz as the reference frequency (for Lissajous patterns) presented horizontally, the 250-Hz reference tone gives the pattern at the top of Fig. 3, which is not difficult to identify; for the patterns that represent closer frequency-ratio intervals, the other factors we described tells the following things about the ratio between frequencies displayed.

The number of crossings across the screen tells the magnitude of the highest common factor of both frequencies. The 1500:1750 pattern is really a 6:7 pattern, and the highest common factor of the frequencies is one sixth of one and one seventh of the other. Consequently there are five crossovers vertically and six crossovers horizontally, across the pattern (not counting the outside edges). In each case, one less than the relevant multiple of the common factor.

The 1500:2125 pattern is really a 12:17 pattern, the highest common factor in frequency being 125 Hz. So there are eleven crossings vertically (five above and five below the center line row) and sixteen horizontally (two sets of four on either side of the center line, on which no crossings fall).

Counting crossings, in rows each way, is the most reliable check. The others help confirm the finding. Locating the loose ends determines which frequeny has the odd numeral of the basic number ratio. The odd numeral pertaining to the vertical deflection frequency causes both loose ends to be either left or right. The odd numeral pertaining to the horizontal frequency causes both loose ends to be either top or bottom.

If both numerals of the basic ratio are odd, the loose ends appear at opposite corners. Both numerals of a basic number ratio cannot be even, because this would mean the ratio is not basic, both numerals having a common factor of 2.

If, for example, the basic frequency ratio happens to be 7:8, instead of 6:7, both loose ends would appear either top or bottom, although otherwise the pattern would look quite similar (in line density) to the 6:7 pattern. The frequencies thus represented might be 1500 and 1715 Hz.

And if the basic ratio should be 5:7, the loose ends would be at opposite corners, although the frequencies would be further off, an example being 1500 and 2100 Hz. The density would be similar to the 5:6 or 6:7 patterns.

The final check feature is the slope of the lines crossing the middle of the pattern. For example, a 12:19 pattern would be quite similar to the 12:17 pattern in that both loose ends would be at one side, and the density would be similar. But the crossing of the center line would be slightly steeper. The frequency of the upper frequency would be 2375 Hz. Here the crossing count is the more reliable check.

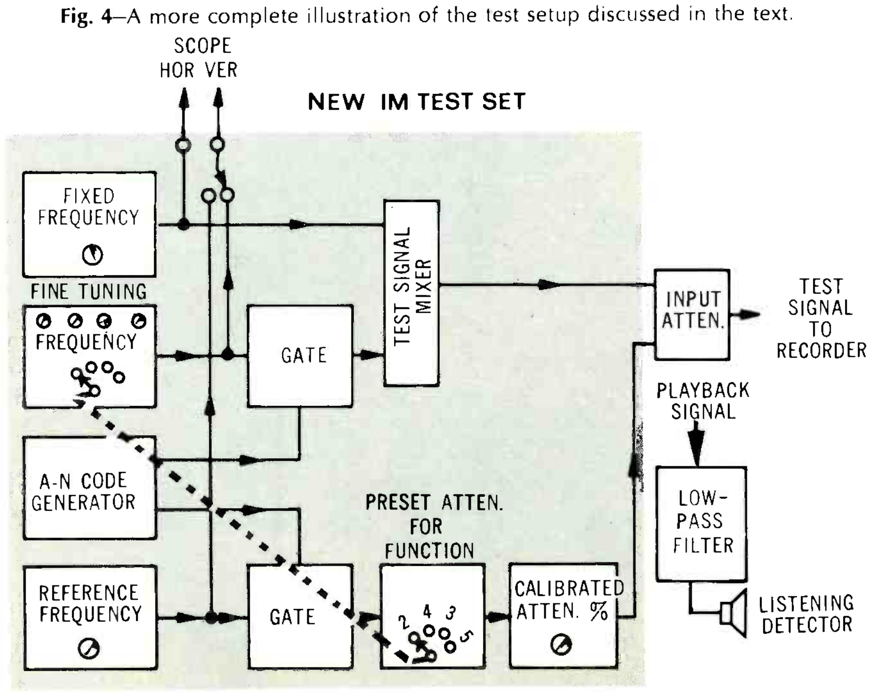
With this help, it should be easy to identify each pattern. Using specially built oscillators, of which one is switchable in frequency, the adjustments will need to be made as a setup procedure only.

When setting up your frequencies, first check that the reference frequency is precisely one sixth of the lower test frequency. Being precisely 250 or 1500 Hz doesn't matter, so long as the ratio is correct. Then for each higher test frequency, adjust its frequency on a preset fine tuner that is switched to change test frequency, until the desired stationary pattern is obtained.

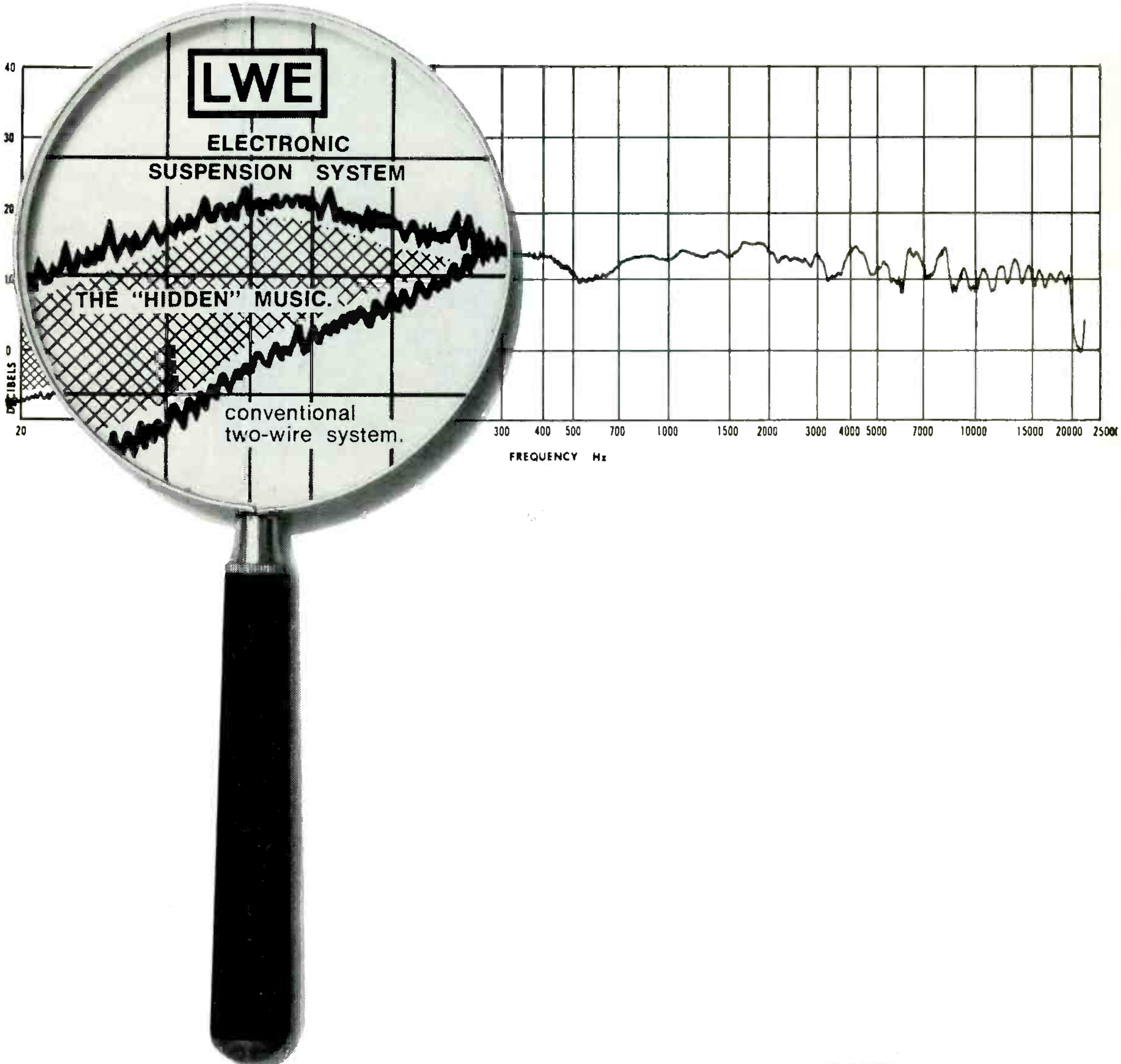
The rest of the test setup can include a preset attenuation in the reference-frequency input to the mixer, so that the same setting on the calibrated attenuator represents the same percentage of that order of distortion as on other positions for other orders. Figure 4 shows the controls for the complete test setup, including the output filter.

In testing a recorder that uses the same amplifier for record and playback, voice announcements may be used to record the settings, so the distortion levels can be identified on playback. With a recorder where the playback can monitor recording, the adjustment can be made and the reading obtained directly, without any need for replaying. Æ

Fig. 4—A more complete illustration of the test setup discussed in the text.



THE CASE OF THE MYSTERIOUS HIDDEN MUSIC...



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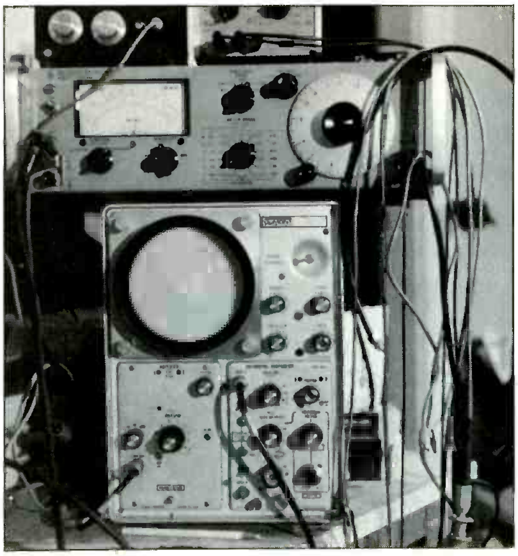
Preamplifier Measurements

James Bongiorno*

The author examines methods used to test audio preamplifiers, emphasizing how to avoid traps that can cause erroneous measurements



It's not uncommon today to find component stereo amplifiers with total harmonic distortion ratings of 0.3 or 0.4 per cent; some are even lower. As a consequence, measurement equipment and techniques that were once most satisfactory for laboratory test purposes no longer give valid results in many instances.

The purpose of this article is to explore test methods for preamplifiers, (where distortion figures are particularly low) that will produce accurate, meaningful measurements.

In examining preamplifiers — the audio amplifier section that precedes the power amplifier (whether it is a separate control amplifier or part of an integrated amplifier or receiver)—we are dealing with only low-level voltage measurements. Thus, this component or section of a component covers everything up to the final power amplifier, which requires high-level *power* measurements.

The most important specifications for a preamplifier are: frequency response, noise, distortion, overload level, and overload recovery. Frequency response is probably the easiest to measure since only an accurate voltmeter and a good generator are required (ideally, however, a scope should be used to monitor all measurements). Before making such tests (for high-level input) the oscillator should be checked to determine its variation in decibels. This procedure should be made with the volume control at its electrical center and the unit driven to its rated output. Figure 1 shows the test setup.

With the volume control at its electrical center, the greatest amount of capacitance will be in the circuit, which would affect the response accordingly. The standard practice of terminating the test cable with 100k ohms in parallel with 1000 pF is *not* subjecting the unit to the normal working environment. This setup is supposed to show the influence of a 25- or 30-ft. audio cable on a preamp's response. However, most persons who use a separate preamp/power amp setup use only 3 or 4 ft. of cable. (Besides which, anyone using the real long cables should be using a terminated system to avoid high-frequency losses.)

*Consulting Engineer

Frequency Response Measurements

Checking frequency response using a preamp's phono input differs dramatically from that for a high-level input. The termination for a phono input should be similar to that of a phono cartridge. Whereas the phono front end might perform well when driven from the low impedance of the oscillator because all the feedback voltage "sees" a virtual short circuit, this may not be the case when driven by a cartridge. The inductance of the cartridge—say, 700 mH—looks at 20 kHz like about 90k ohms in parallel with a cable capacitance of about 80 pF terminated with 47k ohms. Thus, the feedback would be looking back at a complex impedance of around 23k ohms.

Most preamps would not be seriously affected since there should be sufficient loop gain to overcome this load. But some preamplifiers do not enjoy this margin. Therefore, the proper way to measure phono response is to use a test record, such as the CBS STR-100, and a calibrated cartridge.

It is very easy to calibrate *any* cartridge by simply using a millivolt meter terminated with 47k ohms, and using the test record to obtain the response of the record-cartridge combination, as in Fig. 2. Once this is done, it is easy to check the phono-amplifier response against the source response. Any deviation will be the amplifier's error. This will also hold true if the input impedance of the amplifier is other than 47k ohms, especially at high frequencies (due to input capacitance). Again, any deviations in response will be the error of the amplifier. Figure 3 shows how this is done. If you want to check the input impedance of the amplifier, simply insert a *shielded* 47k-ohm resistor in series with the input and measure the response from 20 Hz to 20 kHz, as in Fig. 4. Any deviations in response, measured at the amplifier input after the 47k-ohm series resistor, signifies a change of input impedance.

It is also preferable to use the tape output for all front end measurements. If the tape output is not isolated with an emitter follower, then care must be exercised not to load the tape output, which would cause errors in measurements. Again, a short cable must be used.

Hum and Noise

The next area of measurement controversy is hum and noise. This is probably the most improperly spec'd and improperly measured parameter of them all. The practice of presenting a short circuit to the phono input is unfortunate because the preamp will *never* be operated under this condition. Even using a shielded 10k-ohm resistor is meaningless because the actual noise contribution will be a result of: (1) source resistance; (2) ambient temperature; (3) operating current (primarily of the input transistor); and (4) the effective bandwidth. Numbers (2) and (4) are fairly constant, while (1) and (3) are variable.

The RIAA curve results in an approximate bandwidth of around 5 kHz, but there might be some difference in noise data due to the high-frequency response of the network. Some manufacturers continue the rolloff after 20 kHz, as shown in Fig. 5, while others bring it back around as shown by the dotted curve. While the first gets rid of one evil, it introduces another one. Rolling off the response above 20 kHz will reduce the noise contribution above 20 kHz, but will cause both the transient response and the overload recovery to suffer. Bringing the response back will preserve the good transient response and overload recovery, but it allows some noise contribution above 20 kHz. For proper noise measurements in the audio band, however, a filter *must* be used so this dis-

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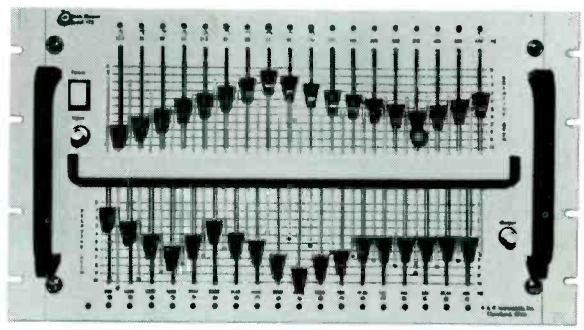

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Fig. 1—High-level frequency response. **Fig. 2**—Cartridge calibration. **Fig. 3**—Measuring a preamp's phono response using a previously calibrated cartridge. **Fig. 4**—Measuring phono input impedance. The oscillator is swept from 20 Hz to 20 kHz. Meter indication should be half of the oscillator's output. **Fig. 6**—Measuring phono noise. Adjust coil for inductance of approximately 700 mH at 20 kHz. **Fig. 7**— Measuring high-level distortion. **Fig. 8**—Measuring high- frequency distortion on phono. Eliminate the filter for low- frequency measurements.

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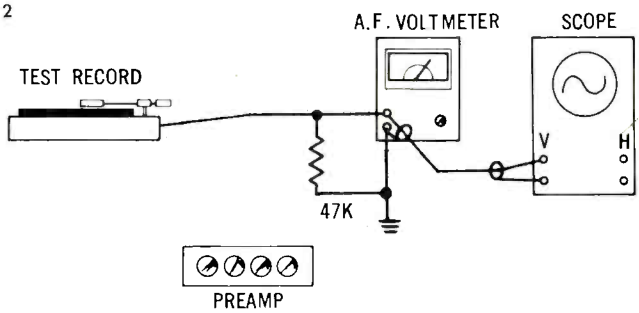

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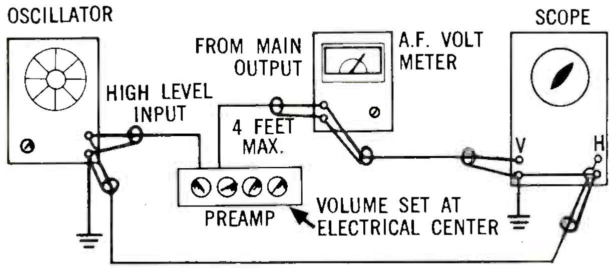

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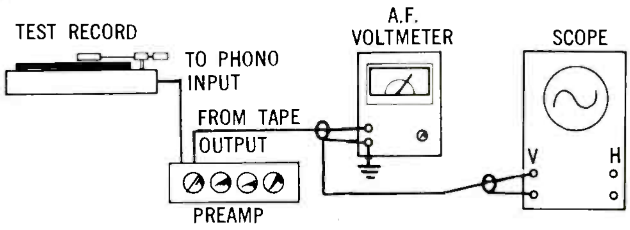

cussion is academic with respect to *measurements*. This filter should be a sharp cutoff 20-kHz filter and should not load the device being tested.

The biggest test discrepancy lies in the effective source resistance. Contrary to popular belief, any amplifier will have it's lowest noise figure when its input is short circuited. However, this is *not* the operating mode of the unit, as previously mentioned. A further error is generally made in interpretation. The only proper and meaning ful way to spec noise is to reference it below a specific input signal *right at the input*.

If the equivalent input noise is 1 μv, then the signal-to-noise ratio will be 1 μv with respect to a given input signal! The gain of the unit has to be taken into account also, and this is the real fault. An example will clear this up, hopefully. Two units, A and B, have gains of 48 dB and 60 dB, respectively. If each has a rated output of 1 volt rms, then the input sensitivity is 4 mV and 1 mV, respectively. Now if unit A had 2 μV of input noise and unit B 1 μV, which is quieter? In truth, unit B is quieter. But, depending on how the manufacturer rates the product, unit A can be made to look quieter. For example, if the manufacturers specs unit A as having a noise figure of 66 dB (2 μV re: 4 mV), then unit A specs better than B. What the consumer isn't told is that, while the signal-to-noise ratio of unit B only specs at 60 dB (1 μV re: 1 mV), it is actually *twice* as good as B because it has 12 dB or four times as much gain. This makes its signal-to-noise ratio 72 dB below 4 mV. This could be corrected by specifying noise in microvolts referred to a 1-mV signal.

Consider, too, the fact that most cartridges don't put out the amount of signal that is implied because most cartridges are rated at a recorded velocity of either 3.54 or 5 cm per second. In other words, a cartridge rated for 5 mV output probably produces about 1 mV per centimeter. If the highest peak modulation on a record groove is around 40 centimeters, then the average recording level will be around 26 dB lower (and probably more). Therefore, 1 mV represents a good average, and to get a signal-to-noise ratio of 60 dB we must have no more than 1 μV of noise at the input.

In reality we will not get the 1 μV mentioned above. The proper way to spec and measure noise is to present the input of the amplifier with the actual source condition that it will see in actual use, as in Fig. 6. What better way to measure noise than to have the input loaded by the cartridge itself or its equivalent? With the cartridge connected, the lowest source resistance the input will see at high frequencies is around 20k ohms, which is a far cry from a short circuit! When using this technique the small hum contributions from the cartridge must be taken into account, of course. It should be obvious that this method results in a noise figure which even though it is correct, will be significantly worse than one specified with an unrealistic source.

Measuring noise on the high-level inputs should be done with the volume control at its electrical center, which will provide the highest or worst-case source resistance. It should be understood that at this setting the noise figure must be at least 30 dB higher than the incoming signal, and *not* the assumed 6 dB, as has often been stated. The 6-dB margin would only apply if the preamp were run wide open or at full volume, which is obviously never the case.

For example, assume that the gain from the volume control to the loudspeaker is around, say, 20 dB for the high-level section plus 26 dB for the power amp = 46 dB total. Further assume that the signal-to-noise ratio is 80 dB below full output. This may seem fine, but we are *not* operating at full power. As a matter of fact, for most speaker systems we will be operating at least 26 dB below full power which, below a reference of 50 watts is around 125 mW. We have therefore *lost* 26 dB in noise figure and are now operating with a 54 dB noise figure. In view of this, it becomes clear that the high-level stages are just as important as the low-level ones in designing for low noise.

Distortion

Measuring the distortion products of low-level signals is difficult. If one is not extremely careful, the results can be grossly inaccurate. Not only is a scope necessary, there is also a special technique that should be used for proper evaluation. For measuring total harmonic distortion (THD), a distor-

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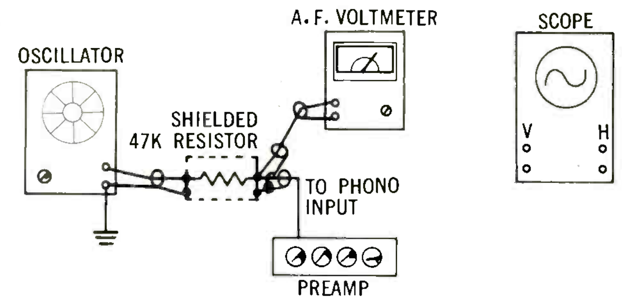

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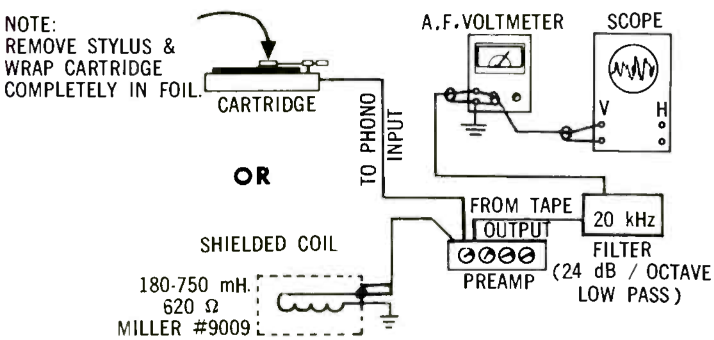

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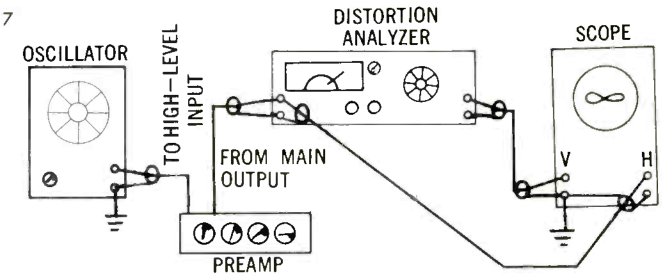

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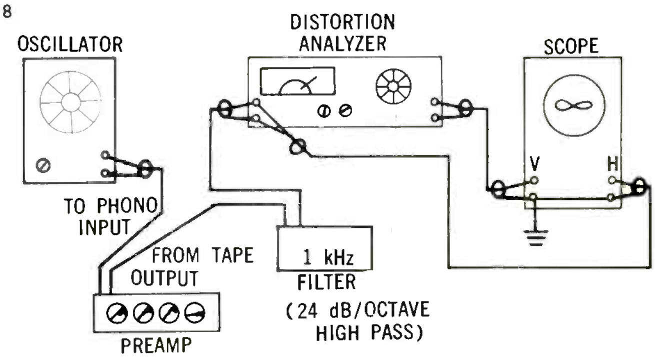


tion analyzer and a scope should be used, the latter in X-Y fashion to obtain lissajous patterns. Either input-output or output-output can be used. I prefer the latter because it eleminates any chance of ground loops and also eliminates most phase errors due to the measuring equipment.

The test setup is shown in Fig. 7. The accuracy of this method will be dependent solely upon the accuracy and residual distortion of the measuring equipment. With component amplifiers' great reduction of distortion during the past few years, measuring equipment should have a residual distortion of less than .01 per cent.

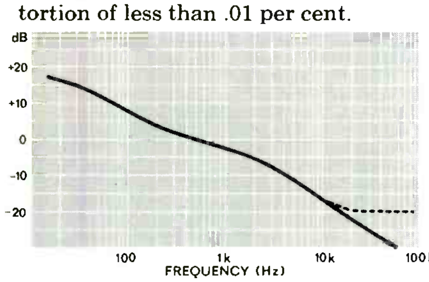


Fig. 5—Solid curve shows required equalization for RIAA response, while dotted curve shows preferred response for better transient performance.

The Hewlett-Packard 331A-334A series of distortion analyzers has served me well in this respect. The unit has a 4-MHz bandwidth, to boot, which is necessary for wideband measurements. This is where other analyzers fail, especially the low-cost kits: they don't have anywhere near the required bandwidth for measurments on sophisticated electronic equipment. The price of the H-P starts at around $640, unfortunately, which places it out of the experimenter's class.

When measuring high-level inpuits no special precautions are necessary other than avoiding overload, especially the tone controls, as there should be more than adequate noise margin. However, I always measure tone-control sections at the extremes because most controls today are negative-feedback controls, which sometimes add considerable distortion when in the boost positions, where feedback is reduced to achieve more gain.

Measuring distortion of the phono front end is tedious, and takes lots of patience. Also, consideration must be made of the RIAA curve which has an equalization spread of around 38 dB from 20 Hz to 20 kHz. This means that the 20-Hz gain will be approximately 80 times the 20 kHz gain. Although there won't be any problems measuring the low-frequency distortion, it might be impossible to measure the high frequencies unless a filter is used. Since most of the noise in the front end is $1/f$ or low-frequency noise, it will be amplified *80 times* as much as the high-frequency test signal. Also, due to the 38 dB difference in gain, the signal-to-noise ratio of the oscillator will automatically be degraded by this factor of 38 dB. In addition, any residual flux in the area will probably leak right into the setup and its cables, creating further problems.

When making these measurements all transformers should be oriented for lowest hum, along with cable orientation. Also turn off any Variacs in use. A good rule to follow is to turn off anything that has a transformer in it other than the specific equipment used for the test. It should be borne in mind that it only takes a couple of microvolts of hum to wipe out a 1-mV test signal completely. The filter should be a 1000-Hz high-pass device with a 24-dB-per-octave slope. *Any distortion contributed by the filter will be measured as total distortion* and will be indistinguishable from that of the front end. Therefore, the filter must have practically zero distortion. Also, the filter should be located at the tape output and, as stated before, it should not load the device being tested. Figure 8 shows the equipment setup. Of course, anyone in possession of a wave analyzer with 80 dB of rejection can consider himself very fortunate.

There is another method of measuring distortion which uses a null technique. The method is useful but is susceptible to external fields if not properly shielded, and phase adjustments must be made. However, two great advantages do exist with the null method. One is that the generator doesn't have to have .01 per cent distortion since the method is a cancellation technique. Secondly, frequency drift in the oscillator will not throw the null off as it will with a distortion analyzer.

Probably the hardest task is obtaining meaningful intermodulation (IM) measurements. There are two kinds of IM products: amplitude modulation

(Continued on page 61)

AUDIO/FM
INSTRUMENT SAMPLER

The average hi-fi buff is never satisfied with the performance of his equipment, but unless he knows how to measure it and unless he has the equipment with which he can make meaningful measurements, he can never be sure that his dissatisfaction is not purely in his imagination. The well-equipped experimenter/hobbyist should have in his "shop" an audio generator, a sensitive a.f. voltmeter, and a distortion meter of some type—harmonic or IM—and possibly a wow-and-flutter meter. With these and a collection of test records and tapes, he should be able to "prove the performance" to his own satisfaction, and he should also be able to find out what trouble (if any) does exist.

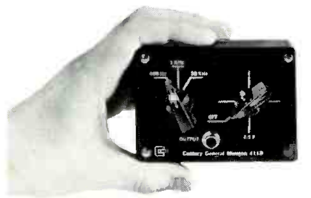
This sampling covers most of the suggested instruments, but does not include the usual volt-ohm-meter, which is assumed to be in every hobbyist's home, nor does it include any oscilloscopes, which are most useful, but which are not in the list of "must" equipment for the non-professional.

For further information, check the indicated Reader Service Card numbers on the card following page 66.

AUDIO-FREQUENCY GENERATORS

Barker & Williamson Audio Oscillator, Model 210 covers from 10 to 100,000 Hz in four ranges. Output up to 10 V into 600-ohm load with distortion less than 0.2% at 5-V output. Response is flat within ±1 dB over entire range. **Price, $326.25.**

Check No. 70 on Reader Service Card

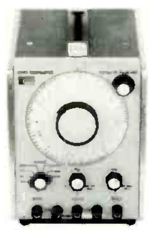


Century General Corp.'s MINIGEN MT #4110 provides three stable frequencies—400, 1000 and 10,000 Hz—from a housing 2⅞ x 4 x 1⅝ in. Output is continuously variable from 0 to 2.5 V. **Price, $14.95.**

Check No. 71 on Reader Service Card

Heathkit Model IG-72 Audio Generator. 10 Hz to 100 kHz with less than 0.1% distortion. Output from 0 to 10 volts continuously variable through eight ranges. **$44.50** kit, **$64.95** wired.

Check No. 74 on Reader Service Card



Hewlett Packard Model 209A Sine/Square oscillator. 4 Hz to 2 MHz continuously variable over six ranges. Output is 5 V into 600 ohms, 10 V open circuit. **$320.00.**

Check No. 75 on Reader Service Card

EICO Model 378 Audio Generator provides switch-selected frequencies from 1 Hz to 110 kHz in four ranges. Output is continuously adjustable from 0 to 10 V into a high-Z load, in eight steps. Meter is calibrated in volts and dB, and 600-ohm termination is selectable by a switch. **Price, $59.95** in kit form, **$79.95** wired.

Check No. 72 on Reader Service Card

Lafayette Model TE-22 Sine/Square wave audio generator. Continuously variable output over four frequency ranges from 20 Hz to 200 kHz. **$32.50.**

Check No. 76 on Reader Service Card

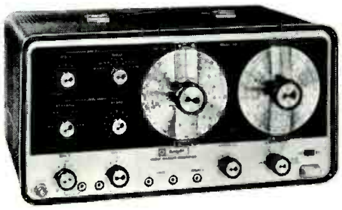
General Radio Co. Model 1311-A Audio Oscillator provides eleven frequencies selectable by a single dial, with a vernier offering ± 2% variation from the indicated frequency. Range is from 50 to 10,000 Hz, and output is continuously adjustable from 0 to 1, 3, 10, 30, or 100 V, while distortion is less than 0.5% at any linear load. **Price, $295.00.**

Check No. 73 on Reader Service Card

RCA Model WA-504A solid-state sine/square audio generator. 20 Hz to 200 kHz in four ranges. Has a 10:1 step attenuator and continuously variable output control. **$95.00.**

Check No. 77 on Reader Service Card

RADIO-FREQUENCY GENERATORS

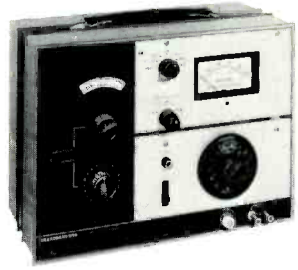


Knight-Kit KG-687 Sweep/Marker Generator, for alignment of FM and TV receivers. Covers from 3 to 220 MHz in five bands, all on fundamentals. Variable sweep width, with marker signals post-injected from 2 to 75 MHz. **$120.00** (kit).

Check No. 78 on Reader Service Card

Lafayette TE-20 r.f. Signal Generator. Covers from 120 kHz to 130 MHz in 6 bands, plus a calibrated harmonic band from 130 to 260 MHz. 400-Hz audio oscillator with separate output provides modulation, or external oscillator may be used. **$27.95.**

Check No. 79 on Reader Service Card



Measurements Model 188 FM Signal Generator. Provides accurately metered r.f. signal over range from 86 to 108 MHz, individually calibrated. Output from 0.1 to 100,000 μV, using mutual inductance attenuator. Internal frequency modulation at 400, 1000, and 10,000 Hz, or will accept stereo MX signal from external generator. **$700.00.**

Check No. 80 on Reader Service Card

STEREO MULTIPLEX GENERATORS

Heathkit IG-37 Stereo Generator. Provides 400, 1000, and 5000 Hz modulation of r.f. signal, with 19, 38, and 67 kHz for thorough multiplex testing. Incorporates three 20-dB switched attenuators plus continuously variable controls. **$79.95** (kit).

Check No. 82 on Reader Service Card

EICO 342 FM/MX Generator. Provides r.f. carrier with MX modulation or composite output, with 1000-Hz modulation, and with or without 19-kHz crystal-controlled pilot, or pilot signal is available separately. **$175.00,** wired.

Check No. 81 on Reader Service Card

RCA WR-52A FM Signal Simulator. Provides 400, 1000, and 5000-Hz audio, and 19- and 38-kHz crystal-controlled frequencies in choice of right or left stereo, mono FM, internal test, and 60-Hz FM sweep. Meter permits setting of signal levels. **$248.00.**

Check No. 83 on Reader Service Card

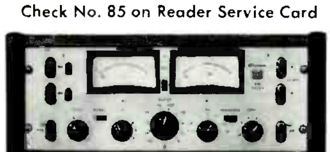
H. H. Scott Type 830 Multiplex Generator. Provides composite signal output up to 5 V (rms) maximum, pilot signal alone, with oscilloscope connections for vertical and horizontal. Fully adjustable for pilot level and phase, and ideal for both laboratory or production testing. **$600.00.**

Check No. 84 on Reader Service Card

DISTORTION METERS & ANALYZERS

Barker & Williamson Model 410 Distortion Meter. Measures audio distortion in five ranges to 1% full scale over band from 20 to 20,000 Hz. Also measures a.f. signal in twelve full scale ranges from mV to 300 V. **$347.25.**

Check No. 85 on Reader Service Card



Crown Model IMA Intermodulation Analyzer. Solid-state unit measures to 0.1% full scale. Features built-in 60- and 7000-Hz internal oscillators and ultra-low residual of less than .005%. Accepts external modulation, and has outputs for 'scope inputs. **$595.00.**

Check No. 86 on Reader Service Card

EICO Model 902 IM/Harmonic Distortion Meter. Provides IM generator signals, individually adjustable as to level, and measures both IM and harmonic distortion to 0.3% full scale. Covers range from 20 to 20,000 Hz in three ranges. **$250.00** (wired only).

Check No. 87 on Reader Service Card

Heathkit IM-12 Harmonic Distortion Meter. Measures distortion over range from 20 to 20,000 Hz in three bands on meter scales of 1, 3, 10, 30, and 100%. Also serves as a.f. voltmeter with ranges from 1 to 30 V. **$65.00** (kit); **$115.00** (wired).

Check No. 88 on Reader Service Card

Hewlett Packard Model 331A Distortion Analyzer. High-quality instrument measures from 5 Hz to 600 kHz with full-scale sensitivity of 0.1%. Input sensitivity 0.3 V for 100% set-level reference. Also serves as a.f. voltmeter with 0.3-mV input sensitivity for full-scale indication. **$650.00.**

Check No. 90 on Reader Service Card

Waveforms 5246A Distortion Filter Set. Measures distortion at eight frequencies, including those required in FCC Proof-of-Performance reports. Resolution is 0.1% full scale. **$500.00.** Model 514A is similar but includes audio oscillator module which provides full range of frequencies from 20 Hz to 10 MHz. **$700.00.**

Check No. 91 on Reader Service Card

Heathkit IM-22 Audio Analyzer. Serves as sensitive a.f. voltmeter and intermodulation analyzer, with built-in generators for test signal. Provides internal loads of 4, 8, 16, and 600 ohms when desired, or measures from unloaded output. **$69.00** (kit).

Check No. 89 on Reader Service Card

WOW & FLUTTER METERS

Gotham Audio Corp. is the importer-distributor for the Woelke ME-104 Wow and Flutter Meter, which contains a 3150-Hz generator (CCIR standard) for the source, and a self-calibrating meter with ranges of 0.3, 1.0, and 3.0% over a linear range from 0.5 to 500 Hz (−3 dB) **$365.00.** Model ME-102B is similar, but with full-scale meter ranges of 0.1, 0.3, and 1.0%. **$475.00.**

Check No. 92 on Reader Service Card

ReVox Corporation imports the W.H.M. Wow and Flutter Meter, Model 3. It contains a 3-kHz generator, and provides a linear range from 0.2 to 200 Hz (−3 dB) and a "wow" range from 0.2 to 10 Hz (−3 dB). Full-scale meter ranges of 0.2 and 1.0% are provided. **$190.00.**

Check No. 93 on Reader Service Card

AUDIO RMS VOLTMETERS

B & K Instruments Type 2409 Electronic Voltmeter measures a.f. from 2 Hz to 200 kHz within 0.2 dB, with full-scale ranges in 10-dB steps from 10 mV to 1000 V. Internal amplifier provides up to 60 dB gain from a 10-megohm input to a 50-ohm output with a maximum of 10 V. **$338.00.**

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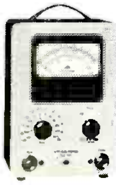

EICO Model 250 a.c. VTVM and Amplifier. Twelve voltage ranges from 1 mV to 300 V. full scale. Input impedance, 10 megohms shunted by 12 pF. Voltage-regulated supply ensures accuracy to ±3% of full-scale indication. Provides 5-V output from amplifier, with maximum gain of 60 dB. **$59.95** (kit), **$89.95** (wired).

Check No. 95 on Reader Service Card

Heathkit IM-38 a.c. VTVM. Ten ranges from 10 mV full scale to 300 V full scale. Response is flat from 10 Hz to 500 kHz, and input impedance is 10 Megohms. **$39.50** (kit); **$54.95** (wired).

Check No. 96 on Reader Service Card

Hewlett Packard Model 400 EL. Completely solid state, this unit has twelve full-scale ranges from 1 mV to 300 V at an input impedance of 10 Megohms. Meter scale is linear from −10 to +2 dB, with secondary scale in rms volts. **$335.00.** Model 400 E is similar with linear voltage scale, **$325.00.**

Check No. 97 on Reader Service Card

RCA a.c. VTVM, Type WV-76A, has nine a.c. ranges from 10 mV to 100 V full scale, with separate dB scale. Input probe switchable from low-capacitance probe to direct input to increase frequency range to 1.5 MHz. May be used as a preamplifier with 38 dB gain. **$79.95.**

Check No. 98 on Reader Service Card

SOUND LEVEL METERS

B & K Type 2203 Precision Sound Level Meter is portable, fully solid-state, and battery operated. Includes attached condenser microphone, and covers a full-scale range from 22 to 134 dB SPL. Integral weighting networks and speed of indication controllable by switch. Provides for attachable octave filter set. **$770.00.**

Check No. 99 on Reader Service Card

Hewlett Packard Model 8052A Impulse Sound Level Meter can be used as a conventional sound-level meter, or can measure impulses of very short duration. Also serves as a sensitive a.f. voltmeter. Measures 100-μsec pulse within 1 dB of true peak level. **$670.00.** Attachable Octave Filter Set, Model 8055A, **$520.00.**

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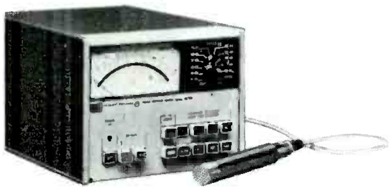
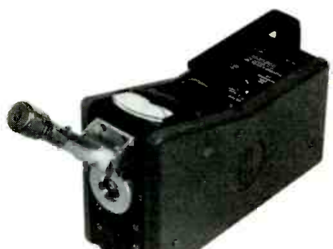


General Radio Type 1565 Sound-Level Meter covers the range from 44 to 140 dB, with switchable weighting networks. Self-contained, battery-operated, with ceramic microphone attached. Accepts connector from vibration pickup or other transducer, or from a cable to a remotely placed microphone. **$315.00.**

Check No. 133 on Reader Service Card

H. H. Scott Type 412 Sound Level Meter measures from 20 to 150 dB, and includes weighting networks. Uses ceramic microphone, and has built-in electro-acoustic calibrator and large meter. Eight transistors and four subminiature tubes result in long useful life from built-in battery supply.

Check No. 102 on Reader Service Card



MISCELLANEOUS

Test Records. CBS Laboratories offers a series of test records: STR-100 is cut with a 500-Hz turnover, and is flat above the transition frequency. It offers separate right and left sweep-frequency groups, spot-frequency groups, and playback-loss groups, reference level bands, and tone-arm resonance bands. **$8.50.** STR-110 is designed for testing with square waves, and to test tracking and intermodulation. Cut with 2.5-deg. vertical angle. **$10.00.** STR-111 is identical, except it is cut with 15-deg. vertical angle. **$10.00.** STR-120 is a wide-range pickup-response-test record, with sweeps from 500 to 50,000 Hz, both right and left, as well as similar sweeps from 10 to 500 Hz. **$10.00.** STR-130 is cut in conformity to the RIAA characteristic, with both sweep and spot frequency bands on each channel. **$10.00.** STR-140 is a pink-noise acoustical test record, **$10.00.** BTR-150 provides both lateral and stereo reference tones, a flutter measurement section and VU-meter calibration signals. **$10.00.** STR-160 is designed for checking vertical tracking angle of cartridges. **$10.00.**

Check No. 105 on Reader Service Card

Test Tapes. Tapes for checking performance of tape recorders are available from Ampex in a variety of types. The most useful are: 31321-04, a 7½-ips 4-track tape with reference and azimuth-adjustment tones and a series of frequencies for response measurement, **$21.95;** 31331-01, a full-track 3¾-ips tape with similar signals, **$21.95;** and 31326-01, a full-track 7½-ips flutter-test tape, **$21.95.**

Check No. 106 on Reader Service Card

Audiotester tape, available from Audiotex, checks both stereo and mono machines for alignment, resonances, equalization, IM, and distortion. In four types: 30-206 (standard, full-track), **$4.95;** 30-206 (professional), **$8.25;** 30-210 (4-track), **$6.50;** 30-211 for portables (3-in. reel), **$4.95.**

Check No. 107 on Reader Service Card

Integrated Controls Inc. meter expander increases the voltage and current sensitivity of any a.f. voltmeter up to 60 dB in three switchable ranges—x10, x100, and x1000—and is designed for troubleshooting low-level solid-state circuits. The unit is self-contained, battery operated, and provides an output up to 2.5 V. **$50.00.**

Check No. 134 on Reader Service Card

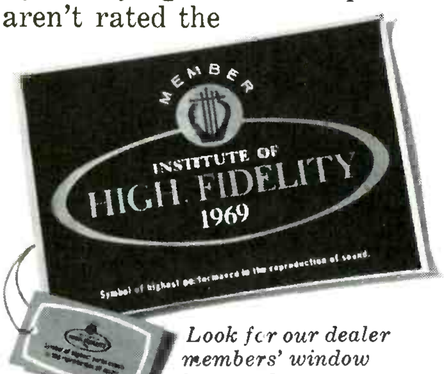
Amphenol Model 880 Stereo Commander combines seven instruments—audio generator, IM analyzer, a.f. voltmeter, MX generator, impedance bridge, marker oscillator, and r.f. sweep oscillator in one compact and portable package. Operates from 117-V a.c., and weighs only slightly over 8 lbs. **$329.95.**

Check No. 135 on Reader Service Card

If you think all watts are alike, you may get apples the next time you buy oranges.

Which is our way of saying that all amplifiers and receivers aren't rated the same way.

The several different methods of rating an amplifier's power capacity are so far apart that an amplifier rated at 250 watts by one system actually puts out only 50 watts by another.



Look for our dealer members' window decal and our manufacturer members' identifying product tag.

It's not a Question of "Right" and "Wrong"

We don't mean that some power rating systems are "wrong" and others are "right." What we are saying is that one component may appear to be more "powerful" (i.e. deliver more watts) than another, when the real difference may be in the methods used to measure their respective outputs.

Let's end the confusion by defining the three main rating methods:

"RMS" Rating—The standard laboratory method. The output of an amplifier is measured at a single given frequency. Not especially useful in measuring a component's capacity to reproduce a complicated signal like music.

EIA Rating—Derived by measuring output at a single frequency. But permits a higher distortion factor (5%), and thus results in a much higher wattage number than the comparable IHF rating (usually at 1%).

IHF Rating—Arrived at in accordance with the published Institute of High Fidelity Standard, which sets forth two methods of power measurement: "continuous power" method (same as RMS method above) and "dynamic or music power" method. Additionally, it specifies that measurements are to be made with all amplifier channels driven. These two methods, as set forth in the publication IHF-A-201, are accepted as the industry standard by quality manufacturers.

The IHF Method is More Musically Inclined

Clearly, the IHF rating of an amplifier or receiver is more meaningful to anyone buying high fidelity equipment, because it uses conditions that the listener encounters, while still maintain-taining strict limits where distortion is concerned.

So it makes sense to check the IHF power rating when you're looking for an amplifier or receiver. The specification sheets of our member manufacturers carry this rating. As the common yardstick of the industry, it best reflects the concerns of those who developed the concept and craft of high fidelity.

INSTITUTE OF HIGH FIDELITY INC

The organization of the quality sound equipment makers and dealers.
Specifications stated in terms such as "100 watt IHF ±1 db" are not true ratings.

Equipment Profiles

This Month:

- **Sony Model PS-1800 Turntable System**
- **Heathkit Model AS-48 Speaker System**
- **Audio Dynamics Model ADC-25 Stereo Cartridge**

Sony Model PS-1800 Servo Turntable System

MANUFACTURER'S SPECIFICATIONS:

Speed: 33⅓ and 45 rpm. Speed-Control Range: ±4%. Starting Response Time: Within 0.5 sec. Wow and Flutter: Less than .08%. Rumble: Over 60 dB. Dimensions: 19 9/16 W x 7 1/16 H x 16¼ D. Weight: 21 lbs. Price: Under $200.

The new Sony Model PS-1800 servo turntable system, with a good tone arm and a handy shut-off/arm-return feature, belongs right alongside other top-quality turntables. It's a handsome, well coordinated component package.

The PS-1800, complete in its walnut base and hinged plastic lid, is an outstanding example of good engineering—from the top of the dust cover to the rubber feet at the bottom of its handsome oiled-walnut base. The two-speed unit, electrically switchable between 33⅓ and 45 rpm, has a fine-speed control that can vary the speed ±4%. A built-in strobe system enables one to exactly set the speed right and keep it there regardless of load or line variations. A thumb-wheel adjustment varies the speed, while a coarser (screw-driver) adjustment is available under the chassis.

The turntable is belt-driven by a slow-speed (300 rpm) d.c. motor which is servo-controlled via an electronic network. Since rumble is a function of mass and velocity squared, a reduction in the rotating speed will reduce the motor-caused rumble by the square, everything else being equal. This presumes good bearings and no eccentricities. The motor in this case is quiet and well suspended. Its pully drives a neoprene belt which runs around an 8-in. diameter turntable wall which is part of the 12-in., two-pound, die-cast, aluminum-alloy platen assembly. The platen sits almost flush with the cast base into which the tone arm is also mounted. A machined ball built into the tip of the platen's shaft rides on Teflon at the bottom of the well. A start/speed selector control, conveniently located just in front of the tone arm's head, starts the motor and gently lets down the arm via a hydraulic arm lift. Pushing an illuminated, red push-button built into the front face of the walnut base causes the one-arm to lift, return to its rest position, and shut off the entire system. The shut-off, lift and return also takes place automatically when the tone arm reaches the lead-out grooves at the end of a record.

Fig. 1—The Sony PS-1800 turntable system. Note the reject/off button on the front of the wood base.

A unique feature of the automatic arm return is the magnetic proximity sensing mechanism. Sony calls it "Magnetodiode." An advantage of this method, which in the initial stage is electronic rather than mechanical, is that the arm can be handled manually at anytime — even in the lead-out grooves—since manual operation overrides the gentle, automatic arm-nudge to get back to rest position. In fact, one doesn't feel the slightest force on the arm when it is held in the middle of its cycle. And, of course, there is no drag on the arm since the arm return operation is initiated electronically.

The tone arm in this package is statically balanced, using one counter-weight for see-saw balance and another, graduated one, for tracking force. A fish-line weight/pulley arrangement provides anti-skating force. The static balance, as opposed to dynamic balance using springs, means the unit cannot be used "upside down," but neither will the tracking force settings change with time. The tone arm is 9-in. long from pivot to stylus, with a 9/16 in. overhang and a tracking error of just over 1 degree. It can accommodate just about any cartridge weighing between 4.5 and 11 grams. The arm has a slide to adjust the stylus overhang precisely for minimum tracking error. Accurate built-in stylus force markings on the rotatable counterweight make it easy to balance the arm and set the proper tracking force. The turntable/arm assembly is spring mounted into the base. Since it is not especially heavy, its suspension is soft.

Performance

We installed an Ortofon Model SL-15-T stereo cartridge into the Sony PS-1800 system for our lab tests. Flutter measured better than 0.04%, while wow was a low 0.03%. The best part was rumble, however. This was a very impressive −41 dB, unweighted, using the NAB measurement method. As many readers know, this is a measure of the electrical effect of low-frequency noise, and does not take into account one's hearing perception. In effect, the unweighted figure might be said to emphasize subsonic frequencies, which, if unusually powerful, could cause audible distortion effects in systems with extended low-frequency response. A "weighted"* rumble measurement, on the other hand, considers the fact that the higher the rumble frequency the better we hear it. Using an "A" weighting network to provide us with rumble measurements weighted in favor of noise that is audible, the Sony PS-1800 turntable system with the aforementioned cartridge measured −67 dB (weighted), which is exceptionally good. Since rumble is also a function of the cartridge used for measurement, a cartridge which doesn't have a good low-frequency response will yield even more impressive rumble figures.

The tonearm handled and performed very well, adding to the overall capability of the integrated unit. It exhibited no reasonances in the audible

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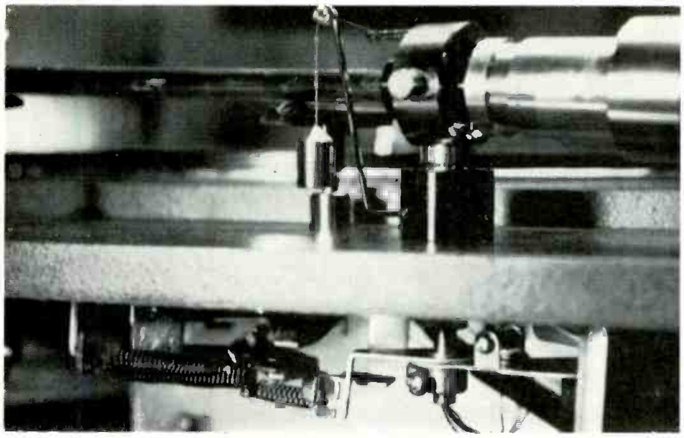


Fig. 2—Side view of the PS-1800's integrated tone arm, showing arm-return mechanism at the moment the arm is returned to a rest position. The actuator engages the arm only at this moment, being free at all other times so that there is no interference with arm operation during play.

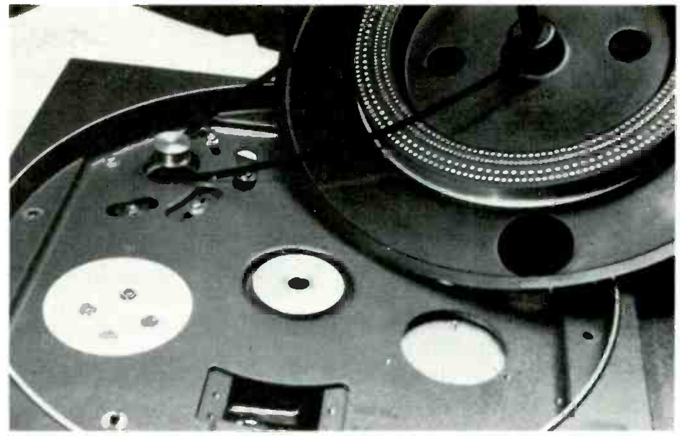


Fig. 3—Looking down into the turntable's drive motor pulley reveals the drive elements. The motor pulley (top) drives the underside of the platter, which is removed and turned over (right-hand corner), via a neoprene belt. Strobe markings may be seen on the platter, as well as a balance weight. The strobe lamp can be seen at bottom.

Fig. 4—The servo-speed-control electronics is pictured here, removed from its underside mounting. A fine-speed-control potentiometer is used, with the shield grounded to the pot's case to minimize noise pickup.

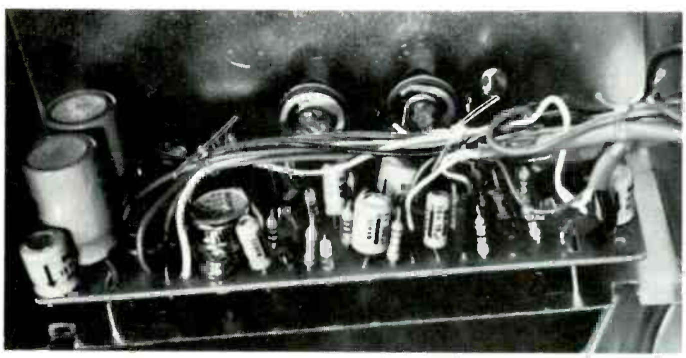
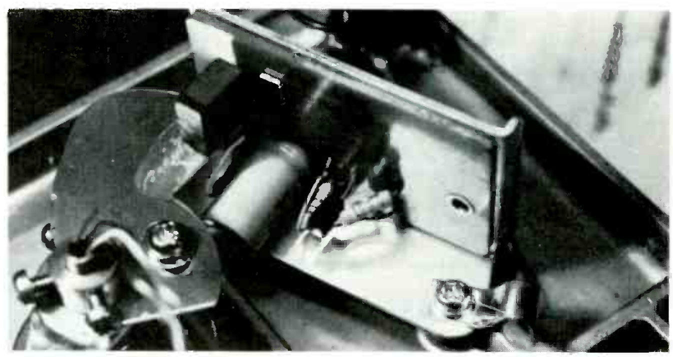
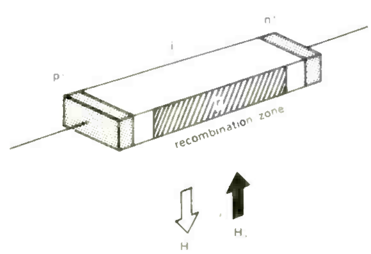
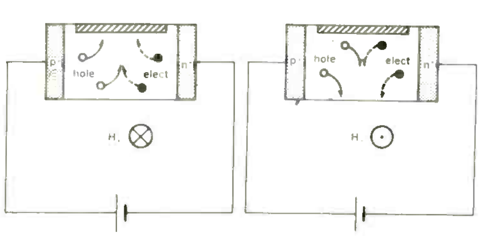


Fig. 5—Here is the underside of the tone arm, showing the arm magnet near the sensing network. The latter energizes a solenoid which starts the lift and shut-off sequence by releasing a spring-loaded linkage.





BASIC STRUCTURE



OPERATING PRINCIPLE

The Sony Magnetodiode

A semiconductor that is sensitive to magnetism, called the "Sony Magnetodiode" (SMD), has been developed by the Sony Corporation. It features high sensitivity, enabling it to operate with low-level magnetic fields. Though not a precision device, the manufacturer says it can be used in many areas of application where extreme accuracy is unnecessary: magnetic field detection, brushless d.c. motor speed control, non-wearing volume control, and as a proximity switch, among others.

The SMD is applied as a proximity switch in the Sony PS-1800 turntable system reviewed here. It's employed as a sensing device which, when activated, triggers a solenoid circuit that acts to lift the arm, return it to a rest position, and shut off the system. Thus, tone-arm return is actuated electronically, rather than mechanically. (See Equipment Profile.)

The magnetosensitive semiconductor's basic structure is shown here. Magnetic fields deflect the paths of injected electrons and holes either toward or away from the "recombination zone." As a result, current decrease or increase depends on the external magnetic field's direction.

spectrum. The pivot friction is very low, enabling use of low-mass cartridges tracking at below 1 gram. The unit's relative immunity to external shock and vibration and acoustic feedback is also very good.

Considering the operating convenience features which make the unit so pleasurable to use, coupled with impressively good performance, the Sony PS-1800 can be termed a great integrated turntable. At its price of under $200 (which includes turntable, tone arm, wood base, and dust cover), it is also a great buy for use with any better-than-average stereo hi-fi system where playing records only singly is desirable.

* For the information of new readers, Fletcher and Munson proved in the early 1930s that loudness depends on frequency as well as on intensity. Robinson and Dadson did similar work in later years, resulting in equal loudness contours, which are illustrated in this issue's *Primer on Sound Level Meters*. These curves use a unit of loudness level, the *phon*, comparing loudness of a reference note to that of a given note. The weighting network used by AUDIO, "A" weighting, whose frequency response is also illustrated in the aforementioned article, is one of three filters employed with many noise meters to obtain subjective measurements. It simulates frequency discrimination of hearing at low levels of sound. Rumble would be more apparent at higher listening levels, naturally. For example, using these International Electrotechnical Commission (I.E.C.)-recommended weighted response curves, a 60 Hz signal would be about 30 dBs below the 1000 Hz's zero dB point with an "A" weighting network, whereas it would only be about 10 dB down with a "B" weighting network, which is used to measure loud noise. Though recognized internationally, these weighting curves do not provide us with what is felt to be an ideal response for our purpose, but it does serve satisfactorily and will have to do until another widely accepted standard is developed. Readers should never compare one weighted rumble figure with another unless each uses the same standard, not to mention the same test setup.

Errata

Last month's profile of the Thorens TD-125 "electronic" turntable stated that its **46-dB** NAB rumble measurement, referenced to **7** cm/sec peak velocity at 1000 Hz, was **11 dB** better than the NAB minimum standard of **−35 dB.** This is the old NAB Standard, of course, which was superseded by a new NAB Standard a few years ago, taking into account stereophonic disc playing and reproducing equipment. Thus, the measurement should have been referenced against the latest standard, which is **5** cm/sec peak velocity at 1000 Hz. Accordingly, the Thorens TD-125 rumble measurement should have read **−43 dB** (NAB), which is **8 dB** better than what the NAB Standard defines as minimum. However, it is possible that the TD 125 is even better than noted because we may well be measuring the record's low-frequency noise (rumble, mold grain, and what-have-you).

Also, on double-checking our measurements with a mint copy of a **CBS Labs** BTR-150 test record, we measured the TD-125's weighted ("A" weighting) low-frequency noise as **−70 dB,** as contrasted with the **−64 dB** figure published last month. In tracking down the discrepancy, we discovered that the test disc used last month exhibited considerably more noise when playing outside grooves (which we coincidentally used during weighted rumble measurements) than when playing inside grooves. On re-testing with the old test record, measurements made while using its inside grooves approached the figure produced with the new test disc.

As a result of the above, we were driven to investigate measurement results garnered from a number of different brands of test records, as well as some copies of each. Interestingly, they differed widely from brand to brand and, in some instances, between pressings of the same label. For example, on a few of the test records, we could not measure beyond the middle-30 dB below the reference level, which indicates that one could employ a test record that exhibits greater low-frequency noise than produced by the turntable under test.

In view of the improvements made in modern turntables (not to mention other components), it is therefore clear that many of the currently available test records are inadequate. Certainly, test records should be developed that exhibit less low-frequency noise than present-day ones do. What we would like to see is a return to the old 1953 NAB definition of a test record, which included a requirement that the record be at least 8 dB quieter in low-frequency noise than the turntable being measured. Based on measurements we made on the TD-125, as well as on the Sony 1800, rumble content of the test record should then not be worse than −51 dB unweighted.

Heathkit Model AS-48 Bookshelf Speaker System Kit

MANUFACTURER'S SPECIFICATIONS:

Frequency response: 40 to 20,000 Hz. Crossover frequency: 2000 Hz. Nominal input impedance: 8 ohms. Power rating: 50 watts program material. Speakers: (Heath by JBL) low-frequency, 14", 8 ohm; high-frequency, 2", 8 ohm. Enclosure: tuned-port, damped reflex. No. 1 grade oak veneer on high-density pressed-wood base, with solid oak grille frame. Pecan finish. Net weight, 42 lbs. Dimensions: 14" H x 23½" W x 12" D. Price: $169.95 (kit).

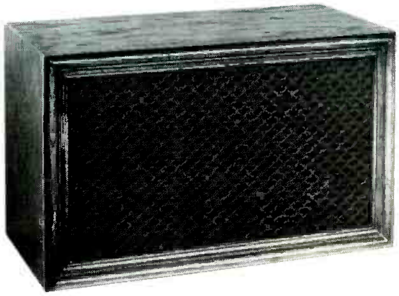


Fig. 1

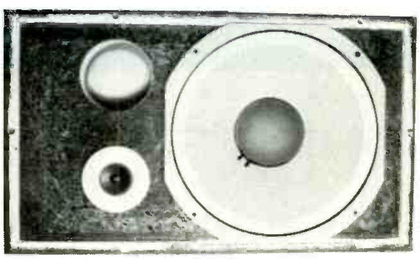


Fig. 2– The Heathkit AS-48 with grille removed shows speakers and port tube.

The Heath Company has made it possible for the hi-fi listener to assemble a good-sized bookshelf speaker system, using JBL mechanisms, at a saving in cost. When the average home constructor builder puts together a speaker system himself, from scratch, he might end up with a poorly designed compromise. Doing the job right involves a thorough knowledge of the characteristics of the speaker mechanisms selected, a knowledge of crossover networks, and a sufficient familiarity with acoustics to be able to come up with a cabinet design which brings out the finest qualities of the speakers selected. And add to this, furniture finishing. It also involves a number of decisions as to whether one should build a completely enclosed cabinet, a bass reflex with the usual port, or a ducted-port design. The latter has a number of advantages, not the least of which is the improved bass response commensurate with the enclosure size. The choice of interior damping material is also important, as well as the amount and the placement.

All the design work has been done in the case of the AS-48, all the parts are packaged, and the builder is assured of a fine product when he is finished, and that's not more than two hours per system.

Construction

The assembly of this kit starts with the preparation of the cabinet, which is finished on four sides in an attractive pecan finish in the Mediterranean style. The cabinet is completely enclosed except for the port in the baffle and an opening in the back for the crossover network, which is gasketed to seal up the opening when completed.

Music lovers, take control!

Specs You Can Brag About. Frequency response: 20-22,000 Hz @ 7½ ips, 20-17,000 Hz @ 3¾, 20-10,000 Hz @ 1⅞. Wow and flutter: 0.09%. Signal-to-noise ratio: 52 db.

Three Heads. Allows monitoring of either input source or the actual recording made on the tape.

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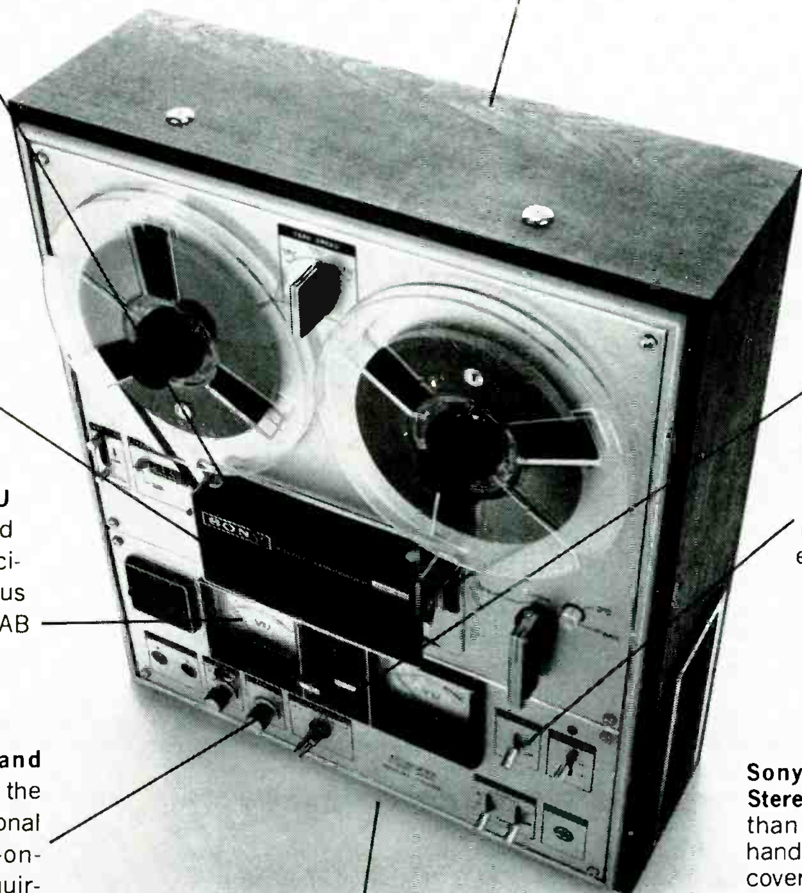

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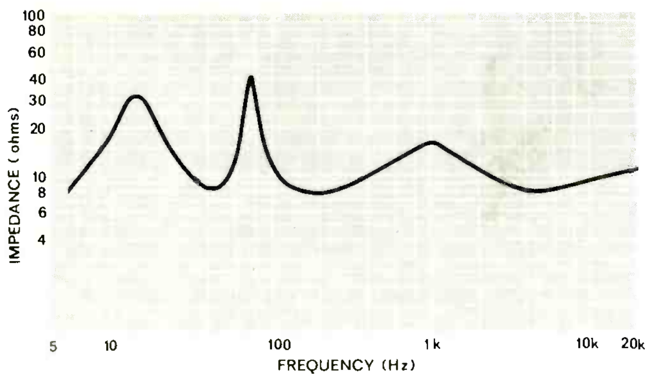

Fig. 3—Measured impedance of the speaker system at the input terminals. The curve shows the balanced low-frequency peaks, which are normal for reflex and ducted-port speakers. The nominal impedance of the system is 8 ohms.

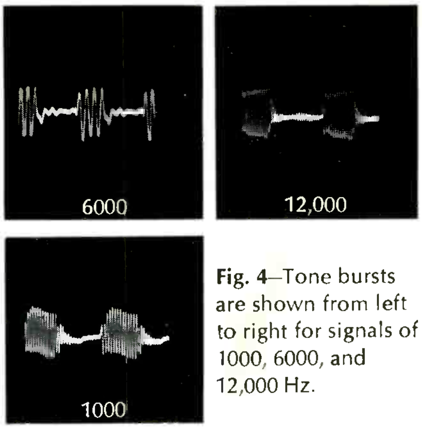

Fig. 4—Tone bursts are shown from left to right for signals of 1000, 6000, and 12,000 Hz.

One first cuts the fiberglas padding into specified sizes, then after applying glue to specified places on the inside of the cabinet, the fiberglas pieces are put in place. Access to the baffle and the inside of the cabinet is provided by removing the grille, which is held in place by spring clips which fit into pre-drilled holes in the sides of the enclosure. To ensure against possible irritation of the skin from the fiberglas, plastic gloves are provided—two with each speaker system. The various pieces of fiberglas are put in place through the opening for the 14-in. woofer, being worked into place before pressing down to contact the glue strips on the inside. All of the preparing takes about 30 minutes.

Next, you will assemble the crossover network. This involves another 30 minutes to mount the switch, two chokes—one a single value and the other with three values—two capacitors, and two resistors. When this is done, you mount it in the cabinet, using predrilled holes and some foam gasketing strips to maintain airtightness, and you have four wires extending from the crossover chassis—two for the woofer, and two for the tweeter.

The two leads for the tweeter are fed up through the small hole and attached to the tweeter mechanism, which is then put in place and fastened with three wood screws. The other two leads are brought up through the large hole, attached to the woofer, and then it is similarly mounted, and the job is done. The cardboard duct for the port is already installed in the cabinet. It measures 4 in. in diameter by 11 in. long, and thus extends nearly to the back wall of the enclosure.

A dress ring of adhesive dark paper is applied around the tweeter basket, and the grille is fitted into place.

The entire assembly is easy to perform, and the kit instructions are simple and lucid, as one would expect from Heath. Complete diagrams make every operation clear, even to the novice.

The crossover network consists of two 8-μF capacitors, three resistors, and two chokes. The woofer is permanently connected across the input at all times, relying on its high damping and its long cone travel to provide a mechanical rolloff at 2000 Hz. The tweeter is connected in series with one of the capacitors across the line in the HIGH position, and through taps on the 3-mH choke in the MED and LOW positions, while the capacitor has shunting resistors across it in the two latter positions. In addition, the other capacitor, a resistor, and the 2.5 mH choke are in series across the tweeter to shape the crossover frequency to the desired 2000 Hz. It is an unusual crossover network, in our opinion, but it does its job well.

Performance

Figure 2 shows the AS-48 with the grille removed, illustrating the locations of the two speaker mechanisms and the port tube. The three-position switch is accessible from the back, and two 8-32 screws with large knurled nuts are used for the connections.

To investigate the efficiency of the crossover network, we measured the impedance of the system, which shows a typical reflex pattern, as shown in Fig. 3. Note the two peaks in the curve below 100 Hz. This is close to the classic impedance curve for a reflex speaker, with the peaks of about equal value distributed to either side of the free-air resonance of the woofer, then dropping down to about the nominal value, remaining there within a factor of two up to the traditional 20,000 Hz.

This speaker system should definitely be rated as a high-efficiency type, since it provides adequate room level with an input of only a bit over one watt, while ten watts is too loud to stay in the room with. Dispersion is excellent, dropping only 6 dB at an angle of 60 deg. from the axis at 8000 Hz, so that it is practically impossible to detect any droop as you walk across the room in front of the speaker. Response is down about 5 dB at 40 Hz, although still audible at 30, and with no doubling. At the upper end, output is still measureable to 20 kHz, with strong audibility to over 15 kHz.

The "h.f. balance" switch on the crossover chassis affects the range above 2000 Hz gradually, with in increase or decrease of 3 dB at 8000 Hz as the switch is turned from MED to HIGH or LOW. This permits adjustment of the response to suit the acoustic environment of your listening room, and starting with the switch in the MED position, you will soon decide whether your room needs more or less highs, and you can boost or lower them as required. In the average room, however, the speaker system is well balanced at the MED position.

Overall listening gives considerable satisfaction over a wide range of program material. The system exhibits the solidity of a heavily damped woofer (due to its 11½-lb. magnet structure) and to the rigidity of the cabinet. Add to this the luxurious appearance and you will find that you have assembled a fine system at a most reasonable price. You can change the grille cloth easily to match the decor of your room, since the grille frame can be removed without tools.

After thorough listening tests, we took some photos of tone bursts, just to verify what we heard. Note that the bursts are quite clean, starting with no overshoot, and stopping quite abruptly. These photos are about what tone-bursts should look like—not as perfect as the source, yet distinguishably clean, both at the start and at the finish of each burst. The signal frequencies used were 1000, 6000, and 12,000 Hz, with suitable lengths of bursts in each case.

In all, the model AS-48 top-of-the-line Heathkit speaker system is a fine-performing, high-efficiency non-floor-standing unit.

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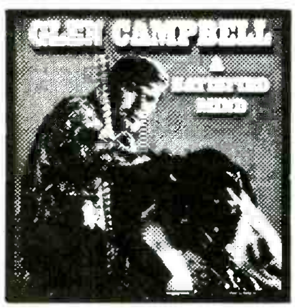

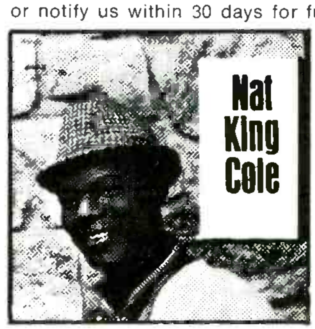

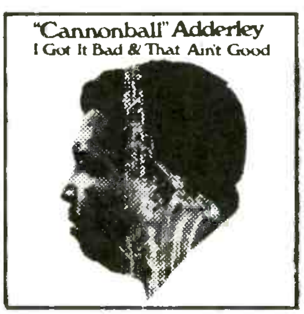

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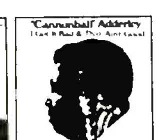

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Audio Dynamics Model ADC 25 Stereo Pickup System

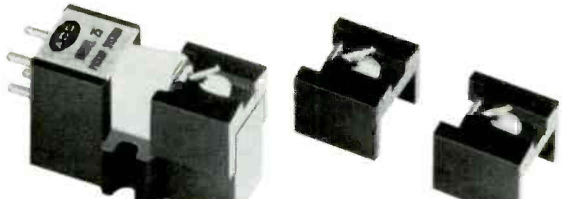


Fig. 1

MANUFACTURER'S SPECIFICATIONS:

Type: Induced magnet. Sensitivity: 4 mV at 5.5 cm/sec recorded velocity. Tracking Force Range: 1/2 to 1 1/4 gms. Frequency Response: 10 to 24,000 Hz ±2 dB. Channel Separation: 30 dB from 50 to 10,000 Hz. Vertical Tracking Angle: 15 deg. Recommended Load Impedance: 47,000 ohms. Price: $100.00 (including three interchangeable styli).

The ADC 25 stereo pickup system makes it possible to interchange your styli without changing tone-arm heads, and while this has been possible heretofore if the user of almost any cartridge thought of it, this is the first time, to our knowledge, that the manufacturer thought of it for you and provided the complete cartridge *and* three interchangeable styli in one package, ready for your choices. The different styli provide the capability of matching the groove with the stylus for optimum performance.

Most hi-fi enthusiasts have a "stable" of different cartridges, and when they find a particular record that doesn't sound just right with one cartridge, they are likely to change cartridges in the search for the one that does give the desired sound quality. This, of course, introduces another variable, assuming that the cartridges are of different manufacture, as is almost sure to be the case. However, with the ADC 25 system, the excellent qualities of one cartridge can be used to explore the possibility of better performance simply by changing the stylus.

The three styli furnished with the ADC 25 are: 0.3 x 0.9-mil elliptical; 0.3 x 0.7-mil elliptical, and 0.6 conical. Each is color coded for recognition. The theory of the different styli is that one may select the optimum shape and size for each different type of groove, considering that different records may be cut with slightly different cutting styli, or pressed with differently worn stampers, or be worn differently by previously used playing styli. For example, if a record were played previously with a certain stylus for a number of times, it would be worn in a certain pattern. Suppose, then, that one played it with a stylus that rode slightly higher in the groove than previous ones did, or even possibly one which rode lower in the groove, it is likely that there would be a difference in the quality of reproduction of the record.

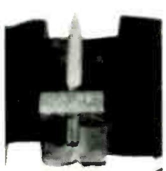


Fig. 2 — Close-up of the stylus assembly shows the tiny magnetic tube at the lower end which induces the magnetic field from the imbedded magnet to the four pole pieces in the cartridge body (see Fig. 3).

Fig. 3—The cartridge body, showing the pole pieces of the coil assembly.

Another example of the proper choice of the playing stylus is in the use of the 0.6-mil conical one for recordings like the RCA Dynagroove records, which are compensated for use with spherical (conical) styli so that the inner grooves do not exhibit the distortion often encountered with some types of records when played with conical styli. These records actually sounded better when played with the conical stylus that they did with either of the elliptical ones.

The cartridge itself employs the "induced magnet" principle of operation. The magnet is imbedded in the plastic molded housing of the cartridge in such a position that it "induces" its magnetism into a soft iron collar around the end of the stylus arm. The end of the stylus arm with the collar is shown in Fig. 2. The movement of the collar in accordance with the movements of the stylus tip induces signals into the coils related to the pole pieces shown in Fig. 3, which are positioned at 90-deg. angles to each other. The 45-45 movements of the soft iron collar therefore induce signals into the two channels proportionate to the groove modulations.

Performance

We measured frequency response and crosstalk with the 0.3 x 0.7 stylus on a CBS STR-100 test record that had been played quite a number of times. Then we secured a completely new STR-100 record and repeated the measurements. The results are shown in Fig. 4. These comparative figures show what a difference a number of plays on a test record can make. Both frequency response and separation measured considerably better with the new record. The measured output per channel was 0.9 mV/cm/sec, which is close to specs, and both channels were alike within ±0.2 dB. Frequency response varied not more than ±0.6 dB over the entire range in either channel. Separation was exceptionally good, especially at the high end of the frequency spectrum.

We must admit that we were surprised at the difference in performance obtained with the different styli. Some of the more flamboyant records of recent release, and played only slightly, actually sounded better with the 0.3 x 0.7 elliptical stylus than they did with either of the other two. Some relatively old records which had been played many times sounded cleaner when played with the conical stylus than with either of the elliptical points. At least, we were able to be convinced of the theory of choosing the correct stylus for each record, if one wants absolutely the optimum results.

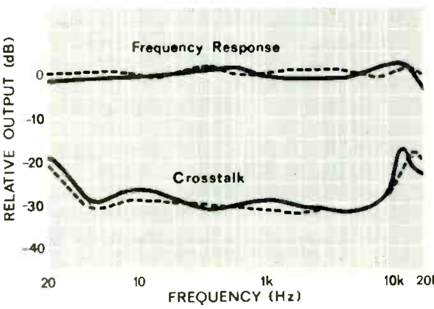
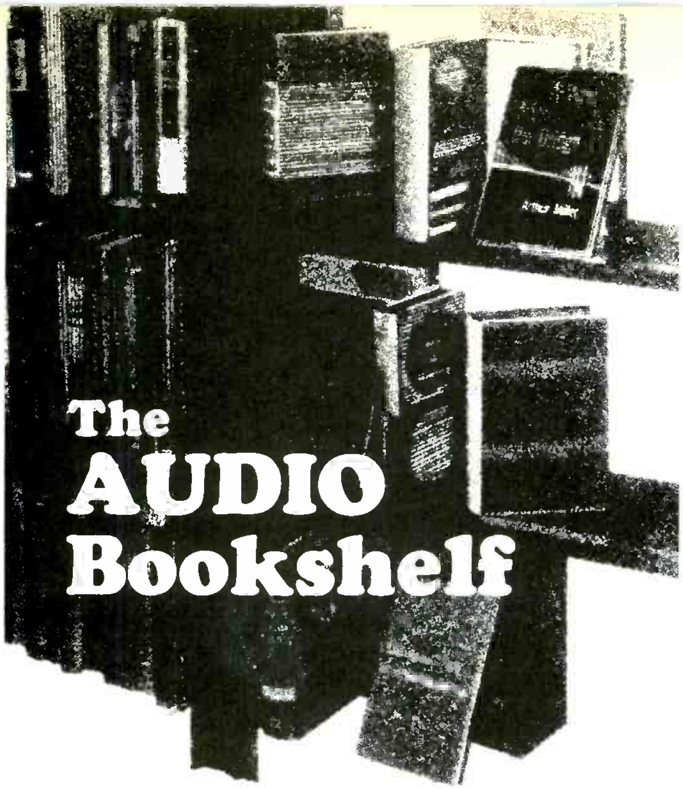


Fig. 4—Frequency response and cross-talk curves. The solid lines represent measurements made with an old STR-100 test record, while the dotted curves were made using a brand new test record of the same type. The inset photos are square-wave responses to a 3.54 cm/sec left-channel-only signal at left, and to a 5.0 cm/sec lateral signal at right.

It would seem, however, that the inconvenience of changing the stylus from record to record might be a nuisance to some persons. But for the serious listener who plays records manually (whether on a manual or an automatic turntable), who is willing to try out all his records and to code them with the optimum stylus for each one, might well be rewarded by better performance for each. This is one example where "you pays yer money and takes yer choice," and you are provided with three choices.



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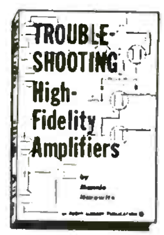

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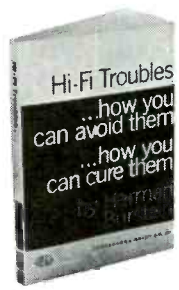

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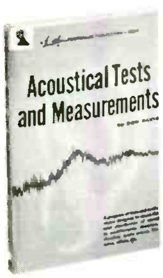

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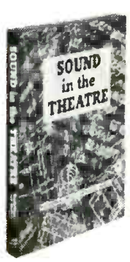

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ABZs of Stereo FM

LEONARD FELDMAN

Sum-and-Difference Stereo FM Transmission Systems

On April 19, 1961, the long-awaited decision was handed down by the Federal Communications Commission: A system for stereo FM broadcasting had been chosen and stations could begin stereocasts starting June 1, 1961. With less than three months to get ready, several stations vied for the honor of getting on the air first. To this day, at least three stations claim to have gone on the air shortly after midnight on June 1 of that year. "Getting ready" was complicated by the fact that the FCC chose the system that high-fidelity manufacturers had pretty much discounted at the time. Murray Crosby had been championing his system since 1959, long before the field tests were even authorized by the FCC, and everyone thought that its superior stereo performance would make it a "shoo-in"—but this was not the case.

It was Crosby, however, who combined the sub-carrier concept with the "sum-and-difference" concept, thereby creating a truly "compatible" system which serves both monophonic and stereo listener with a "balanced" program. Here's how the sum-and-difference technique works:

Referring to Fig. 1, suppose that sine-wave "L" represents the program content of the left channel and suppose that the sine-wave of higher frequency, labelled "R," represents the program content of the right channel. For convenience in illustrating, we have made "R" a sine wave of twice the frequency of "L," but there need be no frequency or amplitude relationship between the "L" and "R" signals. In the diagram representing "R," we have also shown an *inverted* "R," which has been labelled (−R). Now, −R simply means R that is 180 degrees out of phase, or completely inverted in polarity. If we electrically add L to R (by means of an audio mixer, say, having a gain of unity), we produce a waveform such as that shown in Fig. 1C, identified as L + R, or the sum of the left and right program signals. Let's pause here, for a moment, and consider what L + R really is.

If your amplifier has a "stereo-mono" mode switch and you set it to "mono," you are really adding the L and R signals together to form L + R, a monophonic equivalent of the stereo program material. Thus, if the FM station studio were to "mix" L and R together and broadcast it conventionally, listeners would hear a totally monophonic program and would be unable to detect the fact that the record or tape source was really recorded in stereo. Returning to Fig. 1, just as it is possible to ADD two signals together electrically, it is also possible to SUBTRACT one signal from another. If we were to pass the R signal through a phase inverter, we would obtain −R, as shown by the dotted line waveform of Fig. 1B. Subtracting one signal from another is the same as adding the *inverted* or negative-polarity signal to the first. If you were to plot the results graphically (as we did), you would come up with the waveform shown in Fig. 1D, or "L − R." Also shown in Fig. 1D is an *inverted* L − R or −(L − R) which is easily produced by phase inverting this new waveform, just as was done to produce −R. In all compatible stereo broadcasting systems worthy of consideration, the L − R signal is broadcast via a superaudible sub-carrier. Thus, the mono listener hears only L + R, or a fully balanced monophonic program, while the stereo listener goes on to further processing of both the L + R and the L − R signals, as follows:

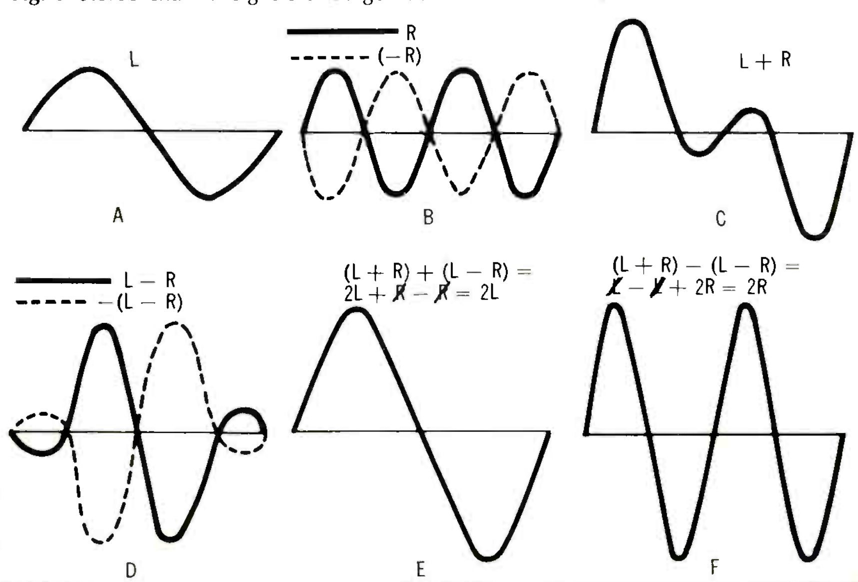


Fig. 1—Stereo-channel signals undergo addition and subtraction before transmission.

First, the L − R program must be demodulated or detected from its sub-carrier (you could not hear the L − R program as it is recovered from the regular FM detection process, since it is really in the form of modulations of a superaudible sub-carrier). Having recovered the L − R as recognizable audio information, it is first added to L + R, the mono signal. Fig. 1E shows what happens graphically as well as algebraically. What you get is simply 2L. Next, if L − R is subtracted from the mono L + R signal, you recover 2R, as shown in Fig. 1F. The factor 2 need not concern us, as it represents an amplitude level and can be adjusted to anything you like by means of your volume control. The important thing is that Fig. 1E contains the waveform shape of L without a trace of R, while the waveform of Fig. 1F contains the correct waveform for R without a trace of L present.

The difference between the Crosby system and the approved FCC system lies only in the nature of the sub-carrier used to transmit this vital L − R signal, not in the concept of sum-and-difference compatibility which would exist with either system. Crosby proposed that the sub-carrier have a frequency of 50 kHz and that this sub-carrier, in turn, be frequency modulated ±25 kHz with the L − R information. In order to accomplish this, two changes in previously approved transmission rules would have had to take place. First, main channel modulation would have to be "backed off" by 6 dB, or 50%, to ±37.5 kHz, since Crosby wished to utilize 50% modulation for his FM modulated 50-kHz sub-carrier for best signal-to-noise performance. Secondly, because frequency modulation of the sub-carrier was to

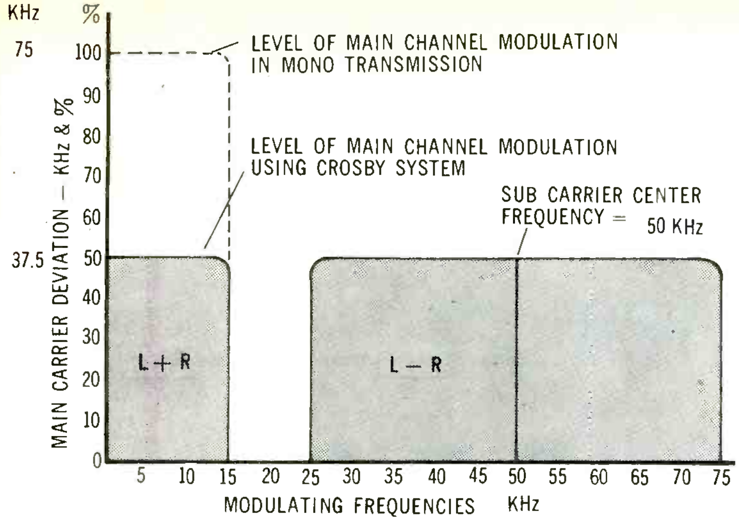


Fig. 2—Spectrum distribution in the Crosby stereo FM system.

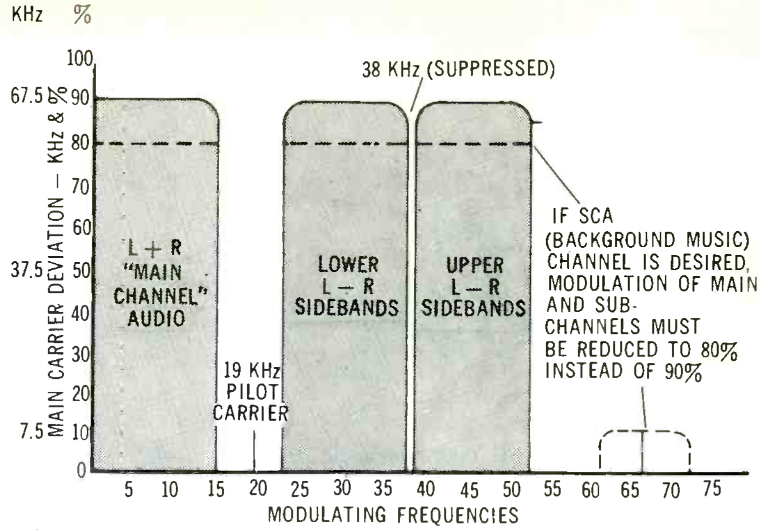
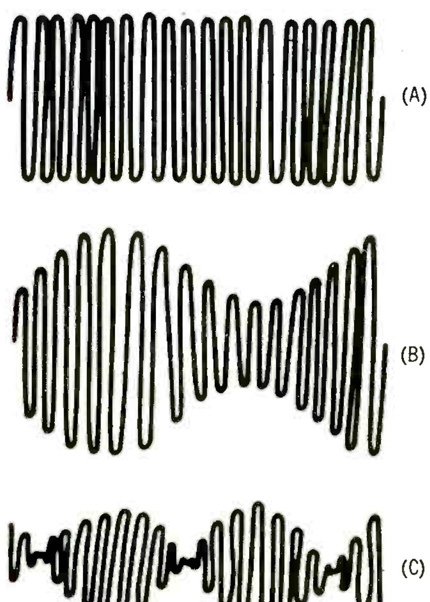


Fig. 3—Spectrum distribution in the FCC-approved stereo FM system.

extend all the way down to 25 kHz and up to 75 kHz, there would be no room left for the previously approved SCA or background-music private point-to-point communications.

These two problems are easily understood by examining tse spectrum distribution diagram of the "Crosby System" shown in Fig. 2. The FCC, in its report and order of April 19, 1961, admitted that the Crosby system was capable of better stereo performance than any other proposed system—insofar as signal-to-noise ratio was concerned. On the other hand, the monophonic listener would have a poorer signal-to-noise ratio by about 6 dB *and* a broadcaster would have had to choose between income-producing, non-public SCA (background music) operation or stereo, since the two services could not take place simultaneously. The fact that the STEREO listener (on whose behalf the decision was ostensibly made) suffers a signal-to-noise ratio degradation of over *13 dB* (compared to what "might have been" with the Crosby system) seems not to have weighed too heavily in the FCC decision!

Fig. 4—Development of "suppressed carrier" sidebands consists of (A) a 38-kHz carrier which is amplitude modulated in (B). The carrier itself is finally removed, leaving only the sidebands, shown in (C).



The system which was actually approved utilizes a sub-carrier principle, too. In this case, however, the sub-carrier frequency is set at 38 kHz and the modulation of this sub-carrier is one of AMPLITUDE rather than frequency. Further, after L − R has been used to amplitude modulate the sub-carrier, the 38-kHz sub-carrier itself is stripped away or "suppressed," leaving only the "sidebands" of the sub-carrier. The situation is much akin to regular AM broadcasting (except that in this case the "r.f." frequency is 38 kHz). Figure 4 shows the step-by-step development of the "suppressed-carrier, double-sideband" technique by which the L − R information is applied to the main, FM carrier. Note, that while the modulation of the sub-carrier is of the "AM" type, the product of this modulation (as represented in Fig. 3C) actually frequency modulates the main carrier, so that the transmission over the air is totally *FM*.

Figure 3 shows the spectrum distribution of the approved stereo FM transmission system. As usual, main channel program material occupies frequencies from 50 Hz to 15,000 Hz. The suppressed sub-carrier sidebands (containing the L − R information) occupy frequencies extending from 23 kHz all the way up to 53 kHz. Note, however, that there is no energy at 38 kHz, the so-called carrier frequency, since the carrier itself has been suppressed as noted earlier. The student of AM technology will realize that the extremes of frequency (23 kHz and 53 kHz) arise out of the well-known fact that when a carrier is amplitude modulated, an upper and lower sideband are created above and below the center frequency by an amount equal to the modulating frequency itself. Thus, if we amplitude modulate the 38-kHz sub-carrier with a tone at 1 kHz, sidebands will occur at 37 kHz and 39 kHz. Since the highest frequency ever transmitted is to be 15 kHz, the most extreme sidebands will occur at 23 kHz (38 kHz − 15 kHz) and 53 kHz (38 kHz + 15 kHz).

In addition to the sidebands, it is necessary to transmit a "pilot" carrier

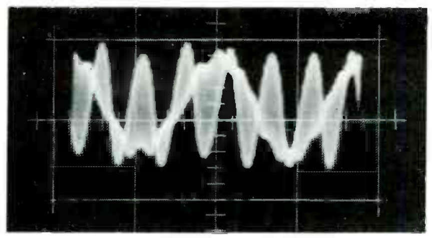


Fig. 5—Oscilloscope photo shows how "left" and "right" channel signals "interleave."

at 19 kHz. This additional unvarying signal will be used to reconstitute the suppressed carrier at the receiver, and we shall discuss its function in greater detail in future installments.

One of the advantages of this system is obvious immediately. Since the highest frequency required by the "sidebands" is only 53 kHz (as opposed to 75 kHz in the all-FM Crosby system), this leaves room for at least one, and possibly two, SCA private communications sub-channels for background music, subscriber services and other similar uses.

The more interesting feature of the system is a process known as "interleaving," which really is a natural "bonus" of the entire system. Note that in Fig. 4, the amplitudes as well as the frequency distribution of all the signal elements are given. By simply adding

(Continued on page 62)

Classical Record Reviews
Edward Tatnall Canby

AUDIO MUSIC REVIEW

Franz Berwald: Sinfonie Singulière; Symphony in E Flat. London Symphony, Sixten Ehrling.

London CS 6602 stereo. ($5.95)

Franz Berwald, the elderly Swedish radical of the middle 19th century, born before Schubert but sounding more like a cross between Berlioz and Mendelssohn, has at last gone into an international revival. A fascinating composer, all fresh early Romanticism but full of later-type experimentation of a sort wholly unappreciated in his own day (not a one of his symphonies was performed, if I am right). Most of all, Berwald was electric, full of tensions, high strung, jittery, his music expressing these feelings in the most marvelously jagged, bouncing rhythms, delicate but explosive. *Very* out of style in the leisurely 1850s. Very in, right now.

These two performances of the most important pair of symphonies, the two last, are good but not tops. The electricity just isn't there often enough. They are ever so slightly mushy, slack, though the warmth is good and the playing earnest under a dedicated Swedish conductor. The golden London sound also helps to obscure the sharpness of detail.

I rather suspect simply a lack of rehearsal and prior public performance here as the main problem. The music just isn't worked up to the proper genial electric tension.

Performance: B— *Sound:* B

Mozart: Excerpts from Zaide, Lo Sposo Deluso, L'Oca del Cairo. Soloists, Mozarteums Kammerchor, Camerata Academica des Salsburger Mozarteums, Paumgartner.

World Series PHC 2-015 (2 discs) sim. stereo ($5.00)

For anyone who knows even a part of a Mozart opera and loves it, these recordings can only be described as touching, even pathetic. Here are surviving segments of three major operas that poor little Mozart, opera's greatest genius, began to compose and never finished. Politics, politics. Being Mozart, they are, as far as they go, entirely polished and professional, right out of his familiar best if perhaps not quite *Don Giovanni*.

The music begins, the familiar Mozart characters (with strange and unfamiliar names) appear on our mental stage, the action gets underway and the complicated plot unrolls—arias, recitatives, big vocal ensemble numbers, the whole bit. You get all involved. Then suddenly—nothing. There isn't any more. Right in the middle.

The major work, carried to the impressive length of three full LP sides, is the unfinished Zaide, K. 344, a German opera composed for Vienna just as the German opera company there fell apart. Never completed. Swinging back to Italian, Mozart began two works, *L'Oca del Cairo* ("The Goose of Cairo," believe it or not) and a buffa with a stock Italian lightweight title, "The Husband Deceived" (Or the Rivalry of Three Ladies for One Lover). Only fragments of these, but impressively worked out at length, great quantities of futile Mozart. Heart-breaking to see how much went for nothing.

It is more than we can expect to find a first-rate stage-type reconstruction of these basically unworkable (from the stage viewpoint) opera torsos. The Salsburg Mozarteum forces, under the circumstances, did a noble job of musical museum-work. The music does come to life and animation, decidedly. That, indeed, is the poignant thing. But we still must rate the performances objectively as so-so Mozart by existing highest standards for the complete operas. No matter—lucky we get anything at all.

The recordings evidently are out of the postwar period a good while back. Very adequately restored and put into moderate synthetic stereo, but not exactly impressive as sound, even so. Again—no matter.

Note that there are other superb Mozart items in this same Philips series, notably the Masonic Music, which I have been hoping Philips (or Mercury-World Series) would reissue. Maybe, with luck. Now *those* performances are really first rate. . . .

Performance: B— *Sound:* C+

Sibelius: Symphony No. 2; Symphony No. 5; Night Ride and Sunrise. New Philharmonia Orch., Georges Pretre.
RCA LSC 3063; LSC 2997 stereo ($5.95 ea.)

Sibelius: Symphonies No. 3, 6. Vienna Philharmonic Orch., Maazel.
London CS 6561 stereo ($5.95)

A Sibelius revival? Seems that way. Here we have two pairs of symphonies (plus a tone poem), the two familiar works, Nos. 2 and 5, on RCA, the two least familiar, the ones nobody ever hears, on London. That leaves the redoubtable No. 4, the most "modern" of them all, and the two lesser known outer works, one at each end. They'll be along any day.

I spent a long and fascinating time with these six big LP sides. These are superior recordings all, upper-bracket in both the technical sense and the musical. And yet they are surprisingly different, and the subtle interactions between recording technique, conductor and composer are not easy to analyze. Without much question I found the London-Maazel efforts musically the most satisfactory. Georges Pretre's encounters with RCA's sound and the New Philharmonia Orchestra have their major points of value, and these two are the hi-fi man's choice.

London's Maazel and the experienced Vienna orchestra without the slightest doubt have recorded the true *musical* Sibelius, with a naturalness, an earnestness and a musical tension that is somehow missing in the Pretre jobs. Among recent stereo offerings, Maazel's Sibelius is the best I know. Moreover, the two unfamiliar symphonies are far from unworthy. As you might guess, they are merely of a less direct appeal than the famous No. 2 and No. 5. No. 3 is excellent and new to me, but it was No. 6 that really

WHY YOU SAY IT...
Magnetic Tape Recorder

Probably from an early German expression for "to tear," in Old English a narrow strip of cloth was called *taeppe*. Strips produced by tearing weren't uniform, so special ones were woven from linen and silk. Such tapes were used for tying garments, as measuring lines, and to mark the finish of races.

About 1884 automatic telegraph systems adopted the use of long paper strips for printing messages. Such a ribbon took the ancient name of "a strip of cloth." From this and similar usages *tape* was borrowed to designate a strip of the marvelous material that is basic to use of your recorder.

Such tape is called *magnetic* as a result of a chain of influences that stretch across many centuries.

Ultimately, the term stems from the name of a city near the mouth of a river in Asia Minor. Very early, Magnesia ad Maeandrum (Magnesia on the Maeander River) became famous as the source of a mineral endowed with magical power. Known to Greeks as Magnetis, the heavy stuff drew iron to itself.

For centuries there was no practical use for it. Eventually someone found that when he rubbed a needle with a piece of stone from Magnesia, the nature of the needle was changed. Arranged so it could swing freely, such an instrument pointed to the north. So the *magnete* became the mariner's most important tool, essential to manufacture of compass needles.

Quality and strength of natural magnets vary widely. But with the invention of the electromagnet, technicians had a precision tool. Until this century, practical applications were limited to the metal trades. Development of *magnetic* tape, whose molecules can be structured and re-arranged by magnetic energy, opened a whole new field of communication.

So the now-deserted site of ancient Magnesia is often visited by archeologists who use magnetic tape to record their observations.

Whether used on an archaeological dig or in a sound studio, the *recorder* itself shows that words are slippery. For the name of the modern instrument stems from Old French *recorder* (to bring to remembrance). Like Spanish *recordar* and Italian *recordarsi*, the verb comes from Latin *recordare* (to think over, to be mindful of).

In ancient and medieval times, if a person wished to be mindful of something he wrote it down. That's how the court recorder got his name. Such a fellow was appointed by the mayor and aldermen of London to sit in a courtroom and "keep the proceedings in mind."

From lawyer with pen in hand, the name passed to early devices using wax cylinders to preserve sounds, and then through a whole series of "memory machines."

—WEBB GARRISON

CLASSICAL RECORDS
(Continued)

Western music, as Christian as anything out of Rome, or for that matter, Salt Lake City. Quite an ear-opener.

Performance: A *Sound:* A—

Joseph Haydn: Trumpet Concerto. Michael Haydn: Horn Concerto. Alan Stringer, Barry Tuckwell; Academy of St. Martin-in-the-Fields, Marriner. **Argo ZRG 543 stereo** ($5.95)

Virtuoses Horn (Concertos by Rosetti, J. Haydn, Mozart). Hermann Baumann; Concerto Amsterdam, Schröder. **Telefunken SLT 43102B Ex stereo** ($5.95)

Enjoy solo brass music? Here are two imports and five brief concerti, all out of a single period and style, the later 18th century, the time of Haydn and Mozart, both of whom are included. Haydn's younger brother Michael was a close colleague of Mozart's at Salzburg. Antoni Rosetti's real name was Franz Anton Rösler; the Italianized pseudonym sounded fancier. He is a gifted composer of easy, tuneful melody in the 18th-century manner.

Both records are impeccably performed and well recorded in truly civilized fashion; among the five works those by Mozart and Joseph Haydn do not in fact stand out particularly. In this graceful concerto idiom there was no need for earth shaking profundity and the two lesser composers were fully equal to their respective tasks. To be sure, the somewhat clumsy bray of the French horn was not ideal for this sort of music. The next century found better uses for the instrument's dark, woodsy color. But these composers manage very nicely to keep the ponderous hornist busy and his music sprightly in spite of a total lack of valves (at the time) and limited choice of notes.

The single trumpet work, the celebrated Haydn concerto, was composed for the first such instrument that could play "all the notes," a keyed affair which was soon replaced by the valved trumpet now in general use.

Performances: B+ *Sound:* B

Takemitsu: Coral Island (Soprano and Orch.); Water Music; Vocalism Ai (Magnetic Tape). Yomiuri Nippon Symphony Orch., Matsumi Masuda, sop., Wagasugi. **RCA Victrola VICS 1334 stereo** ($2.98)

The Japanese do seem to have an inherent inbred delicacy of taste in artistic and decorative matters. I found all these works by a young Japanese-international composer to be sensitively expressed, gracefully shaped and, somehow, innately beautiful. Too many of our own similar efforts are innately gross.

The first work, a long "live" fantasy on Japanese poetics, is one of those extremely contemplative, totally dissonant musical structures where silence, and brief, single sounds are as important as sonic continuity in the usual sense.

The tape pieces, taking account of a different medium, no longer based on the fixed musical scale but free to roam sonically free, pitch blending into color-noise, are of an appropriately different sound, as is quite proper. I particularly enjoyed the Water Music, built from recorded water sounds. (cf. Tod Dockstader's American water music of a similar structure on the Owl label). Vocalism Ai, the Japanese word for love spoken in a thousand ways and made into a tape montage, would likely be a corny mess in anyone else's hands. It comes off well here, being Japanese.

Performance: A? *Sound:* B+

Light Listening

Sherwood L. Weingarten

Anthologies of Hits

The only time the recording industry figuratively removes the cellophane blindfold of LPs is when it offers anthologies of hits, those compendiums of "A" sides that ensure the listener he's purchasing gilt-edged material—or, at least, renditions with which he's familiar.

■ A prime example of a true prize package is THE BEST OF EARL GRANT (Decca, DXSB-7204), a two-disc set with 22 tunes. Pseudo-jazz that's actually pop, the offerings by the 38-year-old meander through a broad musical hallway. But Grant's organ (and piano) performances always run a sawed-off gamut: From great to greatest.

There are those who might fault him for sounding, vocally, like a phantasm of Nat King Cole, yet none would question his individual keyboard style. Whatever your melodic taste-buds desire, assuming you don't abhor the organ, there's something more here to please you.

"Sweet Sixteen Bars," for instance, begins slow but builds to an organ-ized crescendo—with Grant grunting occasionally a la Errol Garner or Oscar Peterson, or oh-yeahing like Ray Charles, who not incidentally composed the piece. "Saints," in contrast, is a Dixie cup of joy, with a heavy grass sound from the right channel meshing neatly with the bluesy piano from the left. A choral display of soul adds body to the number, played more slowly than the usual Southland slugfest. "Ebb Tide" is a novelty, a soft-keyed arrangement complete with simulated bird calls produced by high organ notes; "More" offers a Brazilian beat, and "I Can't Stop Loving You," one of the vocals, starts with a soap-opry organ that leads to a jumpin' Memphis Sound. A gospel-like entry is "A Closer Walk," with the chorus interjecting a staccato assist; "House of Bamboo" goes calypso, and "Stand By Me" is funky, with a superb interplay by a raspy tenor sax.

But the best instrumental selection is "It Was a Very Good Year," a cool pop sound that showcases Grant's piano artistry. Vocals include "Ol' Man River," revamped for speed; "Sermonette," a hand-clapping, jazzy brightener; "Volare," on which Grant sings in Berlitz Italian, and "If I Only Had Time," kind of a soul/Cole goodie. The lone negative factor on the LP is an organ rendition of "Beyond the Reef," which might be termed the bland leading the bland.

■ Will success spoil Buck Hunter? Yup!

The selling power of anthologies has resulted in record manufacturers sometimes filling follow-up products with material that falls far short of first efforts. Case in point: THE RIGHTEOUS BROTHERS GREATEST HITS, VOL. 2 (Verve, V6-5071), with the flip side unable to hold a musical candle to Side One or either side of the first volume. Still, for the most part, Bill Medley and Bobby Hatfield (who since split) formed a Dynamic Duo capable of producing harmonic, soaring soul—despite the fact that both are white.

Of the 11 songs, tops are "What Now My Love?" (with its syncopated, almost march-like rhythm, plus vocal interaction that finds one soloing, then the other, then both) and "Let the Good Times Roll" (featuring a wild rock beat and brassy backdrop, with the vocal racing to a near-hysterical shouting climax). Also excellent are "My Prayer," highly reminiscent of the Platters' hit version, and "Bye-Bye Love," an updated rendition of the Everly Brothers' smash that has stereo jumping like a bullfrog in a swamp.

The one mistake on the first side is "You're My Soul and Inspiration," an over-orchestrated tune that sounds as if the "brothers" are being smothered in an echo chamber. A heavy-voiced chorus doesn't help the tune, which spotlights spoken lyrics and some softer segments that do pass musical muster. The shallow second side is highlighted by "I Just Want to Make Love to You," a bluesy piece with stereo counterpoint; "This Little Girl of Mine," a rocker, and "Loving You," the one really slow, string-accompanied ballad.

■ Another compendium, THE BEST OF NINA SIMONE (Philips, PHS 600-298), shows the thrush's prowess with meaningful lyrics and her ability to make lengthy tunes seem too brief.

"Mississippi Goddam," a Simone original that runs 4:45, is met with enthusiastic applause from an obviously receptive audience. It is, according to its composer, "a show tune—but the show hasn't been written for it yet." The singer-pianist, who switched to RCA after these tracks were cut, begins the album with the George and Ira Gershwin classic that initially thrust her into the lime light, "I Loves You, Porgy." It's a mournful tune that lingers in the mind long after the final bars fade from the stereo. Completing the first side are "See-Line Woman," which quakes from an Afro-calypso rhythm coupled with hand-clapping, and "Sinnerman," an old folk tune arranged by the singer, who offers a frenzied, somewhat nasal, gospel-based sparkler that runs an incredible 10:15.

The flip, with 6 tunes, includes a second Simone original, "Four Women," plus a trio of successes borrowed from a wide musical range. "I Put a Spell on You" is lifted from the ghetto-aimed antics of Screamin' Jay Hawkins, but becomes a slightly incongruous combination of soul and strings, and "Pirate Jenny," a Kurt Weill-Bertholt Brecht stage marvel, is a 6:42 contemporary art song.

"Wild Is the Wind," the best number on the LJ, is a glossy Dimitri Tiomkin-Ned Washington movie melody changed into blues, with classical riffs and slowed tempo. It makes it—brilliantly.

■ Romantic melodies from a blind pianist; mild "jazz" that rarely veers from prescribed notes; pleasant music for the casual fan. Each phrase depicts THE BEST OF GEORGE SHEARING, VOL. 2 (Capitol, SKAO 139).

Standards of playing are high; mostly standards are played. Witness Alec Wilder's "I'll Be Around," aided by woodwinds; "Autumn Leaves," one of two tunes featuring Duophonic Sound "electronically reprocessed for stereo listening," and "I'll Take Romance," a typical Shearing quintet sound—*almost* generating excitement. "I'll Remember April," extracted from a live performance; "Misty," the Erroll Garner beauty, and the Henry Mancini-Johnny Mercer modern classic, "Days of Wine and Roses," are other cloud-floaters. "When Your Lover Has Gone" is easily the jazziest, but even this does not reach third steam inventiveness.

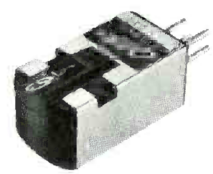
But the best tune, despite some acoustical flaws, is "Dancing on the Ceiling." Although marred by a little surface noise and an occasional tinny sound, the Rodgers and Hart composition becomes an imaginative display of musicianship. Shearing more than usual plays in high registers, perhaps in keeping with the ceiling notion. This contrasts particularly with the almost-Baroque sound midway through the song, which runs 5:27. And another color is injected by pizzicato strings. ■ A different type of anthology, containing 10 authentic back-country melodies, is THE 1968 MEMPHIS COUNTRY BLUES FESTIVAL (Sire-London, SES 97003). Five artists, each accompanying himself on guitar, turn in stellar performances—if you're willing accept the coarseness of true blues. And apparently many are, for the blues bag is the current "in" sound.

Quality, because of the live recording and the very nature of the local performers, is uneven—certainly not studio slick. But the earthiness of it all, including introductions by emcee Jim Crosthwait, illustrates an honesty difficult to match.

Nathan Beauregard, a blind singer whose age is estimated at 102, puts on an amazing show, considering his years. In a quivering voice, with diction sometimes unclear, he gallops through "Highway 61" and "Kid Gal Blues," being met with applause and the ringing of cowbells. Bukka (Booker T. Washington) White, who spends almost as much time introducing himself as singing, offers three: "Hello Central, Give Me 49," "Baby, Please Don't Go" and "My Mother Died." The last, written especially for this recording, unfortunately tends to fade in and out as he moves toward, then away from the microphone. Furry Lewis tells of his arrival at the festival, then tunes up squeakily, and finally slips into his lone number, "Furry's Blues Number Two."

Rev. Robert Wilkins, a slide-guitar expert, is joined by two sons on "What Do You Think About Jesus?"—which features responsive shouting much like a black Southern church service. Tambourine accompaniment is found on "In Heaven, Sitting Down," a spiritual totally woven into a blues framework. Wilkins, who originally toured with medicine shows, limits his work to secular music now, refusing to play "straight blues" for a paying audience. "Mississippi" Joe Callicott, who also introduces himself (too far from the mike), sings "You Don't Know My Mind" and "Great Long Ways from Home," the latter joined by a handclapping audience.

Those who dislike the rough edges of authenticity might consider this amateurish; buffs will revel in it.



More LIGHT LISTENING

"Hair"—London Style

Good things, the cliche says, come in threes. HAIR (Atco, SD-7002), the satirical musical that rocks while rolling into the Establishment, seems to prove it.

As a hippie production, the show originally opened off-Broadway. RCA's cast recording helped it gain respectability and move uptown, where RCA also recorded the expanded version. This, the third LP, captures the sound of the original London cast.

The pungent songs, which sling poison darts at the hypocrisy of the Big Three no-no's—sex, religion and politics, retain the youthful zest the Great White Way rendition became famed for. And the fact that all the performers are unknown this side of the Atlantic merely adds to the possible enjoyment, attention focusing on the composition and not the personalities.

British accents are notably absent, and speech patterns for the most part are clear (there are exceptions, parts of "Black Boys" and "White Boys," plus "Abie Baby" and the title tune). The entire tone is one of frenzy—even the ballads seem to carry an urgency with them—and captures distinctly what the liner notes choose to call a crystallization of "the revolt of youth," a characterization of "the lack of communication between the generations."

"Abie Baby" is probably the best number on this third go-round, the lyrics about the slowness in the coming of equality for all races superimposed on a twee-do, wop, wop vocal accompaniment that spoofs the rhythm and blues ditties of yesteryear. Inferior to the American version, however, are the "Black Boys" and "White Boys" segments, which turn out to be a melange of sound, apparently a pastiche of soul rather than an almost direct parody of The Supremes and The Temptations as in the U.S.

Let the squeamish beware, though, for there is a sprinkling of obscenities. Hi-fi enthusiasts will observe an excess of sound stemming from the left channel, while the right goes virtually unused. And if one wants only a tepid sound, the emphasis on jazz-rock may be more than the ears can stand (not counting the lengthy introductory passage via oscillator). But those who desire an unusual listening experience, or an insight into what is happening, baby, this disc will be rewarding.

■ Jack Jones left Kapp for g[illegible] recording studios at RCA, but [illegible] old bosses had some good tapes sta[illegible]ed away (better in fact, than some of the new ones he's been turning out).

Eleven oldies show up on JACK JONES IN HOLLYWOOD (KS-3590), an album marked by a contrast in arrangements. Nelson Riddle set up a pair ("All the Things You Are" and "You Made Me Love You") that sound like leftovers from antique Sinatra discs, but these are radically different than—and not nearly as exciting as—those reworked by jazz-oriented Marty Paich. Other arrangers are Ralph Carmichael, Pete King, and Jack Elliott. Jones, by the way, is in fine voice.

■ Simplicity in arrangements and a careful attention to lyrical beauty make NANA MOUSKOURI SINGS OVER & OVER (Fontana, SRF 67594) one of the most delightful LPs of the year.

The Greek singer, whose flawless English and magnificent phraseology are a female counterpart to Sinatra's virtuosity, presents a dozen winners recorded in Paris and London. Backing the plain-looking, glasses-wearing brunette with angelic voice is an ensemble called the Athenians (consisting of George Petsilas and Philippe Papatheodorou, guitars; Constantin Troupsios, bass guitar, and Spyridon Livieratos, percussion).

Gordon Lightfoot's "Song for a Winter's Night" becomes pure poetry, both lyrically and musically. A slight Latin background, and vocal accompaniment that doesn't interfere, makes the tune especially moving. Similarly, Ewan MacColl's beautiful ballad, "The First Time Ever," increases in intensity through its simplicity. And "Scarborough Fair/Canticle" is as meaningful and every bit as good as the hit Simon & Garfunkel version.

In contrast, Tom Paxton's "The Last Thing on My Mind," with the Athenians also lending vocal support, is a country-pop spectacle, and "Erene," one of two tunes written by guitarist Petsilas, is an up-tempo swinger with the flavor of a Greek dance and a vocal backdrop that resembles jazz stylings of the Swingle Singers.

"Try to Remember" offers an echo harmony and mellow guitar ripple, while "The Lily of the West," the singer's own composition, is a soft tune with driving beat superimposed on a mixture of English ballad style and western motif.

The album's title is particularly pointed, for the LP *can* be heard "over and over" with the pleasure increasing geometrically each time.

■ **Bert Kaempfert** and His Orchestra are throwbacks to the days when dancers held their partners. Thus, with velvety smoothness as the goal, fox trots grab the lion's share of WARM AND WONDERFUL (Decca, DL 75089).

The 11 tunes include oldies ("I May Be Wrong," "Some of These Days"), recent hits ("Can't Take My Eyes Off You," "This Guy's in Love With You"), and six Kaempfert originals—including one novelty tune, "The Maltese Melody," which features strains of bullfight music. Strings, muffled and muted horns, and a vocal chorus join harmoniously to make it all an easy-listening pleasure.

■ **Charlie Byrd,** once among the light jazz greats, has added a string of commercial "in" gimmicks to his latest LP. Including electric guitar, Fender bass, electric piano, flute, English horn, and recorder. And yet THE GREAT BYRD (Columbia, CS9747) eliminates improvisation almost entirely, focusing on melodies from the top of the hit charts.

Two tunes come across well ("Wichita Lineman" and "Hey Jude"), but neither equals any of the performances on his previous soft, soft album, "Delicately." On the other hand, "Those Were the Days" is instrumentally cluttered, and Byrd makes an unfortunate switch from guitar to mandolins. The theme from "Rosemary's Baby" is even more of a disaster, though, with a large ensemble creating a demoniac avalanche of noise.

Most of Byrd's fingerwork sounds as if he's picking with gloves on in an attempt to keep his virtuosity hidden, afraid to shake up those who prefer Instant Mediocrity.

■ The best stereo effects in a while are offered by **Somethin' Cool**, a vocal quartet, on VOICES IN LATIN (Pulsar, AR-10601). Half the 10 tunes were written by one of the group, Barbara Moore, who also arranged the melodies.

Following the style of the Anita Kerr Singers (and, on "Tea for Three," the Swingle Singers), the four voices are so rich in quality they create an illusion of a much larger ensemble. The voices switch smoothly from one channel to the other without the obvious, sharp break that often becomes annoying in lesser recordings. Witness especially Donovan's "Sunshine Superman" and the Bacharach-David success, "The Look of Love." "Biding My Time" probably illuminates the best instrumentation (though it is excellent on all bands). Clearly defined are piano, guitar and percussion work.

Preamp Measurements

(Continued from page 37)

and frequency modulation, and there is no instrument that can measure both. A wave analyzer will be needed, too, to make useful measurements in either case. The two most popular test methods used are the SMPTE and CCIF methods. The SMPTE method consists of adding a low frequency to a high frequency in a ratio, usually 4 to 1 (60 and 7000 Hz.). After the signal goes through the amplifier, the low frequency is removed, the resultant is rectified, and then the high frequency is removed. The amplitude modulation left over is the IM product. This method, however, is insensitive to the FM sidebands created.

The CCIF method is used to detect the FM sidebands by adding two relatively closely spaced frequencies, say, 5000 and 5100 Hz, in equal ratios. Then, after going through the amplifier, the two frequencies are filtered and the FM sidebands are measured with a wave analyzer.

Neither method can give the total picture. Thus, this is where great care should be exercised in interpreting the results. It might be noted, interestingly, that the algebraic sum of the products of both methods used separately might be used as a basis for stating the total IM products. For example, if one method produced 0.2 per cent IM and the other produced 0.3 per cent IM, would it not be reasonable to assume that the total IM products *might* be around 0.36 per cent. It must be stated, however, that summing all these individual products does not take into consideration all the different phases of the individual sidebands, which would be virtually impossible to do. Also, to get a *meaningful* interpretation of IM results, one would have to know which kinds of sidebands are most objectionable—FM or AM.

Without visual examination of the distortion products on an oscilloscope, we wouldn't have any indication of the *nature* of the distortion, a most important consideration. Is the distortion mostly second harmonic, which is not as disturbing as higher odd harmonics, or is it all higher-order products, which could be most unpleasant sounding even if the indicated percentage is low? The visual indication will also show the presence of noise and hum, as well as their respective amplitudes, independent of the analyzer.

Overload

It is unusual to find a unit today that has poor overload response. Nonetheless, overload characteristics should be checked, and must be stated with a reference. The main reference may be the largest possible groove modulation that can be put on a record. At least one manufacturer shows that his cartridge will track 30 cm. at 1000 Hz, and if we assume that a few records may contain peaks of around 40 cm. this would be a realistic reference. Combining this with a sensitive magnetic cartridge's output level would give us a practical reference level.

Assuming the highest output that a magnetic cartridge develops is 12 mV at 3.54 cm per sec., this converts to approximately 3.4 mV per cm. Multiplying this by 40 cm. yields about 136 mV of output. This gives some indication of what a preamp's phono input must handle. It is most unfortunate, however, that a lot of manufacturers sacrifice sensitivity to get overload. At least one says that 250 mV won't overload his front end. Although the spec is correct, this is at a reduced sensitivity of 16 mV for rated output. Anyone for turning the volume control wide open?

Another big problem facing preamplifiers is overload recovery. Here is where a lot of front ends fall flat on their faces, so to speak. This is known as blocking. I call it "gulp distortion." The condition arises from rectification in the input stage and the feedback loop, and results in unpleasant sound reproduction. I have seen some units that will block for more than half a second when subjected to high-frequency overloads, for example. A properly designed front end with a high enough initial overload will be free of this. It is very easy to observe this, as all you have to do is overload the front end for a few cycles and watch the decay on the scope. The effect is predominant at high frequencies, and could have a bad effect on transient response.

One final area concerning preamps that needs mentioning is filters. It is difficult to design good filters that won't ring. Filters that ring produce a terrible transient response, and also add a lot of color of their own to the sound. If you'd like to see this just insert a square wave into the amplifier and look at it on a scope. Tune the square wave through a couple of octaves above and below the filter cut-off point. The square wave shows up both the ringing and the poor transient response.

A future article will examine measurement practices for solid-state power amplifiers. Æ

ABZs of STEREO FM

(Continued from page 51)

up the percentages, one might draw the conclusion that 190% of allowable deviation or modulation is taking place (90% + 90% + 10%)! Actually, in practice, modulation never exceeds the allowable 100%, which corresponds to ±75 kHz.

The scope photo of Fig. 5 shows all the signal elements needed to modulate the FM transmitter. If you look carefully, you can see a low-frequency sine wave (about 400 Hz) and a higher-frequency sine wave seemingly "occupying the same space at the same time" instead of adding to each other as you might expect. It is this feature of the approved system that has come to be known as "interleaving," and if you follow the "square wave" sketches of Fig. 6, the principle will become clearer.

Suppose that Fig. 6A represents the L signal, while Fig. 6B corresponds to tse R signal: further assume each has an amplitude of "1" when it is maximum positive or negative. L + R is then the algebraic addition of the instantaneous values of L and R, and is shown in Fig. 6C. It has a peak value of "2."

L − R, the algebraic difference between L and R is depicted in Fig. 6D, and has a peak value of "2." Remember that L − R is not itself transmitted, but is instead used to create L − R sidebands of a suppressed 38-kHz subcarrier. Therefore the L − R sidebands are as shown in Fig. 6E. If we add the L + R representation (Fig. 6C) to the L − R sideband representation (Fig. 6E) on a "real-time" basis, we come up with the composite shown in Fig. 6F. Observe that the maximum amplitude of this composite never exceeds "2" because whenever L + R dips to "zero" the L − R sideband picture rises to "2." Conversely, whenever the L − R sidebands equal "zero," the L + R waveform reaches its maximum value of "1." This "interleaving" will take place so long as we deal with signals which are the sum-and-difference of L and R, regardless of the waveform of either L and R alone.

Our illustration used square waves because they're a lot easier to add and subtract graphically than are sine waves. If you don't believe it always works, however, you're welcome to try it by plotting a pair of sine waves of different frequencies and going through the steps corresponding to Figs. 6A through F.

The point of all this is that, as a result of interleaving, it is possible for

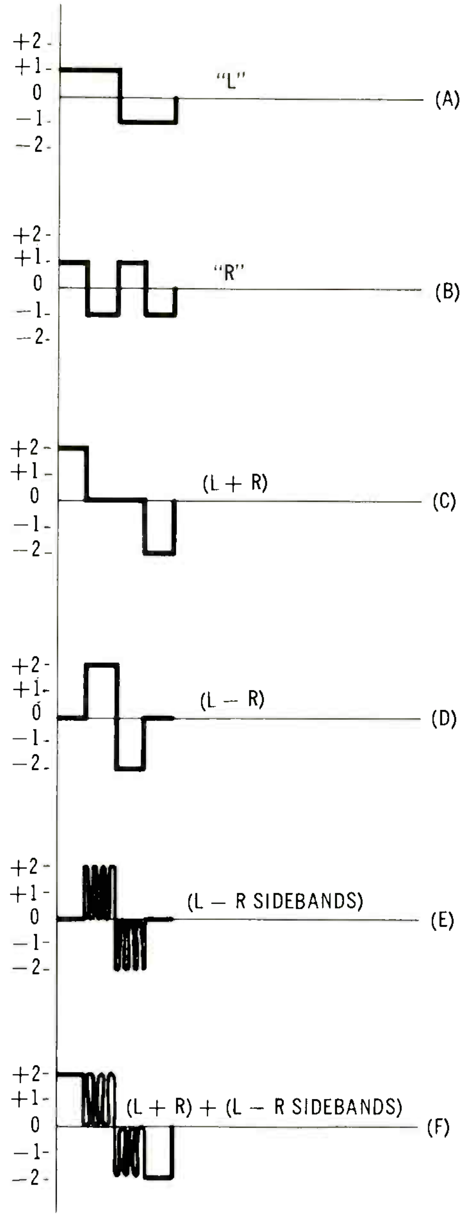


Fig. 6—The interleaving principle permits almost full modulation of the main carrier by (L + R) and L − R sideband signals.

the main-channel information to modulate the transmitter to 90% of 75 kHz. A 10% "backing off" of main channel modulation to make room for the pilot carrier means a little less than 1 dB of deterioration of signal-to-noise for the monophonic listener when a station "goes stereo." This point apparently weighed heavily in the minds of the commissioners who approved the currently used system. The adage about not getting anything for nothing still applies, however, for with all the "protection" afforded the mono listener (most of whom will, hopefully, have stereo FM someday), the stereo listener was NOT given the most noise-free system that he might have had, technologically speaking. Æ

Recorded Tape Reviews

BERT WHYTE

Bouzoukee: The Music of Greece.
Ampex/Nonesuch NSE2004,
open reel, 3¾ ips ($5.95)

This issue comes in the middle of the European travel season. If you are booked for Greece this tape will give you an authentic foretaste of the famed Bouzoukee music, and perhaps you can practice your dancing. It certainly has an irresistable beat and after a few selections you feel like you should be sipping some Ouzo in Athens. Nice clean recording, good transient response and acoustic ambiance.

Roma Oggi: Tony Mottola, Guitar and Orch.
Ampex/Project 3, PJX5032,
open reel, 3¾ ips ($6.95)

You can almost taste the garlic with this tape! Tony Mottola is his usual nimble-fingered self, with his guitar leading the orchestra in a potpourri of Italian hits. Along with your pasta and Chianti you can be regaled with such items as "Come Prima," "Forget Domani," "A Man Without Love" and, of course, the inevitable "Volare," among eight other tunes. Although at 3¾ ips, the sound here is big and bright with good transient response on Tony's guitar, and the reverb is not overdone, nor is directionality. Nothing really sensational, but good substantial music-making.

Percy Faith: Those Were The Days.
Columbia 18-10-0568,
8-track cartridge ($6.95)

This is by far the best Columbia 8-track cartridge I have heard. The sound was quite clean and fairly wide in range, there was very little print-through or crosstalk, and hiss (while still noticeable) was far less than usual. Musically the tape is good, too, characterized by excellent arrangements and some really fine choral work. Good engineering of vocal/orchestral balances and in a spacious acoustic framework. Percy gives us such hits as "Zorba"; "Promises, Promises"; "Little Green Apples"; and the title song "Those Were The Days," with seven other similar types. Topnotch background material.

Tchaikovsky: Symphony No. 2 in C Minor, "Little Russian." Claudio Abbado conducting the New Philharmonic Orchestra. Ampex/DGG, DGC9381, **open reel, 7½ ips, EX-Plus** ($7.95)

Deutsche Grammophon temporarily abandons their German orchestras to record the New Philharmonia Orchestra, which no longer is under exclusive contract to EMI and is presumably free to record for anyone with sufficient wherewithal. The result here is a very rewarding recording of one of Tchaikovsky's most ingratiating symphonies, the 2nd, known also as the "Little Russian." Abbado, who keeps on growing in stature as one of the better of the "young new breed" of conductors, furnishes an admirable performance characterized by clarity of detail and taut control of all elements. It is exciting and he uses great dynamic contrast, yet he is not given to fustian excesses as is so often the case with the Tchaikovsky symphonies.

It is interesting to note the differences between the British engineering we are accustomed to with this orchestra, and the German recording techniques. In general, this recording is on the American style — highly detailed sound miked fairly close in spacious acoustics. It is a big robust sound with plenty of presence and wide dynamic range. Directionality is somewhat more pronounced than with most British stereo and there was an excellent center-channel phantom image. Very clean in general with tight percussion of considerable impact.

The one sour note is that once again in spite of the EX-Plus processing the hiss level is too high at a room-filling playback level. I'm wondering what can possibly account for this at Ampex, as this has been happening with increasing frequency with *Deutsche Grammophon* tapes, which usually are reasonably quiet. Perhaps for some reason, more generations of copies are intervening between master and consumer product?

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Advertising Index

Industry News

■ Altec Lansing: Hewett S. Morris, former V-P/Marketing, named President of Altec Lansing Division, with Alvis A. Ward now Chairman of the Board and President of the newly-formed Ling Altec Group. Other promotions include A. K. Davis to V-P/Manufacturing, W. H. Johnson to Div. V-P/Marketing, and J. J. Noble to V-P/Engineering. ■ Benjamin Sound: Nat Gold named Director of Marketing. ■ Delmonico: Raymond J. Gincavage succeeds Herbert Kabat as President. ■ Fairfax: Tom Forry appointed V-P/Marketing. ■ Harman-Kardon: Milt Dienes appointed Director of Marketing/High Fidelity Products; Burt Brooks named Sales Manager. Leon Kuby to Director of Merchandising and Advertising. Craig Stevenson appointed Marketing Manager of H-K's Professional Audio Div. ■ Marantz: Arthur D. Gaines named Director of Marketing. ■ Nortronics: Mervin Kronfield named General Sales Manager. ■ H. H. Scott: Victor H. Pomper elected President, with Hermon H. Scott, Chairman of the Board. Other promotions announced were: William F. Glaser to Vice President/Marketing, Victor Brociner to Vice President/Planning. ■ Sterling Hi-Fidelity: Jack Passero appointed National Sales Manager. ■ Superscope: Paul Markoff upped to General Sales Manager for Superscope and Marantz. Jay Menduke appointed General Manager of Superscope-New York. ■ United Audio: Murray Rosenberg joins company as Director/Marketing.

The Markgräfliches Opernhaus in Bayreuth, built 1745-48, Germany's only large baroque theater preserved in its original condition. PHOTOGRAPH BY FRANZ EHSON

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The frequency response of the Stanton 681EE was the flattest of the cartridges tested, within ±1 dB over most of the audio range."
Hirsch-Houck Laboratories, HiFi/Stereo Review, July, 1968.

The specifications.* Frequency response, from 10 Hz to 10kHz, $\pm 1/2$ dB. From 10kHz to 20kHz, individually calibrated. Nominal output, 0.7mV/cm/sec. Nominal channel separation, 35dB. Load resistance, 47K ohms. Cable capacitance, 275 pF. DC resistance, 1K ohms. Inductance, 500mH. Stylus tip, .0002" x .0009" elliptical. Tracking force, $3/4$ to $1\,1/2$ gm. Cartridge weight, 5.5 gm. Brush weight (self-supporting), 1 gm. *Each Stanton 681 is tested and measured against the laboratory standard for frequency response, channel separation, output, etc. The results are written by hand on the specifications enclosed with every cartridge. The 681EE, with elliptical stylus and the "Longhair" brush that cleans record grooves before they reach the stylus, costs $60. The 681T, identical but with interchangeable elliptical and conical styli both included, costs $75.

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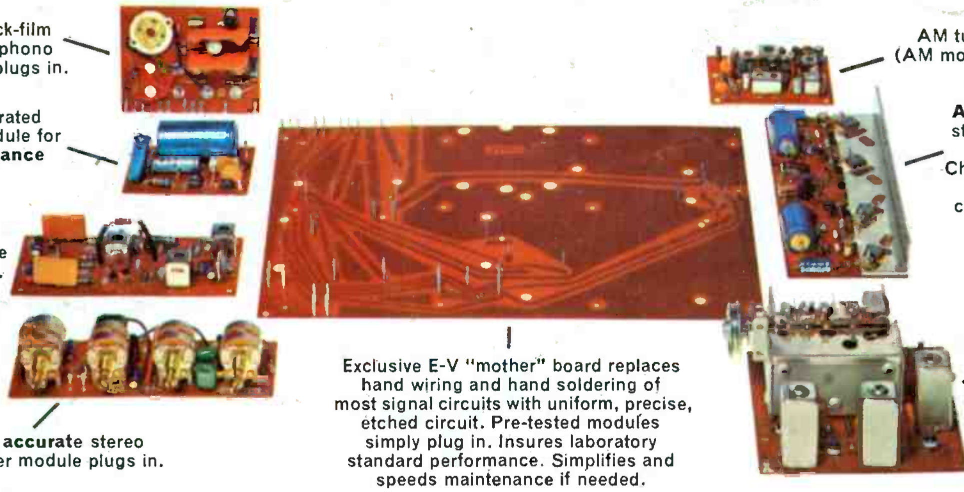

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