the authoritative magazine about high fidelity

AUDIO

STEREO EQUIPMENT & RECORD REVIEWS

JANUARY 1969 **60¢**

FOCUS ON TAPE RECORDERS ■ Cross-field Technique ■ Tape Recorder Specifications ■ The Commonality of Speaker Systems & Musical Instruments ■ Plus Regular Features

Read any good warranties lately?

A product is, in the long run, no better than the competence of the manufacturer; and a warranty simply reflects the manufacturer's confidence in his own product. Scott's philosophy is basic . . . we deliver not just equipment, but performance of the highest level. For this reason, Scott equipment is built with quality where it counts, not just where it shows. Scott equipment is built to last, not merely to sell at a price.

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This warranty covers repair and/or replacement of any part found by the manufacturer, or his agent, to be defective, including any associated labor cost.

The above warranty does not apply to (1) accessory parts explicitly covered by the field warranty of an original manufacturer; (2) units subjected to accidental damage or misuse in violation of instructions; (3) normal wear and tear; (4) units repaired or altered by other than authorized service agencies; and (5) units with removed or defaced serial number.

This applies to 1968 and later model year units.

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January 1969 Vol. 53, No. 1

Successor to RADIO, Est. 1917

AUDIO

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Coming in February 1969

A Layman's Guide to Hi-Fi/ Stereo Specifications—Here's a down-to-earth description of tuner, amplifier, and receiver specifications. Included is information on how to interpret graphs that relate to specifications.

High-Frequency Bias Requirements for Tape Recording—Andrew H. Persoon of the 3M Company describes how high-frequency bias current to a record head compensates for non-linearities, why proper bias adjustment provides a better signal-to-noise ratio and optimum frequency response.

The Commonality of Speaker Systems and Musical Instruments — Antony Doschek concludes this series by discussing idiophones—drums, cymbals, triangles, marimbas, etc.

Electronic Organs, Part 6 — Norman Crowhurst examines methods used to achieve vibrato or tremolo on electronic organs.

PLUS: Equipment Profiles, ABZs of FM, Audioclinic, Tape Guide, Record and Tape Reviews and other regular Audio departments.

ABOUT THE COVER:
Audiophile R. M. Holmes gave special consideration to reproducing music when his home in Canada was being built. His music system, part of which is shown on the cover, was assembled so that he could pre-record daily programs for CFMO-FM, the station he managed at that time. See page 62 for a complete description of his system, including record/playback switching methods.

Audioclinic

JOSEPH GIOVANELLI

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

Stray Magnetic Fields

Q. I have an equipment cabinet which, at present, contains a changer, a tape deck, a solid-state amplifier and a transistorized tuner.

The center section of this cabinet is reserved for a TV set. I shortly plan to put a table model color TV set in this area. Because of the space limitations, this model will probably have a metal cabinet. I realize that the color set will generate a strong magnetic field. I would like to know what effect this will have upon the components, especially the tape deck and the phonograph, which are located in the immediate vicinity.

Is there any way I can effectively shield the center compartment? If not, will there be a detrimental effect on the components?

I hope you can help me with this, because the answers I have gotten range from "no effect at all" to the recommended use of copper sheathing.— Robert Rosenberg, Flushing, L.I., N.Y.

A. You will be glad to know that I doubt you will have difficulty with magnetic fields associated with your new TV receiver. It is possible that there will be some hum if the television receiver and the high-fidelity equipment are operated simultaneously. However, I see no reason to expect deterioration of your high-fidelity system because of these fields.

Even if there was a tendency of the fields around the television set to magnetize your tape heads, they can easily be demagnetizd periodically. You probably are already taking such precautions.

Stereo Discs with Mono Pickups

Q. Recently I saw advertisements of several record companies saying that their records could be played with mono tonearm/cartridges without a loss of quality.

I cannot understand this. Because the stereo groove is a spatial curve, and the mono stylus has its degree of freedom only in the horizontal, not in the vertical direction, the stylus cannot follow the vertical component of the groove. Any attempt to track the stereo groove with a mono cartridge would damage the record permanently because the stylus in its forced vertical motion, hampered by the inertial forces of the tonearm, would grind the grooves, resulting in distorted sound.

Am I right? What is your opinion?— Dr. Helmut G. Lackner, Huntsville, Alabama

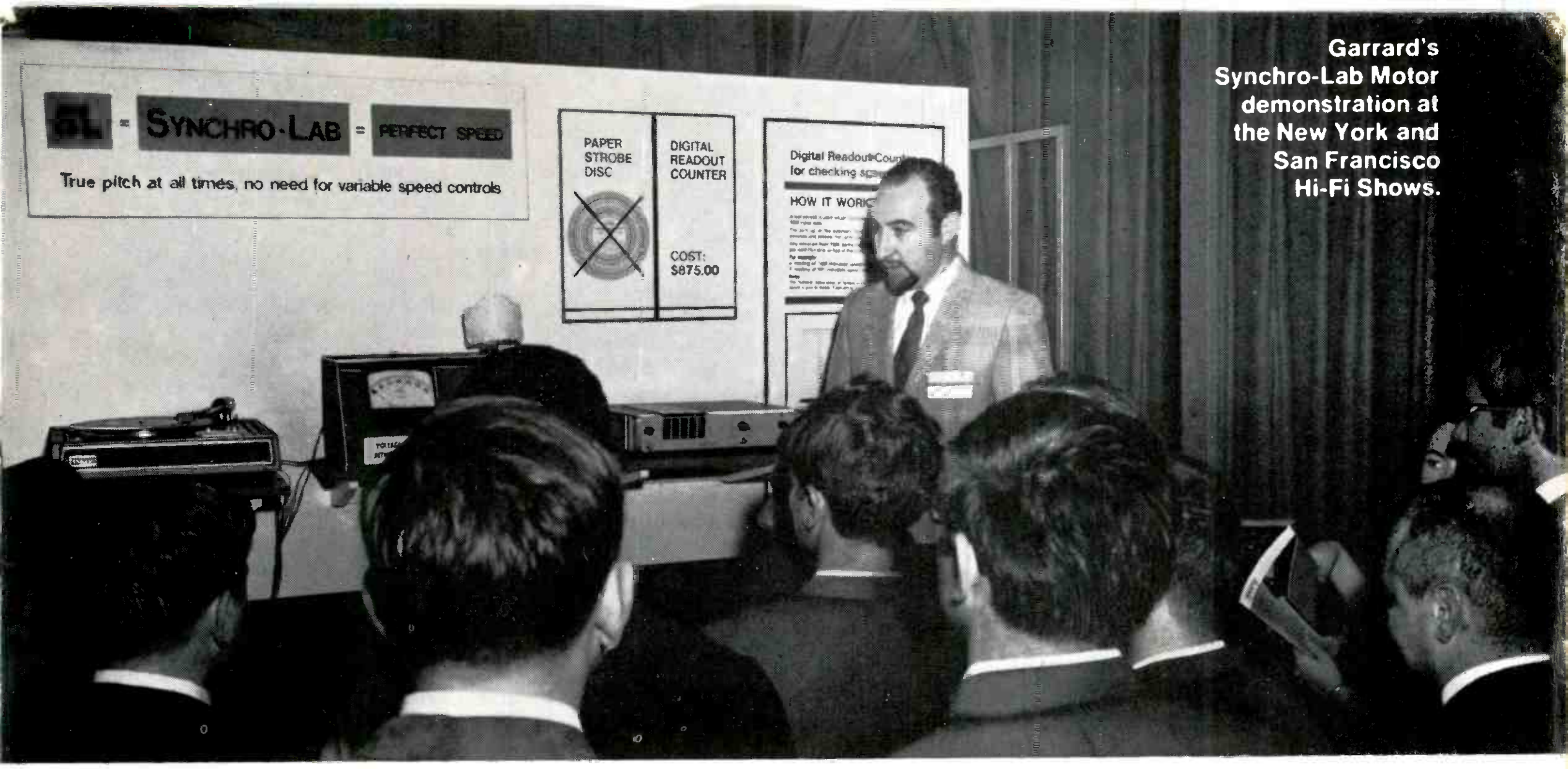
A. Up to a point, you are correct that there would be damage when playing the average stereo recording with a monophonic cartridge. This is more theoretical than practical today, however.

The largest amount of groove deviation takes place because of the low-frequency content of the music. The lows can cause so much trouble that they must be reduced in amplitude in the vertical plane so that the recording stylus does not leave the surface of the disc during the recording process. Suddenly, somebody realized that if this process is carried to a point where most of the bass was recorded having only a horizontal component, stereophonic directionality would scarcely be degraded, and the actual, vertical swing of the groove would be considerably reduced. Playing a record which is processed in this manner on a monophonic cartridge is found to produce little or no audible difference in terms of distortion or record wear. (Also, today's mono cartridges exhibit greater vertical compliance than did earlier ones.)

The only quarrel I have with this arrangement is that merely combining two channels, as is the case when listening to a stereo disc monophonically, will not necessarily give you as good a result as a true, mono mix made during the original recording session. Nevertheless, you will find that the resulting product is a good one, and that you can play it very well indeed with any pickup you choose. I have proved this to my own satisfaction before I undertook to cut similar types of discs.

External Connections to Tape Heads

I have been toying with the idea of adapting my recorder, which is presently a monophonic record and stereophonic playback type, to include both stereo record and playback features. This would utilize external record/ playback electronics in my home and



Garrard's Synchro-Lab Motor demonstration at the New York and San Francisco Hi-Fi Shows.

Customers and Salesmen: Were you there when we proved the need for unvariable speed?

We must have used the most boring record ever played at a hi-fi show... and one of the most instructive. No music on it—only a constant, 1,000 cycle note... held to within 1/10 of one percent accuracy!

It wasn't even meant to be listened to, but to be measured. And the people who visited Garrard's exhibits at the New York and San Francisco shows came not to listen, but to watch, as the record was played back on a Garrard SL 95, with a precision digital counter monitoring its output frequency.

Each day, throughout the 10 days of the shows, dealers and visitors watched the SL 95 playing the same record, hour after hour, for up to 10 hours a day. And, every 10 seconds, the line voltage to the turntable was varied deliberately with a Variac transformer, from a low of 65 to a high of 135 volts, and then back.

Meanwhile, a sophisticated digital readout counter—same type as used in space technology—faithfully monitored the actual frequency at which the pre-recorded, 1,000 cycle note was being reproduced. For the turntable to meet the critical standards of the National Association of Broadcasters (NAB), the output frequency would have to be held within plus or minus tolerance of 3/10 of one percent under normal operating conditions. In other words, the digital counter would have to display a readout of between 997 and 1,003 cycles.

Conditions were, of course, anything but normal: extreme voltage variations; long hours of play; high room and motor temperature; much tougher circumstances than in any home. Nevertheless, the Garrard SL 95 held its speed constant, and the digital counter displayed a readout of between 999 and 1,001 cycles... three times better than the rigorous NAB standard!

To keep the speed—and the record pitch this accurate—required the Garrard Synchro-Lab Motor. Within fractions of a second after it is turned on, it locks in to the precise speed of the record being played, and it stays locked in until turned off—because this motor operates in strict synchronization with the rigidly controlled 60-cycle frequency of the electric power line—reliable and accurate as an electric clock. However, unlike conventional "synchronous" motors, the Synchro-Lab Motor is powerful enough to bring the turntable up to its proper speed in an instant, as only "induction" motors (with far less accurate speed control) could do previously. This is because Garrard's exclusive Synchro-Lab design combines both synchronous and induction windings on a single rotor.

Incidentally, there are significant benefits from the Synchro-Lab Motor in addition to perfectly constant speed. The old-fashioned heavy turntable has now been eliminated, because its flywheel effect is no longer needed for speed accuracy. This, in turn, cuts rumble and preserves the life of the important center bearing. And, you will find no variable speed control on the Garrard SL 95, simply because no such control (even with a strobe disc and special viewing lamp) allows the turntable to be set to correct speed—and kept there—with the unfailing accuracy built into the Garrard Motor.

By the way, you may have wondered how that dull, 1,000 cycle record fared, with over 100 hours of playing time during the two shows. It fared quite well—it's still playable—after a wear test equivalent to years of play for the average record. That says nothing, of course, about the SL 95's motor, but it *does* say quite a bit for the tracking capabilities of its gyroscopically gimballed, magnificently engineered tonearm system.

There are seven Garrard models from $37.50 to $129.50, less base and cartridge. *Five of them incorporate the Synchro-Lab Motor.*

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would include being able to disconnect this arrangement so that the internal facilities could be used when I record outside of my home.

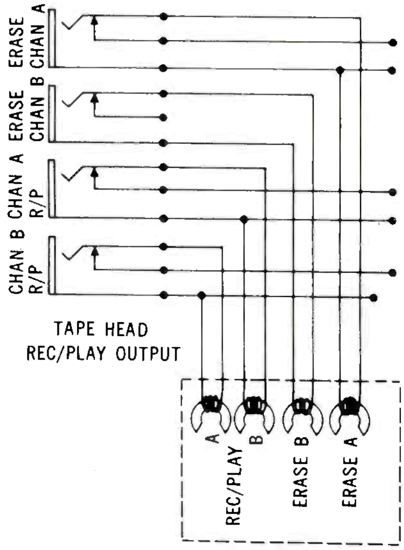


Fig. 1—Tape Head Rec/Play Output.

Figure 1 shows how this was accomplished. To implement this circuit, mount Switchcraft's "Tiny Jax" on the rear of the recorder and wire them according to the diagram. When using external amplifiers, plug them into these jacks and record or play back, bypassing the electronics in the machine.

When I take the recorder outside my home, I merely unplug the external amplifiers, and the recorder is ready for portable use.

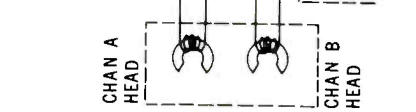


Fig. 2—Tape Head Playback Output.

Figure 2 is an arrangement for stereo playback only, directly from the tape head. I used this circuit arrangement in the past and it worked well.

In my recorder I did have to watch the paths of the wires carefully in order to prevent feedback. This precaution may not always be necessary, but do not be surprised if you must reroute leads a number of times before you get the machine tamed down.—*Name Withheld.*

Audio Techniques

Note: Most of the time we want to keep the items in this column on the short, snappy side. However, when something really interesting comes along, it should be printed in a way as to give it the full treatment that it deserves. Here is one from reader Thomas R. Hackett of New York City. It concerns AM reception, important because so many new component receivers today are available with this broadcast band in addition to FM and FM stereo.

Broadcast-Band Interference ("Birdies") from TV Sets

"Unbelievable as it may seem, interference to AM receivers caused by the radiation of harmonics of a TV set's horizontal sweep circuits can be eliminated.

"The most obvious remedy is to get at the TV set and prevent sweep signals from leaving. Use a high-pass filter in the antenna lead-in, tying it to earth ground and mounting it on a can on the back of the receiver. Then use a line filter (like the Sprague *Filterol*) in the a.c. line to the TV set, again mounting it on the back of the set and tying it to earth ground. (Use the shortest amount of line between the set and the filter which you can reasonably use so that the line cord itself won't radiate appreciable signal.) If the interference persists, use aluminum foil to shield the TV, taping it around the yoke and inside the cabinet. Use high-voltage plastic between the foil and the yoke, and ground the foil.

"The above will usually eliminate the 'birdies,' but, occasionally, further decoupling will have to be performed at the receiver. Also, sometimes you cannot get at the TV set. You have no choice but to work at the broadcast-band receiver.

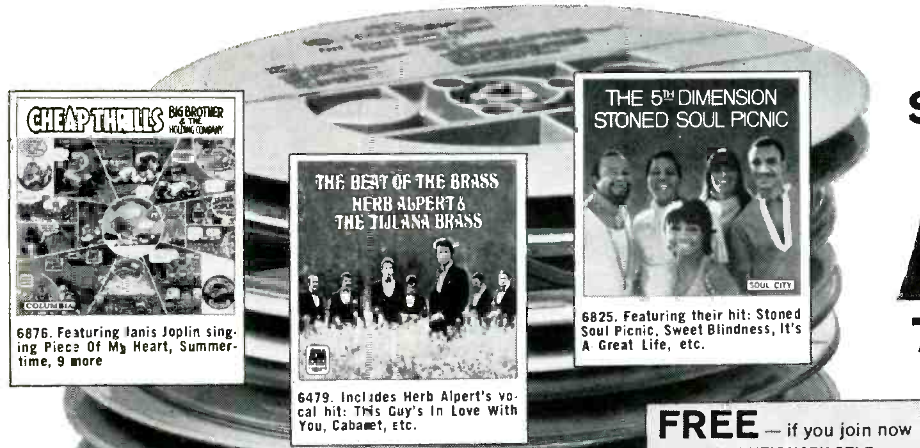
"First, use one of those a.c. line filters to eliminate any TV sweep that is on the power line. Tie the radio chassis to earth ground—*not a.c. ground!* This a.c., or waterpipe, ground always picks up more interference and noise than it eliminates. Use an entirely separate ground spike, or several if possible, and run the shortest possible cable to the chassis, using the largest wire gauge you can—No. 4 if you wish. (You must be careful to observe proper polarity of the line plug if the receiver has a 'hot' chassis.)

"Try antenna re-orientation; if a long wire is used, tune or turn it for a *null* of the TV 'birdies.' If a loop is used, rewind it with mike cable having two conductors plus shield, making a low-impedance loop, which will eliminate much noise by itself. You will have to get an r.f. transformer to match the low-Z loop to the input circuit of the radio receiver. Naturally, the shield is ground, but leave a gap in the shield at some point so signals can enter the loop. You'll be surprised at how much ITV can be eliminated.

"A few years ago I did a thorough investigation of sweep interference, during the course of which I tabulated all possible cases, took many field measurements, constructed a few breadboard receivers, experimented with various types of TV receivers, line filters, etc. Among the fruits of this research were the following facts: The 'birdies' precisely fixed as the two sources of oscillation are closely controlled by FCC standards: BC transmitters must remain within 20 Hz of their assigned frequency. The horizontal sweep frequency is controlled by the TV station's sync generator. The frequency of this generator is 15,734.264 plus or minus 0.044 Hz for color programs, 15,750 Hz (no tolerance) for black-and-white programs. Field measurements of the latter B & W signals indicates tolerance is as close as for color. The only noticeable shift is when the station goes from B & W to color.

"To cite an example, when a station is transmitting B & W, the 43rd harmonic of the horizontal signal is 677.250 kHz, causing a 2,750 Hz beat with any BC station transmitting on 680 kHz. When the TV station switches to color, the 43rd harmonic then becomes 676.573 kHz, causing an audio beat of 3427 Hz, which is noticeable to the ear. The sync generator tolerance of 0.044 Hz means that the audio beat in the radio will shift from a low of 3428 Hz to a high of 3425 Hz, which no one can detect, as it is a slow shift.

"Furthermore, if you *must* have a wide-band AM tuner, most of the channels will be plagued with 'birdies,' unless you decouple the tuner. If you cannot decouple or if this does not get rid of all the hash, and you do not have or do not need a wide-band tuner, and can get by with 5 kHz audio response, you have 34.6% of the AM broadcast band to listen to—or 37 channels. These are the channels on which the beats are above 5 kHz. Examples: 560 kHz, on which the beats are 7000 and 8750 Hz; 590 kHz, 7250 and 8500 kHz; 620 and 640, on which they are 5750 kHz. Of course, you are in luck if there are no



6876. Featuring Janis Joplin singing Piece Of My Heart, Summertime, 9 more

6479. Includes Herb Alpert's vocal hit: This Guy's In Love With You, Cabaret, etc.

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6823. Also: Five To One, Wintertime Love, 11 in all

6550. Program taken from performances at Carnegie Hall

6897. Also: People; The Good, The Bad And The Ugly; 11 in all

6558. Plus: Love Is Blue; Windy; Up, Up And Away; etc.

6480. Includes: Honey, The Mighty Quinn, Lady Madonna, etc.

6762. Plus Do You Know The Way To San Jose, Honey, etc.

6315. "Like the movie, a hit album" —Billboard Magazine

6511. Plus: I'll Get By, Love Is Blue, The Look Of Love, etc.

6489. Plus: Up And At It, Georgia On My Mind, 10 in all

6340. Also: Like A Lover, The Look Of Love, Roda, etc.

6964. Cry Me A River, People, Second Hand Rose, many more

6797. Also: Here Comes The Judge, The Gallop, etc.

5236. España, On The Trail, Waltz Of The Flowers etc.

6706. Plus: Poor Cow, Young Girl Blues, Preachin' Love, etc.

6733. Plus: Look To Your Soul, Whiter Shade Of Pale etc.

5553. Plus: Maria, Moon River, Yesterday, Dominique, etc.

2639. "The best musical score of '65." —Am. Record Guide

6366. Includes: Old Friends, Mrs. Robinson, At The Zoo, etc.

1013. Also: Twelfth of Never, No Love, Come to Me, etc.

1645. Delightful performance of Grofé's soaring tone poem

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1646. Also: Love Is A Bore, My Lord And Master, Autumn, etc.

3442. Also: A Poem on the Underground Wall, Cloudy, etc.

5634. Plus: What Kind Of Fool Am I, Back Talk, etc.

6658. Mrs. Robinson, Young Girl, Lady Madonna, etc.

3720. Also: My Baby, Get Ready, Don't Look Back, etc.

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(Please Print) First Name Initial Last Name

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City . . . .

State . . . . **Zip** . . . .

450-5/T2

nearby stations on those channels, but there are usually some.

"I found that the 'birdies' fell into four classes when heard on a receiver with a 5-kHz passband. Here they are:

> "CLEAR (beats from 7.75 to 6.0 kHz): Since these frequencies fall outside the receiver's i.f. passband, they are not reproduced, and channels having these beats are free from interference.
>
> "BARELY AUDIBLE (beats from 5.75 to 4.0 kHz): These frequencies are on the skirts of the receiver's i.f. response curve, and channels with these beat notes will be observed to have a slight interference, although usually not too objectionable.
>
> "PARTLY BLOCKED (beats from 3.75 to 2.0 kHz): These frequencies fall throughout the range of speech and music, and can be quite annoying. However, on strong AM signals these beat notes are overridden somewhat and interference is minimized.
>
> "COMPLETELY BLOCKED (beats from 1.75 kHz to zero beat): These low frequencies cut through nearby signals, making channels on which they are found completely unusable. Rarely will a station have sufficient intensity to partially override a low-frequency beat, though the channel will never sound very good.

"The stronger the AM station's signal, the less the resulting interference, regardless of beat frequency or location of TV set.

"Beat interference is getting to be less of a problem than it was in the Fifties because the newer sets must limit radiation by FCC edict (FCC Rule 15.63). Also, observe Rule 15.82:

> *"The operator of a radio receiver, regardless of tuning range, date of manufacture, or of certification, which causes harmful interference shall promptly take steps to eliminate this harmful interference.*

"Note that the term 'radio receiver,' as here used, means *a receiver of radio waves,* and includes all television sets because they receive both picture and sound via radio waves. Hence, if your neighbor's TV set is ruining your radio reception, you can, after being polite and trying to cure the trouble, read the law to him and have *him* clean it up.

"If money is no object, I recommend single-sideband techniques, especially a selectable-sideband communications receiver. You can reject 'birdies' on one sideband while listening to the other. If you insist on response to 10 kHz [if the broadcast station transmits this high], this gives you reception on 73% of the channels, while you can listen to all but two channels, or 98% if the response is limited to 5 kHz. (The two unusables are 630 and 1260 kHz, on which there are zero beats.)" Æ

PIONEER offers distortion-free stereo reception in 4 brilliant stages:

Treat yourself to virtually distortion-free AM/FM stereo reception by choosing any one of these ultra-sensitive receivers by Pioneer.

TOP BUY!

The SX-300T

Output: 40 watts (IHF) at 4 ohms; frequency response: 20-20,000 Hz; inputs: magnetic and ceramic phono, tape head and tape monitor; sensitivity: 3 uv(IHF); channel separation: better than 35dB at 1 kHz. **$179.95** (Walnut cabinet optional)

EXTRAORDINARY!

The SX-700T

Output: 60 watts at 8 ohms; distortion: less than 1% at rated output; FM sensitivity (IHF): 2.2uv; signal-to-noise ratio 60 dB; frequency response: ± 1 dB from 25-50,000 Hz; channel separation: 35 dB at 1,000 Hz; full controls. **$249.95** (Walnut cabinet optional)

SUPER VALUE!

The SX-1000TD with FET and IC's

Output: 130 watts (IHF) at 4 ohms, 120 watts at 8 ohms; frequency response: 20-60,000 Hz; inputs: 2 magnetic and 1 ceramic phono, tape head, tape monitor, headphones etc.; sensitivity: 1.7 uv(IHF); channel separation: better than 38 dB at 1 kHz. **$310.** (Walnut cabinet optional)

THE ULTIMATE!

The SX-1500T with FET and IC's

Output: 170 watts (IHF); harmonic distortion: less than 0.1% at 1,000 Hz 30 watts 8 ohm load; power bandwidth: 15-70,000 Hz; sensitivity: 1.7 uv (IHF); signal-to-noise ratio: 65 dB (IHF); capture ratio: 1 dB at 98 mHz; channel separation: 37 dB at 1,000 Hz; full controls. **$360.** (Walnut side panels included)

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What's New In Audio

BIB Tape Head Maintenance Kit

Tape recorder users usually have a problem in keeping track of the miscellaneous collection of devices useful in cleaning heads, and if the bits and pieces are not readily at hand, the cleaning job may be indefinitely postponed.

The Bib kit is contained in a plastic wallet, and provides everything necessary to keep heads in a clean condition, regardless of the type of machine—reel-to-reel, cartridge, or cassette. Two blue applicator tools are included, each resembling a toothbrush handle with a felt pad on the bent end. These are used with the liquid cleaner provided

to remove all traces of tape oxide. Two more such applicators, with white handles, are used for the final drying of the head faces. For removing bits of tape and other particles, a double-ended brush is provided—one end like a small broom and the other a tiny "bottle brush." A supply of "Q-Tips" is also included, together with a packet of Kleenex tissues. These common items can usually be found in the home, but rarely in the vicinity of the tape recorder. The liquid instrument cleaner serves additionally for cleaning all other external parts of the recorder, as well as for other hi-fi equipment. Full instructions accompany the kit. $2.95.

Check No. 8 on Reader Service Card

Tape Head Wear Indicator

The new "Spot Check" heads by Michigan Magnetics are so constructed as to tell when they are about to wear out by showing a red indicator on the face of the head when there are about 100 hours of useful life left. Thus the consumer will be forewarned that a head is about to wear out, and can avoid the disappointment of making a recording only to find that the head has failed. Another benefit is that the user will know when the head is *not* worn out so if frequency response has deteriorated, he will know that the trouble is not the result of a worn-out head.

Check No. 10 on Reader Service Card

"Background Music" Decoder

According to S.C.A. Services Company, its SCA-1 "background music" decoder provides the commercial-free music programs heard in restaurants and other public places, although it is illegal to use this unit for commercial purposes. The SCA-1 works with an FM tuner or receiver, and is available

wired ($64.50) or in kit form ($49.95). The solid-state unit includes two IC's, three FET's, and three transistors. In addition, a "mute" control is said to eliminate noise that occurs during changes in musical selections. The decoder comes with a local "background-music" station list. Dimensions are 6¾ in. wide, 5¼ in. deep, and 2½ in. high.

Check No. 12 on Reader Service Card

New Shure Phono Cartridge Series

Shure Brothers, Inc., announces a new series of stereo phonograph cartridges, including three models, each of which graduates in price and "trackability" performance. All feature an "easy-mount" design: the user mounts a retaining clip in the tone-arm head, connects its leads to the cartridge's terminals, then simply snaps the cartridge into the retaining clip.

Model M91E, top cartridge in the series, has performance characteristics second only to Shure's finest line, the V-15 Type II, according to the manufacturer. It is designed to track at ¾ to 1½ grams, and is equipped with a .0002 in. x .0007 in. elliptical diamond stylus. Because of its light weight, the maker recommends this $49.95 model for low-mass tone arms and high-quality automatic turntables. For the economy-minded audio buff who might be satisfied with slightly lower performance than that of the M91E, Shure offers the M92E cartridge for $44.95. This model also tracks at ¾ to 1½ grams, and is equipped with a .0002 in. x .0007 in. elliptical diamond stylus. The third and lowest-priced ($39.95) cartridge in this series, M93E, is designed for automatic turntables that track in the 1½ to 3 grams range. It has a .0004 in. x .0007 in. elliptical diamond stylus.

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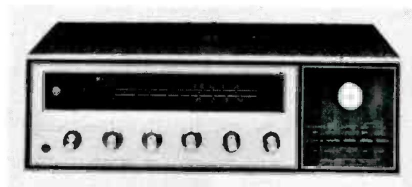
Kenwood 200-Watt Receiver

Model TK-140X is the newest AM/FM stereo receiver on the market from Kenwood Electronics, Inc. It is a 200-watt, solid-state unit, and is priced at $349.95, including cabinet. A luminous on-off dial, stereo light indicator, and tuning meter enhance the receiver's external appearance. The unit contains a four-gang tuning capacitor, three FET's and four IC's. The TK-140X features a capture ratio of 1 dB, and a sensitivity of 1.7μV, according to the



manufacturer. In addition, image rejection, cross modulation, and IF rejection are reported to be better than 100 dB. Harmonic distortion is rated at less than 0.5 % by Kenwood, while alternate channel selectivity is 45 dB. Other features of the TK-140X are: output terminal provisions for two sets of stereo speakers; two-channel preamplifier outputs and main amplifier inputs; silicon power transistors; a muting circuit; and a patented electronic protection circuit. The receiver measures 16½ in. W x 5½ in. H x 12¼ in. D.

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300-Watt Power Amplifier

Crown International marks its second entry into the amplifier field with its DC300 model. According to Crown, this dual-channel unit delivers 300 watts of sustained power from each channel (400 watts IHF). Self-protec-

tion circuits (three are patented) turn the amplifier off when it overloads. S/N is reported to be better than 100 dB; intermodulation is 0.05% and THD is 0.02%. Priced at $685.00, the DC300 measures 7 in. x 19 in. x 9¾ in. and weighs 42 pounds.

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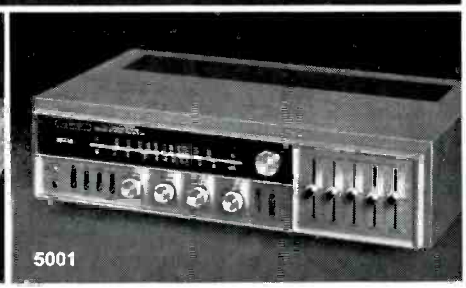

Shown above and described below are just a few examples of the most unique and formidable line of stereo equipment in the world today. From powerful stereo systems, to all-in-one compacts, to breathtaking individual components, there is a model designed for everyone from the most ardent stereo enthusiast to the casual listener.

Model 5303—Powerful Spectrum Speaker System—Non-Directional Sound Total sound diffusion—a full 360 degrees. Four free edge woofers and four horn-type tweeters in hermetically sealed metal enclosures to handle up to 80 watts in input. Frequency response range from 20 to 20,000 Hz. May be pedestal-mounted or suspended from the ceiling. *Diameter: 13½" 26.4 lbs.*

Model 5003—140 Watt Solid State AM/FM-FM Stereo Receiver with exclusive "Sound Effect Amplifier" Tone Control System Full 140 watts power output. All solid state FET circuitry with five IF stages. Automatic stereo switching, two speaker system selector, stereo and fine tuning indicators. Full complement of inputs, jacks and terminals with matching controls. *5⅞" H, 20¾" W, 14¼" D 30.8 lbs. w/cabinet*

Model 1684—Solid State 4-Track Stereo Tape Deck—Built-in pre-amplifier for superb reproduction at 7½ and 3¾ ips. 7-inch reels. Automatic stop device, professional VU meters, 3-digit tape counter, DIN and pin jack connectors. Accessories include full and empty 7-inch reels, DIN cord, splicing tape, dust cover and two reel clamps. Oil-finished wooden cabinet. *12 transistors 15⅝" H, 13⅝" W, 6¾" D 22 lbs.*

Model 6102—Deluxe Automatic 4-Speed Stereo Turntable and 8-Track Stereo Player—Large 11-inch platter for wow and flutter characteristics less than 0.3%. Tubular tonearm with moving magnetic cartridge and diamond stylus. 8-Track Stereo player features a 6 transistor preamplifier and wow and flutter characteristics of less than 0.3%. Fine furniture finished wood with molded acrylic dust cover. *9½" H, 17¼" W, 13¾" D 23.4 lbs.*

Model 5001—60 Watt Solid State AM/FM-FM Stereo Receiver with exclusive Sound Effect Amplifier—With built-in Sound Effect Amplifier (SEA), you have complete freedom and control of the total tonal spectrum in five different frequencies: 60, 250, 1,000, 5,000 and 15,000 Hz. New FET circuitry with four IF stages. Automatic stereo switching. *5⅞" H, 20¾" W, 14¼" D 30.8 lbs. w/cabinet*

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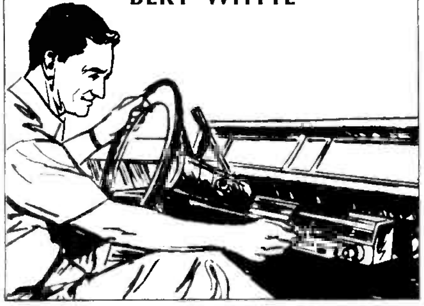
BEHIND THE SCENES

BERT WHYTE



8-Track Tape Cartridges

RCA Victor recently announced that it had produced its eight-millionth Stereo-8 tape cartridge since the introduction of this format three years ago. As of a few months ago, Ampex was producing in excess of 20,000 8-track cartridges *per day!* Other duplicating companies around the country are reporting production statistics which are equally impressive. To an old reel-to-reel man like myself, these figures are staggering. In fact, RCA states that its Stereo-8 sales over the past three years are *five times as great* as all the reel-to-reel tape sales for the past fourteen years!

Obviously, the 8-track tape cartridge is a howling success, in spite of the gloomy predictions in certain quarters that it would fail because of the "gimmicky format," "impossible to maintain production tolerances," "mechanical difficulties," etc., etc. Actually, many of these criticisms had a certain degree of validity and there were unforeseen problems, many of which have yet to be resolved. Unquestionably, the stimulus of the multi-million car market and its vast profit potential resulted in a money-is-no-object approach to solving the major problems, and the production facilities today are far more sophisticated than they were in 1965. Naturally, the quality of 8-track tape cartridges varies from company to company. Some are better than others in terms of hiss, crosstalk, and other distortions. However, I think it would be safe to say that, at least as far as *production* is concerned, most 8-track tape problems are "manageable." It is when we get to the nitty-gritty nuts-and-bolts aspect of the playback of 8-track tape cartridges in the car or home that we run into some problems, some of which are unique.

It is always good practice to examine a new tape cartridge carefully before you insert it into the slot of your playback machine. Check the pinch roller, to determine if it revolves freely. Ninety nine per cent of the time it will be all right, but you will occasionally find the pinch roller frozen in its bearing. When you insert a cartridge and after a reasonable period you don't hear any sound, chances are that it is this pinch roller problem. Also check the cartridge tape for proper slack. Pull the tape over the pinch roller, with your thumb simulating the capstan shaft. The tape should move freely down into the cartridge and onto the reel. If the tape doesn't move, insert a pencil under the tape and pull upwards, forming a loop of tape you can grasp. Sometimes a firm pull will free the tape sufficiently to make the cartridge usable. If reasonable pressure won't free the tape, further effort is useless and you must seek recourse with your dealer. You will also encounter cartridges which are operable, but the little felts of the pressure pads are missing and the bare metal rubbing against the tape can cause trouble.

Now picture this situation. You've checked a cartridge and everything appears to be okay. So you insert it into your machine and you are tooling down the highway blissfully enjoying your Sinatra in stereo. All of a sudden there is a horrible sound . . . Awk! Grunnnchh! . . . and finally no Sinatra, no sound at all. You pull out the cartridge. At last you try to pull it out and find to your chagrin that you have two strands of tape coming out of the cartridge and the apex of the strands appears to be caught in the machine. Zounds, what a mess!

Well, first things first. Let me assure you that there is no way to extricate the tape cartridge without cutting it free. I know. I've tried. Not once but three times this has happened to me and on three different machines. So steel yourself and *cut* the tape. *Don't* try to break the tape with your hands. There is a good reason for this I'll tell you about a little later. Now that the cartridge is out of the way, if you can look into the tape slot, you'll find that the tape has wrapped itself around the capstan shaft! What happened is this: most 8-track playback machines have a drive system wherein a heavy flywheel is part of the capstan shaft and it is used to help smooth tape motion. The capstan shaft is under the center of the flywheel, perpendicular to it, and seated in a bearing situated in the bottom part of the tape machine structure. The flywheel rides in a bearing on top of a yoke, which is connected to the side of the bottom bearing and in which the capstan shaft "rides." Apparently this yoke supports the flywheel and affords a degree of rigidity to help prevent wobble in the shaft. This yoke is not a true bearing and of course, it isn't lubricated. Tolerances are fairly tight, but there is enough clearance between the capstan shaft and the yoke that under certain circumstances the tape is caught between the shaft and the yoke and quickly wraps itself around the shaft. When the clearance is exceeded, the shaft seizes in the yoke.

Why does this happen? I've asked quite a few "experts" and have received quite a variety of answers. The concensus seems to favor the idea that something impedes the smooth flow of tape between the pinch roller and capstan shaft, momentarily "snagging" on the shaft, but enough to upset the equilibrium of the endless loop and thus get wound around the shaft. One expert blamed it on the dynamics of the endless loop itself. As you know the 8-track tape is back-lubricated with graphite. While this is pretty slick stuff, I suppose it is conceivable that some sort of bump or dirt or other irregularity on the back surface of the tape could interrupt the motion and cause a snag. One other idea was that as the tape is played back many times, the edges become "scalloped" and this could upset the dynamics. Mebbe so . . . but I have had it happen with a brand new tape.

One of the most logical-sounding reasons was that of a "bleeding" splice in itself, or this kind of splice worsened by excessive heat. No doubt you are aware that the automatic switching of the four stereo sequences is accomplished by means of a foil contact strip. It probably wouldn't take much "bleeding" or "oozing" of the adhesive under the edges of the foil strip to cause a snag. It is claimed that when the playback machines are used for fairly long periods of time, they get quite warm. This is especially true of the machines built into the dashboards of new cars as original equipment, where lack of ventilation is alleged to cause temperatures in excess of 130 deg. If this temperature is beyond the thermal tolerance of the adhesive it naturally would aggravate the "snagging" problem. At the moment I have no way of knowing if this heat problem is valid. I rather doubt it, but my friends at 3M may be able to cast some light on the subject. Still another opinion was that with the extreme bending angles the tape in the cartridge is subjected to, it is easy to form small "kinks" in the tape which could be pulled behind the capstan

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The cartridge looms large for a simple reason:

It is the point of contact between the entire hi-fi system and the recording. What happens at the tip of its tiny stylus determines what will happen in all those big and impressive components that are so obvious to the eye and, in the aggregate, so apparent to the pocketbook. Worldwide, experts and critics have hailed the discovery of Trackability as *the* definitive measurement of cartridge performance. When evaluated against this measurement, the superb **Shure V-15 Type II Super Track** stands alone. Shure Brothers, Inc., 222 Hartrey Ave., Evanston, Illinois 60204

The analog-computer-designed Shure V-15 Type II Super-Trackability cartridge maintains contact between the stylus and record groove at tracking forces from ¾ to 1½ grams throughout and beyond the audible spectrum (20-25,000 Hz). Independent critics say it will make all of your records, stereo and mono, sound better and last longer. Tracks 18 cm/sec. and up at 400 Hz; tracks 26 cm/sec. and up at 5,000 Hz; tracks 18 cm/sec. and up at 10,000 Hz. This minimum trackability is well above the theoretical limits of cutting velocities found in quality records. $67.50.

shaft. Since this opinion was ventured by a rabid supporter of the cassette format, I tend to discount this possibility.

No matter what the cause, when the tape gets wound around the capstan shaft, you're in trouble. If your playback machine is of the "add on" variety, at least you can remove the unit from the car and work on it at home or transport it to a repair station. If your playback machine is original equipment built into the car, this "tape wrap" problem can be financially catastrophic. According to Wally's Tape City, a New York firm specializing in 8-track car installations, in some cars it is necessary to remove the unit, repair and check it and re-install it in the dashboard. The tab for this can reach 30 or 40 dollars!

Fortunately, there are some things you can do yourself before resorting to professional help. Let's assume you have the kind of unit you can remove from your car easily and take to a work table with a good strong light. Next thing is to get an injector-type razor blade. In a vise or between two pliers break off a piece of the blade approximately ⅜ths of an inch (avert your eyes when you do this). Now grasp the blade with long-nose pliers, insert into the tape slot and carefully cut through the layers of tape. While the shaft is hardened steel, don't take a chance of scoring it by cutting with too much pressure. After cutting the tape, use the long-nose pliers to grasp the loose ends and a good solid tug will usually free the tape from the shaft. An alternative method is to use a long screwdriver to cut the tape. However, most screwdrivers aren't sharp enough to do this without a lot of hacking, and must be given a sharp edge with a file or grindstone. Needless to say, the same techniques can be used on machine built into the dashboards, but you need a good trouble-light or flashlight, a lot of physical agility and luck. If you can't cut the tape in an "add-on" machine, it will be necessary to disassemble the unit to the point where the flywheel/capstan shaft can be lifted out of the yoke and bearing. I must warn you that there are a lot of parts packed into an 8-track cartridge player, some of which are held in tension by the casing. To tackle this job without at least an exploded diagram and considerable dexterity is a chancy business.

Can anything be done to salvage the damaged cartridge? The tape can be spliced like any reel-to-reel tape, with, of course, special attention to the splicing tape for any signs of excess adhesive. You will remember that earlier in this article I cautioned against breaking the tape by hand in order to free the cartridge. This is because most 8-track tapes are made of Mylar and pulling it results in stretching and "tubing," which would destroy more program material than merely cutting the tape. Naturally, there will be music missing at the splice point, because of the tape which was destroyed in wrapping around the capstan shaft. Since we are dealing with the 8-track, endless-loop format the music will be missing at the same point in all four sequences on the tape. Since cartridges range from 6 to 9 dollars each, perhaps you won't be too distressed by the missing material, especially if it's pop music. Hopefully, you may never have to contend with this tape problem, but it evidently happens with sufficient frequency to warrant a thorough investigation by the interested companies and followed by instituting remedial measures in either the cartridges or playback units or both.

There are other playback problems with 8-track cartridge machines. Many of the earlier units had hum and excessive motor noise, of a cyclic variety. What may be termed "second generation" units are much quieter and have better tape motion. In either case, it's a good idea to check the grounds. In machines installed in cars, not only should there be a good ground wire from the tape machine case to the car chassis, but ground points throughout the car should be checked, as they are often broken. In home stereo 8-track units, be sure to run a ground wire from the case to the input of your preamplifier.

One other aspect of the newer 8-track playback machines is that they have an output impedance of 8 ohms, rather than the 2- to 4-ohms impedance of the first playback units. This enables a much greater choice in speakers and the opportunity to employ some really high - quality speakers. Installation space varies among the various car models, but the high fidelity 8-in. speakers made by Wharfedale, Jim Lansing, University, Jensen, and Electro-Voice are shallow enough to make their use possible. I know they will fit into the storage wells in my Corvette, and I intend to investigate these speakers at the earliest opportunity. Bass response remains the major problem in car installations. In most cases the lack of bass is an affront to the musical balance and the ear. The worst situation is where tiny "pre-packaged" speaker/baffles are installed under the dash or on the kick panels or above the sun visors. The sound coming from these abominations is a shrill caricature of the original recording. The car doors are a favorite place for speaker installation and will certainly afford improved bass. Make sure there is plenty of fiberglass stuffed behind the speakers. This seems to help the bass response and also helps to subdue the metallic resonances the speakers excite in the doors of certain cars.

Another aspect of bass response will have to be resolved by the manufacturers of the playback units. I refer to their lamentable practice of furnishing their machines with the type of tone control that apparently increases bass response by attenuating treble response. I would like to see them adopt a fixed standard treble equalization (most car interiors don't vary much in terms of reflection and absorption) and furnish a separate bass control. To anticipate a question, compensatory equalization of the recording to suit the environment of the car has been tried, and is being used to some extent. For a variety of reasons it is only marginally successful, usually more trouble than it's worth . . . the result is generally mishmash. . . .

Like everything else, the playback problems of the 8-track stereo tape cartridge will be resolved by time and money. For the most part, considering the difficult, even exotic configuration of the 8-track cartridge format, it works remarkably well, with a high degree of consistency. The problems that have been discussed are minor in scope, considering the millions of cartridges in use. Nonetheless, these shortcomings do exist and ignoring them won't make them go away.

One final note—and certainly a dubious testimony to the success and popularity of the 8-track tape cartridge—is that the playback units have become the favorite targets of car burglars. I have been a victim and I understand quite a few RCA people have had machines stolen from their cars. A check with my insurance agent reveals this to be a common and ever-growing occurence. It would appear that when an 8-track stereo tape cartridge system is installed in a car, it is prudent to install a burglar alarm as well.

Off-the-air Recording

Some months ago, Mr. Norman Racusin, Vice President and General Manager of RCA Victor, made a speech at a tape symposium in which he voiced alarm at the growing practice of "off the air" recording by means of the stereo tape cassette. His contention was that the cassette has made this type of recording so simple that it can be done by anyone including the teenagers who constitute the majority of the record-buying public. He saw this as a definite threat to the future of the record business. He cited the figures for the cassette business in Britain, 50 per cent of sales being for blank tape cas-

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settes. He stated that if this "off the air" recording trend became really widespread, who would pay for recordings produced by the record companies? In his conclusion, Mr. Racusin said that in order to combat this problem, it might be desirable for engineers to devise some technique which could make a broadcast signal either impossible or extremely difficult to record, without, of course, altering the musical content of the program.

Is Mr. Racusin being unduly concerned, or is his speech a timely warning? There will be those who will raise a supercilious eyebrow about this matter since Mr. Racusin's company introduced the 8-track stereo tape cartridge, which, as you know, is almost exclusively a playback medium. Well, it is not my function to impugn Mr. Racusin's motives. As far as I am concerned, he raises some interesting points that merit serious consideration.

I was sent a copy of Mr. Racusin's speech and in addition, a reprint of an advertisement by Harman-Kardon, the message of which would give palpitations to any record company executive. The ad concerned the Harman-Kardon SC2520, a modular system which combines a stereo record player, stereo FM receiver and a built-in stereo cassette recorder. Emblazoned across the top of the ad was this eyecatcher: YOU MAY NEVER BUY ANOTHER RECORD! The ad copy told how easy and simple it was to record programs off the air, or from a friend's disc recording via the cassette recorder, all with high fidelity quality. I believe a half-dozen blank tape cassettes were being offered as a bonus for purchasing the system. It is easy to appreciate the shock value of the ad blurb, but at a selling price of $479, this isn't going to constitute such a vast market that it is a threat to the record industry.

Let's look at the other end of the scale. It is possible to buy an AM radio with a built-in monophonic cassette recorder for as little as $49. There are AM/FM portable radios with recorders for $99 and on up to 4 band portables with recorders for $149. It is obvious that even for the affluent American teenager, this is "a lot of bread, man!" The ubiquitous transistor radios which seem permanently grafted to the ears of the kids, like some monstrous Orwellian fantasy, range between $5 and $15. This is what they buy for themselves. The jazzier units are usually presents from parents, and it would appear that "dear old dad" would have to furnish the wherewithal for these radio/cassette combinations. While North Americans are probably the most doting and indulgent parents on earth, it seems hard to conceive that they would buy these for their offspring in such quantity as to upset the record market. However, let's keep an open mind and delve a little deeper into the teenage economy.

The kids buy their pop/rock 45-rpm recordings for an average cost of 69 to 79 cents each. There is one selection on each side averaging 3 minutes in duration. So for their money they get about 6 minutes of music. Now you can buy a 30-minute blank tape cassette as cheap as 99 cents. If the kids record it properly they can get five times as much music—at least 10 selections—for 20 or 30 cents more than they paid for a single 45-rpm recording. Consider too, that most of the pop/rock music the kids listen to is very ephemeral in nature—a big popular hit for a few months, even weeks—and then it fades into limbo. Thus when the kids tire of their material or it is displaced from the "top forty," they can record new hits on the same cassette. The way the kids devour records, the cassette approach could save them quite a bit of money and the smarter kids (and their parents) might be encouraged to make the "larger-than-usual" purchase of the radio/cassette recorder figuring that it would soon pay for itself.

This all sounds very rosy for the young'uns, but what about the sound quality of the "off the air" cassette recordings? I've listened to these cheap radio/cassette units and, speaking personally, I could be very crass and give all I've heard a blanket indictment as utter sonic horrors. About the kindest thing that could be said about the better units, is that they have somewhat less distortion than the others, which affords a little better clarity. Actually the cassette recorders are mirroring the source quite well, the playback offering the same quality of music and distortion as the radio. You've heard this kind of sound before . . . tinny, peaky, shrill, nasal, and utterly devoid of any bass response below 150-200 hertz. We must not forget however, that kids are used to this sonic assault. Whether the 45-rpm records they buy sound better through their parents' "mahogany monstrosities"—the typical living room consoles—than their cassette recordings, is a moot point. It is sad in a way —in spite of the rock content, most of which I can't stand, you would be surprised how much high-quality sound you can get from the 45's made by the better labels, when played back over a good component system. In any case, one tends to think that the kids would be satisfied with the quality of the cassette off-the-air recordings. But even conceding this and spelling out the monetary advantages, I still can't see this growing to sufficient volume to depress the record market.

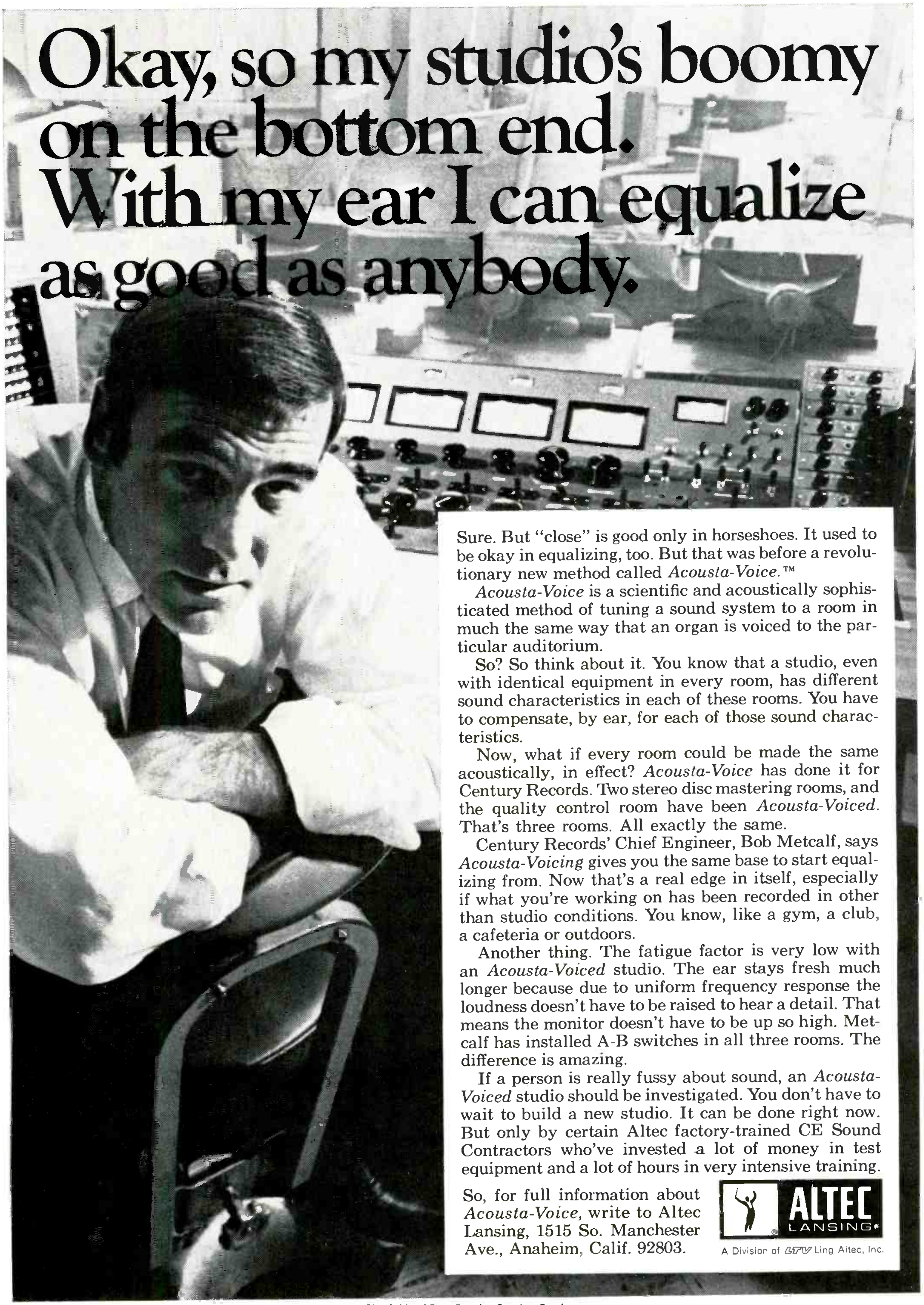
However, for the sake of argument, let's assume that the off-the-air recording grew to epidemic proportions, what could be done to stop the practice? Mr. Racusin's suggestion of some technique to alter the broadcast signal to render it unrecordable, seems impractical. I have discussed this point with AUDIO's own Len Feldman and with Murray Crosby, both eminent radio engineering authorities, and they cannot conceive of anything that would work. In any case, there would be quite a legal and political ruckus involving the FCC and the public if such signal "doctoring" were attempted.

As you know, off-the-air recording via (open) reel-to-reel machines has been going on for years. Mr. Racusin tends to downgrade the reel-to-reel practitioners as being too few, because the techniques involved are considerably more complicated than obtained with cassette recorders. I feel there is more money being lost to the reel-to-reel enthusiasts, because of their ability to make relatively high-quality recordings. This is especially the case with albums of stereo mood music. Given a good quality receiver or FM stereo tuner and a stereo recorder, one can record this type of music *ad infinitum*, with a tremendous variety of program material from which to choose, and at substantially lower cost than buying the equivalent disc recordings. Many also record the classical material, but here the quality differential is on the side of the disc, a fact recognized by most off-the-air recordists.

The legal aspects of off-the-air recording have never been clearly defined. There is a sort of tacit understanding that any recording made off-the-air intended for personal use and not offered for sale is legal. Copying of pre-recorded tapes is technically illegal and some tape boxes proclaim this warning. But whether it is cassette or reel-to-reel, off-the-air or commercial tape, and it is all declared illegal, how on earth could you ever police such activities? It is patently impossible.

In summation, if off-the-air recording ever did become an economic threat to the record business, the record companies would have only themselves to blame. They have sown the seeds of their own destruction by not charging the broadcasters a fee for using their recordings. They have even aided and abetted their downfall by giving free records to the stations. This country is one of the few where stations can broadcast recordings without paying for the privilege. I know this is heresy, but the record companies think they

(Continued on page 77)



Okay, so my studio's boomy on the bottom end. With my ear I can equalize as good as anybody.

Sure. But "close" is good only in horseshoes. It used to be okay in equalizing, too. But that was before a revolutionary new method called *Acousta-Voice.*™

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If a person is really fussy about sound, an *Acousta-Voiced* studio should be investigated. You don't have to wait to build a new studio. It can be done right now. But only by certain Altec factory-trained CE Sound Contractors who've invested a lot of money in test equipment and a lot of hours in very intensive training.

So, for full information about *Acousta-Voice,* write to Altec Lansing, 1515 So. Manchester Ave., Anaheim, Calif. 92803.

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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.

Harsh Sound

Q. The problem with my tape recorder is harsh or raspy highs. This is particularly evident on program material having components above 10 kHz, such as violins and snare drums. The problem appears to be in the record section of the machine, because tapes recorded on another machine and played back on mine sound fine. The type of tape used has some effect on the degree of harshness. Some tests have been run on my machine. Frequency response and harmonic distortion, measured up to 20 kHz, look all right. Bias frequency, waveform, and level have been checked and appear OK. Bias level was even varied, but this did not help. All heads were cleaned with denatured alcohol before the tests. Tape to head contact appears satisfactory. Any assistance you can offer will be greatly appreciated.—Robert O. Kindl, Wethersfield, Conn.

A. It is barely possible that the record head is at fault, although a defective head is more likely to give trouble in the bass region than in the treble range. Perhaps you are over-recording because the record level indicator is miscalibrated. There may be something amiss in the record electronics, such as leaky capacitors, low voltage, etc. You may have an excessively rough pressure pad, or one with excessive tension, resulting in tape flutter and consequent distortion. The record head itself may have accidentally become roughened, causing flutter. A tape guide may have a gummy deposit, causing flutter. And there is the faint possibility that a highly magnetized head is responsible for your difficulty. Clean and demagnetize everything in sight.

To determine whether or not your crossover is operating correctly, feed an audio oscillator into the inputs of your amplifier, making sure that all speakers have been disconnected and that dummy loads of the correct impedance are connected in their place. Connect a voltmeter across your midrange crossover output. See if the voltage drops off at the proper rate of 6 or 12 dB per octave below the lowest frequency for which that network was designed. If the highs are not fed into the midrange portion of the network, make the same test above the highest frequency for which the network was designed.

If the network fails to operate properly, capacitors are usually the elements to be suspected.

Equalization Compatibility

Q. I am considering the purchase of a British tape recorder which records to the European standard designated CCIR or DIN. I am wondering if I am going to experience any difficulty in getting good recordings in association with American equipment that follows the NAB standard. If so, is there any way of compensating for this? I would also like to know how far from the tape recorder heads it would be safe to store a bulk eraser. When the eraser is immediately turned off, does the magnetic field dissipate or is there a residual field present for a few minutes?—John Napoliello, Philadelphia, Pa.

A. On the whole you can probably get satisfactory results even though using CCIR instead of NAB playback equalization for NAB recordings, provided you employ the tone controls of your audio system. Generally, you will have to supply some bass boost and treble cut—in mild amounts. Bear in mind that recording engineers tamper a good deal with frequency balance, so that perfectly flat record-playback response does not necessarily conform to the frequency balance of the original sound source.

As long as the bulk eraser is not activated you can bring it as close to the tape heads as you wish. When activated, keep it at least six feet from the heads. When the eraser is turned off, the magnetic field dissipates almost instantaneously.

The Cross-Field Principle

Q. If the cross-field head (a separate head mounted opposite the record head to supply bias current) really does greatly improve frequency response at a given tape speed, why has only one tape recorder manufacturer used it? I understand that the basic patent is held by Armour Research, and I cannot believe they have given an exclusive to one company.—Gerald Shirley, Tuckahoe, N. Y.

A. About four years ago I discussed this subject with a leading figure in the tape recorder industry, and he expressed the belief that if the cross-field principle were that effective in improving high-frequency response it would have been adopted by more tape machine manufacturers. He wondered whether the improvement in high-frequency response might be obtained at the cost of deterioration of some other aspect of performance. On the other hand, within the past year a manufacturer of high reputation has incorporated the cross-field head in its tape recorder. Hence the answer may lie in the fact that it takes time for improvements to gain wide acceptance, and that it is more costly and mechanically complex to incorporate a separate head for supplying bias current.

For further information, see the article starting on page 21.

More on Bias

Q. Some time ago you commented that cross-field bias does not result in as much high-frequency erase as when the bias is applied by the record head. Could you explain what you mean by this? — William Jackson, APO San Francisco, Calif.

A. When high-frequency current is fed to the record head along with the audio signal, this high-frequency, or bias current serves to increase the amount of signal recorded on the tape and to reduce the distortion of the recorded signal. However, bias current also serves to erase what is on the tape, in the same fashion as when a great deal of bias current is fed to the erase head. Because the amount of bias current fed to the record head is much less than the amount fed to the erase head, the record head has less of an erasing effect. Erasure is predominant at high frequencies, because such frequencies are recorded more closely to the surface of the oxide coating than are the low frequencies; the latter penetrate more deeply into the oxide. Hence in relative terms there is high frequency loss due to bias current in the record head. When a cross-field head is used, the magnetic bias field is applied from the base side of the tape, rather than from the oxide coating side. And it is claimed by some that this arrangement results in less high-frequency loss due to bias current. Æ

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EDITOR'S REVIEW

Tape Explosion

1968 was a great year for the magnetic tape and equipment industry . . . 1969 promises to be an even better one. One industry spokesman predicted that 1968's retail sales of magnetic tape products would reach $500 million, for example. Other bullish estimates were: 1968 tape recorder sales should reach $280 million; $1 billion in cartridge tapes and related playing equipment by 1972; $90 million in retail sales of cassette units for 1969 (compared to an estimated $70 million for 1968); one major producer of 8-track prerecorded tape cartridges estimated their 1968 retail sales at $160 million, with 4-track tape cartridges at $40 million. Reports are that tape duplicators for cartridges and cassettes are hard-pressed to meet present demands for recorded material.

See-Through Radio Antenna

"Trick-or-treaters" during the past Halloween celebration gave my automobile a rakish appearance by bending its whip antenna back to about a 45-deg. angle. Wouldn't have happened with a 1969 Grand Prix auto from the Pontiac Motor Division, though.

According to reports, PPG Industries, Inc. has developed a glass windshield for the Grand Prix model that also acts as an AM and/or FM antenna. A nearly invisible antenna, consisting of an antenna wire that is about twice the thickness of a human hair, forms an extended "T" inside the windshield. A terminal block for connection to a radio is concealed at the bottom of the windshield.

If the new antenna operates as claimed, expect conventional monopole and "rabbit ear" antennas to go the way of the Auk.

Noise Abatement

Excessive noise can induce a hearing loss, as has been noted here on a few occasions. A number of proposals have been made to reduce this hazard, with special emphasis on occupational health. For example, test results of tractor drivers' hearing suggests that deafness is an occupational hazard, and that tractor noise that is sufficiently high in intensity, with exposure over a period of years, causes high-frequency losses.

The British Standards Institution proposed the following noise limits in 1967 (measured outside at 3.6 m away from walls or buildings):

	Max. levels, dB	
District	*Weekday*	*Night*
Rural	50	40
Suburban	55	45
Urban	60	50
General Industry	70	60
Predominantly Industrial	75	65

When noise control is not possible to achieve, ear protection has been used as part of a hearing conservation program. Ear plugs are commonly used, with varying effectiveness, depending on material used. Typical attenuations in decibels are:

Frequency, Hz	*250*	*500*	*1000*	*2000*	*4000*
Fiberglass wool	11	13	17	29	35
Normal ear plug	16	17	24	28	27
Medium ear muff	18	26	43	43	46

Tape Recorder Directory

This issue's tape recorder directory (see page 34) includes 77 audio tape recorder models from 28 manufacturers, and 20 video tape recorders from 6 manufacturers. Most of the audio tape recorders listed are open reel-to-reel types, with a sampling of cartridge and cassette units.

All specifications have been supplied by respective manufacturers, not by measurements made by the AUDIO staff. Due to so many past requests for frequency response specifications, we have listed them in this roundup.

Further information may be obtained by writing directly to the manufacturer or by noting your request on the Reader Service Card at the back of the magazine.

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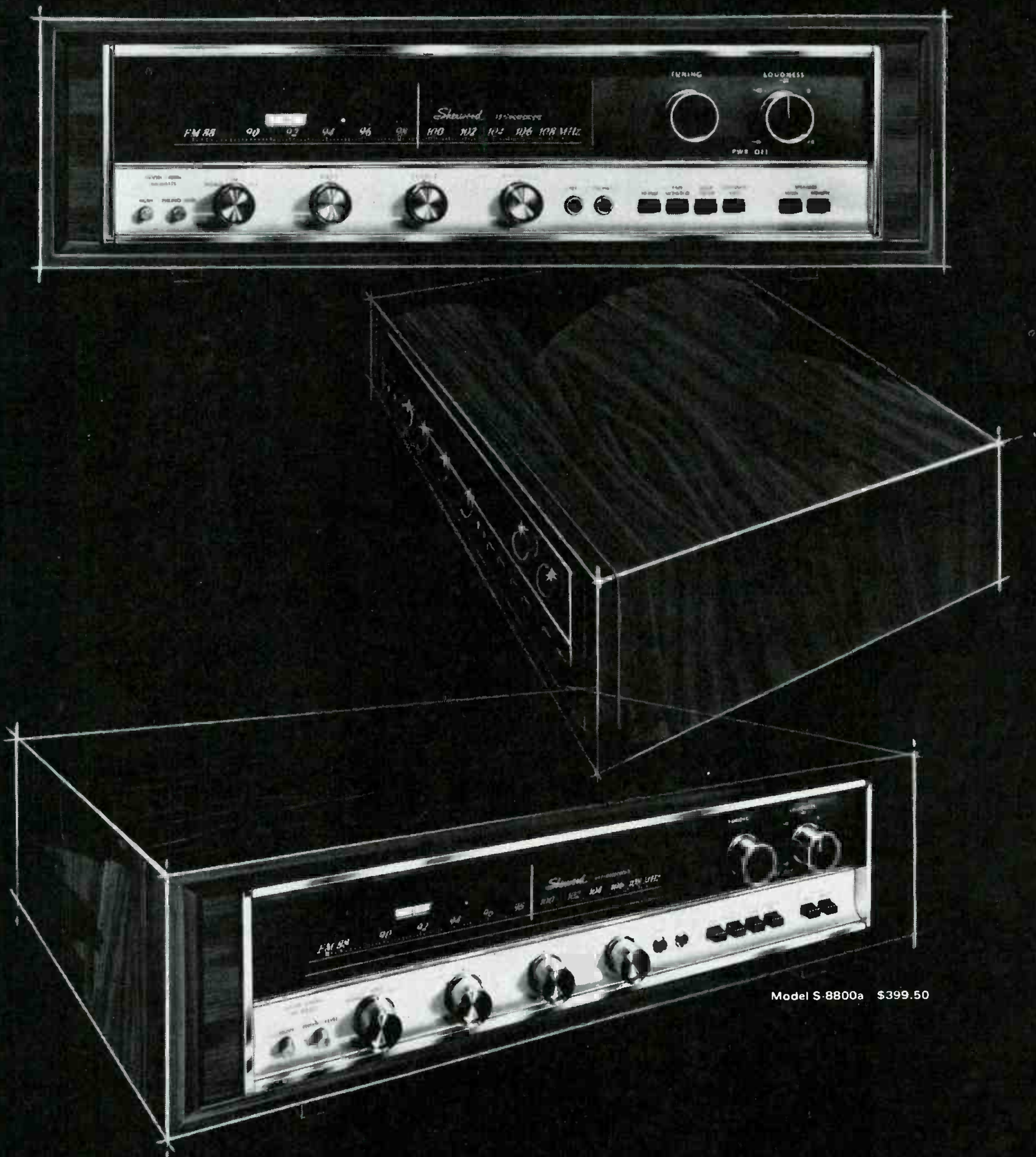


Sherwood

Sherwood Electronic Laboratories, Inc. 4300 North California Avenue, Chicago, Illinois 60618 Write Dept. 1-A

Check No. 20 on Reader Service Card

The Cross-Field Technique

FRITJOF BRODTKORB*

Description of a biasing technique which is claimed to improve performance and frequency response at low tape speeds

Obtainable bandwidth in magnetic tape recording is limited by tape speed. When the wavelength of the signal recorded on the tape approaches the width of the recording zone, the frequency response is severely reduced.

To move the critical frequency upwards, the recording zone must be made narrower. This can be accomplished either by reducing the bias and using thinner tape or by introducing the cross-field technique. The aspects of the two alternatives are discussed here, and it is claimed that the cross-field technique on long-play tape gives 6-dB lower tape noise than the conventional technique on triple-play tape.

As lower tape speeds become more common for sound reproduction from magnetic tape, the difficulties in maintaining a satisfactory dynamic range are accentuated. The limitations are imposed partly by the increased preemphasis required for obtaining a given frequency range at a satisfactory signal/noise ratio.

Recent developments in these fields, based on the work done at Tandbergs Radiofabrikk A/S.

The tape recording technique developed rapidly during and shortly after the second world war when plastic tape with a coating of magnetic material was introduced, opening the possibility for application of high-frequency biasing.

The magnetizing process is inherently nonlinear, of course. If the tape is magnetized by the signal alone, the resulting signal played back from the tape will be severely distorted. In the early days of tape recording, steel wire was used as the magnetic medium. It was then found that the distortion could be reduced by exposing the wire to a permanent magnetic field superimposed on the signal field during recording. This resulted, however, in a strong background noise from the wire during playback. A great step forward was taken when the permanent magnetic field was replaced by an alternating field of high frequency, as the plastic tape coated with a thin magnetic layer became available. When such a tape is exposed to a magnetic field simultaneously excited by the signal and the high-frequency bias, a virtually distortionless reproduction at a very low noise level is obtained. With this technique the magnetic tape advanced to a leading position amongst media for recording and reproduction of sound.

*Chief Engineer, Tandbergs Radiofabrikk A/S

In most recent years, efforts have been aimed at the development of better tapes and recording techniques which will make it possible to record at the lowest possible tape speed while maintaining an adequate frequency range.

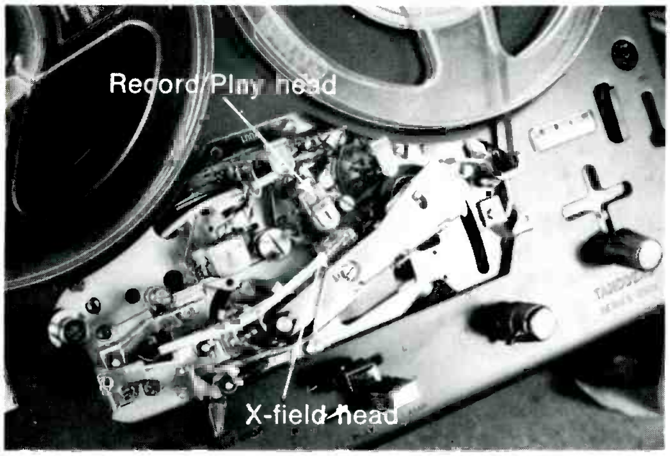
Methods to Extend Frequency Range

Before these improvements are described, it is best to take a closer look at the recording process itself.

An important limitation is imposed by self-erasing, which occurs in the recording zone as the tape wavelength of the signal to be recorded has diminished. to the same order of magnitude as the width of the recording zone. More precisely, the magnetic field will be completely or partly cancelled when the extension of the recording zone along the trailing edge of the recording gap becomes greater than or equal to half the wavelength of the signal to be recorded. At a tape speed of 7½ ips, the critical wavelength corresponds to fairly high frequencies which are of no significance for reproduction of speech and music. At 3¾ ips and 1⅞ ips, however, the cancelling effect occurs within the useful frequency range when conventional recording technique is used. It is therefore desirable to make the recording zone as narrow as possible (shorter extension along the tape) in order to be able to record at short wavelengths.

Several methods have been applied to accomplish this: (1) the design of the recording head has been improved, resulting in a narrowing of the recording zone. (2) It has been found that the frequency range can be extended by using tape with a thinner magnetic coating—the so called triple-play tape. This is, unfortunately, accompanied by a reduction of the maximum available playback signal amplitude and, consequently, a relative increase in tape noise. (3) a relatively new recording technique, the *Cross-field* technique, has been developed, giving a similar extension of the frequency range for normal coating thickness (long-play tape) without any increase of tape noise.

Reduction of Bias. For thick magnetic coating, the recording zone will contract if the bias amplitude is reduced. If the signal amplitude is maintained, this will cause distortion from the deepest parts of the coating, where the bias becomes insufficient. This effect is prevailing for the lower and medium frequencies, which are the more important ones. In order to avoid this distortion, the signal amplitude must be correspondingly decreased so as to have the same depth of penetration for the signal and bias fields. This will, in turn, reduce the available playback signal amplitude. It is thus obvious that recording at reduced bias utilizes the magnetic coating poorly. It leads to less available signal relative to the tape noise, and has the further drawback that inhomogeneities in the coating are



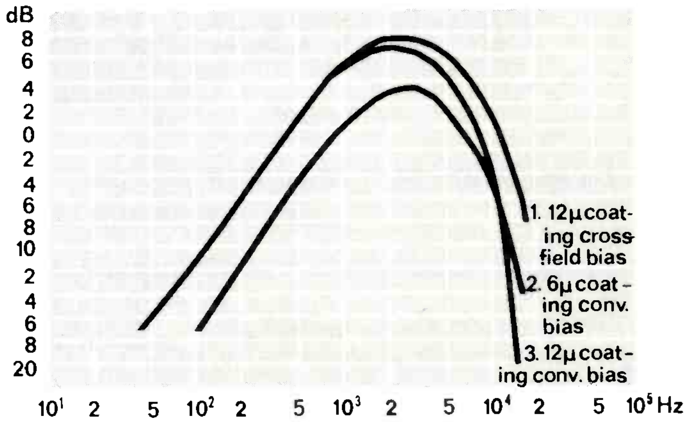


Fig. 1. Tape curves at 3¾ ips tape speed.

accentuated in the form of signal drop-outs.

Generally, it can be stated that the available recorded signal amplitude depends on the bulk of magnetic material being excited. In the lower- and middle-frequency ranges, the signal increases proportionally to the coating thickness for all tapes in current use. The noise level is mainly determined by the surface structure of the tape and is, therefore, practically constant when the thickness of the tape is varied.

A possible method for increasing the bulk of material being magnetized would be to increase the width of the track from quarter-track to half-track. This will increase the signal amplitude by 6 dB. The noise will increase only by 3 dB because of its random frequency and phase relationships. The net gain in signal-to-noise ratio is, therefore, 3 dB for a doubling of the track width.

Reduced Coating Thickness. In order to benefit from the possibilities associated with reduced bias and, thereby, narrower recording zone, thinner tapes with reduced coating thickness have been produced. These tapes will give a weaker signal in the lower and middle frequency range. In contrast, the higher frequencies will have larger amplitudes than those obtained with thick coating because of the narrowing of the recording zone. Consequently, the frequency range is extended upwards, accompanied by a general decrease in signal level. The wider frequency range is thus obtained at the sacrifice of S/N.

Figure 1 shows how the signal amplitude varies as a function of frequency for tapes with thick and thin coating. Curve 3 represents the thick tape with a coating of 12 microns (long-play tape), whereas curve 2 represents the thin triple-play tape with 6 microns coating thickness. Both tapes have been optimally biased; that is, maximum available signal amplitude occurs at 600 Hz for 3¾ ips. The curves have been plotted using conventional recording technique at a tape speed of 3¾ ips, and show the tape characteristic for constant signal recording current when played back through a flat-response amplifier. This enables the relative response for the two categories of tape to be read directly in decibels.

As shown, curves 2 and 3 intersect at 10,000 Hz. At frequencies below the crossover, the thinner coating gives a loss of 6 dB as compared to the thick coating. If the tape is run at half the speed, the crossover frequency is also reduced by the same amount to 5000 Hz. By switching to thin tape coating, the amplitudes of the higher frequencies are not reduced, and it will appear that a 6-dB gain at higher frequencies has been achieved as compared to the lower frequencies. This, however, is gained at the sacrifice of S/N in the most important frequency range where a corresponding attenuation occurs, an unfortunate occurrence because the S/N already represents a serious restriction on good sound reproduction.

The ideal solution would be to extend the frequency range at a given tape speed without deteriorating the S/N ratio. As explained in the following, this is possible by application of the cross-field-bias recording technique.

The Cross-field Technique

The cross-field technique is characterized by an extra head that introduces the bias field, close to the record head gap, in opposition to the signal field. The resulting field is more perpendicular to the tape surface, and the recording zone becomes narrower. The self-erasing effect has now moved towards considerably higher frequencies, and the recording field at middle and lower frequencies penetrates through the thicker magnetic coating. An improvement of frequency response has thus been obtained without any compromise in the signal-to-noise ratio.

In our tape recorder laboratory, extensive measurements have been made to determine the amount of signal gain obtained by using cross-field bias instead of conventional bias. The improvement can be found from Fig. 1, where curve 1 shows the resulting frequency response for cross-field bias. Comparing with curve 3 representing the same conditions for conventional bias, we find that the two techniques at a tape speed of 3¾ ips give equal amplitudes up to 1000 Hz, where the curves diverge and show a difference of 5 dB in favour of the cross-field technique at 10,000 Hz. It can thus be stated that the cross-field technique gives the same signal amplitude at lower and middle frequencies, as compared with conventional recording, and a significant signal

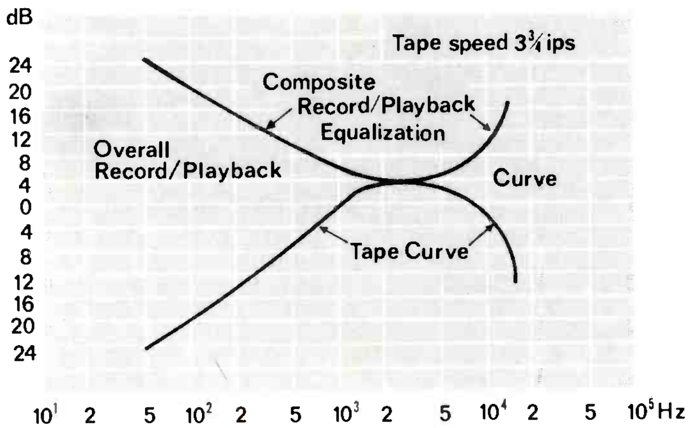


Fig. 2. Construction of Overall Record/Playback Curve.

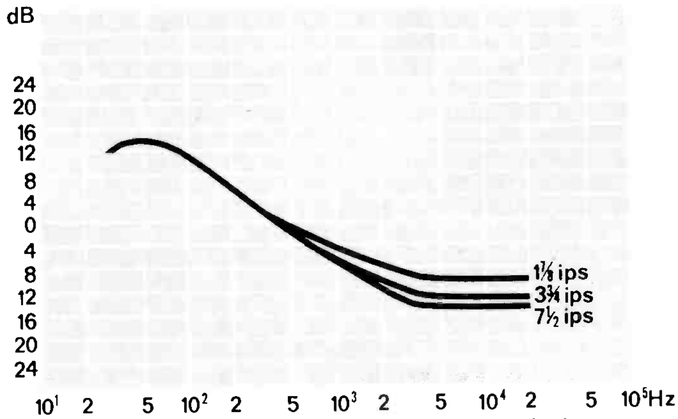


Fig. 3. Playback equalization, IEC—standard

improvement at higher frequencies.

If we compare the curve for cross-field recording on long-play tape (curve 1) with conventional recording on triple-play tape (curve 2), we find the curves to be virtually parallel to one another, with the latter 6 dB down. This means that with cross-field bias, the frequency range for long-play tape with 12-micron coating is the same as that obtained with triple-play tape (6-micron coating) using conventional technique. The gain in S/N, however, is directly expressed by the distance between the two curves; that is, 6 dB.

To recapitulate, there are presently two ways to extend frequency range at low tape speeds. One way is to make the recording zone narrower by reducing the bias. This implies the use of thinner tape, leading to a subsequent decrease of the signal level and a corresponding incease of the relative noise level. The other possibility is to contract the recording zone by means of cross-field bias, whereby the thick tape can be used and the low noise level maintained.

Practical Cross-field Technique

Frequency Corrections During Record and Playback. Before discussing design guidelines for cross-field biasing, it is necessary to review how frequency characteristics of a tape recorder arise. Figure 1 shows that the frequency response of the head and the tape alone is far from being flat. The amplitude drops off radically at the upper and lower extremes of the frequency range.

At lower frequencies, the amplitude rolls of at a slope of 6 dB/octave because recording has been done with a constant magnetic field. At the upper end, the signal drop is caused by the previously mentioned wavelength losses, together with head and tape losses. In order to compensate for this, the gains of record and playback amplifiers are increased at both ends of the frequency range. See Fig. 2.

In the lower frequency range, to the left of the tape curve peak, the playback amplifier gain is increased by 6 dB/octave down, compensating for the negative slope of the tape curve shown in Fig. 2. The location of the peak depends on the tape speed. Therefore, the break frequency for the playback amplifier is set individually for each tape speed, as shown in Fig. 3. The 3-dB points for the frequency curves at the different tape speeds are determined by time constants specified in the international IEC standard, as follows:

7½ ips— 70 μs
(corresponding to 3 dB at 2260 Hz)
3¾ ips— 90 μs
(corresponding to 3 dB at 1770 Hz)
1⅞ ips—120 μs
(corresponding to 3 dB at 1330 Hz)

The dropoff at the upper end of the tape curve is caused by recording losses which can hardly be compensated for during playback because it would result in a severe increase of tape noise. In this frequency range, therefore, the signal level is raised before recording, thereby increasing the distance between signal and noise. This is the so-called pre-emphasis, which is not restricted by international standards. It is up to the manufacturer to freely develop and improve the recording technique; he can choose recording process and pre-emphasis as desired. The only requirement is that the signal be reproduced correctly, using the standard playback curve.

Dynamic Range. If a reasonable quality is to be maintained, the tolerable amount of pre-emphasis at high frequencies with respect to the medium-frequency amplitudes is limited. The consequence of pre-emphasis is that the tape recorder will require a reduced signal level in the pre-emphasized range in order to avoid tape saturation. A less pronounced pre-emphasis gives a wider safety margin against overload phenomena. For this reason, the required pre-emphasis for obtaining the specified frequency characteristics of a tape recorder should always be stated. A flat frequency response up to 10 kHz, attained by 10-dB pre-emphasis, gives a far better dynamic range than if 20-dB pre-emphasis were used for the same achievement.

Generally, the frequency distribution of music and speech shows that the amplitudes diminish with increasing frequencies, and it is fair to presume signal levels 10 dB down at 10,000 Hz as compared to 1000 Hz. It will therefore be tolerable to increase the signal 10 dB at 10,000 Hz with little risk of tape saturation. This is supported by the fact that FM broadcast programs are submitted to such a correction before transmission. The purpose in this case is to raise the signal out of the background noise.

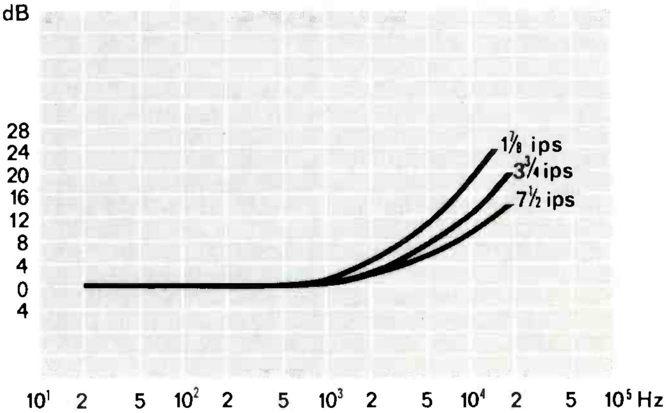


Fig. 4. Record pre-emphasis for cross-field bias.

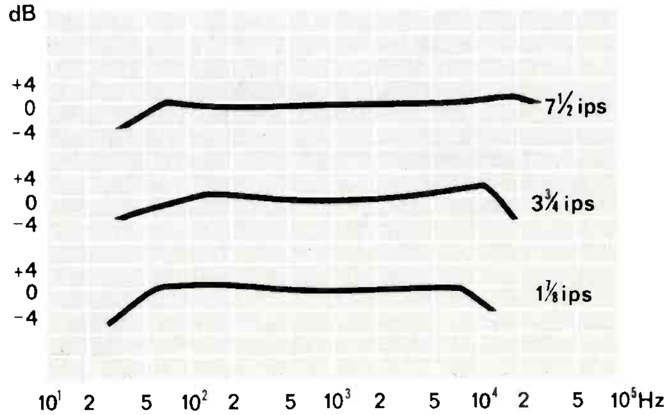


Fig. 5. Overall Record/Playback Curves for cross-field bias.

A limit of 10-dB pre-emphasis at 10,000 Hz is no longer an exaggerated quality requirement. The more modern types of music have, in fact, that much sound energy within the higher frequency range. Therefore, the pre-emphasis represents a risk of tape saturation unless the overall recording level is decreased, which will again lead to a less favorable S/N.

Improvements at Various Tape Speeds. If in spite of the above comments a maximum limit of 10-dB pre-emphasis is taken as a reference, it is interesting to compare what can be achieved at tape speeds of 7½, 3¾ and 1⅞ ips by application of cross-field biasing, with the results obtained by using thinner tape coating. We have already found that the tape curves for the two cases are virtually parallel to one another. Therefore, the pre-emhpasis curves will be equal. Thick magnetic coating gives the highest signal level and, consequently, the best signal/noise ratio.

As previously mentioned, recording losses associated with the width of the recording zone will not occur at 7½ ips. This applies for cross-field as well as for conventional techniques in the relevant frequency range. At this speed, however, other frequency-dependent losses necessitate a pre-emphasis of 8 dB. This means that the established 10-dB pre-emphasis limit is nearly reached. Because the self-erasing problem within the desired frequency range at 7½ ips does not arise, the cross-field will not alter the overall situation at this tape speed. The use of thinner tape will, however, give an increase of the tape noise by 6 dB without any advantages in return.

If the tape speed is reduced to 3¾ ips, the wavelength-depending losses begin to appear. Conventional technique and thick tape require a pre-emphasis of 20 dB at 10,000 Hz. With cross-field technique, these losses can be reduced to a magnitude where only 12 dB pre-emphasis at 10,000 Hz is required. It can thus be stated that owing to the new technique, one has succeeded in keeping the wavelength losses at a level low enough to obtain a frequency response at 3¾ ips that is approximately equal to the one at 7½ ips for conventional technique. This has been achieved without exaggerating pre-emphasis. The tape noise will, however, increase by 2 dB because of the higher playback amplification required for a given signal level in the range from 2000 Hz and upwards at 3¾ ips. See Fig. 3.

At 1⅞ ips a still greater profit is gained by the new technique. A pre-emphasis that compensates for recording losses up to 10,000 Hz will, with cross-field bias, have to be 18 dB, which is nearly the same as needed for 3¾ ips by conventional biasing. Again, 2 dB more noise will have to be accepted because of increased playback amplifier gain from 1300 Hz and upwards. In other words, this will give 4 dB more relative noise than is the case at 7½ ips.

Conclusion

The chart below is a summary of playback data for cross-field recording on thick tape and conventional recording on thin tape. Standard IEC playback curves are assumed. Cross-field recording on long-play tape at 7½ ips is taken as the reference for tape noise.

Tape speed ips	Pre-emphasis at 10 kHz	Tape noise level long-play tape cross-field bias	Tape noise level triple-play tape conventional bias
7½	8 dB	0 dB	+ 6 dB
3¾	12 dB	+ 2 dB	+ 8 dB
1⅞	18 dB	+ 4 dB	+ 10 dB

Figure 5 shows the resulting frequency curves obtained with the pre-emphasis and tape noise given in the accompanying table of playback data when the cross-field technique is used for thick tapes. The greatest advantage obtained by using cross-field recording on thick tape instead of conventional recording on thin tape is a reduction of tape noise. From the table it can be found that cross-field is 6 dB better in this respect at all three tape speeds.

It may be of some interest to know the relative increase of the tape noise when the tape speed is reduced from 7½ ips to 1⅞ ips. Taking the tabulated data for cross-field as a reference, we find that the tape noise will increase by 4 dB for cross-field, as well as for conventional technique, due to the higher playback gain required at low tape speed. Furthermore the tape speed reduction requires a 10 dB higher pre-emphasis in order to maintain the frequency response up to 10,000 Hz. Hence the overload safety margin in the upper frequency range is correspondingly reduced. The 8-dB pre-emphasis at

(Continued on page 79)

Layman's Guide to

Tape Recorder Specifications

AUDIO ENTHUSIASTS pay fairly fancy prices for good home tape recorders; tags on high-quality machines are often $300 and upward. Yet their specifications are not quite as fancy when compared with those for other audio equipment such as tuners and amplifiers. A high-priced tape machine may claim S/N (signal-to-noise ratio) of only 50 dB, while tuners and amplifiers vaunt S/N of 60 dB, 70 dB, and even higher. A tape machine may claim relatively flat response over the range of 50-15,000 Hz, while other equipment will claim virtually flat response from 20 to 30,000 Hz, 50,000 Hz, or higher.

Understandably, in judging the quality of a tape recorder by its specifications—presented by the manufacturer or in an equipment profile—the audiophile will want to know what can be considered excellent performance in light of today's state of the art. And he will want to know what is good, and what is only fair. It is the purpose here to help him acquire such knowledge, guided by (1) performance achieved by today's top-flight home machines, and (2) performance standards set by NAB (National Association of Broadcasters) for professional machines.

Much of what we have to say concerns three principal criteria of performance: frequency response, S/N, and distortion. We shall also talk about such things as motion, crosstalk, channel separation, tape speeds, head gaps, various tape recorder features, and the like.

Interdependence of Frequency Response, S/N, and Distortion

We must remind readers how interdependent the three parameters noted above are in the case of a tape recorder. An improvement in one aspect of performance necessarily entails a sacrifice in one or both of the other two aspects. For example, a significant extension of treble response—say from 15,000 to 20,000 Hz at 7.5 ips (inches per second) —could be achieved if one is willing to let distortion rise appreciably and/or let S/N drop appreciably. A substantial improvement in S/N could be obtained by letting distortion and/or frequency response go to pot. And so forth.

Why is this so? Perhaps we can most easily explain by illustration. Suppose that at 7.5 ips, using conventional tape, a machine correctly specifies that frequency response is down no more than 2 dB at 15,000 Hz; that S/N is 55 dB at peak recording level; and that harmonic distortion is 3% at peak recording level. Without changing the machine or tape or state of the art, what could we do to extend treble response to, say, 22,000 Hz for Fido's benefit? One thing that might be done is to decrease bias current a little. The effect of reducing bias current through the record head is to reduce "bias erase"—the tendency of the head to erase the very frequencies it is trying to record. Since bias erase becomes more severe as frequency rises, a reduction in bias current results in improved treble response.

So far, so good. But something else happens when bias current is cut. Distortion rises, and quite sharply. Hence the gain in treble response comes at the expense of more distortion. On the other hand, might it be possible to avoid the rise in distortion? Yes. How? Simply by recording at a lower level.

But with less signal recorded on the tape, we get lower S/N in playback. Hence we have traded better treble response for a deterioration in S/N. Or we could take a compromise position by trading the treble gain for moderate sacrifices in both distortion and S/N.

With a little imagination, the reader can figure out the consequence of trying to achieve an improvement in S/N or distortion.

S/N Specifications

S/N deals with the ratio, in dB, between the desired audio signal and noise due to the record and playback amplifiers, hum picked up by the playback head, and tape noise.

S/N and distortion specifications tend to be the ones most puzzling, not only to amateur audiophiles but to professionals as well. This is because the meaning of these two specifications is tied to a precise definition of peak recording level (also known as maximum permissible recording level), and unfortunately this definition is not always clearly given.

For a number of years it has been the practice of high-quality machines for home use (and even professional use) to define peak recording level as that which at 400 Hz produces 3% harmonic distortion on (conventional) tape. (To make an important digression: VU meters in machines of professional quality are generally set to read 0 VU either at a recording level that produces 1% distortion or, pretty much the same thing, at a level about 8 dB below that which produces 3% distortion. The reason is to allow for the mechanical lag of the pointer, which cannot follow sharp transients and therefore tends to under-indicate peak recording level. By keeping the VU pointer at or below 0 VU, the recordist therefore has a margin of safety of about 8 dB.) Experience has shown that a recording level which does not exceed 3% harmonic distortion at 400 Hz, where audio energy is apt to be most intense, results in quite acceptable reproduction. The forthcoming NAB test tapes contain an "NAB Standard Reference Level," which is a 400 Hz tone recorded at a level 8 dB below that producing 3% third harmonic distortion at 7.5 ips.

Therefore let us be satisfied to consider peak recording level that which at 400 Hz produces 3% harmonic distortion on conventional tape at 7.5 ips. Accordingly, S/N is the ratio in playback between a 400-Hz signal recorded on a machine at peak recording level and all the noise produced by that machine in the absence of such a 400 Hz signal.

Using conventional tape, the NAB standard calls for S/N to be at least 53 dB at both 7.5 and 3.75 ips for quarter-track operation (and about the same for half-track). However, there are some home machines that under these conditions can achieve S/N as high as 56 dB, and perhaps a bit more. Therefore excellent, good, and fair S/N performance might be defined as shown in Fig. 1.

The peak recording level is sometimes defined as that which produces 1% harmonic distortion. Then the specified S/N ratio should be adjusted upward by about 8 dB. Thus if the specification states that S/N is 44 dB below the 1% distortion level, we can state that S/N is about 52 dB with reference to the recording level that produces 3% distortion. The reference level may be given as 0 VU. Properly—but not always—0 VU should correspond to a recording level that produces about 1% harmonic distortion and is about 8 dB below that which produces 3% harmonic distortion. So again we can add 8 dB to a specification based on 0 VU. WARNING: Be sure

Parameter		Excellent	Good	Fair	Unit
S/N		54-56	50-53	45-50	dB
Frequency response	7½	30-16,000	50-13,000	50-10,000	Hz
	3¾	50-12,000	50-10,000	50-8000	Hz
	1⅞	50-8000	50-7000	50-5000	Hz
Uniformity of playback response		±1	±2	±3	dB
Uniformity of record/playback response		±2	±3	±5	
Wow and flutter	7½	0.1	0.2	0.25	%
	3¾	0.2	0.25	0.3	%
	1⅞	0.3	0.4	0.5	%
Absolute speed error		0.3	0.5	1.0	%
Crosstalk		60	54	48	dB
Channel Separation		40	35	30	dB

Fig. 1—How to interpret Tape Recorder Specifications.

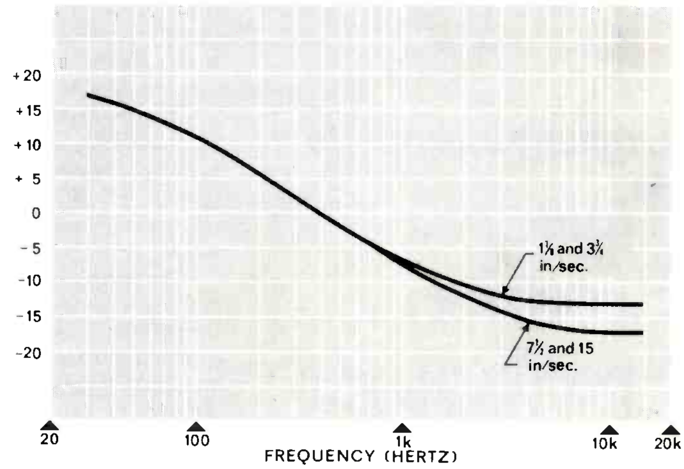


Fig. 2—Standard reproducing characteristics for magnetic tape records. Reference frequency: 400 Hz.

that the distortion level is 1% when the VU meter is driven to 0 VU while recording a steady 400 Hz tone. To be sure, consult the tape machine's specifications or its manufacturer or an equipment profile of the machine.

On occasion one may find that peak recording level corresponds to 5% harmonic distortion at 400 Hz. Then one should subtract about 6 to 8 dB from the specified S/N. Ror example, a rating of 58 dB would be reduced to about 50-52 dB.

One more word of caution: Make sure that the S/N specification pertains to the entire record-playback process, including the heads. At times it has been found that a specification was related only to the tape electronics, enabling a manufacturer to claim a juicy 60 dB.

Distortion

Much of the preceding section bears on the distortion specification as well as on the S/N one. We have seen that distortion is really a matter of definition rather than of design in the case of a tape recorder. For the purpose of calculating S/N, the accepted practice of high-quality home tape recorders is to use as a reference the recording level which produces 3% harmonic distortion on the tape at 400 Hz. The practice might just as well have developed of rating S/N on the basis of 2% or 1% distortion; but this would not mean that the tape machine produces any less distortion. The distortion level is due to the amount of signal that one tries to get onto the tape, not to the quality of the tape machine.

Tape recorder specifications rarely mention IM (intermodulation distortion). The fact is that when a recorder is producing only about 1% THD (total harmonic distortion), IM is substantially higher; a typical figure might be 6% or 8% IM. When a machine is producing 3% THD, measured IM might rise to a figure like 12% or 15% or more. Because such figures are distressing to the eye, they are omitted. But the results appear considerably less distressing to the ear. For one thing, we are talking about IM at or close to peak recording levels, which are only occasional. For another, some part of the measured IM products may be outside the range of hearing.

Frequency Response

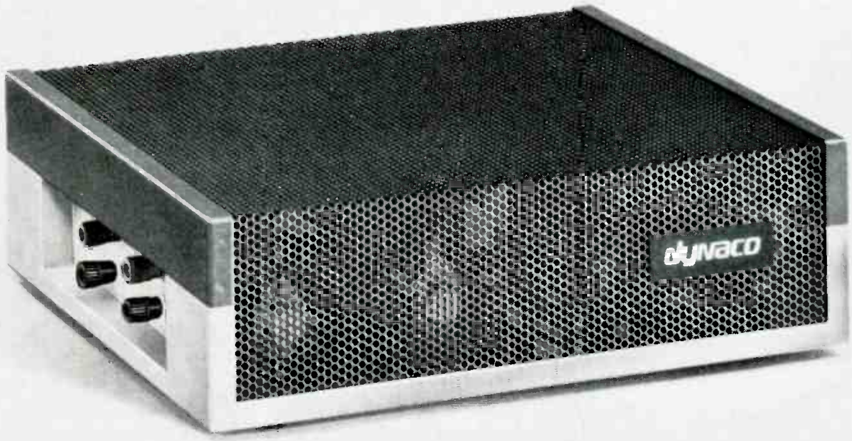
If one were to record and play a tape with a machine containing no frequency equalization, there would be considerable bass and treble loss in playback. For reasons having to do with maximization of S/N and minimization of distortion, it has been found desirable to correct for the bass and treble losses by supplying bass boost largely in playback, and treble boost laregly in recording. Accordingly, there are standard playback characteristics for each tape speed; the characteristic shows how much bass boost shall be supplied in playback. No standard characteristic is specified for recording. Instead, broadly stated, the standards provide that recording equalization (mainly treble boost) shall be such that, when taken in conjunction with playback equalization, the result shall be flat response (within specified tolerance limits). In other words, the record-playback process shall be such that the magnitude of each audio frequency relative to 1000 Hz (or relative to any other reference frequency) shall be the same at the output of the process as at the input.

The playback characteristic of a tape machine should be as shown in Fig. 2. For 15 and 7.5 ips, the standard response curve consists of about 36 dB of bass boost, commencing (3 dB up) at 3180 Hz and leveling off (3 dB below maximum) at 50 Hz. For 3.75 and 1.875 ips, there is about 31 dB of bass boost, this time commencing at 1770 Hz and again leveling off at 50 Hz.

It must be clearly understood that this playback curve is not simply that of an equalization circuit in the tape playback amplifier. Therefore it is not sufficient to measure the playback equalization of the tape amplifier to determine whether playback response is correct. Instead, the standard response curve is the *combined* result of the equalization circuit plus the deviations of the actual playback head from those of an "ideal" head. Compared with an ideal head (which displays response steadily rising 6 dB per octave for constant magnetic flux through the head), actual heads tend to display irregularities in the low-bass and high-treble frequencies. Typically these consist of moderate treble loss (due to gap width, and coil and cable capacitances), and exaggerated bass (due to the entire head and not merely its gap reacting to the flux emanating from the tape at long wavelengths, i.e. low frequencies). The playback amplifier is required to compensate for such aberrations, resulting in the *total* response curves of Fig. 2.

It is beyond the capability of most people to measure the total playback response of a tape machine, including that of the playback head. Therefore the means of checking playback response is to play a test tape and measure response at the output of the tape amplifier. (At the time of writing, the NAB test tapes are not yet available. However, other test tapes, such as those of Ampex, serve in the interim.) If the machine has perfectly accurate playback response, the output of its tape amplifier will be flat. In other words, all recorded frequencies on the test tape will have the same measured amplitude at the amplifier output.

The criteria of playback response are



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the width of the frequency range covered and the uniformity (flatness) of response over this range. In broad terms, the NAB standards suggest that high-quality performance requires a range of about 30 to 15,000 Hz for 15 and 7.5 ips; of about 50 to 10,000 Hz for 3.75 ips; and of about 100 to 5000 Hz for 1.875 ips. And for the bulk of each indicated range, these standards suggest a uniformity of about ±1 dB for 15 and 7.5 ips; of about +1, −1.5 dB for 3.75 ips; and of ±2 dB for 1.875 ips. Reduced to tabular form, these criteria also appear in Fig. 1.

The indications of Fig. 1 must be read with understanding and probably also with some grains of salt. For one thing, the suggested ranges presume that there is a compromise among the conflicting requirements of broad frequency response, low distortion, and high S/N. For another, the reader should not be too literal. For example, if the playback response of a machine at 7.5 ips is ±1 dB to 15,500 Hz rather than to 16,000 Hz, this too is probably excellent. Also, the reader should allow for some extra dropoff at the extremes of the audio range. To illustrate, if a machine maintains ±1 dB response between 50 and 12,000 Hz at 7.5 ips, but drops off to −2 dB at 30 and 16,000 Hz, this again is probably excellent.

We turn now to the question of record-playback response, and here we have a problem, namely the extent to which we should allow the NAB standard for professional machines to affect our viewpoint concerning machines for home use. The intention of NAB is that, regardless how inaccurate the playback response of a particular machine may be, its recording characteristic shall be accurate, enabling tapes recorded on this machine to yield flat response when played on *other* machines with accurate playback response. In other words, inaccuracies in playback response shall *not* be compensated by opposite inaccuracies in recording equalization so as to yield flat record-playback response.

This is appropriate for professional machines, which turn out recordings to be played in large part on other machines. But the recordings of home machines are played largely or entirely on the same machine. Therefore, in the case of home machines, we *are* concerned with the flatness of record-playback response, quite apart from the accuracy of playback response (important only in playing tapes made on other machines, such as pre-recorded tapes). Accordingly we shall be guided by NAB standards only in the following sense: permissible deviations from accurate recording will be added, more or less, to permissible deviations from accurate playback to arrive at a concept of accuracy on a record-playback basis.

Excellent, good, and fair *range* of record-playback response may be considered the same as for playback range of response, already discussed, and are also shown in Fig. 1. As before, understanding and salt are needed. For example, if response at 7.5 ips is down 2 dB at 13,000 Hz and 3 dB at 16,000 Hz, that is still excellent.

Head Gaps

Because a narrow head gap plays an important part in achieving extended treble response, specifications often state the gap width. Thus a typical figure for a playback head or a record-playback head is .00005″ — 50 micro-inches.

The recordist should realize that a narrow gap is crucial only for playback. For recording, a relatively wide gap is more desirable. If the tape machine has separate record and playback heads, an appropriate value for the record head is more nearly 500 than 50 micro-inches.

The question then is how narrow the gap need be to sustain treble response. A close answer may be obtained from the equation $G = 900{,}000S/2f$, where G is gap in micro-inches, S is tape speed in inches per second, and f is frequency in Hz. To illustrate, assume it is attempted to achieve substantially flat response to 10,000 Hz at 1.875 ips. The indicated gap width is $G\ (900{,}000 \times 1.875)/(2 \times 10{,}000) = 1{,}687{,}500/20{,}000 = 84$ micro-inches.

Since in actual tape machines one finds playback gaps as narrow as 50 micro-inches, and perhaps narrower, it is unlikely that gap width of this order is a limitation on treble response—assuming the gap has very straight edges as well as being very narrow. Much more likely as the cause of the limitation are the severe magnetic losses that occur in recording.

Tape Speeds

Earlier discussion has suggested the quality of performance which can be achieved at 7.5 ips, which is now the NAB standard speed, and at 3.75 ips. More explicitly, in the present state of the art—encompassing tape heads, tape electronics, tape, knowledge of optimum equalization techniques, and mechanical design— high-fidelity performance is readily achievable at 7.5 ips, and within grasp at 3.75 ips. In some top-flight home machines, performance at 3.75 ips is little if at all distinguishable to the ear from that at 7.5 ips, although instruments can measure differences. Hence it is desirable that a home machine offer tape speeds of at least 7.5 and 3.75 ips.

It doesn't defy memory to recall a time when tape recorders of good reputation sought to extend response only to about 8000 Hz at 7.5 ips. Today this kind of response is attainable at 1.875 ips, along with reasonably good performance in other respects (S/N, distortion, motion, and so on). Accordingly, 1.875 ips may now be considered a "serious," and therefore desirable, speed for such things as background music, speech, and other applications where requirements are less stringent than for high fidelity reproduction but nonetheless fairly demanding. The art advances.

Format

Quarter-track operation, either stereo or mono, is the usual format for home machines. That is, provision is made for recording four tracks, each nominally 43 mils wide, with three islands of 24 mils each between tracks. With tape moving from left to right and the oxide facing away from the operator, the tracks are numbered 1 to 4 from top to bottom of the tape.

For stereo, tracks 1 and 3 are used in one direction of tape travel, respectively carrying the left and right channels; tracks 4 and 2, respectively carryinging the left and right channels, are used in the other direction. For mono, the operating sequence is 1-4-3-2. In mono, the machine should be capable of recording each track individually; to make this point clear, the machine should not be erasing track 3 while recording track 1, and vice versa; nor should it be erasing track 2 while recording track 4, and vice versa. By the same token, the machine should be capable of playing each track individually.

Motion

The NAB standards require that flutter and wow, on an unweighted, rms basis, shall not exceed 0.2% at 7.5 ips, 0.25% at 3.75 ips, and 0.5% at 1.875 ips. Wow consists of a few (up to about 10) deviations per second from average tape speed; flutter consists of more frequent deviations. The flutter and wow percentage shows the relationship between the amount of speed deviation and the average speed.

Taking into account not only the NAB requirements but also the present capability of high quality home machines, these criteria are also tabulated in Fig. 1.

NAB requires that professional machines have a speed error of no more than 0.2% (plus or minus) throughout the reel. This means that in an hour of

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recorded material, there shall be a gain or loss of no more than 7.2 seconds, which is a rather rigorous requirement. The figures for speed accuracy are also shown in Fig. 1.

As an important operating convenience, particularly where time is money, professional machines provide for very fast wind and rewind of tapes, with a travel rate of about 1200 feet in 30 seconds being typical. In home machines, however, this is apt to take more like 60 to 90 seconds, and sometimes as much as two minutes. To us, a fast wind specification of about 60 to 90 seconds for 1200 feet appears more desirable than one appreciably under 60 seconds. The reason is that home machines seldom wind the tape as smoothly as professional machines do, and excessively fast winding may cause tape stresses that deform the tape and distort the sound.

Crosstalk

This refers to signal leakage between adjacent tape tracks. NAB specifies that between 200 and 10,000 Hz the difference between the original signal on one track and the leakage signal on the adjacent track shall be at least 60 dB. This may also be considered the standard of excellence for home machines. Inasmuch as S/N, although excellent, is likely to be a smaller figure—say 55 dB—then crosstalk is apt to be masked by other noise. Excellent, good, and fair performance criteria are tabulated in Fig. 1.

Channel Separation

This refers to signal leakage between channels of a stereo system—between the left channel and right channel sections of the tape heads, or between the left channel and right channel sections of the tape electronics. NAB specifies that between 100 and 10,000 Hz there shall be channel separation of at least 40 dB; this may be considered the standard of excellence for home machines as well, also shown in Fig. 1.

Why is the requirement for channel separation considerably less stringent than for crosstalk? The reason is that the question of channel separation arises only for stereo signals, which are ordinarily related to each other. Leakage of signal from one channel to the other is therefore unlikely to be audible, and if audible it is unlikely to be disturbing. But in the case of crosstalk, where adjacent tracks contain unrelated signals (see the earlier section on Format), a small amount of signal leakage can be audible and disturbing.

Record-Level Indicator

Inasmuch as the present subject ties in with distortion and S/N, the reader is referred back to the earlier sections on the latter two subjects for necessary background.

If the indicator is a magic eye tube, it has virtually instantaneous and full response to sharp transients. It truly indicates the level of signal peaks, which cause the most distortion. Accordingly, the magic eye should be adjusted so that it barely closes when recording a steady 400-Hz tone at a level that produces 3% harmonic distortion on the tape. Should the eye not close until a higher recording level is reached, excessive distortion may appear on the tape. Should the eye close before the 3% distortion level is reached, the recorded signal level may be of insufficient magnitude, resulting in poor S/N.

If the indicator is a VU meter (or a meter with reasonably similar characteristics), being a mechanical rather than electronic device it will not respond fully to signal peaks; it will tend to under-indicate their magnitude, inducing the operator to record at too high a level, with consequent excessive distortion. Therefore it is customary to provide "headroom" by having the meter indicate peak recording level—that is, 0 VU—well before a steady 400-Hz signal produces 3% THD on the tape. The general procedure is to allow about 8-dB headroom. One way is to adjust the meter to indicate 0 VU when recording a 400-Hz signal at a level 8 dB below the level which produces 3% harmonic distortion on the tape. Another, and approximately equivalent, way is to adjust the meter to indicate 0 VU when recording a 400-Hz signal at a level which produces 1% harmonic distortion on the tape. Hence the specifications should indicate that one of these two methods of adjusting the VU meter has been employed.

(A number of persons believe that 8 dB is often not enough headroom. Some program material may contain peaks as much as 15 and even 20 dB above the level indicated by the VU meter. Therefore, an electronic eye or an oscilloscope may be desired as an adjunct to or substitute for the VU meter as a record-level indicator. Another alternative is a peak-reading meter, rather than one which indicates average level as does the VU meter.)

Other Things to Consider

Thus far in the main we have been discussing the quality of performance of a tape machine as revealed by its specifications. The specifications may have a good deal further to say which is of interest to the audiophile. However, the additional information is likely to bear not on measures of performance but on *features* which provide operating convenience and flexibility. Following are a number of the features that may be specified. (The order of presentation is of no significance.)

Sound-on-Sound. This provides for synchronized, sequential recording of two or more sound sources on a single track. For example, one person can become a trio, quartet, and so on by: recording his voice on track 1; playing track 1, recording this signal on track 3, and at the same time adding his voice afresh to track 3; playing track 3, recording the track 3 signal on track 1, and adding his voice afresh to track 1; and so on as long as desired.

Echo Effect. This permits the recorded sound to be repeated on the same track at small intervals and at successively diminishing magnitudes, thus achieving an effect akin to an echo.

Reverse Operation. This saves the operator the inconvenience of having to interchange the tape reels on the hubs when desiring to operate the tape in "opposite direction" — for example when desiring to record tracks 4 and 2 after recording tracks 1 and 3. Instead, the machine permits the direction of tape travel to be reversed. A number of machines feature automatic reverse; some only in playback, and others both in recording and playback; some only in one direction of tape travel, and some in both directions.

Tape Lifter. Some machines permit the tape to remain in contact with the heads when the tape is being rapidly wound or rewound, thereby accelerating head wear. The tape lifter spaces the tape away from the heads during rapid wind.

Pause Control. Generally, if the tape machine is in the recording mode and if the transport is stopped, the machine is automatically taken out of recording mode, thereby avoiding accidental erasure when operation is resumed. However, a pause control may be offered that enables the user at his option to stop the transport yet keep the machine in recording mode.

Tape Counter. To facilitate finding a passage in a reel of tape, most home machines provide a digital counter with a reset knob or button.

Push-Button Controls. Some machines use relatively "primitive" means of putting the transport through its modes of operation — by knobs or a "joystick." Others offer push-button controls. These may still be mechanical devices, although fancier in appearance. Or they may control solenoids, enabling the user to operate the transport easily and quickly with a light touch.

Inputs and Outputs. The tape recorder should have at least two inputs,

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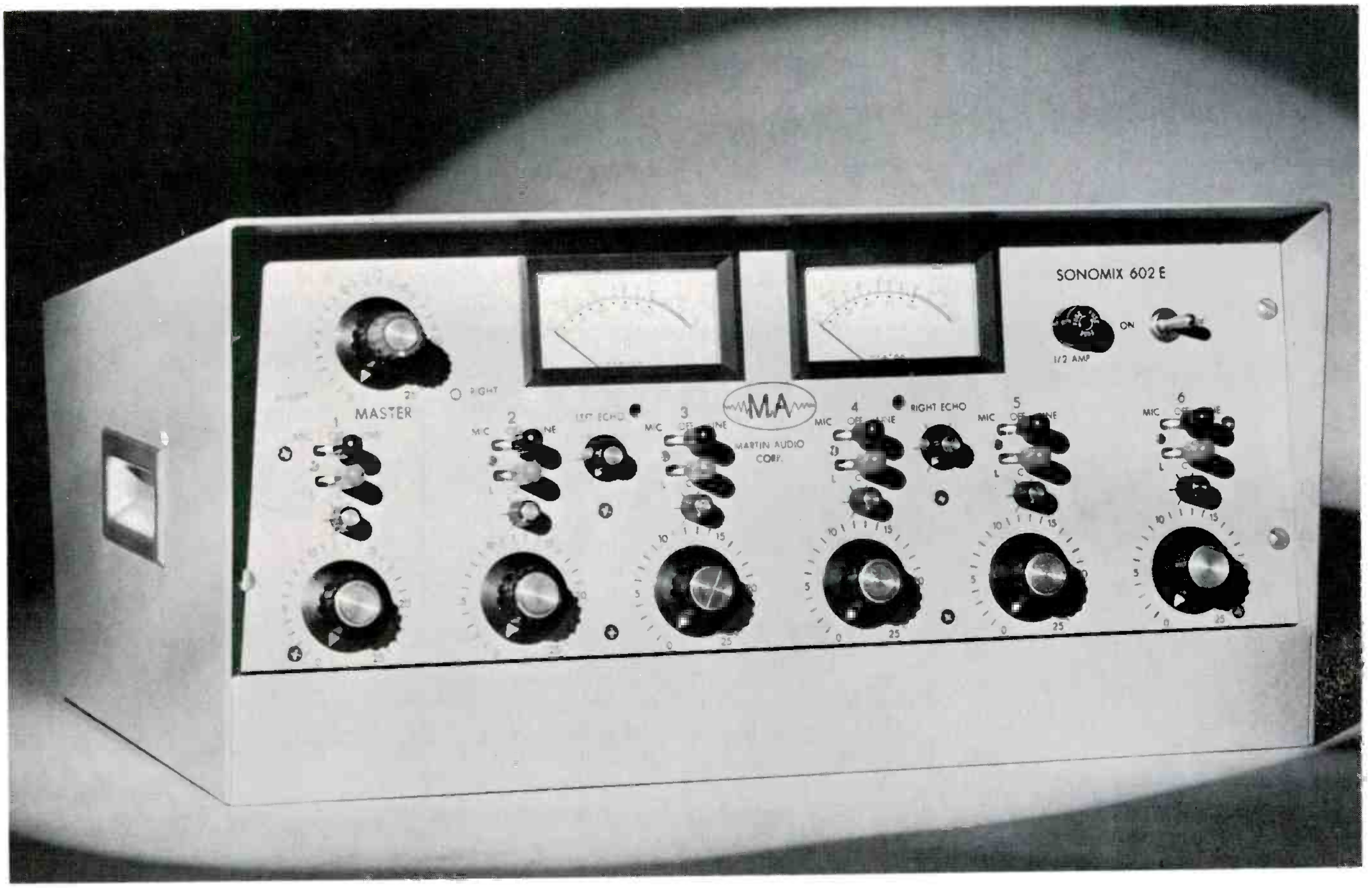

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one for high-level sources such as a tuner or audio preamplifier; and the other for low-level sources such as a microphone (and sometimes for a magnetic phonograph pickup, including proper equalization). If the tape machine contains its own power amplifier and speaker, it should still provide an output jack for feeding an external amplifier. For minimum distortion, the output signal should be taken at a point prior to the output transformer (if any) of the internal amplifier. It is further desirable that the machine provide a second output jack for an external speaker; in this case the signal would be taken from a point following the internal amplifier.

Returning to the subject of a low-level input for microphones, most home machines provide only for accepting the signal from a high-impedance microphone, which puts out a relatively high signal. Some, however, provide for accepting the signal from low-impedance microphones, which deliver less signal but permit a long run of cable between the microphone and tape recorder without appreciable loss of highs. (If the tape recorder will accept only a high-impedance microphone and the recordist wishes to use a low-impedance microphone, it is necessary for him to insert a step-up transformer between the microphone and the recorder.)

Input & Output Sensitivity. High-level sources such as FM tuners, TV, audio preamps, and so on, ordinarily deliver at least 0.5 V. Therefore the figure for input sensitivity of the tape recorder on high-level input should be no more than 0.5 V; in other words, no more than 0.5 V should be required to drive the tape recorder to peak recording level as shown by the record-level indicator. To allow some margin of safety, a number of machines have input sensitivities ranging down to about 0.1 V.

Similarly, the tape recorder should have adequate sensitivity on low-level input. The sensitivity figure should be no more than about 10 millivolts, while a sensitivity of about 2 or 3 millivolts is preferable.

Inasmuch as most high-fidelity amplifiers or preamps can be driven to the desired level by a signal of about 0.1 to 0.5 V, the tape recorder should be able to deliver a correspondingly strong output signal. Allowing for a margin of safety, the tape recorder should be able to deliver peak signals of about 1 V to following audio equipment.

Automatic Equalization Change. Equalization requirements vary with tape speed both in recording and playback. Most home machines automatically provide the necessary change in equalization as the user selects the desired tape speed. However, in some top-flight recorders this change is not performed automatically, and it is necessary for the operator to keep his wits about him to make sure that he does not use the wrong equalization in recording. (Making a mistake in playback is much less consequential, because no *permanent* harm is done by forgetting to set equalization correctly.)

A-B Switch. A machine having separate record and playback heads and thereby permitting simultaneous recording and playback will usually (but not always) incorporate an A-B switch. When recording, this permits the playback signal to be compared with the incoming signal, so the operator can check recording quality for such things as faithful frequency response, low distortion, and high S/N. By flipping the A-B switch between the positions representing the input and playback signals, he obtains an almost instantaneous and valid comparison. The comparison can be made by means of earphones, or by one's audio system if properly connected to the tape recorder. (The A-B switch is not strictly necessary, because audio preamps generally contain such an A-B switch.)

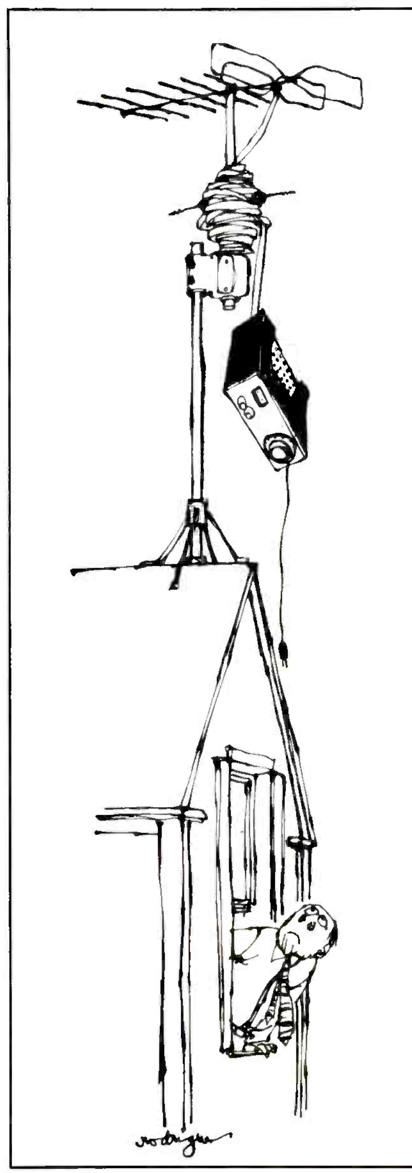
Bias Indication. Correct setting of bias current through the record head is critical in order to achieve the optimum combination of extended treble response, low distortion, and high S/N. This setting is performed by the manufacturer at the factory, or else by a competent technician or machine operator. To make sure that bias is at the proper value, some of the best machines enable bias to be read on the machine's VU meter at the turn of a switch.

Adjustment Facilities. In order to achieve optimum performance, the tape recorder should permit a variety of fine adjustments, including bias magnitude, bias frequency, input gain, output gain, record-level indication, erase current, azimuth, and perhaps others (such as equalization). To the extent that the tape machine contains controls facilitating such adjustments, one can get the maximum performance designed into the machine. (Of course these adjustment controls add to the cost of the machine and to the complexity of maintaining it.)

Editing Facilities. If the user wishes to edit tape in fine detail—for example by making splices at a given syllable or musical note—it is important that the transport provide easy access to the portion of the tape that is directly in front of the heads. It is also necessary that the operator be able to move the tape by hand past the playback head and thereby find exactly the sound he is looking for. Some machines pay careful attention to such editing facilities.

Number of Motors. It is well settled by now that a tape transport with a single motor rather than three (one for driving the capstan and the other two for driving the supply and takeup reels) can deliver mechanical performance of excellent quality. However, for greater durability, greater operating convenience, and faster and smoother rapid winding, three motors tend to be superior. These virtues are generally of more importance to the professional user than to the home recordist. There is some gain with a one-motor machine in terms of a lighter, more compact, and less expensive machine.

The better home machines usually employ a synchronous motor to drive the capstan; this helps to achieve accurate speed and keep speed constant throughout the reel. Æ



the birth of the AR-5

This is a photograph taken immediately after our final test of the prototype of the AR-5. The speaker system was measured while buried in a flat, open field, facing upward, its front baffle flush with the ground. This technique provides more accurate information than indoor tests, especially at low frequencies, where the precision of such measurements is adversely affected by the limited size of an anechoic chamber.

Our standard of accuracy when measuring the AR-5 prototype was the sound of live music, that is, absolute accuracy of reproduction. At AR, the best response curve for a speaker system, like that for a microphone or amplifier, is the one which most closely matches the input.

The specifications which AR advertises are obtained from production units, not prototypes. All AR-5 systems must match the performance of the prototype within close tolerances. To see that this is true, every AR-5 is tested numerous times in ways which permit it to be compared to the prototype. Only in this way can we be certain of what we have made, and consumers certain of what they are being offered.

AR speaker systems have uniformly received favorable reviews in publications which carry test reports. But even more accurate and comprehensive tests than most of these magazines perform are made on the AR production line, of every AR speaker system which will go into a listener's home.

The AR-5 is priced from $156 to $175, depending on cabinet finish.

ACOUSTIC RESEARCH, INC., 24 Thorndike Street, Cambridge, Mass. 02141

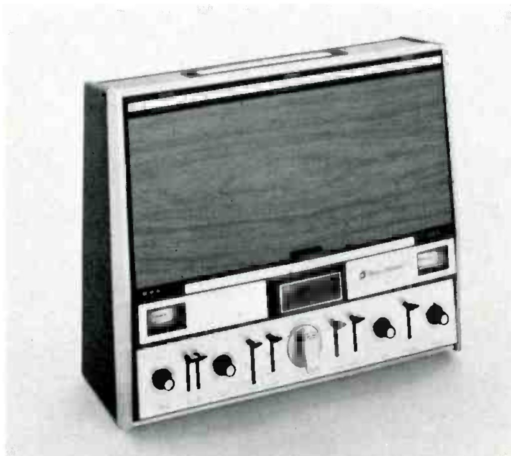
Overseas Inquiries: Write to **AR International** at above address

Check No. 33 on Reader Service Card

AUDIO Tape Recorder Directory

Ampex 1461

Allied TD-1070



Bell & Howell 2297

Crown CX-844

• SPEEDS ARE INDICATED BY LETTERS

A – 7½, 3¾, 1⅞
B – 7½, 3¾
C – 7½, 3¾, 1⅞, 15/16
D – 1⅞
E – 15, 7½, 3¾
F – 15, 7½
G – 15, 7½, 3¾, 1⅞
H – 3¾
J – 3¾, 1⅞
S/S – Sound on Sound
SWS – Sound With Sound

MANUFACTURER (Circled numbers indicate adv. page)	Model	Max. Reel Size, In.	Built-In Power Amps.?	Speeds •	No. of Heads	Tracks	No. of Motors	Drive Motor Type	Drive to Capstan	Wow & Flutter, 7½ ips, %	Wow & Flutter, 3¾ ips, %	THD at Max Rec Level, %	Timing Accuracy, %	1200 Ft. Rewind Time, Secs.	Mic Input Sens., mV.	Mic Input Imp., Ohms	High Level Imp., Ohms	Mixing Facility	Vol. Ind. Type	7½ ips, Freq. Resp., Hz	Dimensions, W x D x H, In.	Weight, Lbs.	Price	SPECIAL FEATURES
ALLIED (82)	TR-1040	7	Yes	A	2	4	1	4-p Cap. start	belt	0.1	0.2	1.1	99.7	95	0.1	10K	100K	No	2 VU	40-16K	18½ x 9⅞ x 13⅝	32	179.95	S/S; det. spkrs; spkr. & headphone outputs.
	TR-1070	7	No	A	4	4	1	4-p Cap. start	belt	0.15	0.2	1.0	99.7	90	0.66	10K			2 VU	20-20K	21 x 18 x 8	36	299.95	Auto record/playback reverse.
	TR-1080	7	Yes	A	4	4	1	4-p Cap. start	belt	0.15	0.2	1.0	99.7	90	0.66	10K			2 VU	40-19K	21 x 19 x 8	42	349.95	As above.
AMPEX (35)	761	7	Yes	A	3	4	1	4-p	belt	0.15	0.15			150		150K	220K	No	2 VU	50-15K ±4 dB	23½ x 8½ x 14	42	329.00	S/S; SWS; echo; cube speakers.
	2150	7	No	A	4	4	1	Hys-Sync	belt	0.12	0.15			130		110K	200K	No	2 VU	50-17K ±4 dB	18⅝ x 7 x 13¾	29	399.00	Bi-directional record; auto reverse; auto threading.
	1461	7	Yes	A	4	4	1		belt					150		150K	220K	No	2 VU	50-15K ±4dB	23½ x 8½ x 14	40	429.00	S/S; SWS; echo; cube spkrs; auto reverse; auto threading.
	2161	7	Yes		4	4	1	Hys-Sync	belt	.08	0.15		99	120	2-600	110K	200K	Yes	2 VU	50-17K ±4 dB	18¾ x 13⅝ x 7⅞	42	499.95	Bi-directional recording; auto reverse; auto threading.
	AG-500	7	No	A opt. F	3	Opt.	1	Hys-Sync.	belt	0.17	0.25	3.0	99.8	90	0.15	30-250	100K	Yes	2 VU	60-10K ±2 dB	14 x 9½ x 15	28	660.00	2 inputs/chan; sep. gain controls; avail. ½ or ¼ track.
BELL & HOWELL	2291	7	No	C	2/4	4	1	4 p	Idler/belt	.09	0.15	<1.0	99.75	120	1.5	150K	240K	Yes	2 VU	40-17K ±3 dB	15½ x 13¼ x 8½	22	299.95	Auto-load; auto-reverse.
	2295	7	Yes	C	2/4	4	1	4 p	Idler/belt	.09	0.15	<1.0	99.75	120	1.5	150K	240K	Yes	2 VU	40-17K ±3 dB	15½ x 13¼ x 8½	25	349.95	As above. but incls. stereo pwr. ampl., 8.4 W/chan, 50-15,000 Hz.
	2297	7	Yes	C	2/4	4	1	4 p	Idler belt	.09	0.15	<1.0	99.75	120	1.5	150K	240K	Yes	2 VU	40-17K ±3 dB	15½ x 13¼ x 8½	25	399.95	As above, but pwr. ampl. is 15 w/chan.
CONCERTONE	790	7½	Yes	C	3	4	1	d.c. gov.	Idler	0.2	0.25		99		-55 dB	50K	75K	No	2 VU	30-15K			239.95	A.C batt. oper.
CONCORD	776	7	Yes	B	3	4	1	Hys	belt	<0.15	<0.18	1.5	98	150	0.5	10	1.5 Meg.	Yes	Dual VU	30-15K ±3 dB	20 x 13 x 13	40	350.00	Auto rev.; auto shutoff.
CRAIG	2704	C-90 CAS	No	D	2	4	1	Semi-Sync	belt		0.35 1⅞	3.0	97	90 (C-60)	0.74	20K	100K	Yes	mtr.	50-10K	14¼ x 3¾ x 9¼	13	139.95	Deck only.
CROWN (80)	SX-724	10½	No	B	3	4	3	Hys	belt	.09	0.18	1.5	99.8	45	0.4	350K	100K	Yes	Dual VU	30-20K	20 x 13 x 13	45	995.00	Dual mixing; 2-track play opt. "X" case & 30-30 ampl. opt.
	SX-824	10½	No	B	3	4	3	Hys	belt	.09	0.18	1.5	99.8	45	0.4	350K	100K	Yes	Dual VU	30-20K	19 x 15¾ x 9	48	1495.00	Pro-800 transport, computer logic; electronics as above; rem.cont. opt.
	CX-724	10½	No	A	3	4	3	Hys	belt	.09	0.18	1.5	99.8	45	0.3 opt.	350K opt.	100K	Yes	Dual VU	30-30K	19 x 15¾ x 9	50	1295.00	Dual mixing; tone conts; echo; plug-in modules; Lo-Z mikes opt.
	CX-822	10½	No	E	3	2	3	Hys	belt	.09	0.18	1.5	99.8	45	.01	250 bal.	100K	Yes	Dual VU	30-30K	19 x 15¾ x 9	53	2120.00	Pro-800 transport, CX-724 electronics; rem.cont. opt; with noisless "Record."
	CX-844	10½	No	E	3	4-ch.	3	Hys	belt	.09	0.18	1.5	99.8	45	.01	opt. 250 or Hi-Z	opt. 600 bal.	2 mics. chan.	4 VU mtrs.	30-30K	19 x 24½ x 9	66	2880.00	Pro-800 transport; opt. Trac-Sync; noiseless rem. rec. control; 600-Ω bal. out.

Will your tape recorder sound as good in December as it did in May?

How do you *know* that a tape recorder will sound as good in seven or eight months as it does when it's new? You obviously don't. Not with most. But you *do* with an Ampex player/recorder. Because of the exclusive, deep-gap Ampex heads.

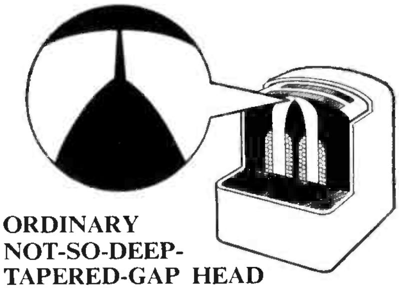
AMPEX 755 TAPE DECK

Let us explain. The head is the most important part of any player/recorder. It is an electromagnet which puts sound on magnetic tape (when recording) and recreates sound from patterns on the tape (playback).

The rest of the recorder is designed to do nothing more than get the most out of the heads.

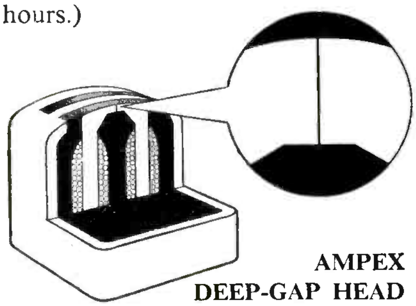
All tape heads are produced to have the smallest possible air gaps between their poles. Because the smaller the gap, the higher the frequency that can be recorded or played back at a given tape speed.

It would stand to reason then, that every manufacturer would try to make its head gaps as small as possible. And they do . . . at the *top* where the tape meets the head. The trouble is, they have a great deal of difficulty keeping the gaps *straight*.



ORDINARY NOT-SO-DEEP-TAPERED-GAP HEAD
(Typical head used by other manufacturers)

Take a look at the drawing of the ordinary tape head above. It has a pole gap distance of about 1/30th the width of a human hair. *To begin with.* But, as the head begins to wear down, the pole gap begins to widen. And the frequency response begins to deteriorate. So the unit can't possibly sound the same in December as it did in May. And in a relatively short time the head has to be replaced. We call this kind of typical head "*tapered shallow-gap head.*" (Under ordinary circumstances it wears out in 500 to 1000 hours.)



AMPEX DEEP-GAP HEAD
(Exclusively on Ampex Player/Recorders)

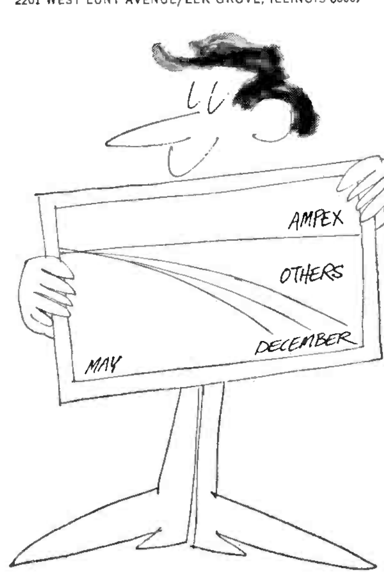
But *Ampex deep-gap heads* don't have that problem. Because they consist of two parallel poles brought together to the precisely proper distance by a unique process. This manufacturing technique is exclusive with Ampex. It's much more time consuming, and requires painstaking microscopic precision. But, it's worth it. Because, even as Ampex heads begin to wear down, *the gap distance continues to remain constant.* And so does your frequency response!

And in addition, because Ampex does not use pressure pads, Ampex deep-gap heads wear much more slowly. Don't be surprised if they last well over twelve years, even if you use your player/recorder two hours a night, every night. (That's about 10,000 hours, as compared to about 500-1000 for other tape heads.)

So, if you're confused by all kinds of claims for frequency response, remember that frequency response usually drops after use. Except with Ampex player/recorders. There's no mystery. (1) *Ampex heads last much longer.* (2) *Even when they do wear, the gap never varies and neither does the frequency response.* Which is why you'll be ahead with Ampex. Way ahead.

AMPEX

AMPEX CORPORATION/CONSUMER EQUIPMENT DIVISION
2201 WEST LUNT AVENUE/ELK GROVE, ILLINOIS 60007



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Tape Recorders (continued)

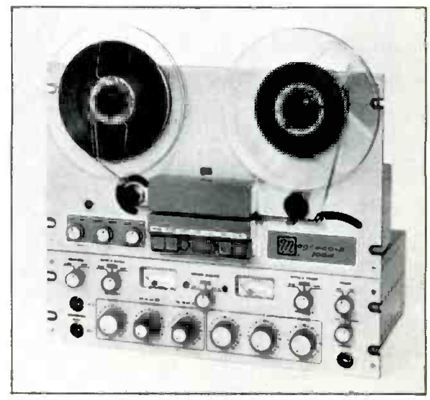
Dynaco B & O 2000

Fisher RC-70

Knight-Kit KG-415

Harman-Kardon TD3

KLH 40



Magnecord 1024

MANUFACTURER (Circled numbers indicate adv. page)	Model	Max. Reel Size, In.	Built-in Power Amps.?	Speeds *	No. of Heads	Tracks	No. of Motors	Drive Motor Type	Drive to Capstan	Wow & Flutter, 7½ ips, %	Wow & Flutter, 3¾ ips, %	THD at Max Rec Level, %	Timing Accuracy, %	1200 Ft. Rewind Time, Secs.	Mic Input Sens., mV.	Mic Input Imp., Ohms	High Level Imp., Ohms	Mixing Facility	Vol. Ind. Type	7½ ips, Freq. Resp., Hz	Dimensions, W x D x H, In.	Weight, Lbs.	Price	SPECIAL FEATURES
DYNACO (27) (81)	B&O 2000	7	Yes	A	3	4	1	Hys	Idler	.075	0.11		99.8	100	.05	200		Yes	2 VU	40-16K ±2 dB	17⅜ x 13¼ x 8¼	38	498.00	Slide-type mixing controls; plug-in circuits.
FISHER (37)	RC-70	C-90 CAS	No	D	2	4	1	d.c. contr.	belt		0.25 @ 1⅞				0.2	600	100K		Dual VU	30-12K	5⅛ x 11 3/16 x 2 15/16	4½	149.95	Auto motor shut-off. Incls. pair of dyn. mics.
HARMAN-KARDON	TD-2	7	No	A	2	4	1	4-p	Idler	0.1	0.12	1.0	99.8		0.5	10K	500K	Yes	Dual VU	30-20K ±2 dB	11⅝ x 9⅝ x 6	16	149.50	Die-cast metal chassis.
	TD-3	7	No	A	3	4	1	Hys	Idler	0.1	0.12	1.0	99.8		0.5	10K	500K	No	Dual VU	30-22K ±2 dB	11⅝ x 9⅝ x 6	16	219.50	As above; 40 micro-inch gap in play head.
	CAD-4	C-90 CAS		D	2	4	1				0.25 @ 1⅞	1.5			0.2	2500	200K		Dual VU	30-12½K ±2 dB		10	159.50	Digital counter, auto shutoff;
KLH	40	7	No	B	3	4	3	Ind.	belt	0.1	0.15	1.0	>99	65	0.5	200K		Yes	VU mtr.	*	16 x 14⅜ x 7¼	60	600.00	Dolby Noise reduc. sys. *Freq. resp. 3¾ ips, 45-15KHz ±2½ dB; 7½ ips, 45-20KHz ±2½ dB.
KNIGHT-KIT (82)	KG-415	7	No	B	3	4	2	4p	belt	<0.2	<0.3	<1.5	98	90	1.5	3000	50K	Yes	2 VU	50-18K	14 x 9⅛ x 14½	30	249.95K K	S/S; SWS; Viking transp.; Kit of electronic components.
LAFAYETTE (79)	RK-920	7	No	A	4	4	2		Dual belt	0.2	0.25		99			10K	500K		Dual VU	30-22K	17 x 8¼ x 15½	38	199.95	3 auto modes, incl. rev. S/S; SWS.
	RK-845	7	Yes	A	2	4	1	4p	belt	0.15	0.15		99		0.15	600	700K			40-18K	15¾ x 7 5/16 x 14	29	229.95	Auto shut-off; 2 6 x 7 spkrs; S/S; SWS.
	RK-960	7	Yes	A	4	4	2		Dual belt	0.25	0.25		99			10K	500K		Dual VU	30-22K	22 x 8¼ x 15½	44	299.95	3 auto modes; incl. rev.; S/S; SWS.
LEAR JET	A-219	ctg		H	1	8			dir.	-	0.3			-	-	-	-	No	-		8 x 7½ x 3	9	119.95	Automobile cartridge player; no record facility. Pwr: 4w/chan.
MAGNECORD (TELEX) (45)	1020	8¼	No	B	3	4	3	Hys	belt	0.17	0.22	1.0	99	80	0.27	50K	hi	Yes	2 VU	45-18K ±3 dB	17 9/16 x 13 1/16 x 6⅝	35	570.00	
	1022	8¼	No	B	3	2	3	Hys	belt	0.17	0.22	1.0	99.8	80	0.38	150	hi	Yes	2 VU	30-16K ±2 dB	19 x 15¾ x 12	48	869.00	
	1024	8¼	No	B	3	4	3	Hys	belt	0.17	0.22	1.0	99.8	80	0.32	50K	hi	Yes	2 VU	45-18K ±3 dB	19 x 15¾ x 12	48	725.00	
	1028	10½	No	F	3	2	3	Hys	belt	0.1		<1.0	99.8	50		50K	160K	No	2 VU	35-16K ±2 dB	17 9/16 x 13 1/16 x 6⅝	47	1198.00	

The world's most powerful, most sensitive, most versatile receiver costs $449.95.*

The new Fisher 500-TX not only puts out more clean watts, picks up more clean stations, features better controls and provides greater convenience than any other receiver in history. It is also the biggest per-dollar value, with a price of $449.95*.

More power.

The Fisher 500-TX delivers 190 watts into normal, 8-ohm speaker systems. Enough power to drive speakers throughout your home. And that's clean, distortion-free power. Harmonic distortion at full rated output at 1 kHz is only 0.5%. Intermodulation distortion at rated output is 0.8%.

More stations.

The tuner section of the 500-TX receiver is comparable in every respect to expensive, state-of-the-art, separate tuners.

Dual-gate MOSFET RF and mixer stages can handle input signals varying in strength over a range of 600,000 to 1, without overload and without the need for a Local/Distant switch! The highly selective crystal filter in the IF strip is the same type as those used in professional communications receivers and makes possible the clean reception of a weak, distant station even when it is between two strong, local stations on the dial. This is one of the main reasons why the 500-TX can add new stations to your accustomed FM fare. (FM sensitivity, 1.7 microvolts, IHF.)

More ways to tune.

There are four ways you can tune the Fisher 500-TX. In addition to conventional flywheel manual tuning of AM and FM stations, there's also Fisher Tune-O-Matic™. This permits electronic pushbutton tuning of any four preselected FM stations. Then there's the unique Fisher AutoScan™. Touch one of two buttons and the next FM station up or down the dial is automatically tuned in. Hold down either button and all FM stations up or down the dial come in, one by one. And a remote control accessory lets you activate the AutoScan from your easy chair.

Many more features.

For a complete listing of features and specifications of the Fisher 500-TX, send for the new Fisher Handbook.

The Fisher®

Mail this coupon for your free copy of The Fisher Handbook 1969. This reference guide to hi-fi and stereo also includes detailed information on all Fisher components.

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*Walnut cabinet $22.95 additional.

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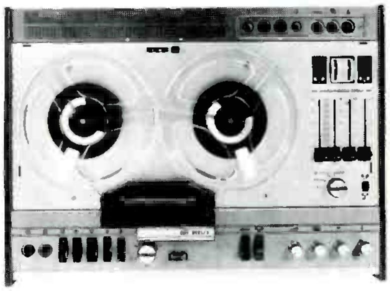
Tape Recorders (continued)

Norelco 4408



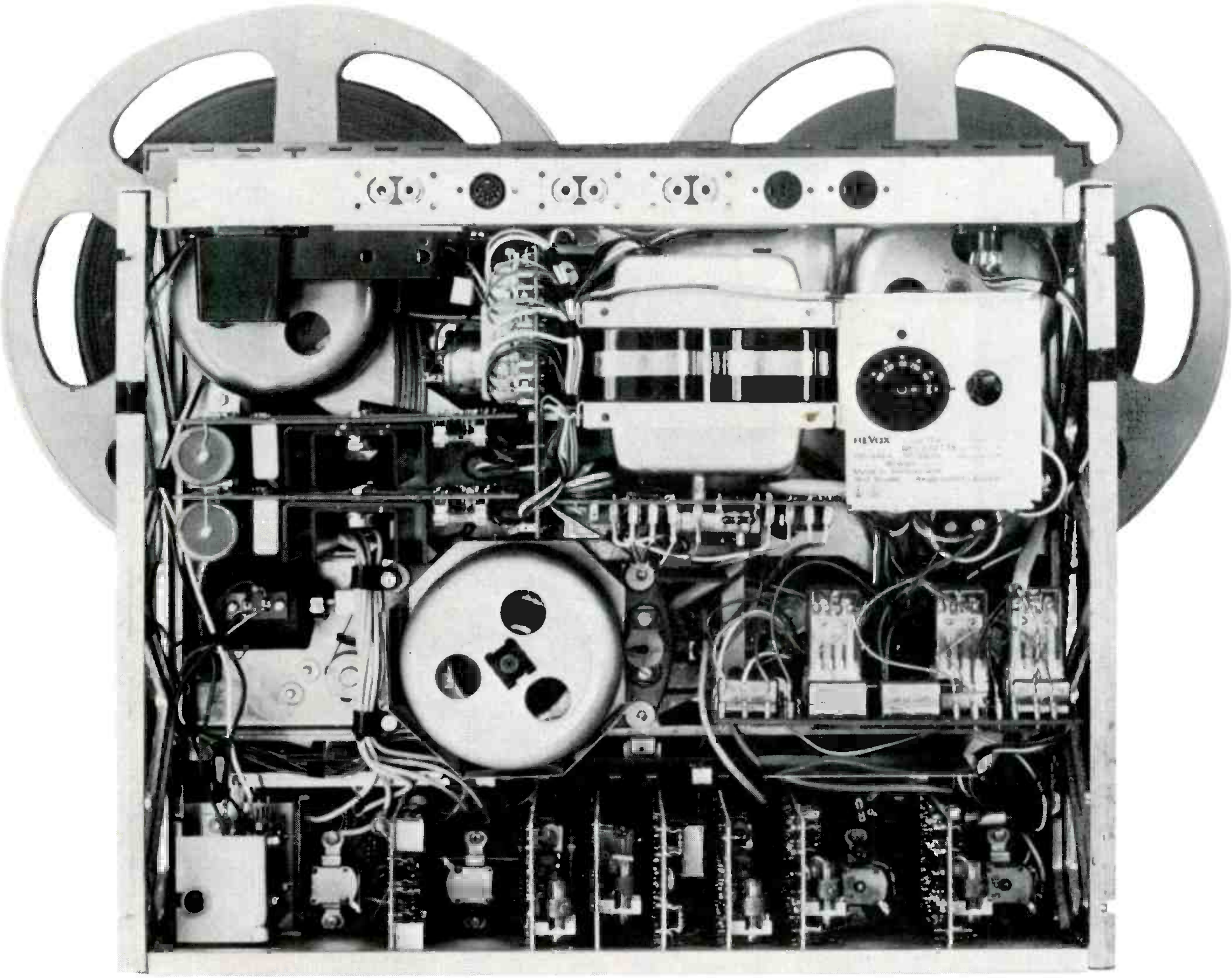
Nordmende 8001/T

Panasonic RS-796US

Sony/Superscope TC-666D

ReVox 77A

MANUFACTURER (Circled numbers indicate adv. page)	Model	Max. Reel Size, In.	Built-In Power Amps.?	Speeds *	No. of Heads	Tracks	No. of Motors	Drive Motor Type	Drive to Capstan	Wow & Flutter, 7½ ips, %	Wow & Flutter, 3¾ ips, %	THD at Max Rec Level, %	Timing Accuracy, %	1200 Ft. Rewind Time, Secs.	Mic Input Sens., mV.	Mic Input Imp., Ohms	High Level Imp., Ohms	Mixing Facility	Vol. Ind. Type	7½ ips, Freq. Resp., Hz	Dimensions, W x D x H, In.	Weight, Lbs.	Price	SPECIAL FEATURES
NORDMENDE	8001T	7	Yes	A	3	4	3	Hys	belt	0.1	0.15	1.0	99	48	0.2	500	10K	Yes	Dual VU	40-18K	20 x 14 x 6	47	429.95	Built-in 4-channel mixer.
NORELCO	150	C-90 CAS		D	2	2	1	tr.reg. d.c.	belt									No	mtr		4¼ x 2¼ x 7¾	3	64.50	Mono cassette "Carry-Corder"; incls. spkr, mic.
	2401	C-90 CAS	Yes	D	2	4	1	Sync	belt		0.4 ±1⅞				0.25				mtr.	60-10K ±3 dB	15 x 9¼ x 5¼	11	249.95	Stacks & plays 6 cassettes automatically; 2 mics; rec, pub. add-
	4408	7	Yes	A	2	4	1	Ind.	belt	0.2			99	60	0.25	2000	500K	Yes	2 mtrs.		19 x 13 x 8½	28½	349.50	Duoplay; S.S. auto-stop; hor. or vert. oper; stereo mic.
PANASONIC	RQ 204	C-90 CAS	Yes	D	2	2	1		belt										ARL	80-8K	9 x 10 x 2¾	4½	49.95	Pop-up cassette player mono ARL = auto. record level.
	RS 766	7	No	A	2	4	1	4p	Idler	0.1	0.15			180		10K	1.5 M	No	2 VU	30-18K	13¼ x 5½ x 11	17½	149.95	
	RS 765	7	No	A	2	4	1	4p	Idler	0.1	0.2			180		20K	100 K	No	2 VU	30-18K	13¾ x 6¼ x 11	16	125.00	Headphone output.
	RS 790S	7	Yes	A	4	4	1	4p	belt	0.1	0.15			180		20K	100 K	Yes	2 VU	30-20K	17 x 9 x 16½	38¼	329.95	Continuous auto reverse; dual capstan system
	RS 796	7	No	A	4	4	1	4p	belt	0.1	0.15			180		20K	100K	No	2 VU	30-20k	19½ x 7¾ x 14	38	249.95	Continuous auto reverse; headphone output.
REVOX (39)	77 A	10½	opt.	B	3	4 2 opt.	3	Servo	dir.	.04	.05	1.0	99.8	45	0.15	10-hi	1 meg	Yes	2 VU	20-22K ±2 dB	16 x 8½ x 14	34	499.00	W/wood case, opt. pwr. amps, $70; other cases & acces.
RCA	MLC-20	ctg.	No	H	1	8	1														6¾ x 9¾ x 3⅝	8	69.95	8-track cartridge player.
ROBERTS (AKAI)	1725-III	7	Yes	A G opt.	2	4		Ind.	belt	0.2	0.3	3.0	97	75	2.0	500K	500K	No	2 VU	40-18K	14 x 13½ x 12	36	269.95	2 detachable spkrs.
	778X	7	Yes	A G opt.	3 2 cart	4		hys	belt	0.18	0.3	2.0 3.0	98	75	0.5	50K	150K	No	2 VU	30-23K	17 x 14 x 11	50	429.95	Compatible reel-to-reel and cartridge rcdr; crossfield head.
SONY/ SUPERSCOPE (17) (77)	TC-50	C-90 CAS	Yes	D	1	2	1	d.c.	belt		0.35 ±1⅞				.078	low		No	mtr.	80-8K	3⁹⁄₁₆ x 1⁷⁄₁₆ x 5⁷⁄₁₆	1¼	125.00	Built-in mic; AGC record mono.
	TC-100	C-90 CAS	Yes	D	2	2	1	d.c.	belt						.078	low	100K	No	mtr.	50-10K	5⁹⁄₁₆ x 2⅜ x 9⅜	3¹³⁄₁₆	99.50	Tone control; AGC record mono.
	TC-230 TC-230W	7	Yes	A	2	4	1	Ind.	Idler	0.1	0.15			150	0.14	low	100K	No	2 mtrs.	30-18K	17 x 9⅜ x 14	29	249.50 239.50	Mag. phono cart. input; W mod w spkrs; wal case.
	TC-355	7	No	A	3	4	1	Ind.	Idler	.09	0.12	<1.6		150	0.19	low	100K	No	2 mtrs.	20-22K	15³⁄₁₆ x 7¹⁵⁄₁₆ x 14	22	229.50	s.s. 160 kHz bias; scrape filter; headphone output.
	TC-666D	7	No	B	4	4	3	hys. sync.	belt	.09	0.15	<1.5		60	0.19	low	100K	No	2 mtrs.	20-22K	17³⁄₁₆ x 8¹⁵⁄₁₆ x 16⅝	48½	575.00	Auto reverse, rec and pb. scrape filter; auto noise red.
	TC-770-2 TC-770-4	7	No	A	4	4	1	d.c. Servo	belt	.09	0.12	<2.0		120	0.2	250	100K	Yes	2 VU	20-22K	16⅛ x 5¹³⁄₁₆ x 15⁵⁄₁₆	24¹³⁄₁₆	750.00	Built-in limiter; scrape filter; auto noise red; speed timing.



the inside story of Willi Studer

The Revox A77 is Willi Studer's brain child . . . born from years of experience designing magnetic recording equipment for the broadcasting and recording industries. This is a great machine that comfortably outperforms recorders costing even three times as much. Audio Magazine reported "the flattest machine we have ever tested." We've shown you the inside, too often overlooked. Let your Dealer show you the elegant styling and fine finish. Priced from $499.00 at leading high fidelity specialists.

To know the detailed inside story on Willi Studer's Revox A77 read the fully descriptive story from **Revox Corporation** 212 Mineola Avenue Roslyn Heights N.Y. 11577 Telephone (516) 484-4650

In Canada contact
Tri-tel Associates Ltd Toronto Canada

REVOX

Check No. 39 on Reader Service Card

Tape Recorders (continued)

Uher 9500

Tandberg 64X

TEAC A-7030

Viking 433

Wollensak (3M Co.) 6200

MANUFACTURER (Circled numbers indicate adv. page)	Model	Max. Reel Size, In.	Built-in Power Amps.?	Speeds *	No. of Heads	Tracks	No. of Motors	Drive Motor Type	Drive to Capstan	Wow & Flutter, 7½ ips, %	Wow & Flutter, 3¾ ips, %	THD at Max Rec Level, %	Timing Accuracy, %	1200 Ft. Rewind Time, Secs.	Mic Input Sens., mV.	Mic Input Imp., Ohms	High Level Imp., Ohms	Mixing Facility	Vol. Ind. Type	7½ ips, Freq. Resp., Hz	Dimensions, W x D x H, In.	Weight, Lbs.	Price	SPECIAL FEATURES
TANDBERG	1521	7	Yes	A	2	2				<0.1	<0.15	<1.0	98.5		0.1	200	1 meg	No	mtr.	30-20K ±2 dB	15 x 11 13/16 x 6¾	19.2	287.00	Mono.
	1241X	7	Yes	A	3	4	1	4p		<0.1	<0.15	<1.0	98.5					No	dual mtr.	20-25K ±2dB	15⅝ x 11 15/16 x 6⅞	23	485.00	Cross field head; 2 int. spkrs, ctr chan output.
	64X	7	No	A	4	4		hys sync		<0.1	<0.15	<1.0	99	98	0.125	5 meg	1 meg	No	eye tubes	20-25K ±2 dB	15⅝ x 11 13/16 x 6¾	23	549.00	Tube-type; cross-field head ctr. chan output.
	11-2	7	Yes	A	4	2				<0.15	<0.25	<0.5	99						VU mtr.	30-20K ±2 dB	13 x 10 x 4	9.5	449.50	Batt. oper. mono. portable; 5" reels w/cover on.
TAPESONIC	70 TRSQ	10½	No	E	3	4	3	hys	dir.	0.12	0.23		99.8	45				Yes	2 VU		21 x 19 x 8½	69**	615.00	**w/case (34.50 extra) VU meters are 4½".
TEAC	A-20	C-90 CAS	No	D	2	4	1	hys Sync	dir.		0.19 @ 1⅞	1.6	99.6	70 (C60)	0.3	600	120K	Yes	dual VU	50-10K ± 3 dB	9¾ x 10 x 4¼	10	139.50	Pop-up cassette holder; incls unidir stereo mic; pause button.
(41)	A-1200U	7	No	B	3	4	3	2-spd hys	belt	0.12	0.15	1.5	99.4	100	1.0	10K	100K	Yes	dual VU	30-20K ± 3 dB	15½ x 17 x 9¾	46	299.50	S/S; walnut cab.; 4-digit cntr. half- and full-track mods. available.
	A-4010SU	7	No	B	4	4	3	2-spd hys	belt	0.12	0.15	1.2	99.5	100	0.25	10K	100K	Yes	dual VU	30-20K ±3 dB	17⅛ x 17¼ x 9¾	48	409.50	Foil-sensing auto reverse; opt. rem. cont; tape-tension control; tks opt.
	A-6010	7	No	B 15 opt.	4	4	3	2-spd hys	belt	.08	0.12	.09	99.8	90	0.5	10K	300K	Yes	dual VU	30-20K ± 2 dB	17½ x 20⅞ x 8¼	46	664.50	Phase sensing auto reverse; rev. and repeat play; rem. cont. opt.; tks opt.
	A-7030	10½	No	F	**	4	3	2-spd hys	belt	.08	-	.04	99.8	120	0.5	10K	300K	Yes	dual VU	30-24K ± 2 dB	17½ x 20⅞ x 8¼	57	749.50	**4 hds: 2-tk 2-chan. fwd. rec., pb, and erase 4 tk, 2-chan playback; reel ten. adj.
UHER	7000	7	No	B	4		1	Sync	Idler	.08	0.12	3.0	99.5	100	0.35	2000	47K 1 meg	No	2 VU	40-18K ± 2 dB	15 x 14 x 7	15	149.50	Tape deck
	7300	7	No	B	3	4	1	Sync	Idler	0.14	0.18	3.0	99	100	0.35	2000	47K 1 meg	No	mtr.		15 x 14 x 7	15	199.50	A-B monitor
	4000L	5	Yes	C	2	2 mono	1	Servo cont. dc.	belt	0.18	0.22	3.0	99.5	120	0.1	2000	47K 1 meg	No	mtr.		11 x 9 x 3½	7	440.00	Portable, batt. oper.
	9500	7	No		4	4 (2)	1	hys	Idler	.05	.08	1.0	99.8	60	0.2	200	47K ½ & 1M	Yes	2 VU	20-20K ± 2 dB	18 x 14 x 7¾	34	450.00	Slide proj. sync; s/s; sws; echo 4 speeds; servo clutch system.
	1000	5	Yes			4	1	ind d.c.	belt	0.1	0.12	1.0	99.5	120	0.2	200	47K 1 meg	No	VU	40-20K ± 2 dB	11 x 9 x 3½	8	695.00	Portable batt. oper. prof. rcdr. w/Pilotone sys. for MP use.
VIKING	811	8-tr cart	Yes	H	1	8	1	ind	belt		0.3												99.95 149.95	Table-top unit; auto & pb track selector w/2 satellite spkrs; 811 W.
(45)	423	7	No	A	2	4	3	ind	belt	0.2	0.2	1.5	99.5	70	0.55	2500	120K	No	dual mtr	80-15K	15¾ x 12⅝ x 8¾	29	274.95	
	88	7	No	B	3	2 & 4	2	ind	belt	0.2		1.0	99.5	90	1.0	hi	100K	No	dual mtr	30-18K	13 x 13 x 6⅝	22	349.95	
	433	7	No	A	3	4	3	ind	belt	0.2		1.0	99.5	70	0.55	hi	120K	Yes	dual mtr	40-18K	12⅝ x 15¾ x 8¾	31	374.95	
	880	7	Yes	B	3	4	2	ind	belt	0.2		1.0	99.5	90	1.0	hi	100K	No	dual mtr	30-18K	21½ x 14⅝ x 9¼	44	449.95	In portable case; headphone jack.
WOLLENSAK	1500 SS	7		B		2				<0.3			98		0.3	27K	470K		mtr	40-15K ± 3 dB	11 x 10 x 6	16	185.00	Mono.
	6200	7	Yes	B		4	2	ind	Idler	0.15	0.2		98	90	0.1	500	270K		dual mtr	40-15K	16½ x 13½ x 6½		200.00	Open front threading, built-in spkrs.; Mod 6100 deck, $140.00.
	6300	7	Yes	B		4	2	ind	Idler	0.15	0.2		98	90	0.1	500	270K		dual mtr	40-15K	16½ x 13½ x 6½	22	230.00	As above, but w/sep. spkrs.
	4800	C-90 CAS	Yes	D		4	1				<0.3 @ 1⅞				0.1	500	270K		dual mtr	70-10K ± 3 dB	13⅞ x 9⅛ x 4⅞	21½**		Cassette recorder/player **Incls. spkrs.

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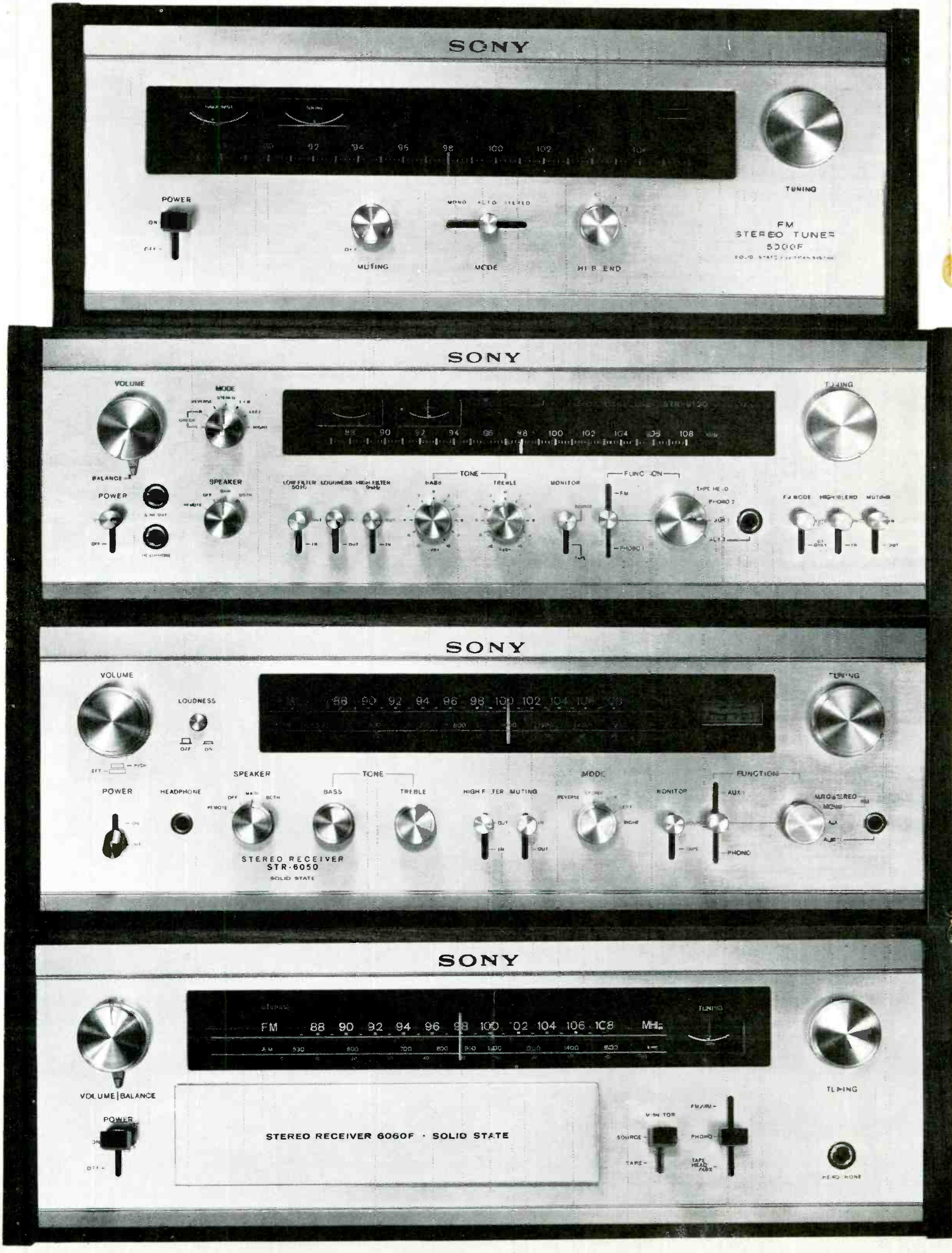
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Video Tape Recorder Directory

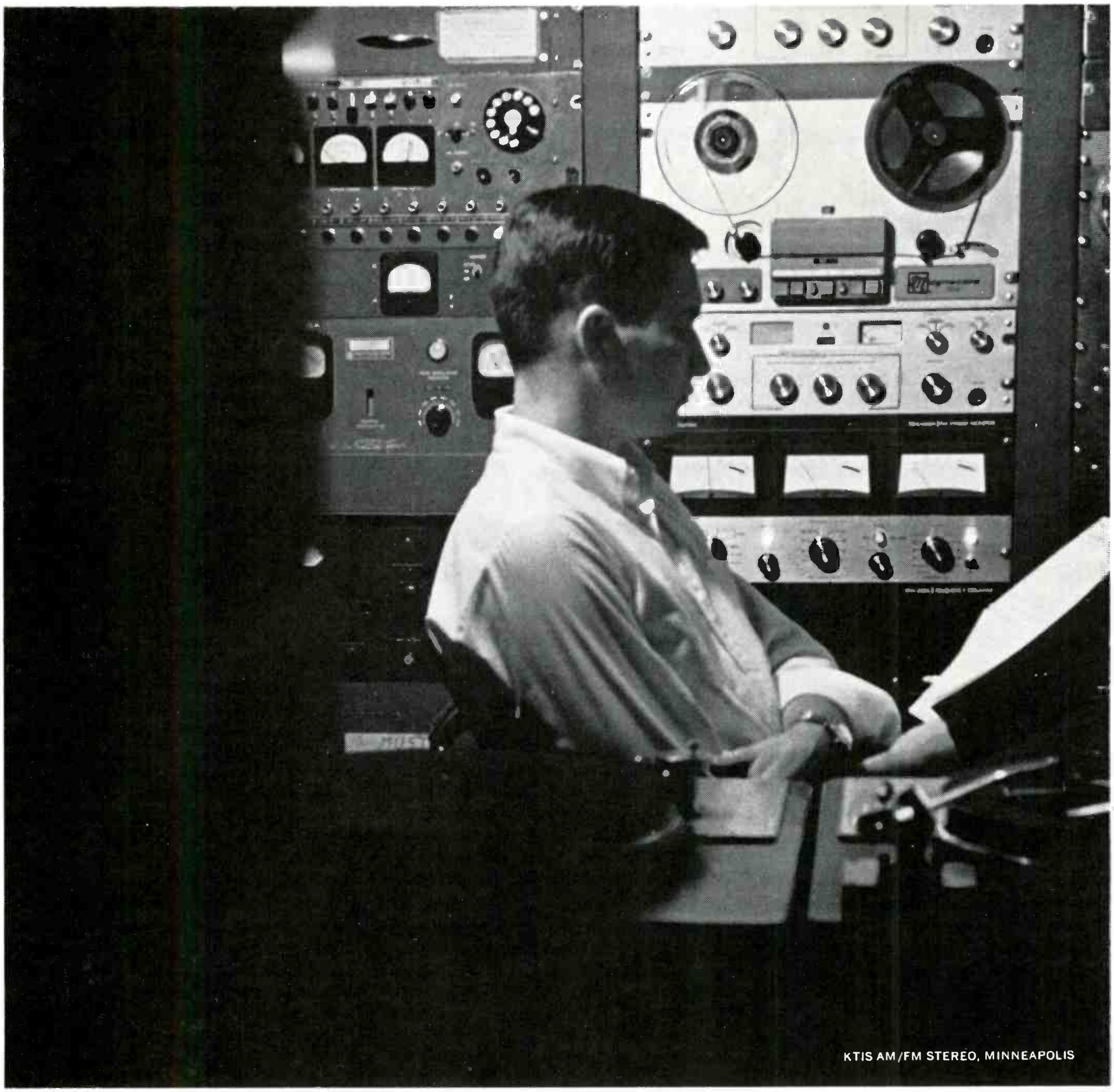
Panasonic NV-8100

Wollensak (3M Co.) VTR-150

Ampex VR-7000

Sony TCV-2110

MANUFACTURER (Circled numbers indicate adv. page)	Model	Tape Width, In.	Tape Speed, IPS	Equiv. Tape Speed IPS	Video Bandwidth, Hz–MHz	Lines Resolution	Audio Freq. Resp. Hz	Weight, Lbs.	Price	SPECIAL FEATURES
AMPEX	VP-4900	1	9.6	1000	30-3.0 +2, −6 dB	3300-330	90-9K ± 4 dB	61	995.00	Playback unit only, 4 min. fast forward & rewind.
	VR-5100	1	9.6	1000	30-2.5	250	90-9K ± 4 dB	62	1600.00	Tapes interchangeable on any other 1" helical-scan Ampex VTR.
	VR-7000	1	9.6	1000	30-3.5	350	50-12K ± 4 dB	100	2500.00	Guar. tape interchangeability on any other 1" hel-scan Ampex VTR; may be modified for color
CONCORD	VTR-900	½	12	484	30-2.5 M	250	50-12K	52	995.00	Simple oper; p.b. controls; plays back thru std TV; portable.
	VTR-600	½	12	484	30-2.5 M	250	80-10K	52	1150.00	Built-in head cleaning; portable.
	VTR-620	½	12	484	30-2.5 M	250	50-12K	52	1050.00	p.b. elect. editing, audio dubbing;monitoring of audio & video; ferrite video heads; p.b. head cleaning.
	VTR-700	½	12	484	30-2.5 M	250	50-12K	60	1495.00	Rem. cont. oper; auto rem. activation; cont. rec. & p.b., auto rewind; auto shut off.
CRAIG	6401	½	9.5			250	70-10K	65	850.00	Rotary-transformer-coupled Video head assembly; color adaptable; automatic audio level control; remote cont. opt.
	6402	½	9.5			250	70-10K	59	1200.00	As above, but with built-in sync generator; editing; slow motion automatic video level control.
PANASONIC	NV-8000	½	12	484	to >2 M	>220	80-10K	54½	800.00	Audio dubbing; r.f. adaptable; video hd. auto clean.
	NV-8100	½	12	484	to >2 M	>220	80-10K	54½	950.00	as above.
	NV-8100D	½	12	484	to >2 M	>220	80-10K	54½	1050.00	as above, plus electronic editing.
	NV-204	½	12	484	10-3 M	350	50-12K	97	3750.00	Still/slow motion; r.f. adaptable, full remote control video head auto-clean.
SONY	CV-2100	½	7½	450	30-2.5	220	80-10K	49	795.00	Video/Audio AGC, Audio Dub, Editing, easy operating, portable.
	CV-2200	½	7½	450	30-2.5	220	80-10K	49	850.00	Video/Audio AGC, Audio Dub, Editing, easy operation, portable, RF Tape Duplicating.
	TCV-2110	½	7½	450	30-2.5	220	80-10K	70	1050.00	Built in Monitor, Receiver, Video/Audio AGC, Audio Dub, Editing, easy operating.
	DVK-2400	½	7½	450	30-2.5	220	80-10K	10.8	1250.00	Battery operated Videocorder/Camera ensemble, Zoom Lens, 1" tube Viewfinder, Battery charger included.
	EV-210	1	7½	600	30-3.5	300	50-12K	88	3750.00	NTSC Color Adaptable, Slow-Still motion, 2 Audio Channels, Remote Control, Electronic Editing option.
WOLLENSAK (3M Co.)	VTR-150	½	7½	180	50-2 M		50-10K	50	995.00	Simple function conts; spec. ferrite head, 1-yr warranty and promise of much longer life.
	VTR-150 MC	½	7½	180	50-2 M		50-10K	275	2495.00	Complete mobile sys. includes above recdr, camera, tripod, mon. receiver; switching control panel; mic; headphones, in convenient console.



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The Commonality of
Speaker Systems & Musical Instruments

ANTONY DOSCHEK

Part 2: Chordophones

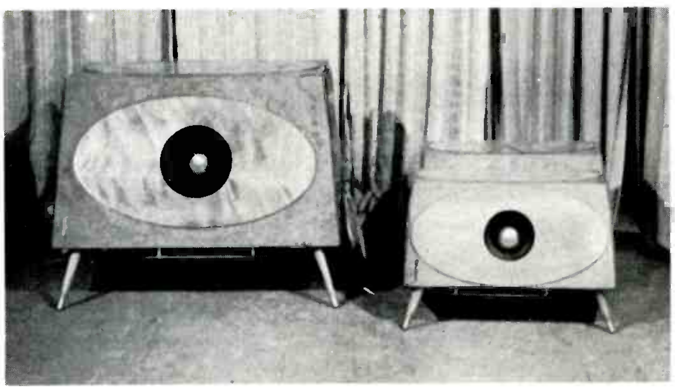
It is reasonable to assume that the very first use of mechanical sound-producing devices was intended merely to attract attention. Acoustical artifacts antedate the growth of musical expression as an art form. But historians still speculate as to whether wind or string instruments were man's first attempts to create mechanical sounds of definite pitch. Though we find Assyrian picturizations of wind instruments resembling the later Greek pipes-of-Pan, we also read of string instruments in early Sanskrit writings. The question is of considerable academic interest in view of the fact that the instruments of the modern orchestra still employ the same acoustical principles that our progenitors used to sound a Philistine alert.

The broad family of string instruments, the chordophones, is divisible into three general classes; depending upon the manner in which the strings are set into vibration. The strings of harps and harpsicords, guitars, zithers, mandolins, banjos, etc., etc., are plucked, while violin-family strings are bowed and piano strings are struck. The chordophones have three other features in common: bridges, resonators, and string tensioning apparatus. The fundamental purpose of bridges is to convey string vibrations to the resonators, and their exact design is of considerable consequence to the character of instrument tone. Resonators may be vibratile slabs or enclosures provided with sound outlets or, as in the case of the banjo, stretched membranes. The fundamental purpose of resonators is to amplify string vibrations to a usably audible level, though here again their design has a predominant effect on tone intensity and color.

For musicologists who still debate the precedence of plucked or bowed instruments, we may offer a guess based on technological arguments: It is probable that the weak, short duration sound given off by early plucked instruments led some prehistoric Heifetz to devise the bow so as to be able to make a sound of long duration; thereby creating the first ancestor of the much abused, but musically prodigious violin family.

The many ancestors of the modern violin are often mentioned by name in musical essays, but there seems to be a certain uncertainty regarding the chronology of the several species. Just for the record, therefore, we may indulge in a mnemonic play involving a cast-of-characters and their order of appearance. The curtain opens on "the villagers"; an assortment of Indo-European and Arabic descent. The principals among them are the *rebec*, the *troubador-fidel*, the *minnesinger-fiddle*, the *gulsa*, the *organistrum* or hurdy-gurdy *vielle*, and a seven-feet-high contraption of string-bean proportions called the *nun's-fiddle* or *marine-trumpet*. (The semantic association of the latter two names is a fine research project for a rainy Sunday afternoon.) The protagonists of this cast were the minnesinger-fiddles who, being dissatisfied with the existing disorder, elected to reform into a consort of viols; two members of which—the *viola d'amore* and the *viola da gamba*—may still be heard (but weakly) in Bach's "St. John Passion." The early leaders of this group were the *discant* (treble viol), the *viola-da-braccio* (arm viol), and *the viola-de-gamba* (leg viol). The viols, with six or more strings apiece and some with drone strings, overtaxed the players' ability to keep them in tune and a transistory simplification was introduced in the form of two five-string viols called the *treble-* and the *tenor-quintons*. However, the end of the quinton's parvenu reign is foretold in the next scene by the appearance of three hybrid furies in the forms of the *tenor-violin*, *bass-violin*, and *basso-da-camera*. The prophesy of the coming of a pontifical hero, the *viola*, thickened the plot; but the hero's feminine lead, the *violin*, was considered to be too sensual to be admitted to

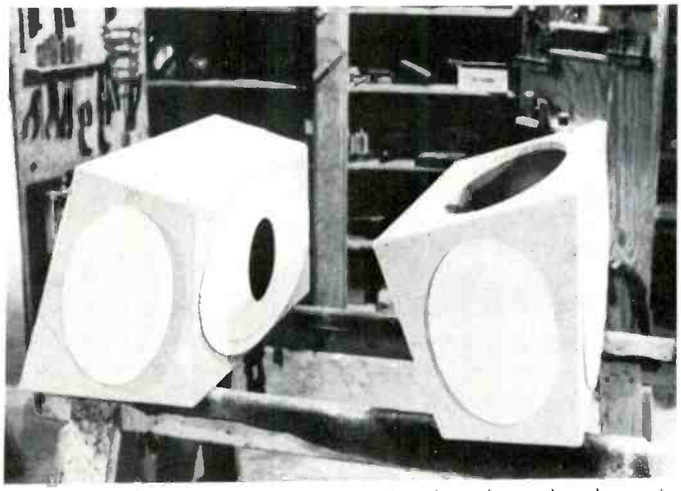
ORCHESTRAD SYSTEMS: paracubical tuned Helmholtz resonators with 5 vibratile sides tuned to a broad series of fundamental frequencies; no internal batting; 12-inch and 8-inch single, wide-range drivers; within the acoustic power handling capabilities—more than sufficient for rooms up to 3000 cubic feet—these systems display a transparent, widely-dispersed sound, but a high-resolution frequency response curve shows a very jagged, large peak-to-trough ratio. Nevertheless, every time that the Orchestrad systems were exposed for judgment alongside some of the best of the flat-response systems, Orchestrads were preferred by a very large majority of the trained listeners that were normally invited (musicians and audiophiles). The reason for this was never discovered.



the church music of the time. It is assumed that the *cello* played the bad guy (badly, because it was sometimes tuned a semi-tone below the other strings) and the bull-fiddle took the comedy relief part. At this point Gaspard da Salo, Maggini, the Amatis, Stradivarius, and the Guarneris, among others, directed the leads into formal lines, setting the stage as we have it today.

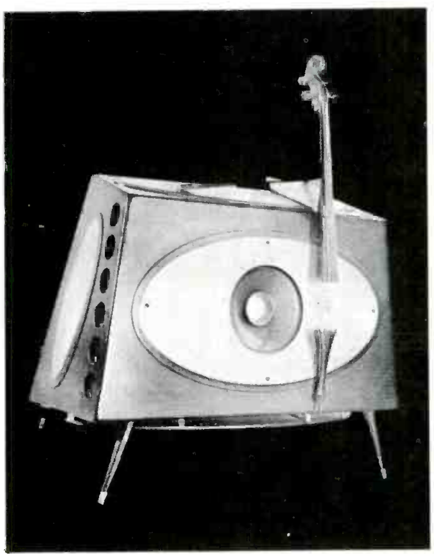
But the play has an epilogue: even after the 'grande luthiers' had perfected the bowed family of strings, three more types made a short-lived appearance in the forms of the *violetta-marina*, the *viola pomposa*, and the *violino piccolo*, for which both Bach and Handel scored parts. Furthermore, scientists still study the acoustics of the violin; a recently developed instrument said to possess great tonal beauty is being demonstrated in the Netherlands. But by far the most concentrated scientific approach to the study of string instrument acoustics is being carried out right here in our United States by individual researchers (see indices of the *Journal of the Acoustical Society of America* and, collectively, by the *Catgut Acoustical Society*.

The vibrating string itself, of course, is the motor that drives the resonators of the chordophone family. The transverse mode of a string's vibration is easily seen by flicking a taut rubber band, which then disturbs the surrounding air sufficiently to produce a weak sound of definite pitch. When a string is spanned across the body of a resonator its physical motion sets the resonator plates and cavity into vibration and these, depending upon their design, amplify the string's vibrations as well as adding new frequencies of their own. However, the 'transverse' is not the only mode of vibration that a string has; two other modes are present simultaneously — the 'longitudinal' and the 'torsional.' If we picture an instrument such as a violin, which has an erect bridge to conduct string vibrations to its *belly* (the plate on which the bridge rests), we can visualize the transverse mode as influencing the bridge into a rolling motion; that is, the bridge actually describes an elliptical movement in its own plane. The longitudinal mode flexes the crown of the bridge back and forth along the axis of the string. But the effect of the torsional (twisting) mode is minor for strings as thin as those used on a violin. Nevertheless, the torsional mode of vibration does influence tone color on instruments using thick and heavy strings, such as the bull-fiddle or the grand piano. Furthermore, a string can vibrate in a large number of frequencies, all at the same time. Its fundamental pitch is determined by its length, mass, and tension; its harmonic and overtone frequencies by the point along its length at which it is plucked or bowed. These complexities are compounded in practical instruments by additional frequencies set up in the belly being fed back to the string via the bridge. It is plain, therefore, that the musical tone produced by a simple vibrating string is a horrendously complicated matter; and it gets more so as we look further into it.



ORCHESTRAD SYSTEMS: shells and plates during one stage of manufacture; the plates were tuned by internal scraping after affixing to the shell. This was done by exciting the shell with an electromagnetic driver while a contact microphone at the center of the plate fed the principal resonant mode to read-out equipment. The plates were made from high quality piano sounding board wood and surprisingly good uniformity was achieved.

ORCHESTRAD SYSTEM: modified with cello assembly to prove that its behavior is similar to that of a string instrument; within the limits of bow crossings, the instrument (hybrid?) was quite playable as a cello and displayed very good bass quality; during a meeting of the Acoustical Society of America, a two-part canon was performed on the instrument by a recorded piano part being reproduced by the speaker while the author played the the second part "live."



First-order approximations of the acoustical behavior of chordophone resonators are easy to understand. The front and back plates, and the *ribs* (sides), of most instruments form a hollow box enclosing a definite volume of air. The front plates are perforated by one or more apertures of definite area called *sound holes,* and these couple the air contained within the body of the instrument to the air of the listening room. When we have, within an enclosure, a known volume of air which can move to the outside through a known area we can apply several formulas to predict the resonant frequencies of the enclosure. The fundamental air resonance of a violin can be demonstrated by blowing across a sharp edge of an f-hole, which should sound a frequency close to the pitch of the open D-string (about 293 Hz). Such an enclosure is called a Helmholtz resonator, in honor of one of the first great investigators in the technology of music and acoustics. However, the thin, graduated plates of a string instrument impart resonant frequencies of their own to the cavity resonator, and the whole assembly acts as a broad-band acoustic amplifier. If the plates and ribs of an enclosure were not capable of vibrating, only those frequencies at or near the resonant modes of the enclosure would be audible to any practical extent, and the enclosure, acting somewhat like a closed-end pipe, would amplify its fundamental modes and a series of odd-order harmonics. This is a clue to the derivation of the name "marine-trumpet" for the previously mentioned nun's-fiddle: because only the fundamental and the odd-order series of harmonics were loud enough to be of any consequence these were the ones normally played, as on a bugle, and, for some reason, the instrument was often found in convents throughout Middle Europe.

Fortunately, the plates of string instruments do vibrate and, therefore, produce resonances of their own to assist the air cavity in providing a more-or-less uniform amplification of all frequencies within the *compass* (range) of the instrument. Ideal plates or slabs—that is, those of uniform density and thickness, under no tension, and of some regular geometric shape such as a square, circle, etc.—show a fundamental vibrational mode and a number of overtone modes which are *not* harmonics of the fundamental. When plates take highly irregular shapes, are not uniform in density or thickness, and are placed under the tension of the strings, varnish, and ribbing, their resonant frequencies completely defy engineering formulas. It is for this reason that the creation of concert-quality string instruments is still a fine art in this age of technical achievement. It is design experience, workmanship, and intuition that makes one builder produce fine pianos, for example, and another great pianos.

Another important factor affecting the sound of chordophones is their directional patterns. Except in high frequencies, most string instruments radiate sound quite well to the rear of their bodies and in many directions other than at right angles to their plates. Design curvatures account for these curious characteristics and, at the same time, avoid interior standing-waves, which would inhibit the radiation of their cavity resonances at standing-wave frequencies. But because the various frequency regions of a string instrument are constantly shifting directions with respect to the listener, their sound is unique and difficult to reproduce with spacial fidelity in a close-up listening situation such as an average living room, whereas the listener can be fooled in an auditorium because much of the sound he hears arrives via wall reflections.

Loudspeaker Analogy

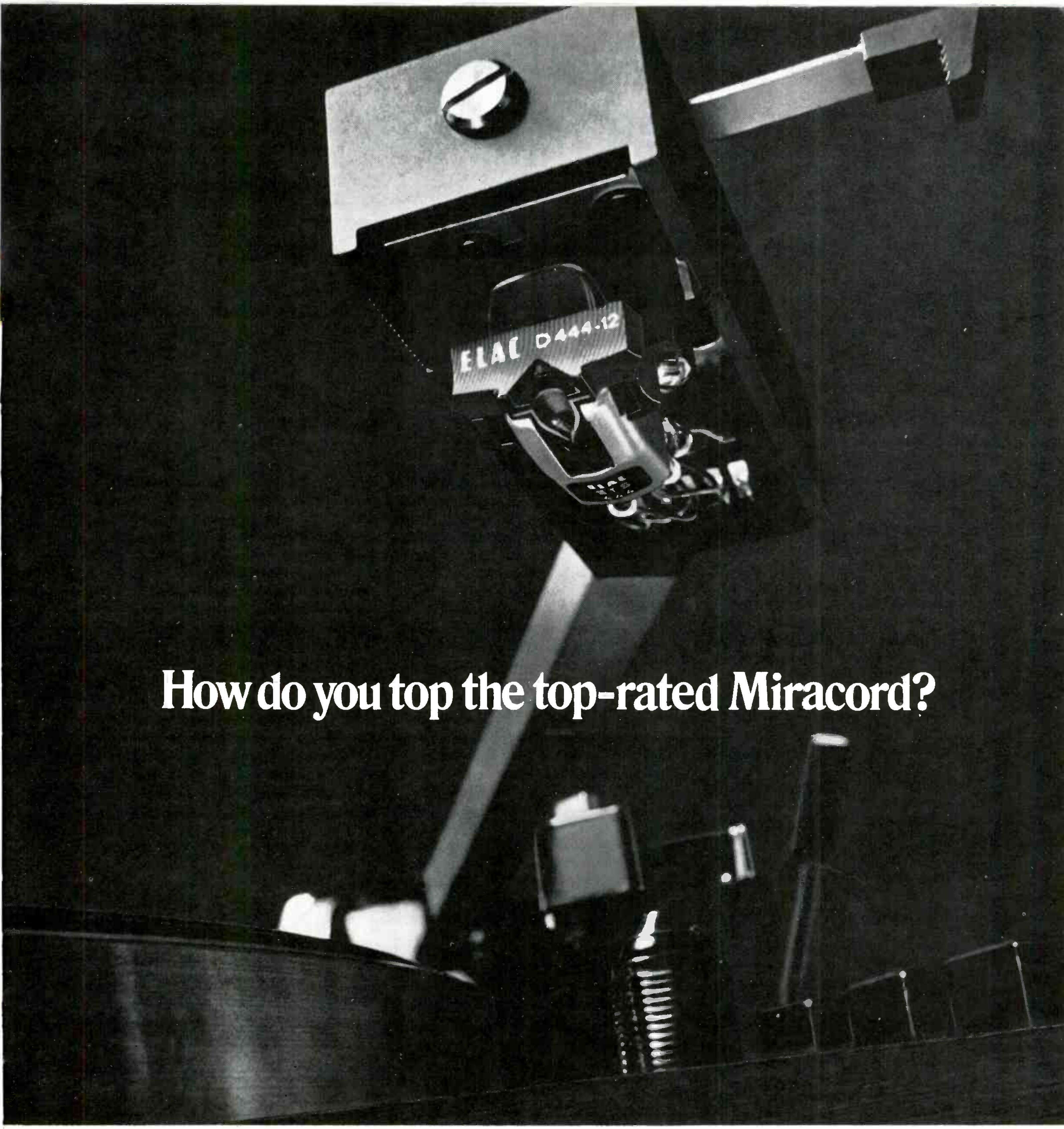
Cone driver loudspeakers and enclosures are kissing-cousins of string instruments. Though fully sealed boxes of *infinite baffles* and *acoustic suspension* systems radiate no cavity sound, their cones do flex somewhat like the vibratile plates of chordophones. Because flexural plate vibrations will generate audible frequencies foreign to the program signal, cones have been designed in which the material (generally paper) tapers radially in thickness, or are hyperbolically or parabolically curved, or carry molded or fabricated reinforcing ribs, or where the cone is stiffened with a phenolic impregnant. None of these expedients is entirely successful, of course, so that loudspeakers all exhibit more or less individual coloration.

In 1932, A. L. Thuras patented the so called bass-reflex enclosure by proving that its efficiency at low frequencies was superior to that of the infinite-baffle system. Briefly, the basic principle is that of the Helmholtz resonator — as used by most string instruments—in which the enclosed air acts as a spring (compressible medium) and the air moving through the *port* (sound hole) acts as a mass with a definite inertial property. As anyone knows who has ever bobbled a weight on a hanging spring in high-school physics, the frequency at which the device will insist on moving will depend upon the combined elasticity of the spring and the weight of the attached mass. But the important feature to note is that the weight and spring will not react to either the direction or the speed of the hand instantly: only after a brief, but fixed time interval. Therefore the design of a bass-reflex enclosure is arranged so that the cavity and port resonate at the lowest natural resonant frequency of the loudspeaker cone, and the direction of the sound-pressure wave from the port corresponds with that from the cone within a very small interval of time, thereby reinforcing cone radiation at low frequencies. But in spite of good engineering intentions the bass-reflex enclosure exhibits a certain hollow coloration unless it is super-critically damped, at which point it begins to lose out in bass reinforcement.

The ideal reproducer would seem to be a perfectly rigid, large piston that would pump air back and forth in perfect accord with the program signal that drives it. And since it is well known that a large piston can be made up of a large number of inherently rigid small elements, engineers devised the electrostatic speaker. Characteristically, electrostatics exhibit super-clean reproduction, but at the expense of some weakness in the very low bass, and a relatively limited dynamic range.

These are the reasons that led another seeker-after-truth to devise a loudspeaker enclosure system that attempted to emulate the acoustical behavior of string instruments as closely as possible. The system was given the technical name, "idiophonic paracubical resonator." This means that it is a self-sounder supported by a resonant cavity of such shape that no two sides are parallel to each other in order to eliminate standing-waves and the acoustic absorption of fiberglass. During its short-lived commercial existence (due to outlandish production costs) it was known by the somewhat less-than-subtle euphemism, "Orche-Strad." Five of its six sides were made of piano sound-board spruce in elliptical shapes and of individually graduated thickness. Each plate was designed to have a fundamental frequency and a series of overtone resonances differing from the others so as to reinforce the loudspeaker driver reproduction substantially smoothly throughout the audible spectrum. The shape and cost of "the thing" was such that only the strong-willed, with brute-force control over their wives, would tolerate it in their homes.

(CONCLUSION NEXT MONTH)



Equip it with today's most advanced cartridge, the new Elac 444-E. The Elac 444-E and the Elac/Miracord 50H have much in common. Both are made by ELAC of West Germany. Both have recently received national acclaim The Miracord 50H rated tops by a leading independent testing organization. The Elac 444-E rated superior by 50 discerning high fidelity salesmen. These hi-fi experts tested the Elac 444-E in their home systems and compared it to their present cartridges. A few comments:

"A great groove-tamer for the straight-from-the-studio sound lover! All of today's terms won't describe the utmost enjoyment I experienced."

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The Miracord 50H automatic turntable with the Elac 444-E cartridge is about the finest record playback system available today. The Elac 344-E cartridge is an excellent choice with the Miracord 620 (also awarded a top rating). Elac offers a complete selection of cartridges from $24.95 to $69.50. Miracord, a choice of automatic turntables from $89.50 to $149.50.

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ELAC/MIRACORD

Equipment Profiles

- Lafayette LR-1500T AM/FM Stereo Receiver
- Knight-Kit KG-687 Sweep-Marker Generator
- Elac STS-444E Stereo Phono Cartridge
- Klipsch Cornwall II Speaker System

Lafayette LR-1500T Solid State AM/FM Stereo Receiver

MANUFACTURER'S SPECIFICATIONS:
Amplifier Section. Power Output: Music Power (IHF), 175 W at 4 ohms, 125 W at 8 ohms; RMS Power, 140 W at 4 ohms, 100 W at 8 ohms. Harmonic Distortion: < 1% at rated output; < 0.15% at 1 W. Power Bandwidth (IHF): 20-35,000 Hz. Frequency Response: 20-20,000 Hz ±0.75 dB. Hum & Noise: high-level inputs, −75 dB; low-level inputs, −57 dB. Tone Control Action: ±12 dB at 50 Hz; ±12 dB at 10,000 Hz.

Tuner Section. (FM) Usable Sensitivity (IHF) 1.5 μV. Selectivity, 40 dB. Capture Ratio: 1.25 dB. S/N: 68 dB. Harmonic Distortion: 0.3%. Spurious Response Rejection: 95 dB. AM Suppression: 50 dB. Stereo Separation: 40 dB at 400 Hz. (AM): Sensitivity: 15 μV. Image Rejection: 50 dB at 1 MHz. S/N: 45 dB.

General. Dimensions: 16¾″ W x 5″ H x 14¼″ D. Weight: 30 lbs. Price: $279.95.

Fig. 1—Lafayette LR-1500T AM/FM stereo receiver.

The Lafayette LR-1500T is the "top-of-the-line" stereo receiver marketed by this well-known mail-order and retail company under its own name. All of the units in this line have been completely re-styled and re-designed to provide an outward appearance that belies their reasonable prices.

The LR-1500T's heavy brushed gold and brown charcoal panel is gracefully complemented by turned metal knobs for main functions and matching charcoal-brown rocker switches for secondary functions. Dial illumination is soft, but adequate, as is the subdued tuning-meter illumination. Just a hint of light green is evident.

If you relish an abundance of controls, this receiver will delight you. Besides the usual ones there are some unexpected controls that bear mentioning. The mode switch has the anticipated MONO and STEREO positions, but it also has such positions as BALANCE R, BALANCE L (a pair of positions which enables you to hear a mono mix first out of the left speaker and then out of the right—a supposed aid in achieving level balance), STEREO REVERSE (a feature that went out of most designs years ago, in view of recording and tape standardization as to which was left and which was right) and, finally, L INPUT and R INPUT—a feeding of either of the input channels to both speakers.

The tape-monitor switch, normally a simple on-off affair, is here given the status of a major control having four positions: off, stereo, left, and right. The "off" position is the normal one to use

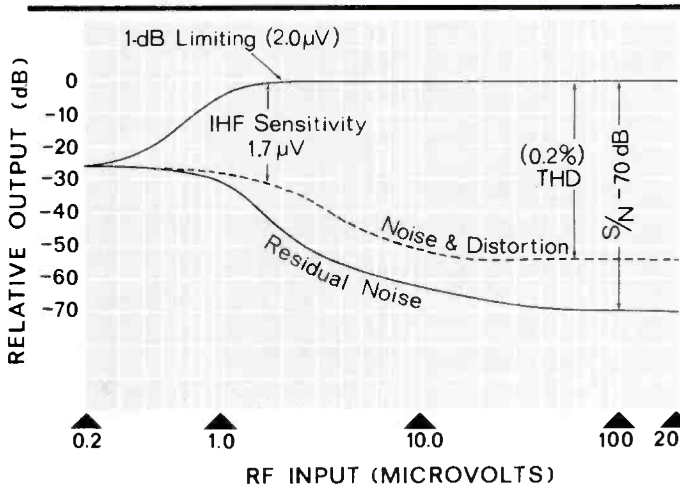


Fig. 2—FM characteristics.

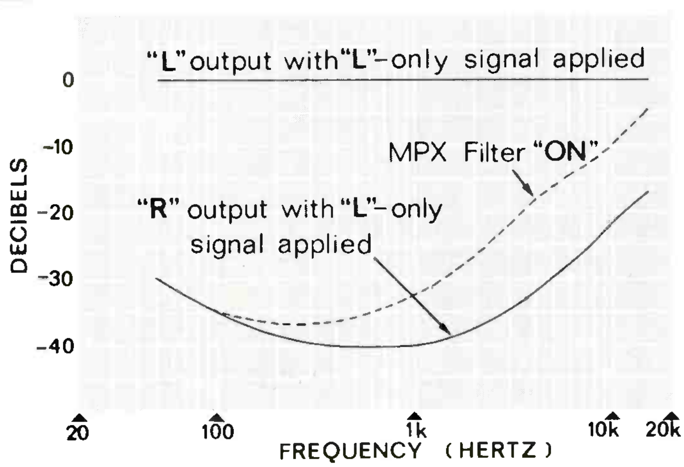


Fig. 3—Stereo FM separation.

Fig. 4—Total harmonic distortion and IM distortion.

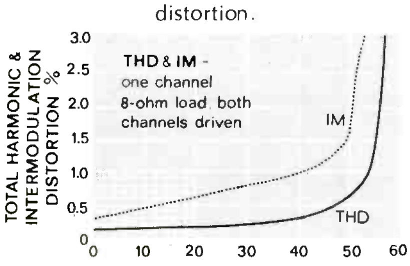


Fig. 5—Power bandwidth.

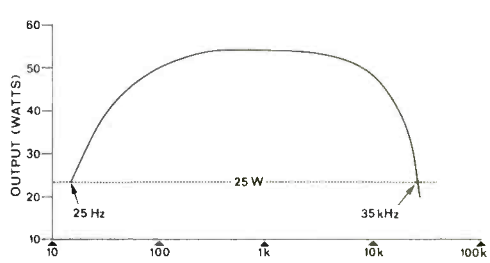
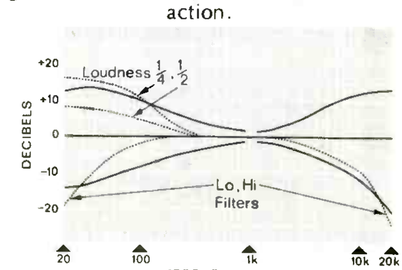


Fig. 6—Tone control, loudness, and filter action.



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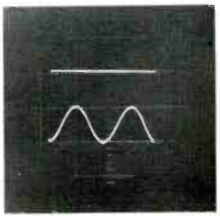

Fig. 7—Forty dB of stereo FM separation on LR-1500T. Upper trace is right-channel output when left only is applied. Lower trace is left output.

when you *don't* want the monitoring function. At first glance this is confusing (though not so when the same word is used on a slide or rocker switch). One tends to think it may be the opposite or, at very least, a power switch. As for the other positions, they indicate what comes out of the tape output jacks. Nomenclature on the dual volume control is misleading. Labelled BALANCE and VOLUME, the implication is that the inner knob is a regular balance control while the outer controls level of both channels—not so at all! They're really a pair of individual channel-level controls. The word balance, as we later learned to interpret it, simply means, "Set the outer knob for desired level from one speaker and then use the inner knob to raise the level at the other speaker until it is 'balanced' with respect to the first"! In other words, there is no balance control as we have come to know it.

A variable mute control, adjustable by rotating the edge of a knob up or down (see Fig. 1) is located between the tuning and speaker-mode controls. Since really effective muting between stations takes place very near the maximum setting of this control, it might well have been a simple on/off switch instead of a continuously variable control. Interestingly, it works on AM as well as on FM, and the AM of this receiver is worth listening to. Bandwidth is all that's claimed by the manufacturers, which no doubt explains why we felt that the AM fidelity was not *that* much inferior to FM. The tuning meter, too, works as a peak indicating meter for both AM and FM, being most effective on AM. On FM, as is true of so many of these meter circuits, it is useful for tuning in center of channel, but not for gauging signal strength. (Anything over 20 μV kicks the meter up to practically full scale.)

The minor objections voiced with respect to the logic of the panel layout are more than offset by the measured and listened-to performance of the LR-1500T. Our measured IHF FM sensitivity was 1.7 μV—a fine figure indeed. Figure 2 tells the rest of the story about quieting (70 dB against claimed 68 dB) and total harmonic distortion (0.2% against claimed 0.3%). Stereo FM separation does indeed make the 40 dB claimed, as shown in Fig. 3, although it is much less when the MPX filter is introduced. Happily, we did not require the use of this filter on 12 out of the 13 stereo FM stations we received with this sensitive tuner section.

As for the amplifier, it is really a rugged performer. Because of its exceptionally high power rating, we decided to do our subjective listening with *two* sets of 8-ohm speakers, with both in the same room. Playing the systems for about two hours at "discotheque" level (about 20 dB higher than "Carnegie Hall podium level") could not break up these fine sounding amplifiers. Audible IM was as low as any we've heard. The amplifiers refused to quit, even though driving four, relatively inefficient "acoustic suspension" speaker systems!

The THD and IM curves of Fig. 4 confirm everything we heard, as do the power bandwidth curves of Fig. 5 and the frequency response and tone-control action curves of Fig. 6. Loudness contour action at ½ and ¼ volume and Lo & Hi Filter action is also shown in Fig. 6. The dual trace of Fig. 7 shows what 40 dB of stereo FM separation

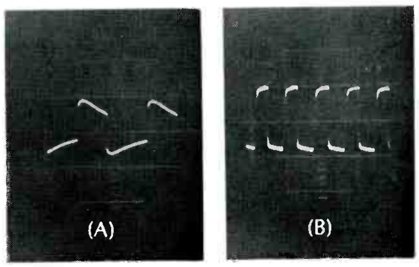

Fig. 8—Square-wave response of LR-1500T at (A) 100 Hz and (B) 10 kHz.

looks like, graphically, while Fig. 8 illustrates square-wave response at 100 Hz and 10,000 Hz.

A real aid in balancing the phono cartridge to match FM and AM levels is the three-position rear-panel phono sensitivity switch. During our tests we shorted the output terminals of one channel and found that the overload protection circuit (dubbed "Computor-Matic"TM) really works—sound is interrupted (and output transistors "saved") until the short is removed.

In summarizing the attributes of the Lafayette LR-1500T AM/FM stereo receiver, it offers outstanding performance (even on AM), many controls (though perhaps too many), attractive styling, and a price that, at $279.95, appears to be unusually low.

Check No. 52 on Reader Service Card

Knight-Kit Sweep-Marker Generator Model KG-687

MANUFACTURER'S SPECIFICATIONS:

Frequency Coverage: 3 to 220 MHz (center frequencies) in five bands all on fundamentals. Sweep Frequency: 60 Hz. Sweep Width: Continuously variable, 0-18 MHz on Band A; 0-8 MHz at TV i.f. frequencies. Output Voltage: 3 to 50 MHz, 0.3 V rms min.; 50 to 120 MHz, 0.1 V rms min.; 120 MHz to 220 MHz, 50 mV rms. min. Marker Oscillator: 2 MHz to 75 MHz on three fundamental bands; additional harmonic band to 225 MHz. Crystal: 4.5 MHz supplied; 500 kHz to 20 MHz crystals of standard Mil Hc/6U type holder may be used. Output Impedance: 75 ohms. Blanking: r.f. shutoff during retrace. Output Attenuator: 4-step switched. Horizontal Phasing: screwdriver adjust. Dimensions: 14¾ W x 7¾ H x 10¼ D. Weight: 13 pounds. Price, $120.00.

Occasionally, the audio buff needs a sweep generator to align his or another's FM tuner or receiver, or possibly to perform the usual miracles so that his (or another's) TV set resumes its usual high-quality performance. For this purpose, the sweep generator is practically indispensable.

Since the fundamental requirements of the sweep generator are the same regardless of the basic frequency range, it is readily possible to construct a sweep unit which performs equally well in the TV frequencies and in the FM range. The basic principles of operation is the characteristic of a saturable reactor to be modulated by a variable a.c. voltage so that the oscillator windings on the same core are modulated by the a.c. signal. The oscillator consists of a transistor stage operating as a shunt-fed Colpitts oscillator with the inductive winding wound on the core of the saturable reactor. The output of the oscillator is fed through two cascaded emitter followers to the attenuator and and the output, thus minimizing oscillator loading. In order to maintain a constancy of signal output, part of the output from the second emitter follower is rectified and fed back to an automatic level control transistor stage which varies the bias on the oscillator so as to maintain a constant voltage output over the swept range.

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A variable-frequency marker oscillator is also supplied which provides marker "pips" over the range from 2 MHz to 75 MHz, with additional harmonic coverage up to 225 MHz. Furthermore, there is provision for a crystal, together with the necessary transistor oscillator. A final transistor serves as a mixer amplifier. Nine transistors and seven diodes are used in the circuit. One useful feature is the provision for two separately adjustable d.c. voltages to be used to bias certain stages in a TV set as specified in the alignment instructions for the set.

The generator is equipped with a BNC output receptacle, and with phono jacks for connection to the set being aligned and to an internal demodulator; additional phono jacks serve to connect to the vertical input of the scope for the demodulated signal, and another sweep signal for the horizontal amplifier of the scope. This voltage is in phase with the swept r.f. signal so as to portray the output in phase with the sweeping oscillator. Sweep width is adjustable, and output voltage is adjustable in steps as well as by a vernier.

Construction of the kit is simple, requiring a maximum of about 15 hours, which includes the makeup of the connecting cables and the final calibration. Final alignment makes the dial calibration come adequately close to the actual frequencies of the output, and is clearly delineated in the instructions.

With the flexibility of signal generation and modulation, together with the wide range of marker signals available, a generator of this sort is indispensable to the serviceman, or to the neighbor-

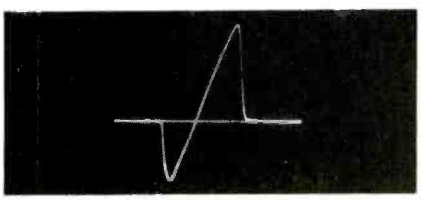
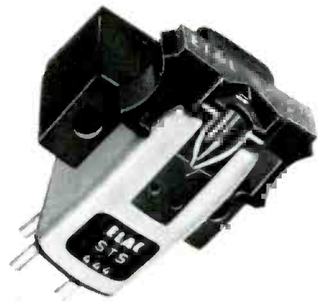


Fig. 2—Typical waveform encountered in aligning an FM discriminator or ratio detector.

hood specialist in hi-fi and other electronic phenomena—the average hi-fi buff. With this generator he can perform the necessary "miracles" relating to correcting the performance of his—or his friends'—hi-fi tuners and TV sets. He will, of course, require an oscilloscope, but if he is any kind of a serious audio buff, he already has one.

Elac Model STS-444-E Stereo Cartridge



MANUFACTURER'S SPECIFICATIONS:

Frequency Range: 10-24,000 Hz. Stylus Force: 0.75 to 1.5 grams. Sensitivity at 1000 Hz: 10 mV at 10 cm/sec. Channel Difference at 1000 Hz: 1.5 dB. Stereo Separation: 26 dB at 1000 Hz, 17 dB at 10,000 Hz. Tracking Ability: 3.8 cm/sec. for 100 Hz at 0.75 grams. Diamond Stylus: Elliptical (frontal 0.9 mil, lateral 0.2 mil). Price, $69.50.

The Elac STS 444-E is a fine stereo cartridge. It represents the top of Benjamin Electronic Sound's new line of five cartridges. In descending order of price they are Model STS 444-E, STS 444-12, STS 344-E, STS 344-17, STS 244-17. Like its predecessors, such as the popular STS 322, reviewed here in November 1967, it is a moving-magnet type, but is an improvement over the earlier units. The major difference is in tracking ability and channel separation, a difference great enough to be audible.

The STS 444-E is small and light. Thus it is ideal for modern low-mass tone arms, and should fit any of them. As in the earlier Elac designs, the pull-out stylus assembly, which is replaceable by the user, has a stylus which retracts (completely, this time) into a semi-tube when excessive pressure is exerted on the stylus. Because the stylus assembly is so small, there is lots of room in the tube for the stylus to retract—even at a 45-deg. angle—as would occur if a tone arm were accidentally pushed sideways and downward.

This is a nifty feature, aimed at saving time and trouble in replacing a bent and otherwise damaged stylus. The elliptical configuration ratio of 2 x 9 mils is rather severe, which is probably why Elac recommends using this cartridge on stereo records only. It also means that exact parallel alignment of the stylus to the disc is mandatory for optimum operation.

For our tests, we installed the 444-E in an SME Model 3012 series 11 tone arm, set to track at 1.3 grams. We found that the cartridge easily exceeded its modest specifications. Figure 2 shows the frequency response and

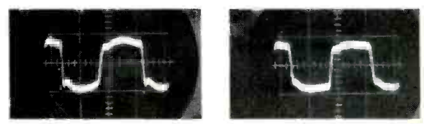


Fig. 3—Square-wave photos: left channel, 5.0 cm/sec and 3.54 cm/sec velocity.

separation between channels. Except for the resonant peak at approximately 16 kHz, the unit has very smooth response, with excellent separation throughout the audio spectrum. Note that even at 25 Hz and 15 kHz there is still 15 dB of separation. The square-wave photos of Fig. 3 show the excellent transient response of the cartridge. The slight overshoot at the leading edge of the waveform is due to the 16-kHz peak.

IM distortion at high velocities was judged to be relatively low for this type of design, and the cartridge tracked

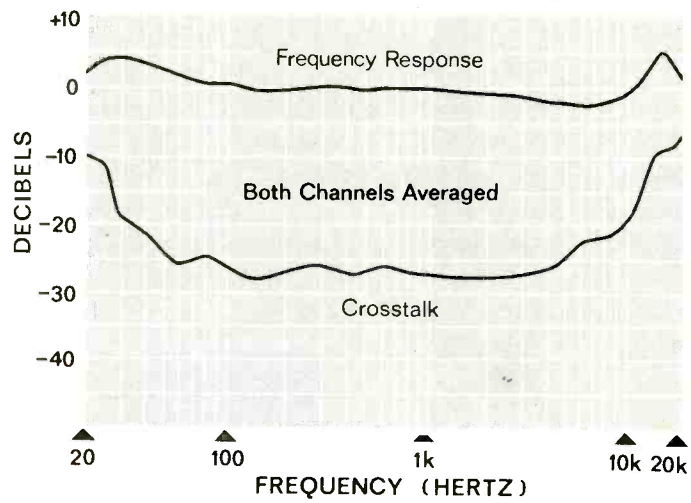


Fig. 2 – Frequency response and channel separation.

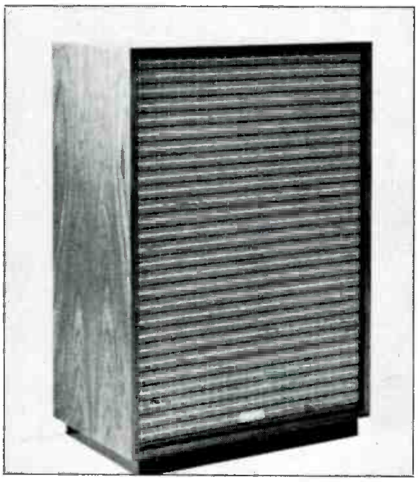
most of the standard difficult-to-track records at just under 1.5 grams. We measured its output at 3.6 mV for both channels, exactly, at 1000 Hz referred to 3.54 cm/sec rms 45-deg. velocity. This is a hair more than the specified 10 mV/10 cm/sec, and is an average output as far as sensitivities of cartridges go. We were able to get a signal-to-noise ratio of 62 dB through a wide-band RIAA preamplifier. This is an excellent figure and attests to the unit's effective hum shielding.

Listening to various records reproduced by this cartridge turned out to be a most pleasant experience. We heard a clear, crisp sound, with a perfect stereo image. The peak at 16 kHz could not be detected aurally. Perhaps the combination of a limited amount of information at 16 kHz stored on most records and the relatively low IM distorition of this cartridge accounts for this.

In any case, we like the STS 444-E and urge those looking for a fine stereo cartridge to try one.

Check No. 56 on Reader Service Card

Klipsch Model Cornwall II Speaker System



MANUFACTURER'S SPECIFICATIONS:

Total Modulation Distortion: Max. 3%, SPL 90 dB at 2 ft. Input Capacity: 60 watts. Response: 30-19 kHz. Dimensions: 35¾" H x 25½" W x 15½" D. Price: $311 to 415, depending on finish. Horiz. or vert. base, $8 to $25 extra.

The Klipsch Cornwall II is a console-size speaker system which ranks third from the top of the Klipschorn line, for which inventor Paul Klipsch is famous. Whereas the Klipschorn is a 3-way system that utilizes horns in each of its sections (as does Klipsch's La Scala model), the Cornwall uses a 15-in. direct-radiator woofer, operating in a ducted port reflex system for the bass range. Its K600 mid-range horn and K77 horn-type tweeter comprise the top end of the speaker system. They take over at 600 and 6000 Hz, respectively. The system is intended for use in a corner or against a wall—thereby the name, "Cornwall." It performs best in a corner, as would be expected.

According to Klipsch, modulation is the largest single fault of loudspeakers, with well-designed horn-loaded loudspeakers exhibiting lowest distortion. The reduction of distortion comes about by limiting the travel of the speaker diaphragm to a very small excursion, then coupling the sound acoustically to the room by means of a horn. Therefore, the horn acts as an impedance transformer, between the vibrating diaphragm and the air space to be excited by sound waves. The resulting increase in efficiency is said to minimize distortion.

The Cornwall II, besides use as the bridged center speaker of Klipsch's "wide stage stereo" system, in which two flanking Klipschorns are the left and right speakers, is an excellent speaker system in its own right. It is a floor-standing unit that can be placed either vertically or horizontally, since it is finished on all four sides. (Although its 90-deg. polar pattern is about the same in either position, we found a slight decrease in treble dispersion when we oriented the unit horizontally.)

Paul Klipsch feels that a speaker's response should not be changed to match a particular room. Instead, he believes that the acoustic properties of the room should be corrected if deemed necessary. Accordingly, the Cornwall does not have level controls to adjust say, brilliance. "Any attempt to insert presence controls, pads, attenuators in a loudspeaker system would merely introduce distortion. Their use would be comparable to asking the recording artists to play extra loud or extra soft within a specified range of notes," says Klipsch. While we feel this is an idealistic viewpoint, without regard to some special acoustic room problems, it is just as valid a contention as the one recommending lots of controls. After all, most amplifier manufacturers still furnish tone controls on their units, which are certainly more accessible than those at the rear or side of speakers. Furthermore, modern tone controls are very effective in changing treble balance.

Using a multiple-microphone technique, we measured an impressively smooth frequency response of 45-17,000 Hz ±6 dB for the Cornwall II. The bass started to roll off below 70 Hz. There were no significant peaks or dips in the audio range, as evidenced by tone bursts. Harmonic distortion was judged low at the difficult low frequencies, and doubling could only be induced at high levels below 50 Hz. Unfortunately, we were unable to measure the "modulation distortion" that Klipsch mentions. He defines Total Modulation Distortion (which is part of all Klipsch speaker specifications) as the rms amplitude of modulation sidebands in per cent of amplitude of the modulated frequency. As a function of total power output, it is expressed at a specified sound pressure level. We've not measured it on other speakers, nor do standards for this measurement exist. We did note, however, an apparent clarity and body in the sound reproduced by the Cornwall II, even at high listening levels. Placed in a corner, the unit produced some awesome bass, and could be driven to "concert hall" levels with a 30-watt power amplifier. Thus, compared to other direct-radiator speakers the Cornwall II could be considered to be a high-efficiency system.

When connected at reduced level as the bridged center speaker of a Klipschorn-Cornwall stereo array, across a 25-ft. wall, it blended in perfectly with the flanking speakers, and enhanced the stereo performance of the system. This combination recreated the most exciting sound images we have heard to date in the home. Of course, we're talking here about over $2000 worth of speakers. When played singly or in pairs, the Cornwall II provided a big, clear reproduction — especially from clean source material. We also tried a pair of them in a small room. Performance here was impressive, too, at various listening levels.

The speaker system is available in six wood finishes, unfinished, and as a utility model which comes in black fir, without grille cloth. Though there is a standard grille cloth for each type of wood finish, any grille cloth can be ordered with any wood finish. A 2-in. riser base and 4-in. caster base are also available for either vertical or horizontal placement. The unadorned, finished speaker cabinet is beautifully made, with attention to detail evident throughout.

For those who have the floor space and can afford it, the Cornwall II certainly offers fine performance.

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ABZs of FM

LEONARD FELDMAN

More on FM Detection

HAVING EXAMINED the two most popularly used forms of FM demodulators (discriminator and ratio detector), we cannot overlook two more recent forms of FM detection circuits that have had some acceptance. These are the "gated beam" detector and the "counter" detector.

In its earliest forms, the gated-beam detector utilized a specially constructed tube, the 6BN6. When grid voltage values changed from negative to positive, plate current of this tube rose rapidly from zero to some predetermined maximum value, which remained constant regardless of how positive the grid voltage became. Current cut-off was abruptly achieved when grid voltage reached a negative value of 2 volts. Later, simpler forms (structurally) of tubes were developed that resembled pentodes physically, but which still exhibited sharp current turn-on and turn-off characteristics.

Perhaps the most popular of these is the 6DT6, and we shall use this tube number to demonstrate the action of a gated-beam FM detector. Figure 1 will help to illustrate the operation of this circuit.

R1 serves to apply 1 or 2 volts of cathode bias to the tube. Under such conditions of bias, incoming 10.7 MHz signals need not have much amplitude to cut off current flow during negative half cycles of the signal. Similarly, for positive halves of the signal cycle, tube saturation is reached. In this way, the tube acts as an effective limiter, clipping any AM components from the incoming signal. The grid construction is such that current flow is released and ended suddenly. Therefore, tube current flow appears in the plate circuit in the form of pulses. The screen grid (sometimes called the accelerator grid, in this circuit) has a positive voltage applied to it which accelerates the electron stream and increases its velocity.

The upper grid (known as the quadrature grid), instead of being bypassed to cathode or ground (as would be the case in a conventional pentode hookup), is connected to a parallel-resonant circuit consisting of L3 and C3. These components are chosen to be resonant at the 10.7 MHz incoming i.f. frequency. During periods of conduction, pulses apply bursts of energy to the quadrature resonant circuit and, because of the Q of this circuit, sinusoidal signals are developed across the resonant circuit. Construction of the tube and the nature of the coupling to this grid causes this quadrature signal to lag the input signal by 90 degrees.

Since either the signal grid or the quadrature grid can influence current flow in this tube, either grid can cause cut-off of current flow when it has a sufficiently negative voltage applied to it. As shown in Fig. 2A, when both the input and the quadrature grid have positive voltages, in phase, current flows for a full half cycle. If the two grids ever have voltages which are 180 degrees out of phase, no current will flow (as in Fig. 2B). In Fig. 2C we see the condition described above—voltage on the quadrature grid is 90 degrees behind incoming signal grid voltage and the resulting pulse-width of plate current is only half as great as in Fig. 2A, or one-quarter of a cycle in duration.

As the incoming signal is frequency-modulated, the carrier frequency (applied to the first signal grid) shifts above and below its center. This frequency variation also alters the situation with respect to the quadrature grid voltage. As the incoming signal shifts to a higher frequency, the resonant circuit C3L3 (Fig. 1) becomes capacitive and the signal voltage lags the input signal voltage by more than 90 degrees, as illustrated in Fig. 2D. Under these conditions the current pulses that appear in the plate circuit become narrower. Conversely, as the incoming signal becomes lower in frequency, the quadrature resonant circuit begins to look inductive and the voltage lag is less than 90 degrees. The result is an increase in plate current pulse width, as shown in Fig. 2E. As the carrier shifts above and below the 10.7 MHz center frequency in accordance with desired audio modulation, a series of pulses of different widths is developed in the plate circuit. The full series for a single alternation of sine-wave is shown in Fig. 3A.

At this point, the "counting" or integrating circuit consisting of R4 and C4 (Fig. 1), acts upon the square-wave output pulses. In effect, it "averages out" the d.c. value of the pulse train, as shown in Fig. 3B. This "ragged-edged"

Fig. 1 — Partial circuit of "gated beam" FM detector.

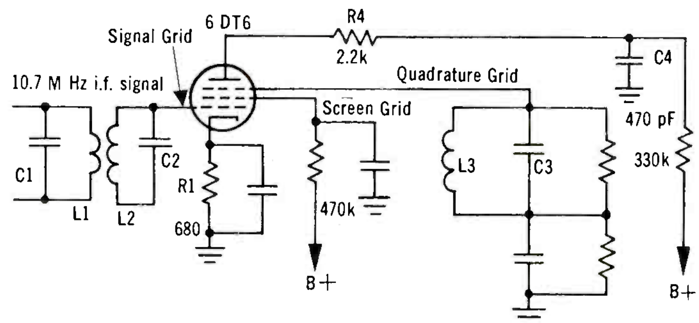
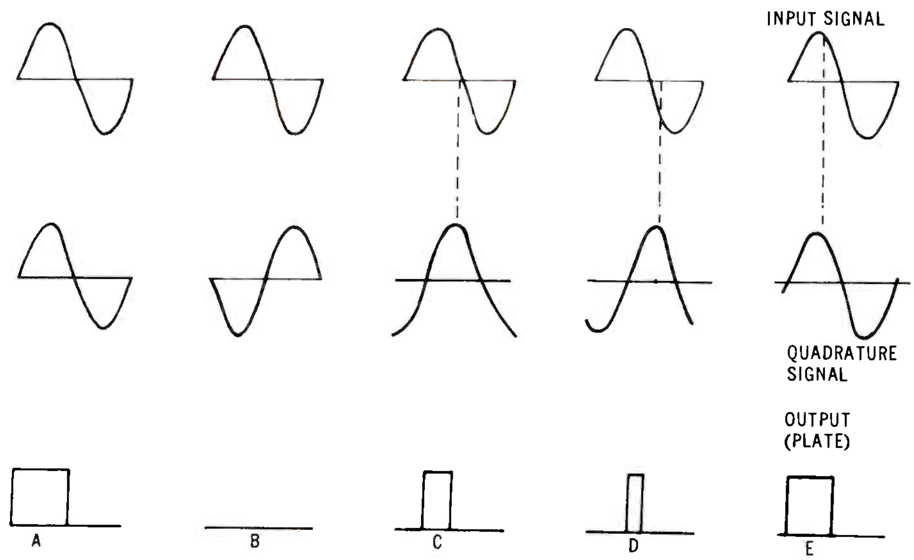


Fig. 2. Gated-beam tube signals "C" corresponds to "no modulation" condition, while "D" and "E" represent deviation above and below 10.7 MHz respectively.



waveform corresponds exactly to the desired audio signal. While further filtering can be used to remove the sawtooth edge of the waveform, even if it were applied to an audio amplifier "as is" you would hear only the desired audio because its fundamental repetition rate of 10.7 MHz would be inaudible. Usually the de-emphasis circuit required to restore correct frequency response, as shown in Fig. 4, will remove any remaining 10.7 MHz because the required time constant is 75 microseconds.

Solid-State Circuitry

You may recall that the audio information, as applied to the transmitter modulating circuits of the transmitter, was deliberately *pre-emphasized* to improve signal-to-noise ratios and now, regardless of what type of FM detector is used, corresponding *de-emphasis* must be inserted following demodulation.

Translated to solid-state circuitry, a simplified form of gate-quadrature type of demodulator is shown in Fig. 5. This circuit is similar to the one described by me in the October 1968 issue of AUDIO, in connection with a demodulator for SCA (Background Music) FM transmission. Aside from a change in the values of L1 and C1 to conform to the Q and resonant requirements of an incoming signal of 10.7 MHz, the principles are the same.

A logic gate consisting of Q1 and Q2 has signals applied to the respective base inputs which are 90 degrees apart in phase (in this case, a series resonant circuit is used, and voltage to the lower input is taken at the junction of L1 and C1 to effect the 90-degree phase shift). Conduction through the gate takes place only when both bases are positive, and this period will vary as the modulated i.f. signal varies above and below the center value of 10.7 MHz. Unlike the gated-beam tube arrangement, however, limiting must precede the gate circuit so that a pair of "clipped" or square waveforms are presented to the two inputs of the gate. Once again, the output pulses are integrated by an R-C circuit of suitable time constant, and normal de-emphasis is applied after integration.

The two circuits described, while discussed as "counting" circuits, have an advantage over the so-called pure counter detector. In the latter circuit, the incoming signal is first fully limited, as usual. Conduction may be further limited by differentiating the pulses so that they are very narrow spikes. As the incoming frequency is lowered, because of modulation, the pulses will be further apart; with increasing frequency, the pulses will be closer together. By applying these pulses to another stage of amplification, followed by an integrating or "counter" circuit, the instantaneous d.c. value of the pulses is averaged; this average represents the wave shape of the desired audio information.

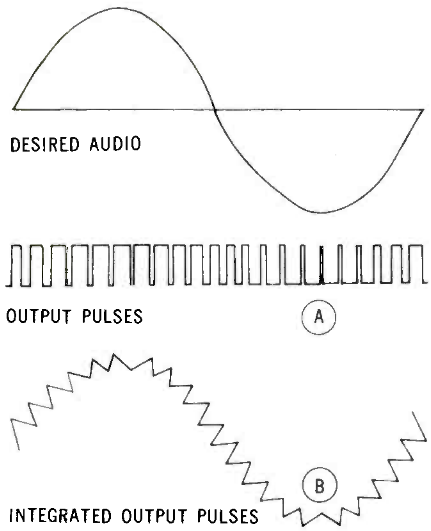


Fig. 3—Varying widths of output pulses are integrated or "counted" to reproduce desired audio in a gated-beam detector.

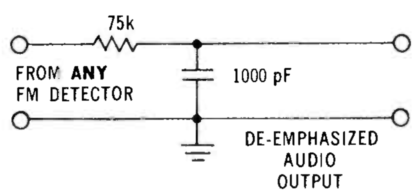


Fig. 4—Typical values of R and C used in FM de-emphasis network. Product of:
R × C = Time Constant, in seconds.
$75 \times 10^3 \times 1000 \times 10^{-12} = 75 \times 10^{-6} =$
75 microseconds.

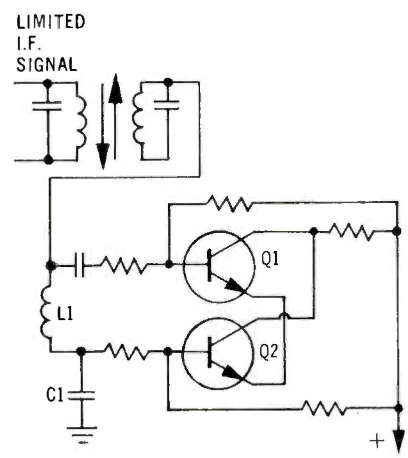


Fig. 5—Two transistors arranged in a "gate" circuit for FM demodulation. L1-C1 effects a phase shift of signal applied to Q2.

With a center frequency of 10.7 MHz and a maximum possible deviation of only 75 kHz above and below this center value, you can readily see that the difference in "spacing" between pulses, even at the two extremes, will be very small, relatively speaking. It is for this reason that this form of detector, while extremely linear, recovers very little audio output and is usually followed by one or more audio amplification stages. While these stages increase the level of audio, they do not materially improve the inherent signal-to-noise ratio of the system. For this reason, the "pure" counter detector is now seldom used in commercial FM circuitry.

If one had to rate the detectors discussed in terms of popularity, it would run about like this: The discriminator, once the most popular form of FM demodulator, now rates in second place, and a low second place at that. Some of its recent disfavor stems from the ratio detector's inherently lower cost and less-stringent limiting requirements ahead of it in the circuit. A less apparent reason is the comparatively lower output impedance associated with the more popular ratio detector circuits. A low output impedance means that capacitive loading associated with shielded output cables (in the case of tuners only) will not adversely affect frequency response. Further, in the case of stereo FM, it is necessary to recover frequencies (audio) all the way up to 53 kHz for application to the stereo FM decoder circuits which follow. Even a small amount of stray capacitance across the output of a high-impedance discriminator might attenuate the higher frequencies involved. Finally, since solid-state circuitry has become so popular, the output of a ratio detector, being low impedance in nature, is most easily applied to the audio amplifier input stages which normally follow, without the necessity of having extra stages of impedance matching circuitry.

The demodulation circuits examined this month are not used nearly as often as the ratio detector or even the Foster-Seeley discriminator (at least in the field of broadcast FM). The gated-beam tube is often found in TV sets, however, where the sound portion of the signal is frequency modulated. In this application, the high sensitivity of this form of detection (high audio recovery) is particularly attractive, since, as we all know, *sound* is deemed to be relatively unimportant by TV manufacturers.

Next month we shall examine the circuit that was invented to do one job but, for years, has been touted for another—AFC (Automatic Frequency Control). Æ

Electronic Organs

NORMAN H. CROWHURST

PART 5 of a series. Keying methods vary from simple switching to complicated diode and transistor circuits.

The more traditional organs merely switch the tones through, (called audio keying) by using bus bars or wires which make contact with springs attached to individual notes (Fig. 5-1).

The keying mechanism on organs that still use this method can become extremely complicated. The one key may depress 10 or more springs to make contact with the various bus wires. The Hammond mechanism is like this. In that organ, the wires are used for synthesis, so the arrangement of bus connections is a little different from other organs that use multiple keying.

Newer organs use semiconductor keying, which provides greater versatility with less contacts. The basic circuit of diode keying consists of biasing the switching diodes well into cut-off, or non-conduction, until a key is pressed. This then applies a reverse bias to the diode, causing it to conduct and pass the signal (Fig. 5-2).

In this circuit, a small positive voltage keeps the diode non-conducting until the key is depressed. When the key is depressed, a negative voltage overcomes this, rendering the diode conducting throughout the whole of the note's waveform. This method enables a single key, or note contact, to control several tone variations with such dissimilarities as diverse attack times, added transient effects, inclusion of tremolo on different channels, and so forth. It is an inexpensive approach to multiferation of tone.

By using a square waveform at the point where diode keying is used, the changing bias is utilized to change amplitude. When the negative keying voltage is reduced, part of the square wave is passed to the signal output bus. With a time-constant capacitor, this can control "attack" time (Fig. 5-3). From here on the tricks really begin. The circuit can be arranged to have quite fast attack by charging up the capacitor quickly, but a slow decay or sustain, by allowing it to discharge (through the diode circuit) quite slowly.

Capacitors can also be arranged to produce overshoot at the beginning of notes (Fig. 5-4). This gives a percussive effect. When the key is first depressed, the percussive capacitor is discharged so that only the unbypassed resistors determine diode conduction. As the current flows, the percussive capacitor charges and the resistor in parallel with it limits diode conduction. Therefore steady tone is less than the initial level.

Adding diodes can arrange to pass certain tones only transiently, as the note starts "speaking" (Fig. 5-5). In this case, R_1 is large enough so that, after C_1 becomes fully charged, the transient tone source is stopped because the positive bias (that holds the note "off") overcomes the steady value of the negative keyed bias. R_2 is much smaller than R_1, and C_1 determines the duration of the initial transient sound. Resistors R_3 and R_4 determine the steady tone level. But R_3 is much smaller than R_4, unless appreciable sustain is needed to give a "big organ" effect (which can also be augmented by

(Continued on page 78)

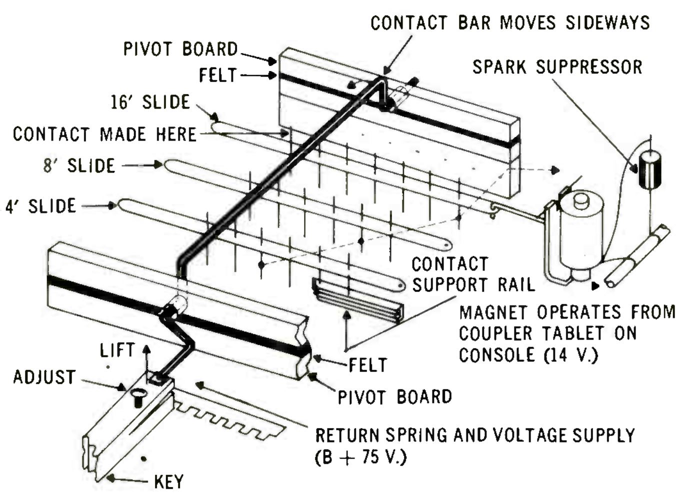


Fig. 5-1

Fig. 5-1. One of many arrangements of contacts operated by the keys of an organ. (Courtesy Artisan Organs, California)

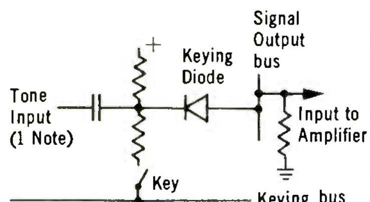


Fig. 5-2

Fig. 5-2. Diode keying in its simplest form.

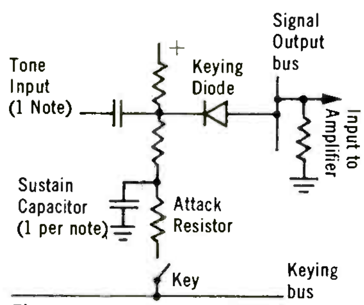


Fig. 5-3

Fig. 5-3. Diode keying with attack and sustain added.

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Front of equipment console is shown at left. Below, speaker systems are hidden behind cloth at sides of fireplace. The last photo shows a view from the separate recording booth looking at the equipment console desk.

Sound & Decor Styles

R. M. HOLMES

THE IMPORTANT PART of my house insofar as music reproduction is concerned is the music-living room, with overall dimensions of 34 ft. by 21 ft. with an 8-ft. ceiling. Liberal use was made of wood paneling and other textured material, such as jute and cork, to minimize spurious resonances and standing waves. The structure used to house the equipment is constructed completely of teakwood, and contains a small voice-track recording booth, equipment desk and console with some record storage space. This is a free-standing structure with room space on all sides and removable panels in the back for easy access to all the wires.

The front of the equipment console is shown in the first photo. Starting from the top, one can see two speakers used exclusively for the stereo cue system (for cueing records and tapes to proper position for entry into program material). These speakers are driven directly from the cartridge by a Shure

preamplifier and a 10-watt EICO amplifier. Also shown is the monitor system, composed of a Citation I, II, and III. Also shown are the three tape recorders of the system. On the left is a Crown 822 tape player with preamplifier and Crown SA-20-20 solid-state amplifier. In the center position is a Viking "stereo compact" used for reproducing pre-recorded voice tracks. On the right is the master recorder, another Crown unit. All program materials are fed into the recorder from pre-recorded material on the other two recorders (voice tracks and music). On the desk and to the right is a Thorens TD-124 turntable with a 9-in. SME tone arm. I use two cartridges, depending on the program material: Shure V-15 Type II and the Ortofon S-15. The turntable is placed on a shock-mounted platform, with a felt pad glued to the rubber mat on the platter. This allows the platter to turn under the record to obtain tight cueing. Record and tape storage shelves may be seen at the right.

If one looks carefully on the left, a lighted window is visible, where a Shure professional microphone is situated. The window backs into the small recording booth that is part of the struc-

What's behind the BOSE 901

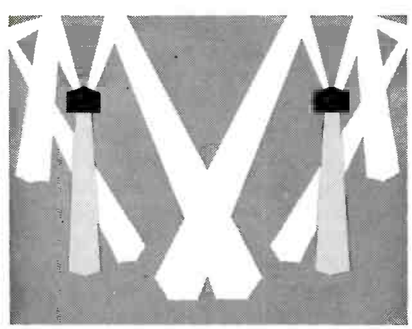
DIRECT/REFLECTING™

Speaker System?

If you have heard the BOSE 901 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.

In this issue, we'd like to tell you what our research revealed about the roles of direct and reflected sound in the reproduction of music. The direct sound is what you would hear if the walls and roof of the concert hall were removed. If you have ever listened to an orchestra outside, without a reflecting shell, you know that it is very soft and dull compared to what you experience in the hall. The difference is the reflected sound.

The reflected sound comes to your ears from the walls of the concert hall in almost equal quantities from all directions whereas the direct sound comes to you from the direction of the instruments. The direct sound is responsible for your sense of localization while the reflected sound contributes to the fullness, presence and warmth of the concert hall performance. As the research indicates, "this spatial property of the sound incident upon a listener is a parameter ranking in importance with the frequency spectrum of the incident energy for the subjective apprecation of music."*



HOW THE 901 INCORPORATES THESE FINDINGS

The 901 has eight speakers on the back panels and one on the front. This accomplishes two objectives. First, it provides the desired ratio of about 89% reflected sound to 11% direct sound. Secondly, by proper choice of the angles of the rear panels (see fig.) the 901 projects the image of a musical performance spread across a stage that is located about two feet behind the speaker. This image is established to the extent that it is possible to hear the full stereo spread from a wide range of listening positions including directly in front of one speaker — a feat that is not possible with conventional speakers.

This concept of direct and reflected sound would result in an improved speaker by itself but it would fall far short of providing the realism offered by the 901. There are three other essential advances that must be used in combination with the direct and reflected sound to obtain the full benefits offered by the 901. These will be the subjects of other issues.

In the meantime, 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.

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Sound & Decor Styles (continued)

ture. Another photo allows us to look through the booth door into the booth and through the window to the desk and turntable. Also noticeable in the booth are the remote switches and controls for operating the Crown 822 recorder. The VU meters on the Crown can be made visible by use of a mirror.

I should point out that all of the controls and switches for routing the various program materials to the right place are located on the panel just below the Viking recorder. The other small knobs on the left are controls for routing music through the rest of the house.

Another picture here gives some indication of the size of the living room/music room. The speakers, which are a double set of AR-3s, are located behind the jute cloth cover on either side of the fireplace. The jute is stretched over a wood frame; the frame was made so that it has a tight fit. On each side, one speaker is placed at knee height and the other at head height. This produces the best spread and dispersion of sound for my listening area.

Most of the wiring for this installation, including the speaker leads, was accomplished while the house was being framed, concealing all wires within the framework.

When the music was first turned on I was disappointed because of a distinct nasal quality to the sound. Experimenting with various panel and drapery materials, the truest sound was obtained by placing a layer of cork on the rear wall of the room (behind the equipment console structure), and also by using bamboo drapes on either side of the room near the front.

A great deal of flexibility has been built into the system. For example, it is possible to record tapes in any configuration of ½ to ¼ track except full track monophonic (I use two-track monophonic, which is just as useful). With voice tracks on the Viking (pre-recorded on the Crown), musical inserts on the Crown player, and entire recordings on the turntable, it is possible to create a very diverse kind of program, commercial, or announcement. One of my programs, called "Music Omnibus," was a semi music-appreciation presentation, where it was often necessary to illustrate, demonstrate, and repeat various sections of music to obtain the clarity of understanding that I wanted. Æ

Playback-Record Switching

■ In all likelihood, one can find shortcuts in the system of switching outlined below. Being plagued with switching "pops" and turntable/cartridge hum problems, I used this system to eliminate the last vestige of extraneous noise.

Figure 1 shows a diagram of the plate that accommodates all the function switches used in routing the various signals from the Thorens turntable, Viking tape recorder, Crown tape player and Citation tuner, to the audition (listening) system, to the recorder for insertion in a recording, or to the cue system for preparation for recording. Note that each program source has 2 bat-handle switches. The top switch of each source (turntable, Viking, Crown, Tuner) has a cue-off-aud (audition) position. In the "cue" position, signals are routed to the cue amplifier and speaker system. In the "off" position, all sources are turned off and the input of the cue amplifier is shorted. The "aud" position routes signals to the lower switch where either "rec" (recorder) or "off" or "aud" (audition) mode is selected. In "rec," the signal is fed to the Crown recorder and to its appropriate input; in "off" the inputs of the recorder or audition system are shorted; in "aud" the signals are fed to the audition or listening system via the "output" switch. Figures 2 and 3 present the wiring of all sources to the switches.

The "output" switch (Fig. 4) has four positions that correspond to all possible combinations of the Crown and Citation systems. Therefore the "Ci-Ci" position selects the Citation preamplifier and amplifier; the "Ci-Cr" position selects the Citation preamplifier and the Crown SA-20-20 amplifier; the "Cr-Cr" position selects the Crown preamplifier of the recorder and the Crown SA-20-20 amplifier, and so forth. An amplifier or preamplifier has its input shorted when it is not selected. In fact, this procedure was used throughout the switching to eliminate "pops" in the audio when various sources were selected. The present arrangement gives smooth, silent switching.

Figure 2 shows the upper half of the turntable selector switches. Note that shorting contacts are used, and that the Shure preamplifier is isolated by one section of the switch to eliminate it from the circuits when the other higher voltage sources are used. The lower switch of the turntable input is similar to that of the other sources. Also observe that the diagrams show only one channel of the stereo system, and that the ground leads are not connected.

Signals from the Citation or Crown amplifier are fed to the voice recording booth, where a switch selects the booth speakers or the AR-3 monitor speakers. Further, a headphone jack is available to provide facilities for recording voice on one channel while listening to voice on the other (the headphone jack opens the circuit to the booth speakers). The switch also provides for disconnecting all speakers while recording voice tracks; also for turning on either booth or monitor speakers to check quality of voice tracks without leaving the booth. Tape-recorder controls are also available in the booth. All speakers and headphones have independent volume controls. Æ

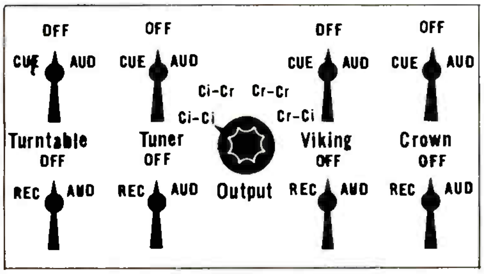


Fig. 1 — Escutcheon plate showing mounting of switches for control of program material.

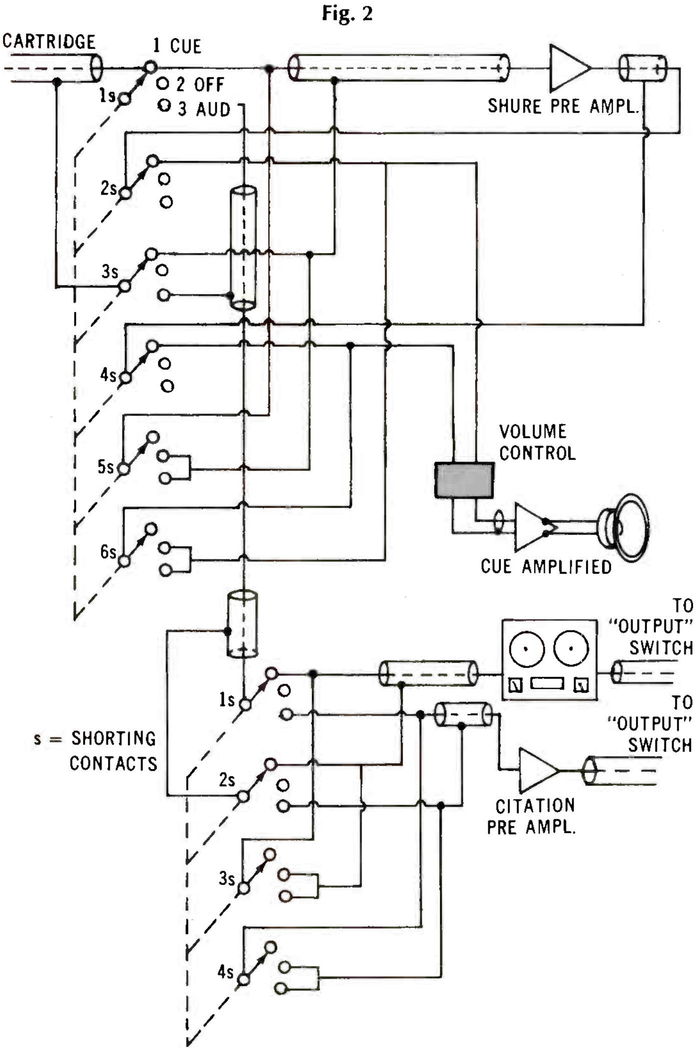
Fig. 2—Wiring diagram of "turntable" switches for routing cartridge signals to "Cue," "Recording," and "Audition" systems.

Fig. 3—Wiring diagram of switches for tuner, and Viking, and Crown tape players.

Fig. 4—Wiring diagram of output switch to provide all possible combinations of Citation and Crown preamplifiers and amplifiers.

Fig. 5—Wiring diagram of record booth switch to monitor voice tracks or recordings from within booth.

Fig. 2



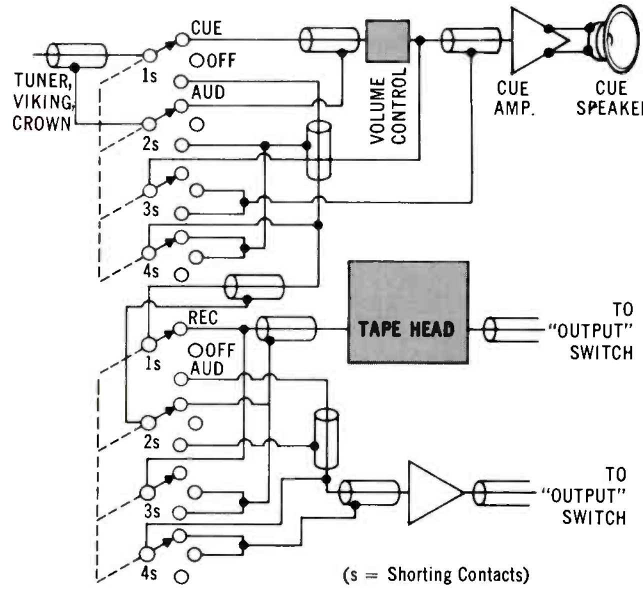


Fig. 3

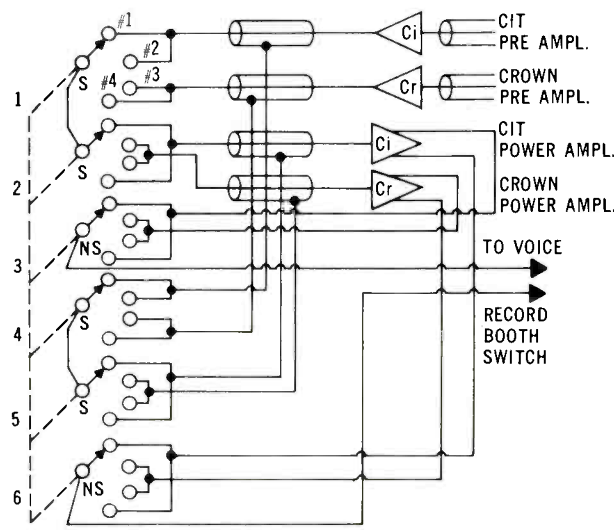
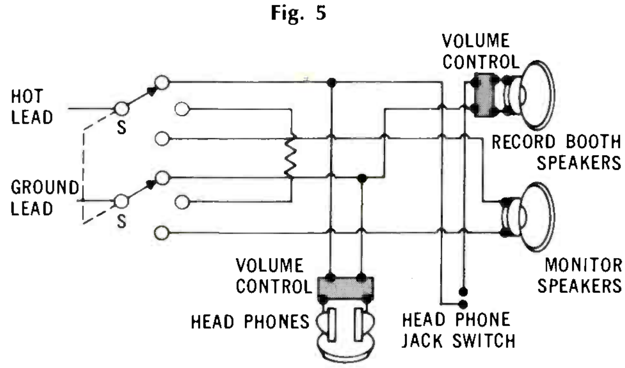


Fig. 4

Fig. 5



AUDIO MUSIC REVIEW

Classical Record Reviews

EDWARD TATNALL CANBY

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German Music of the Renaissance. Ambrosian Singers, In Nomine Players, Denis Stevens.
Dover HCR-ST 7270 stereo ($2.00)

Here are three recent discs, out of literally dozens, bringing to performance some of the vast quantities of secular or "popular" music of the sixteenth century and back. Formerly unknown to the general public (and seldom heard, though often seen, by musicologists) these little bits and pieces for instruments and voices more or less *ad lib*, except for the straight dance music, are increasingly popular as light listening of a classical sort. Only occasionally are they profound (as Isaak's lovely "Innsbruck ich muss dich lassen"), the harmonies are mostly rudimentary and the tunes not always—but sometimes—catchy. But there is bounce, humor and rhythm to them, with occasional real pathos and a great deal of honest human earthiness. Nothing of the museum! And the old instruments, including drums, tambourines, etc., are good fun.

The most costly, Telefunken, disc—"Peasant Dances and Street Songs in Germany c. 1500"—is excellent. The singers, while professional in sound, manage to avoid the arty, throaty approach (cf. the Denis Stevens disc, below) and to get over the earthy style and content. More important, their singing is dead-accurate, without flossy vibrato, and so we can get the tunes themselves and the harmonies with commendable ease. These performers and their instruments do for an earlier period what the Concentus Musicus in Vienna does for the eighteenth century Baroque.

RCA Victrola's recording, performed by an anonymous ensemble, all apparently Germans, is also excellent. Here we have dance music minus voices; but there is a good deal of contrast among the many tiny pieces, between slow music and fast, serious and light; between strings and winds; between German music and French. A nice collection of well played viols, recorders and crumhorns, plus lute and dulcian.

Denis Stevens' many recordings have often been worthwhile, but this one really got me down. For voices predominantly, with some instrumental cuts, it is *not* for beginners, though those who are familiar with the music and the period will make good sense of it.

The trouble, first, is with the singers, who are the modern trained type, excellent for Italian opera, English oratorio and German Lied but just plain lousy for this much more intimate close-up music. The instrumental music, by the In Nomine Players, is stodgy, inaccurate in ensemble and generally stuffy.

For those whose guideline to record selection is performance, not price, just try the two German discs. Then you'll see how good Renaissance Pop can sound.

Organ Music

Yankee Organ Music (Hewitt, Ives, Paine, Chadwick). Richard Elsasser, Organ of the Hammond Museum, Gloucester.
Nonesuch H 71200 Stereo ($2.50)

Richard Elsasser and this enormous and eccentric organ were once an M-G-M property. Now Nonesuch sets them to work in an interesting, if not too consequential, survey of quaint organ Americana. Included are the impudent "America" variations by Charles Ives, plus an outrageously dissonant setting of "O Come All Ye Faithful" (Adeste Fidelis), enough to make any modern congregation quail, not to mention one in the 1890s! Ives had his fun, all right. Then there are some innocuous Fourth of July happenings and a solemn set of variations on "Yankee Doodle" by the earlier Hewitt (Beethoven's time) and two works by those granddaddies of American music in our century, John Knowles Paine of Harvard and George Chadwick of the New England Conservatory. Paine is heavily Brahms-like, with thick French overtones; Chadwick is all extroverted lushness, Debussy turned inside out and combined with Sousa. Good fun, and imaginatively played.

Performance: B+ *Sound:* B

J. S. Bach: Orgelbüchlein (Little Organ Book). Vols. I, II. Anton Heiller, Metzler Organ (1964) at Netsal, Switzerland.
Vanguard Cardinal VCS 10026, 10027 Stereo ($3.50 ea.)

Bach: The Complete Organ Music, Vol. 2 (Trio Sonatas, Chorales, Prelude and Fugue in E Flat BWV 552). Lionel Rogg Silbermann Organ at Arlsheim.
Epic B3C 169 (3) Stereo ($17.37)

Anton Heiller's gently Austrian performances of the "little" chorale preludes are warm, colorful, plastic in rhythm, beautifully contrasted and registered so that the melodic line is always clear. Since no specific registration was indicated, there are no definitive ways of playing these works, but this is one of the most satisfactory and deeply enjoyable versions I have ever heard. Low price, too, on Vanguard's intermediate Cardinal label. The organ is a modern "Baroque" instrument, a very fine one and set in excellent acoustical surroundings.

Lionel Rogg's monumental series

(Continued on page 70)

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BEST BAROQUE, 1968

Telemann: Suite: The Prostitute; Concerto in B♭ for 2 Flutes, 2 Oboes; Concerto in D for 3 Trumpets, 2 Oboes, Tympani; Concluding music from Production III, Tafelmusik. Esterhazy Orchestra, David Blum.
Vanguard BGS 70695 stereo
($5.79)

Telemann, not so long ago almost totally neglected, now rolls on ever upward, a composer who in his thousands of genial works is ideally suited to today's Baroque taste in terms of recorded music. His works are colorful, large-scaled and impressive, yet also intimate (compared to a symphonic sound), precisely the finest combination for living room reproduction—and much better there than in any modern concert hall.

This is one of the finest Telemann discs yet. Not only in the colorful and interesting music, so widely varied in instrumentation, but in the unusually sympathetic and musical performances by the Esterhazy Orchestra under David Blum (known already for their Haydn playing). No Baroque banging and bouncing here, no stridency, no heavyweight plodding, none of the half-baked non-phrasing of melodic lines that so often ruins Baroque performance today. All is carefully proportioned, expressively, dynamically shaped, with earnestness and accuracy, too. Pardon my superlatives!

As always in Telemann, the music is full of surprises within the relatively familiar shapes of suite and concerto in the Baroque manner. Surprises in the music, plus the over-all surprises, so to speak, inherent in each of the dramatically different special combinations of instruments and tone color, each piece featuring its own.

The semi-popular Suite with the exotic title (the original is in French, *La Putain)* engagingly combines a batch of obviously popular folk tunes with the standard tributes of the orchestral suite; it must have afforded no little amusement to its knowing first hearers. Each also used one of the tunes in the *quodlibet* (musical free-for-all) that ends his Goldberg Variations for harpsichord. The massively colorful Baroque concerti represent the ultimate in this sort of "exhibition" music, positively gorgeous in sound.

It is indeed a positively gorgeous record, and beautifully recorded in stereo. I'd call it the Baroque Record of the Year.

★ ★ ★

Bach: Ouverturen 1-4. (Orig. instrumentation). Concentus Musicus, Vienna, Harnoncourt.
Telefunken SAWT 9509/10 stereo, 2 discs ($11.90)

And this, surely, is the Baroque Album of the Year. In a splendid box, with a dozen pages of text and pictures inside, these two records cover the four Bach orchestral Suites (originally called "overtures," since the form came out of the early opera overtures) in, at last, a *fully* authentic rendering, down to the last instrument, strings and all.

Every violin, viola, etc. in this orchestra is a revamped model, restored to the Baroque state. Every solo wind instrument is a Baroque original, from the wooden flute to the striking coiled-tube *clarino*, the high-pitched valveless trumpet.

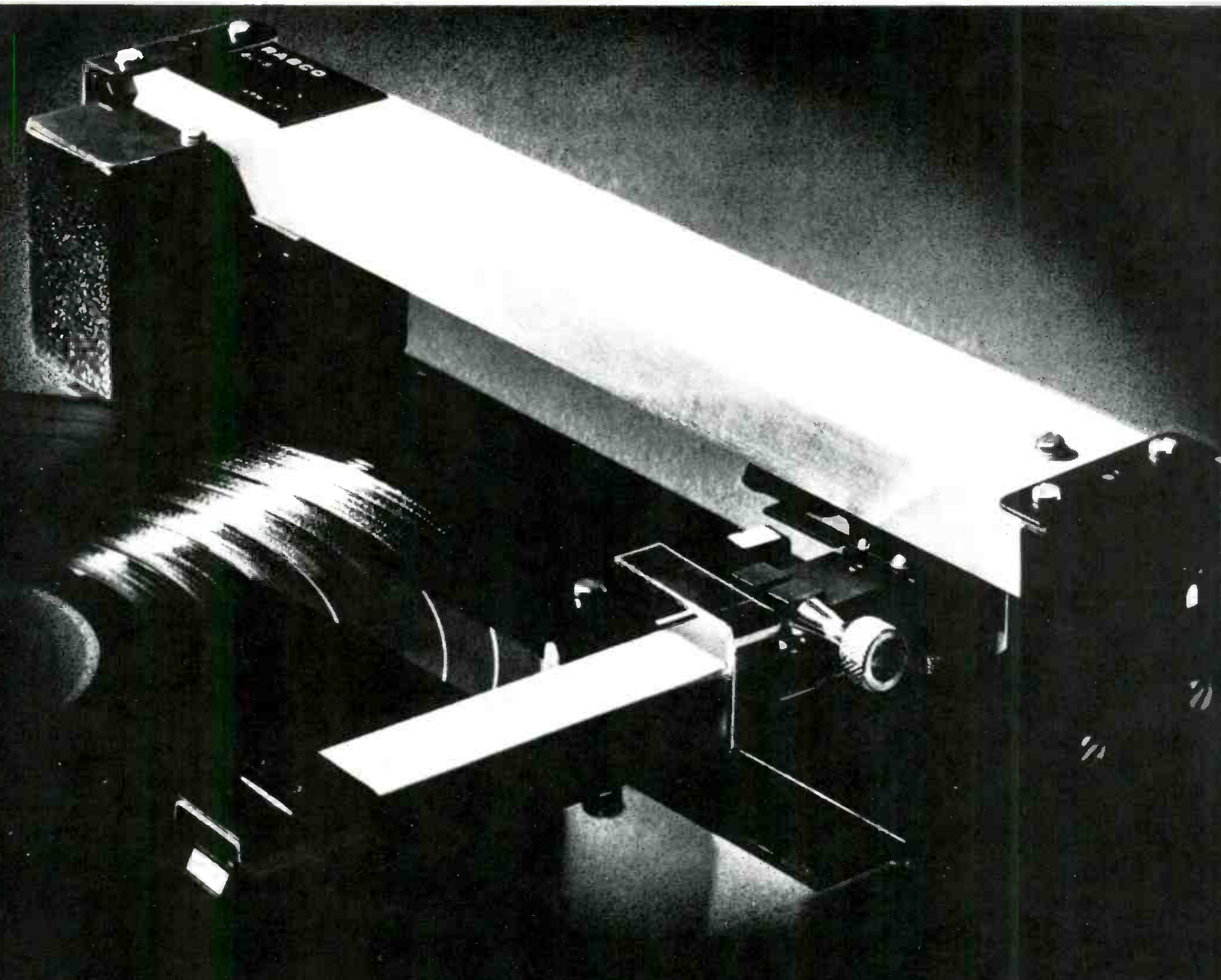
In view of this almost archaeological approach, the brillance of the musical execution here is astounding. None of the clumsy, out-of-tune bumbling that has been typical of earlier totally "authentic" performances on old instruments! You will not hear a trace of clumsiness, nor a note out of tune, from beginning to end; the music plays with all the ease and fluency of any performance on modern instruments. From the old finger-hole oboes and wooden flutes, minus modern keys, to the valveless coiled trumpets, on which the different tones are produced entirely by varying lip control, the old instruments sound just as versatile, just as "easy" to play, as their modern counterparts, for all their power steering (the complicated mechanical valves) and the rest.

In other words, the old playing techniques, thought to be permanently lost, if they had ever existed (many cynics thought not), have been regained, and in a remarkably short span of years. Amazing.

And thus it is clear in seconds, as you listen to this Bach, that *when rightly played*, the "obsolete" instruments are superior to the modern ones for the music of their own day. Many of us have long supposed so—but could they ever be played properly? Just listen and find out for yourself.

Compared to the modern oboe, the old oboes are sharper, mellower in color, throaty in sound, more oboe-y, like natural cheese next to the processed variety. The wooden flute is breathy, more flute-y in sound, the strings are stringier, a lovely silken effect. The *clarini*, the valveless coiled trumpets, are unbelievably true and brilliant and there is not a false note to be heard from them, valves or no valves! All of which is marvelously revealing in these 100 per cent competent performances.

If you must sample, by all means begin with the big Suite No. 4, which features three *clarini*, two Baroque oboes, two solo violins and a viola plus old-style tympani (very loud!) against the old-type string orchestra. Never heard such a brilliant sound in my life, and what excellent stereo placement of the various groups!



(Continued from page 66)
also features a splendid organ, one of the most impressive of the old instruments. This young Swiss (Geneva) is of the new and forthright generation; his Bach moves on smartly as though time were of the essence, his rhythms are somewhat rigid and unyielding, with never a pause for a bit of musical "give"—very modern. But he registers beautifully on the instrument, and his phrasing of the Bach lines is always careful and musical, which is more than can be said for some of our more famous organists.

In line with the Rogg playing style, the recorded sound is closer and drier than Vanguard's Heiller sound. In some pieces (depending on pipe location) it is almost too clinically close, but by a hair, so to speak. A grand project, this one.

Performance: B— *Sound:* B

More Baroque

Telemann: Orchestral Suite in F Minor; Suite in A for Recorder and Orch. Concentus Musicus, Vienna, Harnoncourt, Brüggen.
Telefunken SAWT 9507 stereo ($5.95)

If your phono has an "old Columbia" or "LP" equalization position on it, you may be able to enjoy this fancy import. On standard RIAA playback it is inexplicably shrill and distorted. Sounds like a hold-over from 1954 or earlier!

The Das Alte Werk series on this label, subtitled *Musik und ihre Zeit* (Music and its Time), offers that combination of LP record and book of texts and pictures. The albums cover five pages of excellent background material, on the instruments, the music, the times.

The two big, colorful Telemann Suites are played vigorously and with drive. The blurring acoustics of a rather too-large hall is a minor fault tending to force the mikes a bit too close to the players in compensation.

The first suite features two violins and viola plus two recorders, a sumptuous solo group. The second is none other than the once-familiar *A minor Suite for "flute,"* once widely played in a grossly symphonic version by our major orchestras, virtually the only Telemann that was known at the time.

Performances: B+ *Sound:* C

Rameau: Suite from Le Temple de la Gloire. Grétry: Suite of Ballet Music from the Operas. English Chamber Orch., Leppard.
Oiseau-Lyre SOL 297 stereo ($5.95)

Rameau: A second Suite from Le Temple de la Gloire. Campra: Suite from L'Europe Galante. English Chamber Orch., Leppard.
Oiseau-Lyre 302 stereo ($5.95)

This symphonic treatment, modernizing the old eighteenth-century music, was promoted by such famed arrangers as Felix Mottl (the works of Gluck) and Sir Thomas Beecham (Handel), as well as Leopold Stokowsky, who made the supposedly difficult and mathematical music of Bach juicy enough for popular consumption.

These interesting Rameau-Leppard Suites (and Grétry-Leppard, Campra-Leppard) have a curiously nostalgic quality to them. They are far more modern in style than old Sir Thomas Beecham's concoctions; they preserve the approximate original instrumentation, including harpsichord (with the conductor at the keyboard) and the orchestra is not of "symphonic" size, though made up of modern instruments.

The playing here still sounds Beecham somehow. The sound is too big (or it sounds that way). The playing is overly dramatic and a bit unctuous, trying hard to put over the various effects. There are untoward crescendi, the endings typically drag out in the exaggerated old-time Beecham fashion; and the ornaments, trills, extra notes and the like, though often rightly done, still manage to sound typically 1930's.

"Le Temple de la Gloire" was a pageant-type piece, not really Rameau's *forte*, for he tends towards a complex sort of musical thinking. He tries hard to be "popular" here, but the best numbers revert to his more intellectual style. The first Suite, I would say, culls the most useful music from the work. The second Suite is good, but somewhat tougher going.

Grétry, on side 2 of the first disc, is excellent. This little man, who managed musically to stay afloat from the days of Louis XVI straight through the French Revolution, wrote some wonderfully vigorous popular music in the Mozart style, and these English players hit it off perfectly. Campra, on the second disc, is a less subtle composer; his Suite (again one of Leppard's) is somehow rather colorless, though pleasant enough listening.

These discs are fine for those who are not Baroque purists.

Performances: B *Sound:* B

Lully: Pièces de Symphonie. English Chamber Orch., Leppard.
Oiseau-Lyre SOL 301 stereo ($5.95)

This is a Leppard suite made up from various sources, though largely from two Lully works, *Thesée* and *Amadis;* these numbers are, in Lully's own words, the "symphony pieces," or orchestral show interludes, from operatic stage works. Those who know Handel (or Handel-Beecham!) and, in particular, Henry Purcell, will be impressed at their indebtedness to the earlier Lully, who died when Handel and Bach were two. (Much of the shape and formation of later orchestral music was originated by Lully, including the familiar "French overture" of many a Handel or Telemann or Bach work, and the very concept of the orchestra, as based on a string band.)

Performance: B *Sound:* B

THE WORLD OF TWENTIETH CENTURY MUSIC by David Ewen, Prentice-Hall, 1968, $14.95, 1000 Pages.

This opus can serve two needs: reference book or reading pleasure.

Since subject is arranged alphabetically by composer, it is thus in the nature of a specialized encyclopedia. Under each man we find a brief write-up and evaluation of his life and place (so far) in today's music. Then Mr. Ewen, under each composer-heading, moves on to a brief, chronological study of a group of the composer's representative works. However, Mr. Ewen's arbitrary excisions and his bias toward orchestral music and the large-scale symphonic concert renders this study controversial.

As a reading-for-pleasure book about music, it has plenty of interest, of course, if only for its skillful assembling of enormous quantities of fact and opinion. But you will not find it of much use in direct listening. Almost none of the twentieth-century composers on my shelf were in Mr. Ewen's book, and among those who were—John Cage, Janacek, Riegger, Rawsthorne, Hovhaness—I found only one short piece, by Janacek, specifically described.

Of course, the undertaking of such a voluminous task, alone, is commendable, and I would place this book beside the 1952 version it replaces, "The Complete Book of Twentieth Century Music," on my library reference shelf. But, as anyone can guess, the new "World" is very, very far from complete in the literal sense.

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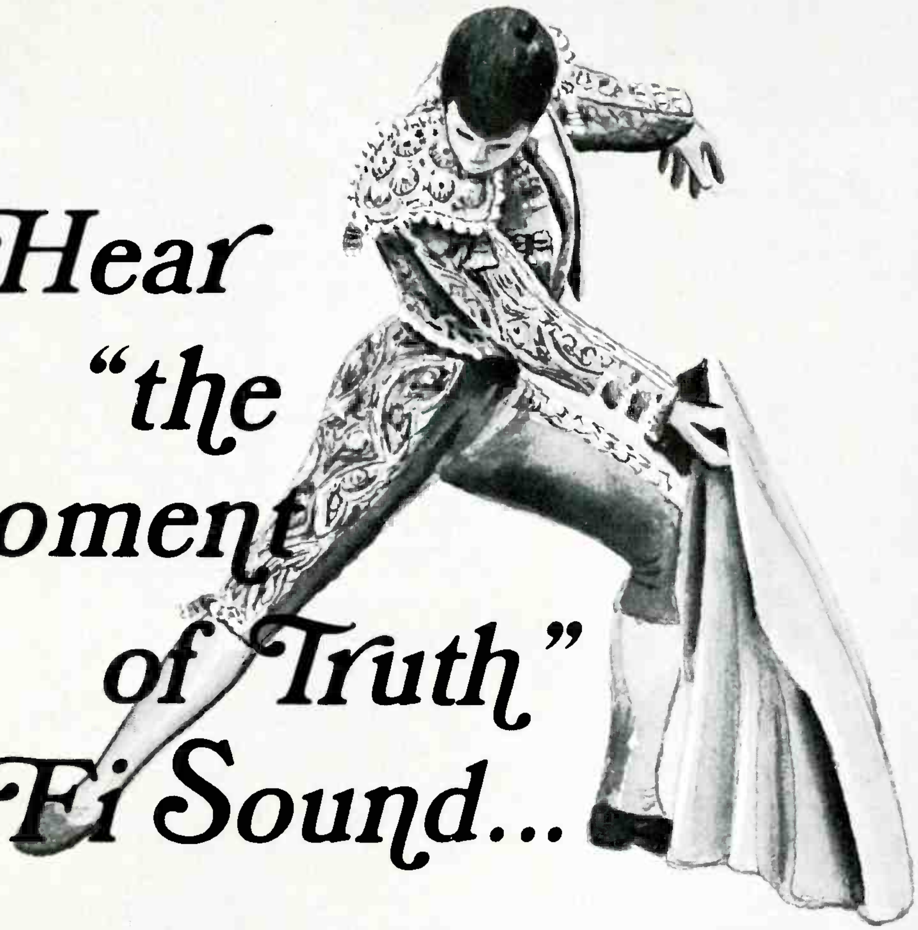

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Light Listening

STUART TRIFF

Theatre & Film

Soundtrack albums are of special interest this month. It's rare nowadays to find background scores that can hold their own when separated from the visual action they were meant to accompany, and so it's a pleasure to be able to report on no less than four exceptionally-distinguished current soundtracks.

For the screen treatment of Morris L. West's novel, "The Shoes of the Fisherman" (MGM SIE-15 ST), *Alex North* has composed some beautiful music, impressively scored for a very large orchestra, and capturing all the pageantry and poignancy inherent in the drama of a Russian labor camp prisoner who becomes Pope.

At the risk of speaking heresy, I must say that the over-generous sampling of dialogue included in the highlights-disc from the Franco Zeffirelli production of "Romeo and Juliet" (Capitol ST-2993) really intrudes on the enjoyment of *Nino Rota's* effective 15th-century Renaissance-flavored score. Composer *John Barry* is no less successful in capturing the atmosphere of England in the 12th century, in his remarkable scoring and choral writing for "The Lion in Winter" (Columbia OS-3250). Finally, the remake of "The Charge of the Light Brigade" (United Artists UAS-5177) boasts some highly individual themes by *John Addison,* including a real rouser of a march!

Hollywood-renderings of stage musicals are more often than not disappointing. A happy exception is "Oliver!" (Colgems COSD-5501), very well-cast with *Ron Moody* as Fagin—a role he created in the original 1960 London production, and *Shani Wallis,* giving an affecting portrayal of the ill-treated but ever-faithful Nancy. *Lionel Bart*'s charming and appropriate songs fare beautifully under the guiding hand of veteran *Johnny Green.*

Boston Pops & Others

ARTHUR FIEDLER and his versatile BOSTON POPS ORCHESTRA are represented with two new releases, the first of which features pianist *Peter Nero,* playing his own "Fantasy Variations for Piano, Jazz Bass & Drums, and Symphony Orchestra," an ambitious title for a superficially ambitious piece that is no more than pleasant at best, but is more frequently dull and long-winded, impressing one as just second-rate Gershwin. One need only go to the flip side to confirm this, as Nero plays the solo part in Gershwin's Concerto in F. Maestro Fiedler turns out to be his own competition here, for his previous version of the work with Earl Wild is an infinitely better performance, more felicitously-coupled with the same composer's "I Got Rhythm" Variations and "Cuban Overture."

The second *Boston Pops* disc contains Richard Hayman's done-to-a-turn arrangements of "Up, Up and Away" (RCA LSC-3041) and other current favorites including "Yesterday," "A Man and a Woman," and "Georgy Girl." The only stumbling block preventing wholehearted endorsement is the inclusion of an undistinguished performance, with Newton Wayland as soloist, of the slow movement of Mozart's Piano Concerto No. 21; popularized anew as the theme music for the film "Elvira Madigan." Its presence here is otherwise pointless, since the complete Concerto is available in several editions by front-rank pianists.

Robert Russell Bennett, the dean of Broadway show orchestrators, has fashioned Symphonic Pictures of "My Fair Lady" and "The Sound Of Music" (Command CC-11041 SD), beautifully played by the PITTSBURGH SYMPHONY ORCHESTRA under *William Steinberg.* Bennett did the arrangements for the original stage productions of these musicals, and has since scored the music for bands and orchestras, both large and small. To question what more he could possibly have to say about these scores is to underestimate his indefatigable imagination and consummate good taste. These are not merely medleys, but symphonically worked-out scenarios that always remain true to the composer's original intent. Command's stereo is absolutely gorgeous!

In the same genre is *Jerome Kern's* "Symphonic Scenario On Themes From 'Show Boat' " (Vanguard/Cardinal VCS-10023), a work commissioned in the early Forties, and orchestrated by Charles Miller. This is a stereo "first," and the only currently-available recording—a welcome entry, sumptuously played and reproduced. The overside bonus, and a fitting companion piece to the Kern, is the best version now in the catalog of Bennett's well-known Symphonic Picture of "Porgy and Bess." The playing of the UTAH SYMPHONY under *Maurice Abravanel* could not be better. A highly recommended disc, especially at the label's budget price of $3.50.

Instrumental "Pop"/Latin Percussion

Leading off a batch of instrumental "pop" albums, is "The Contemporary Sound of Nelson Riddle" (U.A. UAS-6670), displaying *Nelson Riddle's* fine arranging talents in such tunes as "Gentle On My Mind," "Light My Fire," and "Where Do I Go?" (from "Hair"). Effective use of guitars, organ and a battery of percussion instruments.

If you enjoy a good many of today's pop tunes, but, like myself, don't "dig" the lyrics too much, an ideal solution is the series by that lush group billed as the *Hollyridge Strings.* Their newest, arranged and conducted by *Mort Garson,* is devoted to a dozen *Simon and Garfunkel* songs (Cap. ST-2998). Most of the S. & G. favorites are here, including "Feelin' Groovy" and the themes from the movie, "The Graduate." Much the same approach is applied on "Donovan My Way" (Epic BN-26418), with *Vic Lewis'* big orchestra delivering power-packed renditions of *John Cameron's* swinging settings of songs composed by the talented British singer.

"The Big Latin Band Of Henry Mancini" (RCA LSP-4049) is a made-to-order demo disc, employing an endless variety of Latin percussion, deployed in warm, bright Dynagroove stereo. Best tracks in a highly-enjoyable program are *Lalo Schifrin's* theme for the TV Series, "Mission Impossible," and Mancini's own "Las Cruces" and "A Touch Of Evil." Nice solo trumpet work by *Graham Young.* Still in the Latin mood, is "New Dimensions In Sound" (U.A. UNS-15538), with the *Lyrio Panicali Orchestra* playing Brazilian tunes, notably those of *Antonio Carlos Jobim,* with gently swaying vocals by *Clara Nunes* on "Insensatez" and "A Felicidade." Æ

Jazz

BERTRAM STANLEIGH

Henry "Red" Allen.
RCA Victor Mono LPV-556

From 1929 until his recent death, Red Allen was a respected performer on the New York musical scene. Brought to Manhattan by Victor Records in the hope that this young New Orleans trumpeter might be an "answer" to Louis Armstrong, Allen soon demonstrated that he was not only no mere copyist, but that he was not so rooted in tradition that he could not study and integrate more recent jazz styles into his personal mode of expression. No other seriously creative musician has developed over so long a period with such consistent advancement with the times. A portion of that development is reflected in this splendid set of reissues that extends from 1929 waxings with what was in fact Luis Russell's orchestra and included Albert Nicholas, J. C. Higginbotham, Pops Foster, and Paul Barbarin, to some 1957 sessions that feature J. C. Higginbotham, Buster Bailey, Coleman Hawkins, and Cozy Cole. The big technique, involved ideas, and the suave New Orleans *panache* are all present in this fine sounding transfer.

Performance: A — *Sound:* A

Miles Davis: Miles in the Sky
Columbia Stereo CS 9628 ($4.79)

Playing with Herbie Hancock, piano and electric piano, Wayne Shorter, tenor, Ron Carter, bass, Tony Wiliams, drums, and with George Benson, guitar, on *Paraphernalia,* Davis turns in four very polished, deft, tightly controlled performances. No feeling of strain pervades these offerings, and there is a chance that some listeners may take this poised, calm approach to mean that Davis is less totally engaged on this set than on some of his more frenetic albums, particularly the "live" ones. For me, the present set is one of Miles' more profound statements, and a fine studio recording offers this close collaboration in the perfect perspective.

Performance: A — *Sound:* A

Dave Brubeck, Gerry Mulligan: Compadres
Columbia Stereo CS 9704 ($4.79)

Sound-effects devotees will be interested to hear that there is a 33-second band of audience applause at the start of this platter. Music lovers will be disturbed to learn that similar extended bits of audience interruption occur at regular intervals throughout this live recording made during a Mexican tour by the Brubeck-Mulligan group as part of the second annual Newport Jazz Festival in Mexico. In my view, the finest element in the old Brubeck quartet was Paul Desmond. Mulligan is certainly the best single element in the new group, but even his contributions do little to offset the dull routines of Alan Dawson, drums, and Jack Six, bass. And while Brubeck's accompaniments during Mulligan solos are discreet, his own piano solos are just as replete with tasteless vulgarism as ever. Only the most dedicated Mulligan fans need bother with this one, though I do feel duty bound to state that the recorded sound is of a particularly high quality for a live recording.

Performance: B — *Sound:* A

Eddie "Lockjaw" Davis & Paul Gonsalves: Love Calls
RCA Victor Stereo LSP-3882 ($4.79)

One might expect two of the top tenor saxophonists to engage in a "cutting" contest when they get together for a session of duets, but everything is *aprez-vous cher Alphonse* as these two titans improvise together in a thoroughly cordial spirit of camaraderie. Roland Hanna, piano, Everett Barksdale, guitar, Ben Tucker, bass, and Grady Tate, drums, form an expert but unobtrusive accompaniment as Davis and Gonsalves wallow in a dozen romantic ballads. Each takes one solo to himself, and the liner notes are careful to point out the order of each solo in the duets. The stereo sound provides wide separation, and the joy generated by two mutually inspired collaborators makes this one of the most rewarding of recent collections.

Performance: A+ — *Sound:* A

Willie, "The Lion"

Born in 1893, and still a vigorous and exciting performer, Willie "The Lion" Smith has always been a voluble talker whose feats of braggadocio have made him a somewhat unreliable informational source on jazz history. A stride pianist who was the companion of James P. Johnson and "Fats" Waller, Smith developed in Harlem during the era of the speakeasies and the rent parties. Some of the color of the era and a bit of the personalities of Duke Ellington, Eubie Blake, and Louis Armstrong come through on this two-record set on which The Lion talks and sings material from the period starting before World War I and stretching through the Thirties. But, entertaining and informative as this set may be, it's a pale portrait of an artist who is a born talker, eager to tell of his adventures and exploits and of his relationships with other musicians.

The recordings, made at RCA's 24th Street studios during the last week of April 1968, were made without audience. Two tape recorders were set up to permit uninterrupted continuity. Producer Mike Lipskin asked questions as Smith sat at the keyboard and talked and played. Lipskin's questions have been deleted from the finished disc, and no doubt, many of The Lion's anecdotes have been truncated or wholly eliminated.

There's a lot of Smith's music that's missing from this set, too. The Lion was a prolific composer, and a number of his tunes are included, but rather a bit of time is occupied with extended versions of Waller and Ellington numbers played by Willie in his own style.

For a recording of so recent a time, sound is adequate, but by no means up to the standard that we have recently come to expect from the RCA 24th Street studios. No doubt the problems of maintaining good voice pickup raised special problems of balance between piano and voice. At any rate, this set does serve notice that there has been no lessening of the very special talents of The Lion.

The Memoirs of Willie The Lion Smith.
RCA Victor Stereo LSP-6016

Performance: B *Sound:* B

Recorded Tape Reviews

BERT WHYTE

The "Classical" Sound

Wagner Orchestral Favorites: Leonard Bernstein Conducting the New York Philharmonic.
Columbia MQ1007, **stereo, 7½ ips** ($9.95)

Bernstein has never done very much in the way of Wagnerian music and, on the basis of his performances, it would be interesting to hear what he could do at the Met. They almost certainly would be controversial opera performances, but they sure wouldn't be dull! On this tape Bernstein essays such chestnuts as "The Ride of the Valkyries," "Magic Fire Music," "Prelude to Act 3 of Lohengrin," the "Love Death" from *Tristan und Isolde*, and others. The overall approach is very intense, a tendency to step up the pace in the fast sections and broaden the slower parts of the scores. Thus his "Valkyries" really gallop, while his "Love Death" is almost as emotionally charged as Stokowski's famous reading. With his orchestra responsive to him, Bernstein gets playing of unusual brilliance, with especially fine sound on brass.

The engineers have furnished a big sound, properly scaled for Wagner, with spacious acoustics, nicely detailed. Good directional balances with woodwinds right in the phantom center-channel where they belong. Wide dynamics and clean, heavy percussion were notable. Tape hiss quite low, but noticeable print-through and crosstalk. At the conclusion of the "Overture to Tannhauser," I noticed several momentary dropouts of sound in the left channel. They are too pronounced to be regular tape dropouts. They sound more like the tape was lifted away from head contact. I examined the tape visually to no avail and checked the whole playback system using other tapes, and it is definitely on the tape.

Handel: Water Music (complete). Rafael Kubelik conducting the Berlin Philharmonic.
Ampex/D.G.G. DGC8799, **stereo, 7½ ips** ($7.95)

Most people know the Water Music from the oft-performed Suite, usually the Hamilton Harty version. Here it is performed complete, and there is so much more musical substance than the Suite it is almost like discovering a new work. Kubelik's overall performance might be characterized as "stately," with careful attention to balances and inner detail. I hasten to add, it is never stodgy and the dances have a proper lilt and liveliness that I find most ingratiating. Kubelik elicits some truly virtuoso playing from the Berliners . . . their string work is just plain marvelous.

The sound is very grandiose, with spacious acoustics combining with good orchestral definition to give us great presence. Everything is pristine clean with an especially full, sonorous bass line. Moderately-wide dynamics and good center-channel fill. The *EX-Plus* processing afforded low hiss level, but there was moderate print-through and a smidgen of crosstalk. There are other versions of the complete Water Music, but the combination of the fine Kubelik performance with the best sound yet tip the scales in favor of this recording.

The Art of Julian Bream: RCA Victor R8S1100, **8-tr. cartridge** ($6.95)

Julian Bream is a superb classical guitarist as well as an outstanding performer with the lute. His program on this tape is nicely balanced ranging from Cimarosa, Frescobaldi and Scarlatti. It contrasts with Albeniz and Ravel, the latter composer's contribution being his lovely "Pavan for a Dead Princess." Bream's guitar is a richly sonorous instrument, and his playing wonderfully sensitive and expressive.

The transients of the guitar are very sharp and clean. High-level transients of the guitar are notorious for producing print-through, but there was surprisingly little in evidence. Some low-level crosstalk and moderate hiss. This is the kind of "stereo 8" cartridge that is best played in the home; in the car some of the more delicate playing is masked by the ambient noise of the mobile environment.

The "Now" Sound

Jackie Gleason: The Now Sound for Today's Lovers.
Capitol Y1T 2935, **3¾ ips, open reel** ($5.95)

The big man is at it again, dressing up his orchestra of strings with the currently "hot" Indian instruments, the sitar and tabla, plus a wide variety of exotic percussion instruments. Then he proceeds to apply all this lush instrumentation to some fairly current romantic hits such as "It Must Be Him," "Live for Life," "Yesterday," and others of similar stripe. It may sound cornball, but the Indian instruments and the percussion are nicely integrated into the ripe Gleason strings and produce an extremely pleasant and intriguingly different kind of sound.

The sound itself is very clean, nicely detailed in modest reverb. Tape hiss, print-through and crosstalk are all pleasingly low. A fine background "mood" album. "And awaaayyy we go!"

The Big Latin Band of Henry Mancini.
RCA Victor P8S1371, **8-tr. cartridge** ($6.95)

This is the best Mancini in a long time. The program is an admixture of movie and TV themes, plus a few numbers of Latin persuasion. They are all arranged in Mancini's unique orchestrations and played by the top musicians in the business out Hollywood way.

The sound is sensational, a superb mixing job by my friend — engineer Mickey Crofford. All the multi-mix trickery and deft handling of reverb are to be heard in this big bright recording. Processing is fine too, with moderate hiss, little print-through, virtually no crosstalk. This is a genuine sonic treat!

Finian's Rainbow: Original Soundtrack.
Ampex 8WL 2550, **8-tr. cartridge** ($6.95)

This is from the new movie version of this beloved musical starring that indestructible chap, Fred Astaire, and Petula Clark. This is typical movie recording . . . everything up close for maximum articulation and the emphasis on the vocals and dialogue.

The overall sound could be a bit cleaner, but it is pretty good and balances are excellent. The movie got mixed reviews, but I don't care. I like the Astaire wit and light approach and I think the whole tape is one big treat! Perfectly delightful, the music is as fresh as ever and I urge you to try it.

Andre Kostelanetz: Scarborough Fair and Other Great Movie Hits.
Columbia CQ1006, open reel, 4 tr., 7½ ips ($5.95)

Kostelanetz is still at his old stand, turning out recordings that may vary in musical content, but rarely in style. He is one of the last and the most able practitioners of the pop ballad set to huge, lush orchestrations. The typical sweeping strings are still his trademark and here we have a full complement of them abetted by the bloated, over-reverbed, yet clean sound. A curious blend this, that Kostelanetz has carefully nurtured over the years and is immediately identifiable. The music is the usual pop movie hit bag, with such standards as "Laura," "That Old Black Magic" and "Stella By Starlight," spiced with such new items as "Scarborough Fair" (from the controversial film, "The Graduate") and "The Look of Love." Tape processing good, in general.

BEHIND THE SCENES

(Continued from page 14)

must have exposure for their products in order to ensure sales. Stop and think a minute. What would one helluva lot of stations use for program material if they didn't have free access to records? The high school marching band? Local barbershop quartet? Any two-bit station can acquire the technical facilities and then dip into this ready-made program pool, with little more expense than some under-paid deejays.

The whole thing is simple. The record companies are doing a big volume of business, but due to the mad discounting that is prevalent, profits are declining. No profits, no record company. And with no record companies, no one will have to worry about the encroachment of off-the-air recordists. The record companies need the broadcast fees to improve their product and their artist rosters, to continue research and development, to underwrite the static classical market, commission new works, aid musical education, open new recording possibilities for many more musicians and orchestras. Of course they are not philanthropic institutions, and no one expects them to be. But they are intimately woven into the musical fabric of the country and, if they are to fulfill any of these objectives and prosper, they must re-assess their relationship with the broadcasters and move in the direction of performance fees. Æ

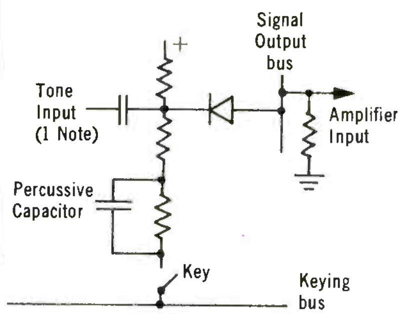


Fig. 5-4. Diode keying used to obtain percussive effect.

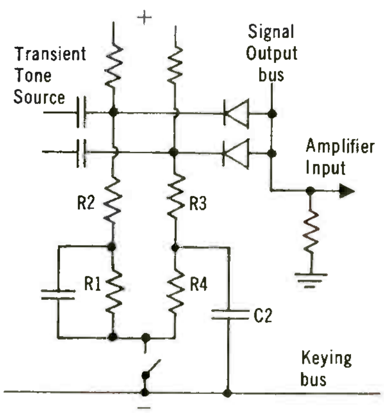


Fig. 5-5. Diode keying used to add a different transient tone to the start of a note.

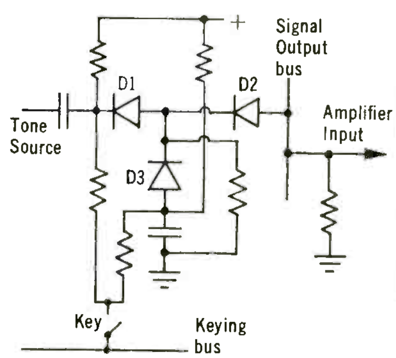
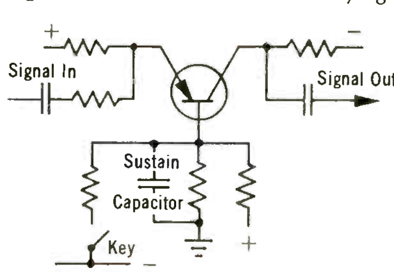


Fig. 5-6. Multiple diode keying, to achieve more complete action.

Fig. 5-7. One form of transistor keying.



(Continued from page 60)

reverberation). R_4 with C_2 slows the attack so that the steady tone grows as the initial transient dies.

If sustain is needed as well, R_3 is made a larger proportion of the total value $R_3 + R_4$, which determines full transmission by the lower diode, and C_2 will need to be larger to achieve the same attack time. Sustain time is controlled, primarily, by time constants. But decay time can be expedited by using a larger positive "off" voltage. This is the way usually adopted to provide alternative sustain times, short and long.

Changing values in diode circuits enable almost infinite variety of transient effects to be obtained, limited only by the ingenuity of the designer. Other designers use slightly more complicated semiconductor arrangements for switching. Unless diodes are very thoroughly biased, with carefully chosen associated circuit values, or multiple diodes are used to provide greater attenuation, an audible breakthrough occurs when no keys are pressed and the swell pedal is pressed forward for full gain. Multiple diodes will cure this by having two that go from non-conduction to conduction, while the other one goes the other way (Fig. 5-6).

Before the key is pressed, diodes D_1 and D_2 are non-conducting and D_3 is conducting, providing high attenuation. Pressing the key reverses the situation. Diodes D_1 and D_2 conduct and diode D_3 becomes non-conducting, completely removing the attenuation. Some designers prefer to use a transistor, rather than more than one diode. Control can be effected in a variety of ways. One way is to change the bias in the base circuit, controlling grounded-base operation (Fig. 5-7). This keys and amplifies at the same time.

Semiconductor switching, either by diode or by transistor, is usually combined with multi-spring keying to provide the full range of possible effects. Semiconductor keying is used to provide all the different attack and decay effects and to achieve synthesis from different tone generators for individual notes, while different contact springs are used to provide various voices and coupler effects.

Various couplers can make a note on one manual operate other notes, such as at octave or partial intervals, on the same manual. Or they may make the same notes on a different manual speak, according to the tabs there selected. This method can also be applied to produce the tonal effect needed for chimes. We will go more thoroughly into special effects in the next installment. Æ

THE CROSS-FIELD TECHNIQUE

(Continued from page 24)

7½ ips will allow a program of the previously mentioned standard spectral-sound-energy distribution to be recorded at maximum level in the lower and middle frequency range, with no risk of saturation at high frequencies.

A pre-emphasis of 18 dB is required at the reduced speed and, under the same conditions as above, the recording level at lower and middle frequencies must be reduced by 10 dB in order to avoid saturation at high frequencies. The tape noise will then increase by a corresponding amount.

The increase of tape noise at low tape speed consists of one fixed amount caused by the augmented playback amplification and another amount that varies from 0 to 10 dB, depending on the energy distribution of the program. The latter noise contribution is the same for cross-field recording on thick tape as for conventional recording on thin tape because the pre-emphasis is the same in the two cases. If the recorder has an instrument that indicates the maximum tolerable signal amplitude at any frequency, one will automatically set the record level according to the loudest tones. If the sound energy is concentrated at high frequencies, one will reduce the record level, and the relative tape noise will increase.

It can be stated that, for cross-field, the tape speed reduction from 7½ ips to 1⅞ ips is accompanied by a possible tape-noise increase from a minimum of +4 dB up to 4 + 10 = 14 dB, depending on sound energy distribution. The corresponding figures when one switches from cross-field recording at 7½ ips to conventional recording on thin tape at 1⅞ ips are: +10 dB up to 10 + 10 = 20 dB.

These viewpoints clearly show how important it is to consider frequency range, pre-emphasis, and tape noise as a whole when judging the quality of a tape recorder. Furthermore, these quality requirements must be considered in relation to the particular program to be reproduced. Æ

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