How to select the right one for your system

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3. Dual tone controls for maximum adjustment of any program material.
4. Exclusive Scott balancing method for perfect stereo regardless of speakers or program material.
5. Conservatively designed power supply assures years of trouble-free enjoyment.

**SPECIFICATIONS**

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<thead>
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<th>299D</th>
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<th>200B</th>
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<td>High Level Inputs</td>
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<td>3</td>
<td>2</td>
</tr>
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 AUDIO • SEPTEMBER, 1963

Successor to RADDY, EST. 1917

Electro-Voice engineers approach the design of audio components on a very simple basis: design to get an output that faithfully reproduces the input. The input may be electrical (loudspeakers) with an acoustical output; or acoustical (microphones) with an electrical output; or mechanical (phonograph) cartridges with an electrical output.

In each case, design parameters also include minimum distortion, maximum stability and long useful life. All this must be developed within a functional envelope that is aesthetically acceptable.

Another requirement is wide range frequency response coupled with high signal-to-noise characteristics commensurate with justifiable costs. Insensitivc transducers can burden the user with gain or power requirements that add unnecessary cost and complexity. Where sufficient gain is available, however, sensitivity can sometimes be reduced to achieve other design goals.

Perhaps our pragmatic approach to component design results from our experience with all types of audio transducers. We know that high performance standards can be achieved in sound pickup, reproduction, storage, and reinforcement. We are therefore less prone to compensate one type of transducer for imagined deficiencies in other transducers within the system. Compensation is effective only when we intimately know every system characteristic. Obviously this is impossible when transducers are sold in component fashion, as is typical of high fidelity. When a “package” can be tailored, however, considerable economy can often be effected.

Cost, of course, is always a consideration in new product design. For this reason, we make available to our readers the following Electro-Voice and Strata products from which the consumer chooses a unit that just meets his performance requirements. However, the designer has a moral obligation to protect unsuspecting customers from false economies. For example, economizing on magnet structure size and weight in a loudspeaker is easy. But loss of magnet, while reducing cost, will also affect efficiency, forcing the consumer to purchase a higher-powered amplifier at a cost that may possibly exceed the saving in speaker cost. He has also lost the benefit of additional magnetic flux that can significantly improve the speaker performance.

It can be seen that designing lower-cost products without sacrificing critical performance characteristics requires considerable technical acumen on the part of the designer.

These are some of the many technical and economic considerations we investigate before any Electro-Voice product is marketed. Basic to the success of such an investigation is the E-V philosophy of fidelity that has been developed and refined over a wide range of products and during a period of many years.

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Construction—
How to build a new type of transistorized microphone mixer composed of separate modules each designed for its own special purpose. The author, Peter Stark.

Measurement—
Continuing his series of articles on test and measurement, Mannie Horowitz contributes some new thoughts on harmonic distortion and how to measure it.

Musical Instruments—
Winthrop Pike discusses many of the fundamental problems encountered in attempting to play classical organ music on an electronic instrument, and gives some excellent pointers on the selection of a stoplist suitable for the organ literature.

and Equipment Profiles—
The Heathkit Electronic Organ Kit EICO ST-97 FM/MX tuner and ST-70 integrated amplifier
Sennheiser HF-polarized condenser microphone

In the October Issue
At your audio dealer's, on the newsstands, or in your own mailbox

Send questions to:
Joseph Giovanelli
2819 Newkirk Ave.
Brooklyn 36, N. Y.
Include stamped, self-addressed envelope.

Noisy Tuning
Q. When I tune in a station on my FM tuner, there is a noticeable fluttering or rustling sound as I try to tune sharply on the station. What can be causing this?
Larry D. Boester, Chicago, Illinois.
A. The noise you hear when tuning in a station is probably caused by the wiper of the variable capacitor making an intermittent contact with the moving rotor assembly. Use some contact cement on this wiper and the problem will most likely vanish.

Vertically Mounted Systems
Q. I am considering a top-opening cabinet which would mount the record changer, and tape deck horizontally, but would hang an integrated amplifier and AM-FM tuner vertically.
Is there any disadvantage? Should a small fan be used for cooling? Jerome E. Hanson, Salt Lake City, Utah.
A. Mounting the tuner vertically will probably not result in malfunctioning of or shortening the lives of its parts. However, when the tuner is mounted above an amplifier, the heat rising from the amplifier may be distributed over the surface of the tuner in such a way that the stability of the oscillator may be decreased. This, in turn, may result in the tuner wandering off station. If possible, therefore, place the tuner below your power amplifier. Because of the manner in which you are mounting the equipment, there may be some confusion as to the meaning of the terms "above" and "below." Above means away from you, and below means toward you in this particular connection.
In an installation using a separate pre-amplifier, it too should be mounted below the power amplifier.
The amplifier may be affected, especially the rectifier tube or tubes; check a tube manual as to whether the tubes used can be mounted in all positions.
Ventilation is always necessary when equipment is located in cramped quarters. In addition, when equipment is vertically mounted, heat rises and passes over its entire surface rather than rising away from the tops of the tubes as it would when the equipment is mounted normally. The heating of the entire unit may shorten the lives of some components, such as electrolytic capacitors, even with good ventilation. Convection currents may not remove enough of the heat from these components. Therefore, forced air cooling is probably desirable in such an installation.

Line Voltage
Q. The specifications given by the manufacturers of my tape deck and amplifiers are measured with the equipment operating under a line voltage of 117 volts. I assume therefore, that for optimum performance with these components that they should operate with this line voltage.
The line voltage in my house varies with the number of appliances in operation, the time of day, and so on. The only way I have of measuring these variations is by observing the bias meter on my power amplifier. Maximum variation of the meter reading on each output tube is about ½-in. For example, in the morning with few appliances in operation, the bias meter may read 1½-in. below the line on all tubes, a difference of ½-in. The use of a constant-voltage transformer has been suggested.
This brings up the question of audible difference, as opposed to measurable difference. I would not like to purchase any of these transformers and find after careful A-B comparisons, that there is absolutely no audible difference with or without the transformers in the circuit. Hence, I would like your opinion, as to the possibility of an audible difference with the use of such a device.
Also, what other advantages might be derived from its use? What are the disadvantages? Is one constant-voltage transformer required for every appliance, or would one be sufficient? Robert De Salvo, Franklin Square, New York.
A. You wanted to know about problems which might be encountered with fluctuation in line voltage. Most power lines exhibit a considerable amount of voltage variation, depending upon the appliance load and upon the wire size of the line. This is especially true in old buildings where the wiring is inadequate to cope with all the appliances now available.
The variations in your particular location may not be great enough to warrant concern. The amount of variation of the bias meter pointer is not an indication of the amount of variation in line voltage. If you are unable to hear the difference in performance in your music system with normal line voltage and lower line voltage, you need not be concerned about the voltage fluctuation.
It is possible that the difference in distortion between the conditions you describe can be measured. I personally do not think this is important, so long as the slight changes in the amount of distortion present cannot be detected audibly. There is no danger to the equipment when the voltage drops.
A far better indicator of line voltage change is the operation of the rewind motor of your tape recorder. If you find that the motor is sluggish when the voltage drops, you can be sure that the voltage drop is
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Professional performance with true convenience...one excellent reason why more Garrards are used in the finest systems than all other high fidelity record playing components combined. (Type A Automatic Turntable - $79.50, AT6 Automatic Turntable - $54.50, Autoslim Intermix Changer - $39.50.) For Comparator Guide, write Dept. GM-1223, Garrard Division, British Industries Corp., Port Washington, N.Y.

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A Finco FM antenna will deliver a clean, undistorted signal and bring in more stations, regardless of location.

Guarantee yourself the best seat in the house for tonight's FM concert... install a fidelity-phased Finco FM antenna.

FM Reception with Master Antenna Systems

Q. My question concerns FM reception in fringe areas. I have tried putting all kinds of antennas and adaptors on my FM tuner to improve reception. To date, I have failed. I want to connect my tuner to the master antenna in the apartment building in which I live.

If doing this is not satisfactory, could you inform me how I could improve reception without putting an illegal antenna on the roof of the building. Bernard J. Cohen, Bronxville, New York.

A. To answer your question satisfactorily a brief discussion of the operation of a master antenna is in order.

Because of a need to distribute the incoming signals to a number of receivers the signals must be amplified after leaving the antenna.

Some amplifiers are "broad-band" units. Such amplifiers will pass all signals from Channel 2 through Channel 13. The FM band lies within this range. In an installation using a broad-band amplifier only one such unit is required.

Other amplifiers used in association with master antennas are "narrow-band" devices, amplifying by a single channel. An installation employing this kind of an amplifier uses several of these units—one for each of the locally available TV channels.

If a master antenna system of this latter type is used to distribute FM signals, an additional amplifier designed to pass the band of frequencies between 88 and 108 must be utilized.

(Continued on page 79)
Famous RCA Broadcast Quality Microphones
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• CONAX's preempts program material emphasizing form for efficient high frequency control. The device is based on the integrating properties of the human ear. The CONAX action is visible and instantaneous.

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• CONAX reduces distortion in tape recording and tape duplication.

• CONAX minimizes channel crosstalk in stereo broadcasting.

• CONAX eliminates high frequency "splitter" between stereo channels and SCA channel.

Why not let the FAIRCHILD CONAX help you maintain your high average audio levels.

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Name: ___________________________
Firm Name: ______________________
Address: ________________________
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LETTERS

You Pay More Yen . . . 1"

Sirs:
It would be difficult not to comment on a few of the statements made in Mr. William Hecht's article "A Fresh Approach To Compact Speakers" in the March issue of Audio. Mr. Hecht refers, on page 32, to a "voice coil of insufficient length" as a source of transient distortion. While a long voice-coil winding certainly improves low-frequency output, it also, unfortunately, degrades resonance damping (and presumably transient response). This is due to additional coil mass and the series resistor effect of overhanging turns. This is a case of trading one desirable performance element for another, and is typical of the kind of compromises the speaker designer must make.

I am in no way arguing the merits of "oldy-current" damping, however, I think it is misleading to ascribe a higher order of merit to this type of motional damping as opposed to other kinds of friction damping. Essentially there are all "affected by frequency" as Mr. Hecht writes. It is easy enough to over-damp (mechanically) the bass range of a compact system by many different methods. The suspension viscosities, treatment, the spider fabric weave, the shape, size, and porosity of the dust button, and the enclosure damping treatment can all be designed to provide lower mechanical Q (higher damping). The cure of the problem revolves around how much bass damping to incorporate consistent with mid/low-frequency balance and performance below 70 cph.

CHARLES MCMANUS,
Consulting Engineer,
Sherwood Electronic Labs.,
4500 N. California Ave.,
Chicago, Ill.

Class-D Amplifiers
Sirs:
Mr. Cooper's articles on class-D audio amplifiers struck a responsive chord. I had examined all of the material I could find, and Mr. Cooper indicated, it was with a coffee cup instead of a soldering iron in my hand. However, I should like to point out two errors in which Mr. Cooper made in his second article.

Mr. Cooper described two basic types of modulation: the first, in which the time at which the wave is sampled depends upon the instantaneous value of the wave at the trailing edge of the pulse, is called natural sampling, and the second, in which the wave is sampled at exactly regular intervals, is called uniform sampling. Mr. Cooper then stated that uniform sampling is preferable because each carrier-frequency component has only a single pair of sidebands. This is not true. Not only does each carrier-frequency component have its full complement of sidebands, but the spectrum also contains harmonics of the message wave. As Black comments in his book on modulation theory, we have a deterioration of quality when the sampling is uniform instead of natural. I have not read the paper by Fairchild, but over time I have not doubt that the natural method would eliminate these drawbacks.

GEORGE FLETCHER COOPER

Off-center Center Holes
Sirs:
With all of the money being spent today on improving the soundings, it comes as a surprise that nobody has bothered about the small matter of proper placement of the center hole in a record.

The majority of turntable and record changer manufacturers show a reasonable degree of pride in maintaining a fractional percentage of wow. Manufacturers take pride in being able to maintain the exact pitch on long sustained notes. Why don't the record manufacturers take pride in retaining this information by properly placing the center hole?

I have measured deviations of about 1/16 in. with some as great as 3/32. In order to have wow of not more than 1/16 per cent at the 2-in. radius, the center hole cannot be off more than 1/64 of an inch. In pursuing this end, every attempt should be made to reduce this wow to a fractional percentage, keeping in mind that these records must be able to slide over the spindle. If the hole is accurate from the center of the grooves, then the accuracy of placement provided by some turntable manufacturers, (using a spring loaded tapered spindle) will not be in vain.

A. L. BOYNTON,
Cal Poly,
P. O. Box 759,
San Luis Obispo, Calif.
What new recorder is virtually custom-built?

The F-44 is a brand new 4-track stereo recorder from Ampex. It's Ampex through and through. And there's this, too: at every stage of manufacture Ampex tunes, adjusts and aligns each F-44 to obtain its maximum performance—far beyond minimum specifications. Thus, no two F-44s are quite alike. Each is virtually a custom-built recorder. Each performs to the utmost of its capabilities. And each gives you the best possible sounds today—and for many years to come. As an F-44 owner, you'll receive from Ampex a record of the individual performance specifications of your own F-44. This record shows the frequency response curve, the signal-to-noise ratio, the flutter and wow, and the crosstalk rejection measurement. And it is signed by the Ampex engineers who tuned and adjusted your recorder.

The new Ampex Fina Line F-44 also features a new special design hysteresis motor for smooth, quiet, accurate operation; an easy-to-read point-to-point record level meter for each channel; multiple sound-on-sound capability; new simplified controls; and the Ampex one year warranty. See and hear the new F-44 at your local Ampex dealer. Brochure? Write: Ampex Corporation, Redwood City, California. Sales and service throughout the world.

AMPEX F-44
The Merry Widow (New English Translation), Columbia Tape OQ 517
The Merry Widow (Highlights), M-G-M SE 4098

The recording industry has never been one to ignore Franz Lehár’s most popular operetta, “The Merry Widow” seems set for a banner year in 1963 with a host of new releases designed to appeal to more than one category of Warner Bros-Ted Mack’s. The fanciest new package is Angel’s complete recording with Elizabeth Schwarzkopf repeating in the role of the widow that she created seventeen years ago. In this four-track stereo tape, Columbia’s English version of the operetta offers a 45 minute tour of the score with Lilo Della Casa of the Metropolitan Opera in the title role. Mixing new and old for an hour and a half is only one side of a stereo disc featuring a performance of Bizet’s rare but familiar German cast. Some Lehár fans will veer toward the new Columbia version just to find out for four-track stereo fans, in the course of this tour of Gainsborough, Franz Lehár’s operetta highlights. The MGM record is one of a series of four stereo discs devoted to opera highlights featuring European casts originally released not too long ago by the Polydor division of Deutsche Grammophon. Here, too, the same three-pressings of the actual Polydor import. I can vouch for the import because I am familiar with the transfer to the domestic label. High points from “The Count of Luxemburg” fill out the other side. The operetta was first performed at the Met by Lehár’s work, this series features operettas by Ruth Beran, Eduard Knnecke, and Otto Knepper, with one other record in the series are distinguished by their composers rather than their leads. The young Hungarian tenor whose operatic appearances in Europe and at the Met have not interfered with his fast-rising career in the leading operetta roles once handled by Richard Tauber and Peter Andrews.

The Phoenix Singers
Warner Bros. Tape WSTC 1485

Does the Phoenix Singers, too, have an inside track somewhere in the processing plant of United Stereo Tapes? Some of their four-track tapes are among the first to have delivered sound that is several cuts above the “speed” of reels that went through the UST plant during the same period for other labels. Since the possibility of favoritism is keenly felt by the public, we have taken a situation under the economics of assembly-line production into account. The Phoenix Brand, now with a national distribution, is a welcome news. The artists are chosen from a group of artists who have performed in the past. The Phoenix Singers, among several other factors help the sound of the stereo recording. In addition, the voice that was left with the assumption that Warner’s product is delivered to Amsco on a recording that responds very nicely to playback in stereo. In the case of this reel by a new male trio called the Phoenix Singers, several other factors help the sound of this recording. The voices have a completely fresh quality and the enthusiasm of the performers. Della Casa is a conductor of a group. At the first ring of the ladder of fame, you won’t find a trace of the coyness that so often influences folk ensembles. The voices of Thompson, Ned Wright, and Arthur Williams are more easily through a far-ranging program that would seem more fitting for a much more famous groups of folk singers. Work songs, calypso, a French tune and the Australian Jolly Swagman are handled with the same easy conviction that the two fine spirituals that close the album.

Paul Lavalle: 18 All-Time Great Marches
M-G-M 4114

The Band of America that Paul Lavalle has been leading these many years is a conspicuous exponent of march music treated in unioin- dox fashion. Although the band can handle a conventional arrangement of a march with the best of them, it has made its reputation on the “extras” it brings to its performances by means of variations in rhythm and color. Many marches in this collection are played “straight” but the selections that immediately serve to identify the band are the free-wheeling paraphrases that Paul Lavalle likes to highlight. The recording finds the band really shooting from the hilt in Lippe-Lavalle paraphrases of Dixie, Garry Owen, Parade of the Wooden Soldiers, and other staples of the repertory. Old-time band leaders would hardly know what to make of some of the Lavalle ideas, but the listener in search of a band like this band of America could do worse. The sound on this latest Lavalle disc is a bit on the fuzzing side. Most of his previous releases have featured a commendably realistic frequency response. The relatively weak response of the bass instruments in this recording may be traceable in part to the distant mike pickup employed.

Paulo Alencar: Great Hits of Brazil
Kapp Tape KTL 41051

In a recording made in Rio de Janeiro, the tenor Paulo Alencar and his chorus bring us up to date on current happenings in Brazil. Perhaps few people are aware of this latest release. Alencar, who has sung in English as well as his mother tongue. He has recorded. The album offers a unique opportunity to hear Brazilian music. The tenor has sung in many different languages. In this recording, the tenor and the chorus are heard on the dry side and the highs on the tape require a fair amount of rooth.

Les Djinns Sing Songs of Paris
ABC-Paramount Tape ATC 829

Outstanding European musical attractions cannot contend that trifles of any kind are offered up to the American market. Not only is the process of infiltration an easy one (assuming an act really has something to offer) but with the recording of a large audience here can be surprisingly short. Les Djinns, a teen-age chorus of 60 vicarious French girls, made an immediate hit locally with their first ABC album some three years ago. In their fourth release to reach these shores, Les Djinns prepare the way for their forthcoming tour of the States sometime in 1963 with the promise of a thrilling night of exotic music in Paris life. Bells always seem to figure prominently in the repertory of French popular Groups (Mellinet le Djinns de la Chanson?) and the Djinns are no exception. Le Carillon and Les Cloches de Paris give the group an exotic opportunity to imitate no more than one type of bell. The tape from Warner Bros-Ted Mack’s is a wide circulation to an Italian baritone who holds a record of sorts in the matter of acceptance by the American public with his album’s first release in this country, AI Di La, hit the Top Ten of the best-seller lists. His “funky Christmas song is just one of the Italian-flavored tunes he delivers on this reed in English as well as his mother tongue.

Dennis Day: Shillelaghs and Shamrocks
Reprise R 6065

If the presence of only a few songs, a Dennis Day album on dealer’s shelves has been bothering Emerald Islanders and Jack Benny fans with a long memory, this new release should be welcome news. Those who own Day’s earlier albums, however, may feel that the passage of time in the sound of his voice. The years somehow manage to make an exception whenever they’re dealing with the taras of an Irish tenor, particularly one who has led the clean life dictated by a salary from Jack Benny. In a burst of non-fragility that may haunt him in later years, Benny himself is “contributed” to the album jacket. The greater part of this release is devoted to some of the Irish-flavored tunes that sound best with a male chorus in the background. Pete King’s Chorale is a model of precision in its arrangement of old favorites—“MacNamara’s Band, Dear Old Dublin, Boston’s Boys, the Irish Washerwomen.” Day’s indelible son has his finest moments when the chorus behind him recedes a bit during a “soft tenor duet as Danny Boy and Two-Roo-Loo-Roo-Loo-Lo.

Percy Faith: American Serenade
Columbia CS 88757

Theories pertaining to recording techniques change from year to year, as the recording industry is constantly in search of new ingredients of successful albums remain about the same. One of the more steadfast adherents to this view is Columbia’s veteran arranger-conductor, Percy Faith. No matter what the origin of the popular American music Faith may be dealing with, in any album, he consistently comes through with recordings of lasting value. Unfettered by rigid formulas that other conductors have ridden to success, Faith has always subordinated the style of his arrangements to the material he has to work with in each tune he has recorded. This approach appears especially true in actually recorded. Faith is an exceptional group of musicians to carry out an arranger’s wishes with such effortless ease. “American Serenade,” his latest release, brings a modicum of instrumental choirs is applied to a program of songs that represent American cities and states of America best known to Tin Pan Alley. The list of tunes ranges from the necesita of “American Serenade” to the more “ indoors” to the general coverage of “American Serenade” to the traditional “Home” of the most recognized songs of the American music, to the big screen. The arrangements already carry a built-in relaxation factor, it is not surprising that the equalization on the record’s somewhat of level.

Advances in Paradise, Vol. 3
ABC-Paramount Tape ATC 827

Here is more invitation to escape by the line of talent responsible for the best-sellers most beloved by listeners devoted music to the Pacific Islands. The variety of this label contains more than enough material for every kind of release of light music that sounds at its best when strained through the apparatus of popular music. Alfred Aljoka gained quite a reputation through his many Hawaiian recordings on the Decca label, as well as his work on the Ed Sullivan television show. Roy Sack, continuing a career of more than thirty-five years as a writer and publisher, has created a separate collection of albums on the ABC-PARAMOUNT of Hawaiian material. In the Hawaii section of the Paradise and the Islanders under the direction of Stier complete the varied ensemble of tropical tunemakers. Each variety in your Hawaiian-style albums, this could very well be your dish. In the sound department, four-track tapes are being used these days with this sort of musical talent.
Critics choice: the XP-4A

"...among the cleanest and smoothest-sounding of any compact we have yet auditioned with virtually no trace of coloration or 'boxiness' and a high order of definition of all sounds."

- HIGH FIDELITY
FEBRUARY, 1963

"...the XP-4A is one of the smoothest and most accurate speakers we have tested for some time: it reproduces music as close to the original sound as we have heard in a system anywhere near its category."

- AUDIO
MAY, 1963

"over-all, I would rate the XP-4A as one of the best most truly musical reproducers available today."

- HI FI STEREO REVIEW
DECEMBER, 1962

The Fisher XP-4A incorporates several notable advances in speaker design, including the totally new concept of a voice coil wound on pure electrolytic copper. This provides a pronounced damping effect on the moving parts of the speaker, permitting extremely compliant suspension for the woofer, without any speaker hangover. Besides providing accurate reproduction of the most complex bass waveforms, this method of speaker production furnishes superior dimensional stability despite variations in temperature and humidity.

This 2 1/2-cubic foot speaker system rivals in sound quality the huge theater-size systems of just a few years ago. Like all Fisher speakers, the XP-4A can be placed either horizontally or vertically. It is priced at $199.95.

FISHER RADIO CORPORATION
21-29 44th Drive, Long Island City 1, N. Y.


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There's no end to your listening pleasure with Concertone double Reverse-O-Matic®

Now, there is literally no end to the unattended playing time you can enjoy. Concertone, who doubled your listening pleasure with exclusive Reverse-O-Matic, now presents Double Reverse-O-Matic in the dramatic 505 Imperial Series. This exclusive automatic playback feature plays 4-track stereo tapes from end to end, reverses, and plays the other 2 stereo tracks as it rewinds...then automatically "takes it from the top" again to repeat the cycle. For a full evening of uninterrupted listening, the Concertone 505 Imperial is your instrument. Create your own personal program...then let it play to your perpetual pleasure. All the fine craftsmanship and features you expect of Concertone. Stainless steel faceplate for extra beauty. Learn all the exciting details of this magnificent new recorder. Write for complete information today.

CONCERTONE 510

Instant monitoring...the Concertone 510. Unmatched recording flexibility in one compact unit. The 510 incorporates all the features of the 505 plus twin speakers and sound-directing panels which provide instant monitoring of the recorded signal. Luxurious ebony naugahyte carrying case. Stainless steel panel. Exclusive Reverse-O-Matic feature.

CONCERTONE 400 COSMOPOLITAN

For people on the go...it's the Cosmopolitan—Combination Tape Recorder with AM Radio.

A versatile companion and co-worker for business or pleasure travels. 5" reel capacity.

Push-button operation. Amazing fidelity.

Remote mike. Foot-pedal control. This all-transformerized recorder has big recorder features in miniature form.

NEW LITERATURE

- **Audio Cables.** The 1963 Electronic Wire Catalog from Belden Manufacturing Company features four new cables for mono and stereo applications. Belden 8416, a dual-channel audio cable, is a 25-AWG two-conductor, parallel, coaxial cable. Each conductor is tinned-copper shielded with 25 AWG, tinned copper braid. Belden 8417 is a single conductor cable shielded with tinned "Belden" stranded. This 100 per cent shield eliminates all outside interference. Belden 8701 is a 22-AWG, three-conductor, parallel, speaker cable. Belden 8700 is a miniature, 28-AWG, 20-ohm coaxial cable, insulated with polyepony. The cable is only 0.044 in. in diameter. Operating temperature is 185 degrees F. Belden Wire and Cable, 115 S. Kilpatrick Ave., Chicago 44, III.

- **Cardioid Microphone "Facts and Fiction" Guide.** A new, highly definitive guide detailing specific unidirectional characteristics and technical features which should be expected from a true cardioid microphone has been announced by Shure Brothers, Inc. The guide explains common claims and, for the information of manufacturers, reveals cardioid microphones with facts based upon a precise mathematical formula. It lists limits and defines the term "cardioid." In addition, it describes common sound problems caused by insufficient microphone rejection and describes sounds and microphone ineffectiveness in picking up the desired sound. Specific information on how these problems can be solved through the use of a quality cardioid unidirectional microphone with a uniform pickup pattern is also provided. Copies are available free of charge from Shure Brothers dealers or by writing directly to: Shure Brothers, Inc., 222 Hartley Avenue, Evanston, Illinois. Ask for Folder No. 184.

- **Telstar Story.** Copies are available of the 72-page, illustrated, color reprint of the April, 1963, issue of the Bell Telephone Laboratories' Magazine, "The Bell System Technical Journal." It contains ten semi-technical articles about the engineering that went into the Telstar project, the communications equipment in the satellite, the An- dover ground station, and the satellite launch operations. Free booklets are available by writing: Telstar Record, Bell Telephone Laboratories, 465 West Street, New York 14, N. Y.

This Month's Cover

Lt. Col. John H. Ralph, owner of the cover installation, enjoyed this system overseas (especially in Japan). Now back in the United States, he still feels his system is tops. His equipment includes: Citation I preamp, Leeke Stereo 50 tub amp, Sherwood 5210 preamp, Leak Stereo 5010 tape deck, Draper 5210 head amplifier, Wharfedale three-way speakers, Krell Electronics tape deck, and Ballsymatics dual-reel cassettes. The cabinet was custom-built in Japan.

Fig. 1. View of control panel which visually indicates the mode of operation, and also has two V-U meters, one for each channel, and a line-voltage meter.

for further information write:

AMERICAN CONCERTONE, INC.
A DIVISION OF ASTRO-SCIENCE CORP.
40 W. JEFFERSON BLVD. • CULVER CITY • CALIF.

10

www.americanradiohistory.com
150 Watts of the cleanest audio power ever produced!

The Fisher SA-1000 is a challenge to the severest critics and most discriminating judges of professional sound reproducing equipment, both as to specifications and listening quality. Its music power rating is 150 watts IHF Standard, with both channels driven. The RMS power rating, again with both channels driven, is 130 watts (65 watts per channel). However, as a glance at the intermodulation curve will show, each channel will deliver 80 watts at 0.5% IM distortion, thus indicating the extreme conservativeness of the official rating.

**Total Harmonic Distortion at 1 kc**

<table>
<thead>
<tr>
<th>Type</th>
<th>Solid Line</th>
<th>Dotted Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsonic Filter</td>
<td>Dotted Line</td>
<td></td>
</tr>
</tbody>
</table>

The output stage of the SA-1000 is engineered around the newly developed 8417 beam power pentodes, *never before used in any electronic device*. Designed specifically for use in this amplifier, the 8417 offers extreme linearity, resulting in greatly reduced distortion, and has unusually low drive-voltage requirements, permitting the previous stages to 'coast' at their lowest possible distortion levels. The unique cavity anode design of the 8417 is an important factor of its superior performance characteristics.

**Frequency Response (0 db = 4 watts)**

Subsonic Filter: Dotted Line

Each pair of 8417's in the SA-1000 drives a giant output transformer via plate-cathode coupling — a modified and improved 'ultra-linear' configuration that provides 12 db of the most desirable and stable type of negative feedback in the output stage. The custom-wound output transformer is unlike all others in that their response rolls off below 5 cps and above 200 kc without the slightest peaks or dips. (See the frequency response curve.) This results in exceptional stability and superb square wave reproduction.

The driver stage, too, is entirely novel. A triode-connected GUH8/ELL80 dual power pentode circuit developed by Fisher engineers is capable of delivering 40% more drive to the output stage than is required — and at a remarkably low impedance. The result is very low distortion, the fastest possible recovery time, great stability and hence outstanding transient response.

For the pre-driver and phase inverter stage, an ECC83/12AX7 dual triode is used in a DC-coupled cathode configuration characterized by extremely low distortion and phase shift. A feedback loop from the output transformer secondary to the pre-driver cathode provides 17 db of distortion-reducing feedback.

The input stage of the SA-1000 is of a type widely used in laboratory oscilloscopes but never before in high-fidelity amplifiers. A compensated input attenuator in conjunction with a cathode-follower circuit permits adjustment of the input signal from 0 db to —12 db in closely calibrated 3 db steps without the slightest effect on input impedance and frequency response. This feature in effect provides five different input sensitivities, ranging from 0.5 to 2.0 volts (for full rated RMS output), so that the preamplifier volume control can be operated strictly within its optimum range.

A switchable subsonic filter has also been designed into the input stage, in keeping with the widely held engineering opinion that, for the majority of practical applications, response should be flat down to 20 cps only and then fall off as rapidly as possible. (See dotted part of frequency response curve.)

The power supply of the SA-1000 is one of the most elaborate ever used in a stereo power amplifier. Regulation and filtering are of the highest order and all silicon diodes as well as filter capacitors are most conservatively operated.

Bias is readily adjustable on each channel by means of the built-in laboratory-type calibration meter, but the controls for these rarely needed adjustments are ingeniously concealed behind an attractive hinged cover — another Fisher exclusive.

**Total Harmonic Distortion (One Channel)**

<table>
<thead>
<tr>
<th>Frequency (c/s)</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distortion (%)</td>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
<td>2.0</td>
<td>2.5</td>
<td>3.0</td>
<td>3.5</td>
<td>4.0</td>
<td>4.5</td>
</tr>
</tbody>
</table>

The SA-1000 is priced at only $329.50. It is also available as the K-1000 StrataKit for only $279.50. Both carry the famous Fisher Warranty covering all tubes and diodes for a period of one year from date of purchase.

**51.00 VALUE — ONLY 25¢**


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21-29 44th Drive, Long Island City 1, N.Y.
Please send me the new 64-page Fisher Handbook, I have enclosed 25c (double-wrapped) to cover the cost of handling and mailing.

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Address: ____________________________
City: ____________________________ Zone: ______ State: ______

The Fisher Radio Corporation
BRISTOL, THOMAS J. LTD., HULL, QUE.

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1. MAGAZINE MURMURS

Those moments when, occasionally, I look at a back issue of this journal and read a paragraph or two out of my own past are apt to be tremendously enjoyable experiences for me. Ghosts—only two or three years old. Prophesies of Soloman weight, some come true, thank heaven! Some are merely gone with the winds of time and just as well forgotten.
I like the true ones best.
Thus I’ve recently been drawn back for good reasons to issue of July, 1961. I must report that we did pretty well in that issue. The back-number charge that you’d pay for it would exceed the cost of any copies left, which we don’t. (Ee.) would probably be worth it. In my department (match, one of my principal concerns), I found two animations that applied vividly to the then-dim-distant future, September, 1963, as well as to the far-away summer of ’61. Mainly there was a hot item of uninflected business entitled “Remember the Magazine?” which has me quite warm under the collar. No—such magazine number if and still long. What I meant was the kind of magazine we generally like to call a cartridge, thereby confusing the conversation. A tape cartridge.
You’ll remember that “way back in the late fifties there had been a sensational RCA tape cartridge for the home, launched as I remember in two successive years with the biggest Guns of publicity. Strangely enough, this gadget was with only a modest pop. RCA tried and tried, but nothing much ever succeeded to happen to its tape cartridge. None. (1962), the RCA cartridge is still manfully with us, in the guise of a new and handy portable home recorder, stereo. The once-vaulted RCA tape cartridge is not being very widely promoted right now. I have three or four of them left (along with the monstrously big original RCA player) which I expect to preserve for posterity, in case RCA forgets.
Then in 1960, CBS—who else—discreetly announced another cartridge. Discernent is definitely the right word. The thing wasn’t launched; it was simply announced, and demonstrated, demonstratively, maybe, but RCA had to be fought on solid ground when the fighting was good.
This CBS cartridge, developed by CBS Labs for 3M, was far more revolutionary than RCA’s which had used conventional tape at 3½ ips. (But RCA did start off the 4-track development with 4½ ips.) CBS did not depart from the basic roll tape, which still looms commercial.) The CBS cartridge was startlingly different. It was much smaller, with a new and narrower tape, extra-thin, extra-fast, and the astonishing ability to be changed—like a disc changer. But as I noted in the July, 1961, issue, a year or so after the first CBS announcement, the policy in regard to this cartridge-tape venture appeared to be one of very great caution. No more RCA-like publicity blasts! Not, at least, until the field was very thoroughly explored.
Not until all sorts of specialized applications outside of the straight home entertainment field had been probed, moreover—for the tape cartridge was potentially a marvelous gadget in a wide variety of automations and memory services quite aside from home hi-fi.
Indeed, I pointed out that there were then two reasonable approaches to the tape cartridge—the “niche” and the “multi-niche.” Either you limited your cartridge deliberately to a special and specific function—as did Westrex this summer with its battery portable miniature cartridge recorder. Or you launched your cartridge quietly into whole raft of little new markets and might on its own insufficiency to support the venture, though together, and with the basic cartridge easily adaptable to various uses, these multi-niche applications could turn in a joint profit. That was clearly the CBS intention. CBS wasn’t likely to go for narrow specialization.

Said I, for the multi-niche approach, “just make the one device [the basic tape magazine and associated equipment] in the millions, load it up and fire it off in many directions at once, in the thousands, niche by niche. Near-future first, but aim carefully, choose little bits and pieces. The targets for such a magazine were obviously plentiful. In fact, I suggested, “it is conceivable that the tape magazine recorded might never show up at all, or turn up as a relatively minor side-operation.” I seem not to have been far off. We must remember that home-entertainment audio is a relatively tiny bump on the side of the huge and growing electronics colossal.
I’d be happy to quote you my humorous 1960 speculations as to possible other uses for the Columbia-3M tape magazine but will refrain, for fear of being repetitive. But if you have or can find a copy, look back and read all about the fanciest idea I had, the hypothetical CBS Automatic Household Programmer. It would even have let the cat eat at eleven o’clock each night. Some cartridge!
Well, I stuck my neck out, in 1961, and prophesied that no tape magazine was ever going to replace anything—and especially, it would never replace the good old fashioned 12 inch disc.
There were those, then, who prophesied the doom of the disc in short order. They were wishful thinkers. They still are. This, I gather, was well understood by the CBS people, who since then have made no comment and have used more their little discer with the LP itself—to launch a wholly new “system” designed to take over from disc. Caution, sober investigation, into carefully limited markets, was obviously to be the tape magazine future as far as this revolutionary CBS gadget was concerned.
And so—time passed. No magazine. No fancy launchings. No formal announce-
Can you find another kit that offers so much for $99.95?

EICO ST70, 70-WATT STEREO AMPLIFIER

Beyond the performance level of these two units, possible improvement is merely marginal and very expensive. That's why with EICO's ST79 and ST80 you strike the optimum balance of cost and performance—each costs less than $100 as a kit. You can also get the ST70 and ST79 factory-wired for $149.95 each—and you couldn't find comparable wired units at the price.

If high power isn't your primary need, you can get superb sound for even less with EICO's ST40, the 40-watt counterpart of EICO's outstanding ST70. The ST40, essentially equal to the ST70 in all but power, costs $79.95 as a kit, $129.95 factory-wired.

ST70 DATA: As the center of your stereo system, the ST70 accommodates all program sources. It even has separate inputs for both tunable and record changer, preamplified tape signals and tape head with correct equalization for both fast and slow tape speeds. A center channel output feeds directly on a center channel speaker or, where desired, extension speakers throughout your house without any additional amplifier. Ceniter parts—filter capacitors, rectifiers, output tubes—all operate well below their ratings to assure long trouble-free life. Overseas output transformers deliver full rated power all the way down to 20 mW. And as a kit builder, you'll like the spacious layout. We got rid of all those tight places. Kit $99.95. Wired $149.95. (Includes metal cover.)

SPECIFICATIONS ST70 Output Power: 70 watts (continuous sine wave 50-watts per channel) IM Distortion: 1% at 70 watts. Harmonic Distortion: less than 1%. Frequency Response: ± 1/2 db 10-20,000 cps. Inverse Feedback: 17 db. Stability Margin: 10 db. Hum and Noise Level: mag. phono — 43 db; tape head — 54 db; tuners, multiplex — 78 db. (All measurements according to IHF standards.)

ST79 DATA: Building the ST79 FM stereo tuner requires no instruments, no critical adjustments. The front and back stage are fully wired and pre-aligned. The tunable coils of the stereo demodulator are factory-adjusted. With four IF stages plus a stable, sensitive front end, the ST79 pulls in clear stereo even under fringe conditions, and EICO's filterless zero-phase shift stereo detector (patent pending) maintains reliable channel separation. EICO's unique tuning eye makes tuning simple and precise. Stereo stations are automatically identified by a pilot light. Semi-kit $99.95, Wired $149.95. (Includes metal cover and FET.)

SPECIFICATIONS ST79. Sensitivity: Sav (30 db quieting), Sensitivity for phase-locking (synchronization) in stereo: 2.0 µv, Full limiting sensitivity: 1.5 µv, Detector Bandwidth: 1 megacycle, Signal-to-Noise Ratio: — 55 db, Harmonic Distortion: 0.05%, Stereo Harmonic Distortion: less than 1.5%, IM Distortion: 0.1%, Frequency Response: ± 1 db 20 cps-15 kHz, Coupler Ratio: 5 db, Channel Separation: 60 db, Controls: Power, Frequency, FM Tuning, Stereo-Mono, AFC-Defeat (all measurements to HFIM standards). Actual distortion meter reading of derived left or right channel output with a stereo FM signal fed to the antenna input terminals. See your dealer's catalog.

Can you find another kit that offers so much for $99.95?

EICO ST97 FM STEREO TUNER

ST97 DATA: Building the ST97 FM stereo tuner requires no instruments, no critical adjustments. The front and back stage are fully wired and pre-aligned. The tunable coils of the stereo demodulator are factory-adjusted. With four IF stages plus a stable, sensitive front end, the ST97 pulls in clear stereo even under fringe conditions, and EICO's filterless zero-phase shift stereo detector (patent pending) maintains reliable channel separation. EICO's unique tuning eye makes tuning simple and precise. Stereo stations are automatically identified by a pilot light. Semi-kit $99.95, Wired $149.95. (Includes metal cover and FET.)

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See these stereo components at high fidelity dealers everywhere. For FREE $13-page catalog: Stereo HI-FI Guide (enclose 25c for handling) and dealer's name, write EICO ELECTRONIC INSTRUMENT CO., INC., 3200 Northern Boulevard, Long Island City, New York. Export Dept., Export Agencies Inc., 421 Greenwich Street, New York 13, N. Y.
July, 1963, issue. Just about what I would have expected, as of 1961.

The editor never had much use for me, he just forgot, or maybe he hadn’t read the July, 1961, issue. (He wasn’t editor then, any-
how.) No published battle, free speech, no plane rides and no speeches. Nothing. Revere hasn’t said anything to
me. (Perhaps they think I’m merely a stereo fan—or so they think. My stereo camera is their ex-Wolfe snackel, and a beauty.)

So one of these days when you get a chance, you go out and buy a bow, or
steal a Revere. Marvel at the ingenuity of the car, itself and its wholly new
beads, tapes, handling machinery. Marvel especially that some could hap-
pan plus 50 Columbia tapes to match—
with the finest publicity campaign in
the entire history of home bud. (Part is,
of course, that Revere/3M has not yet
made any national announcement or
sequence of publicity. Indeed, the BSTC
has been introduced city by city, starting
last November in St. Louis. Chicago was
introduced to it in May, and New York is
just now getting the “treatment” (En)

P.S. Who—’ll better cover my defenses.
It’s always possible that there will be a
dehauling of news, later on when distribution
gets distributed. If I’m invited you can
be sure I’ll attend. And meanwhile I’m
going to try to persuade the editor, or someone,
to lead me a Revere Stereo Tape
System and a handful of those little Co-
Dima music-biquits. Will report.)

2. ELEVEN AND A HALF

The second half of my July, 1961, de-
partment was entitled “Miniature Dream-
E.” It concerned some musings of my
own on the possibilities for a genuinely
portable, genuinely hi fi “stereo.” To be
sure, I went all-out and tried to figure
a bench system which would run minu-
power lines and yet produce flossy stereo
sound. But my basic idea kept popping
through—a compact, portable phonos with
two tiny speakers attached (and remov-
able) as part of the system, the whole to
display via the most ingenious thinking
available, a maximum size-use-quality ratio.
Something really hot from the sound stan-
pont not a mere “mass produced” port-
able stereo, of which there were already
plenty on the market. It was obvious what had put me onto
this kick. The compact little KLH Model
Eight FM radio. “There’s your nucleus,”
I said, “in the shoe-box Model Eight
speaker.” The idea was to squeeze a
maximum of good sound into an arbita-
ry minimum of space, via maximum-throw
small speakers and probably with the aid
of a specially-curved amplifier output.”
I went on to describe the possibilities and
probabilities. “This system would be good,
maximum-good, using every bit of ingenuity
that the mind can discover, taking ad-
antage of our newest technology all along
the line. It might cost $150-200 or more.
It would be worth it, and no excuses for
confusion with a million ‘ordinary’ port-
able, made out of plaid-covered cardboard
and plywood, with cheap speakers and
good amplifiers for their so-called hi fi.
Not that at all. Something much better.
Maybe it ought to cost $300.
Well, I guess KLH isn’t reading me.
KLH has meanwhile moved on through
Nine and Ten and beyond. Their new Model
Eleven is a portable stereo It is in a good
many respects the precise answer to my
challenge, for it does indeed aim to do ex-
actly what I dreamed about, minus only a
few theoretical compromises. Mine was to be
battery-portable (for the bench) but with
117-volt alternative connections. I sug-
gested one of the ingenious wind-up
units that are a workable but not ultimate
might do as well as 1961. KLH has put a
Garrard changer into its Eleven, which
is a bit baffling, but one assumes that
though the rest of the Model Eleven, being
at all-transistor, could well be operated minus
house current. The Garrard is equipped
with a Reston (a sort of P.S. Whoa) and a
Magnet (Ferroba II) although the most
f prostate model (Santon Fluxvalve to you), not
the fanciest model but almost as good—and
the Magnet is conditioned. I came away
from the mass market. The playing department,
then, while of excellent quality, is the one
aspect of this Model Eleven which can be
considered conventional. The rest is quite
in the elegant alley, including the pair of
compact speakers based on the Model Eight,
the built-in electronics, the transistor drive
minus heavy transformers (if I’m right),
the snap-on arrangement that mounts the
speakers on the maincase to make “one suit-
son-sized bun.” As it is in 1961. As I had speculated, the speakers are
mounted in semi-weatherproof configura-
tion for carrying, their insides painted in
the covering material is nicely glazed and
could even take a few showers; the speakers
designed to be clamped on the side of the
mass-market speaker, the best of both.
Which is one reason why the Eleven is per-
haps a bit bigger than one might have
hoped for, given the size of the tiny speaker
boxes.

Indeed, my one major reservation is simply that this particular bit of practicali-
ity seems to go too far. The Garrard
is small as changers go but it is hardly a
miniature, and its overhead mechanisms
and under-deck springings make take-
undue space—in a suitcases and offer
undue shakeability—in shaky spots where portables are apt to be played. The KLH
cover, for this reason, is rather more
bit clumsy, in order to fit over the Garrard.
One has an unavoidable urge—in this
very special situation—to chuck the whole
changer and its swinging arm so that a
really flat cover could be snapped on.
Purely romantic—it isn’t possible. (May-
be what we need is a Revere tape cartridge
changer! But that’ll have to wait.)

The older KLH Model Eight is one of
those pieces of equipment that grows on
you. After a goodly span of years, mine is
even now my best and most official FM
radio, though without stereo. It is a minor
miracle, that little two-box system, an ex-
cellent and very sensitive tuner and a per-
fectly astonishing little speaker, which
habitually sits on the floor at the foot of
one of my ‘large speakers and just as
habitually fools me into thinking the large
speaker is in operation. Don’t think you
wouldn’t be fooled. You’ll hear a big sound
from such a little source. Not anywhere
else.

Not anywhere else except in the KLH
Model Eleven, with two speaker boxes that
are each slightly smaller than the rectan-
gular wood-encased Eleven. The
Eleven speakers are necessarily in a dif-
ferent type of enclosure, somewhat rounded

(Continued on page 81)
Condenser Microphone with Transistorized RF Circuitry

...INNOVATION by SENNHEISER

This response curve is not a theoretical projection. It was individually plotted for a random-picked Sennheiser Model MKH 104 Condenser Microphone, and it is virtually identical in shape and output level to the separately plotted, signed curves provided with all Sennheiser Transistorized RF Condenser Microphones in this series. (All Sennheiser professional microphones are packaged with individually plotted curves.) Note the broad frequency response, exceptional flatness and the controlled peak at the upper-frequency extreme. Also note the absence of peaks and dips in the critical portions of the spectrum. Need we say more?

The actual size photographs on this page are not simply of the microphone itself, they depict the entire system, including the compact, low-voltage, power supply. The microphone barrel contains a transistorized, 10 mc RF push-pull oscillator feeding a bridge circuit. The output of the bridge circuit is then amplified by an additional stage before being applied to the microphone terminals. This Sennheiser configuration guarantees stability, noise suppression, and smooth extended response at good output levels.

Low-impedance circuit design renders the system insensitive to interference from magnetic fields. The rugged, meticulously designed structure assures insensitivity to mechanical noise, air-pressure shock waves, and high humidity.

For complete technical specifications, call or write Sennheiser Electronic Corporation N.Y. For demonstration of this model and the full Sennheiser line, call or write Harvey Radio Co., Inc., franchised distributor for the New York metropolitan area.

Sennheiser
103 West 43rd Street,
New York 36, N.Y.
(212) Juulson 2-1500

HARVEY
Audio
Audio
September, 1963

\[ \text{Actual size of Sennheiser Condenser Microphone Model MKH 104, Professional Net $195.} \]

\[ \text{Actual size of Battery Adapter Model MZA 6, Professional Net $18.} \]

\[ \text{TECHNICAL DATA} \]

- Anechoic system: \( \frac{\text{pressure response}}{\text{frequency response}} \) (omnidirectional)
- Noise voltage: \( \frac{\text{1 mV}}{\text{10 dynes/cm}} \)
- Frequency range: \( 50 \text{Hz} \text{ to } 15000 \text{ Hz} \)
- Power supply: \( 8 \text{ V} \text{ DC} \text{ or } 10 \text{ V} \text{ AC} \)
- Temperature range: \( -10 \text{°C} \text{ to } +50 \text{°C} \)
- Dimensions: \( 150 \text{ mm} \times 50 \text{ mm} \times 50 \text{ mm} \)
- Weight: \( 150 \text{ g} \)

\[ \text{VERSATILE MOUNTING FOR THE MKH 104} \]

- Mounting options: \( \frac{\text{condenser}}{\text{microphone}} \) and \( \frac{\text{bridge}}{\text{microphone}} \)
- Mounting accessories: \( \frac{\text{miniature}}{\text{accessories}} \)

\[ \text{WHO IS SENNHEISER?} \]

If you have worked with quality microphone systems, you are familiar with Sennheiser products. Established in 1945, Sennheiser Electronic has become Europe's largest manufacturer of quality microphones, supplying them to world renowned manufacturers who have been marketing these products under their own brand names for use in professional recording and broadcasting, high fidelity systems, tape recorders, dictating machines, hearing aids, and many other applications. "Sennheiser" is synonymous with leadership in microphone engineering.

And two more Professional Tapes to improve your recordings:

SOUNDCRAFT HIGH OUTPUT MASTERING TAPE — Provides optimum combination of high output, high signal to noise and low distortion characteristics — resulting in wider dynamic range for your critical master recordings.

SOUNDCRAFT DUPLICATING TAPE — Has 25% greater high frequency output and 7 db better signal to noise ratio than conventional duplicating tapes. Used throughout the industry when quality reproduction is required.

Write for your free "Guide to Sounndraft Professional Recording Products".

REEVES SOUNDCRAFT

Division of Reeves Industries, Inc., Darien, Conn.
New York, Chicago, Los Angeles, Foreign Offices:
25 Warren St., N.Y.C. Canadian Radio: Vancouver: Toronto

AUDIO • SEPTEMBER, 1963

15

17

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A FIGURE OF MERIT FOR FM-Stereo Tuners

Last month we noted that FM-stereo tuners are being specified as though they were mono tuners. We recommended that standards should be drawn specifically for multiplex tuners. We would like to carry the thought one step further this month and suggest that a figure of merit would be the best and most convenient way to specify this type of equipment. In the past we have been rather hazy on schemes specifying equipment by means of a figure of merit. We felt then, as we do now, that such a rating system is inappropriate for equipment where subjective taste factors are important (headspeakers are a good example of this). However, in the case of FM tuners, the only variable of great significance, aside from the technical properties of the tuner, is geographic location; there are no taste factors involved.

To make the point we would take the important technical attributes of an FM-stereo tuner and weight them in accordance with reception problems of a geographic area. Thus we would know which characteristics are most important for a particular area. Then the weighted characteristics could be tallied to an overall figure of merit for a particular geographic area.

For example, let us take an area where sensitivity and selectivity are very important. We would weight these parameters, let us say, 5 and 9 respectively on a DuPont scale. In another area they might be rated 2 and 9. Thus a tuner with sensitivity of 2 µ and selectivity of 40 db would have a figure of merit of 376 in one area and 34 in another. (Multiply the characteristic by the weighting.) Obviously this is a rather simple way of presenting our thought, and also it needs further work to become a workable system, but it does show the basic idea.

One objection we would anticipate would be the necessity for having a different weighting for each locality. On the other hand, after some analysis, it becomes obvious that we do not have a large number of different geographic conditions to deal with. It might really be simpler than appears at first glance.

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We do need a figure of merit for tuners. We do need a way to do the work. The best candidate would be that organization which first started standardizing tuner parameters, the Institute of High Fidelity.

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We have received a sizable amount of correspondence in the last few months concerning the articles by Remmold and Williamson (electrostatic speaker, condenser microphone). Many of the questions centered about the problem of locating the diaphragm material for both these projects. Strangely enough, the material was the same in both cases although the thickness was different. The material is Mylar® with a coating of metallized aluminum. The Mylar is made by DuPont, but unfortunately they do not apply the aluminum. Instead, if you contact the DuPont Company, they will give you sources which do metallize Mylar.

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1 micron = 0.00003937 in.
6 microns = 0.00023622 in. = 0.25 mil

Obviously, it would be best to obtain the exact thickness he used to duplicate his results. On the other hand, we understand that DuPont does not make less than a 0.5 mil thickness. Naturally, if that is all you can get, use it. It will work.

A few words about the electrostatic speaker and combined amplifier designed by Mr. Remmold, please be informed that some errors and changes have been brought to our attention. If you are at the amplifier stage please write and we will send you the corrections.

WE'LL MEET YOU IN NEW YORK, LOUIS

Unfortunately for New York, it doesn't rhyme with Louis, and the names it does rhyme with sound peculiar. Anyhow, we will meet you during the New York High Fidelity Show on the fourth floor of the New York Trade Show Building, 35th and 8th Ave., September 11-15. We will be pleased to meet you and discuss any topic that pleases your fancy—about audio of course. Especially, we will be interested in ideas for articles and other projects. If you have built something you are particularly proud of, why don't you stop by and tell us about it.

By the way, there are going to be some rather interesting things at the Show this year. First of all there will be several full-length live-recording records on the Performances. The purpose of these performances is to demonstrate that equipment available at the Show can produce music which is as close to the live as possible. Also there will be a great deal of emphasis on the ability of components to integrate with almost any decor. In addition, there will be an exhibit which shows how phonograph records are made.

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Last, but not least, will be the display of manufacturers' exhibits, showing the latest and best equipment available.

EDITOR'S REVIEW

Harold Lawrence
Condenser Microphone with Transistorized RF Circuitry

...INNOVATION by Sennheiser

Actual size of Sennheiser Condenser Microphone Model MKH 104, Professional Net $195.

Actual size of Battery Adapter Model MZA 6, Professional Net $18.

This response curve is not a theoretical projection. It was individually plotted for a random-picked Sennheiser Model MKH 104 Condenser Microphone, and it is virtually identical in shape and output level to the separately plotted, signed curves provided with all Sennheiser Transistorized RF Condenser Microphones in this series. (All Sennheiser professional microphones are packaged with individually plotted curves.) Note the broad frequency response, exceptional flatness and the controlled peak at the upper-frequency extreme. Also note the absence of peaks and dips in the critical portions of the spectrum. Need we say more?

The actual size photographs on this page are not simply of the microphone itself, they depict the entire system, including the compact, low-voltage, power supply. The microphone barrel contains a transistorized, 10 mc RF push-pull oscillator feeding a bridge circuit. The output of the bridge circuit is then amplified by an additional stage before being applied to the microphone terminals. This Sennheiser configuration guarantees stability, noise suppression, and smooth extended response at good output levels.

Low-impedance circuit design renders the system insensitive to interference from magnetic fields. The rugged, meticulously designed structure assures insensitivity to mechanical noise, air-pressure shock waves, and high humidity.

Power for the MKH 104 Transistorized RF Condenser Microphone is readily furnished by Battery Adapter MZA 6. The adapter may be plugged directly into the microphone base or anywhere along the microphone cable. It holds 6 miniature mercury cells of the hearing-aid type. Mallory RM-525 or equivalent. One set provides 50 to 60 hours of continuous operation.

WHO IS Sennheiser? If you have worked with quality microphone systems, you are familiar with Sennheiser products. Established in 1945, Sennheiser Electronic has become Europe's largest manufacturer of quality microphones, supplying them to world renowned manufacturers who have been marketing these products under their own brand names for use in professional recording and broadcasting, high fidelity systems, tape recorders, dictating machines, hearing aids, and many other applications. "Sennheiser" is synonymous with leadership in microphone engineering.

TECHNICAL DATA

Acoustic system: Pressure sensitive
Directional characteristics: Suberbial (omni-directional)
Frequency range: 20 to 20,000 cps
Noise level transmission coefficient at 1000 cm (Sensitivity measured in anechoic chamber): 0.002
Impedance: 1000 ohms
Noise voltage: Approx. $20$ dynes/cm²
Distortion at sound pressure: Approx. $0.002$
Overload level: Approx. $0.002$
Power-supply voltage: Approx. $0.002$
Operating current: Approx. $0.002$
Temperature range: Approx. $0.002$
Dimensions: Approx. $0.002$
Weight: Approx. $0.002$

For complete technical specifications call or write Sennheiser Electronic Corporation (N.Y.). For demonstration of this model and the full Sennheiser line, call or write Harvey Radio Co., Inc., franchised distributor for the New York metropolitan area.

Harvey Radio Co., Inc.
103 West 43rd Street, New York 36, N.Y.
(212) JUdson 2-1500

Sennheiser electronic CORPORATION (N.Y.)
25 West 43rd Street, New York 36, N.Y. • (212) Longacre 4-0433
Plant: Bissendorf/Hannover, West Germany

AUDIO ● SEPTEMBER, 1963
A Visit to the French Radio (Part One)

Harold Lawrence

PARIS. The Radio-télévision française (R.T.F.) government hopes to replace its lossy, knit-organization with an efficient broadcasting center containing the latest electronic equipment and utilizing the most up-to-date studio techniques.

Four radio stations will broadcast from the Maison de la Radio; all are owned by the state. The air waves from these stations, or "programs," are called Paris Inter-France 1, Regional-France 2, National-France 3, and Minitélé-France 4.

A visit to these stations can be highly informative. Fortunately, the directors of France 3 and France 4 are able to give you a tour of the facilities.

France 3 is the French equivalent of the R.A.C. Third Programme, and France 4 the PM "good music" station.

I arrived in Paris after completing a series of recording sessions with the London Symphony toward the end of July. Parisians were balking the city in all directions, leaving the capital in the hands of the tourists. Those Frenchmen who stayed sang the refrain: "Le voyage, monsieur, c'est en vacances." (I'm sorry, sir, but Mr. X is on vacation.)

In view of this, I had very little hope of finding anyone to talk to at the R.T.F. Fortunately, the directors of France 3 and France 4 and the_form_ (the short form) had not yet joined the exodus, and would be in their offices during the next few days.

The Maison de la Radio looks like a modern sports stadium, except for the 50-foot-high glass panels lining the front of the building, and the contemporary wood and steel structure adorning the lobby. A sort of shell-within-a-shell, the Maison de la Radio is divided into four elements: 1. an outer shell, containing reception halls and 1000 offices; 2. large halls; 3. an inner shell, including some fifty studios; and 4. a rectangular arching tower.

Concerts were still in progress when I entered the administrative section. Painters, electricians and carpenters were everywhere, and you didn't watch your step. You might find yourself tripping over a paint bucket or plucking down a hole in the floor. The office of the director of France 3, Henry Barraud, was quite a distance from the elevators, down a winding gray corridor, and past maroon-colored doors. M. Barraud, slender, tall, and gray-haired, sat behind a bare gray metal desk, in a gray room looking out into the gray arches tower. I was received by the chief of the R.T.F., H. G. Well's movie, Things to Come.

Seizing my reaction, the building, Barraud said, "It's not quite as bad in office. We are in the room of one of my colleagues which I borrowed for this meeting. My own office, Paris and the Seine. I have another advantage, too: not all of my walls are metal; one of them is a real wall, and I intend to use it. You see, M. Barraud rapped his knuckles on the wall behind the desk, "the walls in this office are like nearly all the walls in the Maison de la Radio - metal. Which means you can't call anything into them."

During our talk, we could hear the click of the high heels of secretaries passing by in the corridor outside our room. Barraud smiled shyly, "No matter where you are, you can't get away from those heels; except, of course, in our offices."

Apart from the looks and sounds of the new building, what did Barraud think of the novel? "It was certainly long overdue. Now our people won't have to tour halfway across Paris to get from one centre to the other. All our archives, our technical, musical and administrative staffs will be in one place, except for one or two centres which we may still retain for special purposes."

As an active composer as well as administrator, guides the destinies of one of the most powerful cultural arms of the French government. Although he oversees all programs on France 3, including drama, poetry, news and music, his chief preoccupation is with things musical. One of Barraud's responsibilities is the commissioning and selection of new works to be broadcast over R.T.F. "Naturally, I don't have the time to read every score that is submitted to us," Barraud explained. "With 3000 composers in France, producing at least one work a year, you can see that this is impossible. The French government, under the Musique Information, has set up a Comité de la Musique especially for this task. This committee is composed of twelve of France's leading music minds; none of whom is connected to the R.T.F. You will probably recognize their names: Roland Manuel, Henri Sauget, Louis Fourestier, and Jean Rivier, to mention a few."

"The Music Committee," Barraud continued, "meets every two weeks to examine new scores. Their recommendations are given to me, after which they are submitted to the Ministry of Information, or, more accurately, for the Roger Payfertier."

In creating programs for France 3, Barraud functions as a sort of government impresario. With the encouragement of his orchestras, organizations both at home and abroad; he surveys the output of composers, tried and outlived; and he commissions works of all kinds for performances both in the studio and over the air. The R.T.F. employs six orchestras, none of whose personnel is hired permanently. They are: 1. L'Orchestre Lyrique, 2. L'Orchestre Philharmonique, 3. L'Orchestre Lyrique, 4. A chamber orchestra, 5. Radio. And 6, a virtuoso ensemble founded by Martin Constant, the brilliant musical director of France 4. Musicians total more than 365, and this does not include singers and choral groups."

Where do these performances take place? I asked Barraud. "When our new studios and offices are finished—this should be early in 1964—we shall have at our disposal five halls here in the Maison de la Radio," Barraud replied. "One will be a fully equipped theatre, with revolving stage and elaborate lighting arrangements. Two will be devoted to large-scale musical performances. The public will be invited to one of these concert halls, which will have a seating capacity of 1000. ... Would you like to hear it?"

Along the way, I asked Barraud how he liked the acoustics of the new halls. "It's not too bad, really," he countered, "but the acoustics around a hall mean a lot to me. I think you'll find the theatre has better acoustics. Did you have any say in the construction and design of these auditoriums?"

"No," Barraud said, "the technicians seldom consult musicians."

All three halls are located on the Seine side of the Maison de la Radio, off the entrance to the outer shell. There is much work to be done.

Even with the seats and most of the rugs, both concert halls seemed to lack resonance. I climbed my hands in the first hall and gave it a good shake by pulling the hip echo, or "slap," that sounded like the whispering of a large bird's wing. When I pointed this out to Barraud, he said, "Yes, I wonder if the acoustics are not one of this."

In the same hall (the one which the public is not invited) the artists had just completed the installation of a sheet of tape covering the entire back wall, a creation of Roger Rezomnes out of old pieces of rugs, tapestries, and remnants. "A "luxury this," Barraud commented, "one will see it but the musicians who play here." Barraud did not hazard a guess as to what effect all this damping will have on the sounds produced by these musicians. (CONTINUED)
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AUDIO • SEPTEMBER, 1963
A FIGURE OF MERIT FOR FM-STERO TUNERS

Last month we noted that FM-stereo tuners are being specified as though they were mono tuners. We felt IHF standards should be devised specifically for multiplex tuners. We would like to carry the thought one step further this month and suggest that a figure of merit would be the best and most convenient way to specify this type of equipment. In the past we have been rather leery of schemes specifying equipment by means of a figure of merit. We felt then, as we do now, that such a rating system is inappropriate for equipment where subjective taste factors are important (loudspeakers are a good example of this). However, in the case of FM tuners, the only variable of great significance aside from the technical properties of the tuner, is geographic location; there are no taste factors involved.

To make the system work we would take the important technical attributes of an FM-stereo tuner and weight them in accordance with reception problems of a geographic area. Thus we would know which characteristics are most important for a particular area. Then the weighted characteristics could be totalled up to an over-all figure of merit for a particular geographic area.

For example, let us take an area where sensitivity and selectivity are very important. We would weight these parameters, let us say, 8 and 9 respectively on a 10-point scale. In another area they might be rated 2 and 9. Thus a tuner with sensitivity of 2 μV and selectivity of 40 db would have a figure of merit of 376 in one area and 364 in another. (Multiply the characteristic by the weighting.) Obviously this is a rather simple way of presenting our thought, and also it needs further work to become a workable system, but it does show the basic idea.

One objection we would anticipate would be the necessity for having a different weighting for each locality. On the other hand, after some analysis, it becomes obvious that we do not have a large number of different geographic conditions to deal with. It might really be simpler than appears at first glance.

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We do need a figure of merit for tuners.

Who should do the work? The best candidate would be that organization which first started standardizing tuner parameters, the Institute of High Fidelity.

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18 AUDIO • SEPTEMBER, 1963
Plug-in head assemblies with pre-mounted cartridges for Type A and Model AT6 Garrard Automatic Turntables.

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Includes U/38 Stereo Fluxvalve Cartridge (premounted) with D3807ATG Golden SAFE V-GUARD "Floating Stylus".

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Includes U/38 Stereo Fluxvalve Cartridge (premounted) with D3807ATG SAFE V-GUARD "Floating Stylus"

Featuring Pickering's exclusive "floating stylus"...so little mass that it actually floats on water...so light it "floats" over the surface of your records. The Pickering "floating stylus" action protects the diamond and the life of the record while it plays.

FOR THOSE WHO CAN HEAR THE DIFFERENCE
Pickering

Pickering & Co., Inc., Plainview, N. Y.
Why did Sherwood zero-in on the problem of tuning accuracy?

It takes wider bands to broadcast the multiple information for stereo FM multiplex, and the most precise "dead-on-center" tuning to receive it... with maximum stereo separation and minimum distortion.

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Gain three tuning advantages
- Tune accurately, the first time.
- Tune low-power Class "A" stations interspaced between more powerful broadcasts.
- Tune with professional surety.

Added value features of the S-3000 Tuner
- Stereo Indicator Light: identifies stereo broadcasts.
- Superb sensitivity: 1.8µv (IHF) for -30db. noise and distortion.
- No background noise: pace-setting 2.4db. capture effect.
- FM Interchannel Hush: suppresses between-station noises.
- Flywheel tuning: smooth as silk.
- 20% longer dial scales: professional accuracy.
- Price: $165.00. (Leatherette case optional at $7.50.)


Prices slightly higher in the Far West.

Mobile FM-Stereo Reception

NORTH C. HAM

Stereo reception with an automobile FM receiver has proven feasible for a large percentage of the Los Angeles metropolitan area.

The pleasure of two-channel audio reproduction in an automobile was the motivation for embarking on the project of building a mobile FM-stereo receiving system. Immediately many questions arise concerning the feasibility of such reception—questions such as: 1. Would the near spacing of the two-channel speakers and the close proximity of the listener to the automobile consume the desired subjective reaction? 2. What is the effect of differential phase delay between the two audio channels created by r.f. transmission? 3. What results from doppler effect, multipath reflections, and signal-to-noise threshold when frequency modulation at vhf is used? and 4. What general implementation problems must be considered? The fact that a few broadcast stations were broadcasting FM-AM stereo in the Los Angeles metropolitan area made it possible to obtain answers to questions 1 and 2 before any further work was expended. The two-channel reception and acoustical radiation was accomplished by installing a mobile FM receiver within the automobile in addition to the normally installed AM receiver. The loudspeakers were placed at the rear deck behind the back seat (sedan automobile), one on the left side and the other on the right side spaced approximately 3 ft. apart. The usual arrangement of directing the speakers to radiate upward against the rear glass window was used. (See Fig. 1.) Subjectively there was a marked enhancement of the program. The sound, although emanating from the two closely spaced speakers, is reflected from the rear window (glass having a very high reflection coefficient to sound waves) in conjunction with the surrounding side windows and windshield, and low resultant time delay between incident and reflected wave produces the illusion of enveloping sound. Similarly, while the transmission was achieved by two widely different radio frequency carriers with varying propagation characteristics, the resultant phase error (this has not been quantitatively measured at this time) under mobile conditions produced no subjective listener objections. The FM-AM process has definite limitations because of propagation factors, fidelity, requirement of two receivers and limited program broadcast by this media, and thus I directed my effort toward FM-FM multiplexing of two-channel stereo.

Problems with the FM-FM form of...
transmission at VHF during mobile operation are associated with propagation factors. A review of the multiplexing process will clarify these factors. The L-R information is transmitted as the normal upper and lower sidebands grouped closely around the FM carrier for compatible or monophonic broadcast while the synchronizing signal and the L-R information sidebands are further away from the carrier. (See Fig. 2.) The sync signal (pilot signal) which is phase coherent to the suppressed 38-ke subcarrier falls conveniently at 19 ke within the spectrum gap between the L-R sideband and the lower L-R sideband components of the 38-ke subcarrier.

The detection, or demodulation, process for recovering the L and R information involves demodulating the entire spectrum data from the r.f. (or i.f.) region and translating it down to d.c. by the action of the frequency discriminator. (See Fig. 3.) The demodulator then strips out the 19-ke sync signal, by selective circuits, amplifies it and uses it to phase synchronize a 38-ke subcarrier oscillator.

The 38-ke phase coherent signal is used as the local injected reference signal for demodulating the L-R sideband information from the product detector. The resultant L-R and L-R information components are then further processed, such as matrixing, to obtain the desired L and R audio channels.

The system of DSB-SC (double-sideband, suppressed-carrier) transmission has the disadvantage in the necessity of knowing $\cos \omega_c t$ at the receiver. This method is referred to as coherent or synchronous detection since the detector must have a carrier wave that is in synchronization with that used at the transmitter.

For DSB-SC demodulation, the output from the product detector is equal to the absolute magnitude of the vector sum of the reference carrier and the transmitted sideband signals. (See Fig. 4.) The expression for the transmitted sideband with suppressed carrier is shown by:

$$e_{\text{sid}} = E_m \cos (\omega_c + \omega_m) t + E_m \cos (\omega_c - \omega_m) t$$  \hspace{1cm} \text{Eq. (1)}$$

where $\cos (\omega_c + \omega_m) t$ represents the upper sideband and is shown as the rotating vector $\omega_m t$ in Fig. 4. The process of demodulation is accomplished by multiplying the local reference subcarrier to the sidebands signal. Equation (1) can be rewritten to a mathematical expression for DSB-SC as follows:

$$e_{\text{sid}} = K E_m (t) \cos \omega_c (t)$$  \hspace{1cm} \text{Eq. (2)}$$

which still states that a pair of sidebands are symmetrically located about the subcarrier frequency, $\omega_c$. The process of multiplying the local reference subcarrier to the received sideband signal is shown in Fig. 5 with these results:

$$f'(t) = \frac{1}{2} K E_m (t) \cos \omega_c (t) \cos \omega_c + \phi$$  \hspace{1cm} \text{Eq. (3)}$$

where $\phi$ is any arbitrary phase difference of $\phi$ degrees between the original and reinserted subcarrier. The output becomes:

$$f''(t) = \frac{1}{2} K E_m (t) [\cos (2 \omega_c + \phi) + \cos \phi]$$  \hspace{1cm} \text{Eq. (4)}$$

and after filtering the high-frequency terms $E_m (t) \cos 2 \omega_c t + \phi$ located above the subcarrier, the output is:

$$f'''(t) = \frac{1}{2} K E_m (t) \cos \phi$$  \hspace{1cm} \text{Eq. (5)}$$

The maximum output occurs when $\phi = 0$ deg. and disappears when the injected subcarrier is 90 deg. relative to the original carrier. The suppressed-carrier detector is thus phase-sensitive and synchronous detection must be used to ensure maximum output.

The completion demodulation process involves two forms of detection: a pulse-counting averaging detector (discriminator) and a synchronous post detector (phase detector). The characteristics of these detectors in relation to the S/N ratio is shown in Fig. 6. It is obvious that the main detector (discriminator) should have a lower "threshold" point than the post detector for a properly designed system.

The "threshold" of the detector is the operating point at which it ceases to perform its task. In this case where the information is program material the "threshold" would be influenced by the subjective listener. Hence this point may be where its performance is degraded by some arbitrary amount or where it ceases to perform completely. The synchronous detector functions distinct from the discriminator in that its "threshold" appears to be well defined and ceases to perform below this point. The conventional description of the FM discriminator "threshold" has been defined as the knee of the curve, the point $K$, where the output S/N is decreasing at a faster rate than during the condition of high signal strength. However in the case of stereo broadcast transmission, the "threshold" generally occurs below this point, such as point $S_l$.

Doppler effects can be neglected since the maximum doppler shift in received frequency will be less than 10 cps when driving at normal freeway speeds. The

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Fig. 4 (left). Relationship of reference subcarrier to sidebands. Fig. 5 (above). Balanced phase detector (product detector).
Doppler shift can be calculated from the formula:

\[ f_{\text{doppler}} = \frac{v}{c} f_s \text{, where } v = \text{velocity of moving vehicle, } \text{mph; } c = \text{speed of propagation, } \text{mph; } f_s = \text{transmitted frequency, } \text{cps.} \]

FM receivers that employ discriminator feedback to the local oscillator will further reduce this factor.

Multipath factors should degrade the reception in several distinct ways. One is the effect upon the phase and amplitude change to the 19-ke sync signal, another is the phase delay differential of the L-R subcarrier sideband information relative to the L-R main carrier sideband information, and finally the resultant S/N ratio at the receiver. Multipath interference is the phenomenon of the transmitted signal arriving at the receiver by a direct path simultaneously with a secondary or indirect path by reflection from objects in the vicinity of the receiver. (See Fig. 7.) The result is that the received signal is a composite of the main signal plus a time delay, \( A \), of the same signal. If the time difference is very small compared to the period of the modulating frequency, the effect is constructive or destructive interference between the two received waves. If the resultant signal strength after destructive interference is still above threshold, the net result is a lower output signal-to-noise ratio and subjectively appears as no degradation. Anomalous phase and amplitude changes to the received 19-ke sync signal has the effect of changing the phase reference of the 38-ke locked-oscillator signal either by a direct phase shift or a momentary loss in sync signal—a resulting phase ambiguity between the 38-ke inserted subcarrier relative to the original subcarrier. The result is that a momentary non-optimum phase exists between the L-R sidebands and the 38-ke local subcarrier. Since this composite signal is eventually matrixed with the L-R composite signal, as shown in Fig. 3, both the L and R audio signals are reduced in the same relative amplitude with the net effects of reduced audio volume.

However, when the multipath destructive interference reduces the effective received signal strength below the threshold of the synchronous detector, the result is a loss of the L-R sideband information and only L-R monophonic signal appears at both loudspeaker outputs. When the car is in motion it will intercept alternate constructive and destructive peaks and nulls along the path of motion (see Fig. 7), and the signal will “flutter” in and out with high- and low-amplitude variation, varying signal-to-noise ratio, and stereo-mono reception all occurring at a periodicity dependent upon the rate of motion and the spacing of these wave combinations. The spacing of the wave combination is also dependent upon the direction of car motion relative to the transmitter and the terrain conditions. The reception is still listenable modified by the tolerance of

---

**Fig. 7.** Main and reflected waves creating multipath interference.

**Fig. 8.** Block diagram of receiving system.
the listener and the degree of signal strength variation below threshold. In the extreme case when the destructive interference reduces the signal below the threshold of the main receiver discriminator detector, complete loss of audio output occurs at the "flutter" rate, and the received station is not listenable under these conditions.

The discussion up to this point has been largely qualitative and more rigorous analysis would require complete information on the transmitted portion of the system, quantitative information by instrumenting the various subsystems of the receiver and continued field test. Suffice to say, since the primary objective was to determine the feasibility of reception and its enjoyment, it has proven more than adequate. Quantitative data may be obtained in subsequent tests and means of improving the receiving system is discussed in later sections.

Receiving System Implementation

The receiving system is comprised of the basic FM automobile receiver together with the demultiplexer, secondary audio amplifier, and auxiliary power converter and control panel, as shown in Fig. 8. The basic receiver is the Motorola FM-900 receiver which was chosen because of its sensitivity and ease of adaptability. The receiver is a complete receiver containing the entire r.f., i.f., discriminator, and audio amplifier circuitry. Modification involved the extraction, at the proper point, of the transmitted spectrum; an emitter-follower, low-output impedance, cable, and control panel of the vacuum-tube filaments to operate from the 12-v. d.c. car battery source, input connection to the power supply filter network from the 360-v. d.c., d.c. converter output voltage, the addition of the stereo indicator relay for the remote light indicator at the control panel and the automatic removal of the 38-ke local oscillator injection during non-stereo reception, and the addition of the main gain control circuitry. The main gain control circuitry permits an overall stereo volume adjustment without

Fig. 9. FM receiver with control panel and cable driver.

![Fig. 9](image)

Fig. 11. FM receiver modification and cable driver.

![Fig. 11](image)

Fig. 10. Audio amplifier, multiplex adapter, and d.c.-d.c. converter in position under rear deck of car.

![Fig. 10](image)

The electrical modification to the FM receiver is shown in Fig. 11. The multiplexer output is derived from the discriminator output point preceding the de-emphasis network and applied to the emitter follower. If a particular tuner does not have the desired response at the higher modulation frequencies, a phase lead network may be inserted to compensate for the "roll-off." The nominal signal amplitude at this point is approximately 5 volts peak resulting in an output level of about 4 volts peak to be applied to the demultiplexer. The audio circuit is connected to a small switch to allow audio input from the normal de-emphasis source or from the multiplexed channel 1 source. Both the emitter-follower and the

---

altering the 19-kc sync signal. The main volume control is thus remotely controlled from the receiver control panel (momentary type spdt lever switch) while the differential gain matching between channel 1 and channel 2 is accomplished by the normal FM audio amplifier gain control. The remote control technique used may appear sophisticated; however, it was found the simplest expedient of changing the audio circuit gain with the one-megohm potentiometer. This scheme does not require any additional gain nor does it upset the phasing of the side-band information. The 12-v. d.c. reversible motor and relays are of the garden variety of components, readily obtainable from surplus dealers. Fortuitously this scheme was ideal from the human engineering viewpoint because of its momentary lever action where the downward position is for reduced volume, and vice versa, with the length of actuation determining the degree of change. Changes occur in stepped amounts and result in the least distraction to the driver's attention from the road. Other schemes such as bias-controlled vacuum tubes or voltage-control level attenuators could be used dependent upon the complexity and ingenuity desired. Figure 13 is the schematic of the particular d.c.-d.c. converter used to provide B+ for the multiplex adapter vacuum tube. This scheme was chosen because the d.c.-d.c. converter oscillator frequency of approximately 3 ke could be efficiently filtered to reduce conducted interference in the 12-v. d.c. supply line. In this respect "L-section" line filters, utilizing 80-mh/2.5-amp chokes together with appropriate bypass capacitors, were necessary to reduce a.c. interference in the alternator, FM receiver d.c.-d.c., and multiplex adapter d.c.-d.c. converter. (See Fig. N.)

The second channel audio amplifier is a transistor power amplifier, as shown in Fig. 15. The volume control permits adjusting the nominal audio power for this channel and is normally set in conjunction with the main gain control for the desired dynamic control range. The normal FM receiver audio gain control is used to balance the channels. Additional decoupling in the 12-v. d.c. lead to the bias network of the input transistor, Q1, was necessary to further reduce conducted interference. The 500-pf bypass across Q2 was necessary to remove high-frequency instability in the feedback loop.

The usual problems of chassis loop currents, improper grounding, and attention to additional filtering and bypasses to the automobile electrical system must be fought through on any system installation and depend upon the characteristics of the particular automobile.

It can be stated here that the reception of FM-stereo within a moving passenger automobile is feasible and practical and certainly enhances the enjoyment of FM reception. The coverage is limited largely by the transmitter site location, effective radiated power, receiver sensitivity and propagation anomalies. In general, (Continued on page 62)
Crossover Design

NORMAN H. CROWHURST

This two-part discussion covers all the practical aspects of crossover design, from choice of circuit configuration and calculation of the necessary values, to making your own coils and checking out the over-all result. This first part covers the broader questions of circuit choice and value calculation.

In Two Parts—Part 1

The basic function of crossovers needs no introduction to the readers of Audio. However, there are some aspects in their function that need clarifying before design data can be intelligently applied. The earliest crossover designs were adaptations from classic filter theory. Apart from the fact that, even correctly terminated, such filters do not perform precisely according to their theory, a practical loudspeaker “load” never correctly terminates a crossover filter at all frequencies. This fact, for various motivations, led to the adoption of the type known as “constant resistance.”

This term was strictly for the amplifier’s benefit. But, without explanation, it led to some misunderstandings. Although some people still believe it to be so, a constant-resistance network does not enable any pair of impedances to be connected to the output, with the input automatically presenting constant resistance to the amplifier. What “constant resistance” means is that, if the low frequency and high-frequency terminals are each terminated with the true nominal impedance for the design, as a resistive value, then the input terminals will present this same resistive impedance to the amplifier, at all frequencies.

This is more than could be said for networks designed on classic theory. Because of this, the so-called constant-resistance types have more tolerance for the inevitable variations, due to the impedance characteristic of loudspeaker units, than do the classic types, which are already “off” with true resistance termination. But the constant-resistance type have no more magical properties than their classic forebears.

At the majority of frequencies, removed from the immediate vicinity of crossover, either type of network reflects the terminating impedance back through the filter that’s operative for the particular frequency, virtually unchanged. In the vicinity of crossover, termination with units whose impedance is close to nominal and close to resistive in this range, will result in close approximation to constant-resistance load for the amplifier in the same range, and in correct distribution of energy between the two outputs. Deviation from this ideal will cause less serious departure from theoretical performance than was the case with classically derived filters.

Having explained that bit, we now come to the question of choice of configuration. First let’s clarify the designation of filters by a “db per octave”

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*P. O. Box 631, Gold Beach, Oregon,
This seems to have different meanings when used by different people. The meaning we will use, which has the widest general acceptance, refers to the ultimate cut-off slope (Fig. 1). At crossover frequency, where each output should receive precisely half the total power, there should also be precisely half the nominal ultimate phase shift to each, and the slope will be precisely half the nominal ultimate value for the configuration.

On that basis networks come in db/octave figures that are multiples of 6. A simple network, using a capacitor in series with the tweeter and an inductor (or the voice-coil inductance itself) in the woofer circuit, results in 6-db/octave crossover. Two elements in each filter (four in all) result in a 12-db/octave crossover. Three elements in each filter...
Fig. 4. The four basic constant resistance crossovers, arranged for parallel connection (top row) or series connection (bottom row). The elements are coded to identify the reference lines used to find their values on the chart of Fig. 3.

(six in all) result in 18 db/octave, while four in each result in 24 db/octave.

At the half-power point, the loss in each output is 3 db and the slope half the ultimate values above quoted, in each output. Phase angle is half ultimate too, which is 90 deg. for 6 db/octave, 180 deg. for 12 db/octave, 270 deg. for 18 db/octave and 360 deg. for 24 db/octave. As each output varies from zero phase shift (a theoretical ultimate within the pass band) up to this ultimate value (at theoretical infinite attenuation) and the two are complementary, these figures are the phase difference between the two outputs at all frequencies, when correctly terminated.

If we were only concerned with the usually stated ideal of delivering only the frequencies below crossover to the woofer and only the frequencies above crossover to the tweeter, then we would prefer the filters with the steepest db/octave slope in effecting this transition.

But there are other factors. Apart from the obvious fact that more elements make the crossover more costly, the increased slope is not all gain. The more elements the filter contains, the more critical is its exact response upon precisely correct termination.

Even assuming we take care that each is correctly terminated, within say an octave on either side of crossover, this does not say that the 24-db/octave type is necessarily the best for the job. All crossovers introduce progressive phase shift, which is a time delay discriminative of frequency. In the simpler circuits, this phase shift closely approximates a constant time delay. The sharper the cut off, the more abrupt the change in phase shift in the immediate vicinity of crossover, and the consequent variation in time delay with frequency at this point.

This means that, especially noticeable on transients, the signal fed to the loudspeaker units will have the time relationship of its component frequencies shifted much more by the sharper circuits. On this basis alone, we would plunk for the simplest, or at most the 12-db/octave type.

As with most things in audio, we have to end up with a compromise which depends on the type speakers used. In some types, notably those with correctly matched horn radiator, there is a rapid transition from correct acoustic loading, allowing the unit to handle its full rated power, to almost no loading at all, resulting in distortion and/or damage to the unit, if available power is not rapidly curtailed beyond the proper range of use. With this type of system, there may be good argument for the steeper-slope crossovers.

With systems made up of cone radiators on the other hand, there is, relatively, no sudden cut-off frequency in the acoustic sense. Maybe cone break-up in the woofer leads to rough response above its allocated range, while cone excursion should be controlled below the allocated range of the tweeter. For these

Fig. 5. Illustrating how the chart of Fig. 3 is used to calculate values for a crossover of the type shown in (H) of Fig. 4.

Fig. 6. The values found as shown in Fig. 5, inserted in the schematic.
new from SHURE originators of scratch-proof high fidelity tone arms

SCRATCH-PROOF CARTRIDGE ASSEMBLY FOR GARRARD AND MIRACORD OWNERS

Attention music lovers and felineophiles; interesting to note that both cat and cartridge have retractile styli for gentleness and protection from scratching.

GREATER RECORD AND NEEDLE PROTECTION . . . FINER RECORD REPRODUCTION

Now, owners of Garrard Laboratory® Type "A" and AT-6 and Miracord Model 10 and Model 10H Automatic Turntables can assure themselves unprecedented and unparalleled record and needle protection, and highest sound quality simply by plugging in the Shure Stereo Dynetic GARD-A-MATIC "floating" cartridge assembly. Nothing else to buy . . . no wiring, no soldering, just plug in.

Ingenious GARD-A-MATIC cartridge inside a special tone-arm shell ends scratching due to dropping the tone arm or accidentally dragging it across the grooves . . . records stay new, sound new. Needles last longer—can't be damaged by pressing arm on record. Does away with tone arm "bounce" from floor vibrations, etc. Even plays warped records. And, the performance characteristics are those of the famed Shure Stereo Dynetic cartridges.

SPECIFICATIONS

<table>
<thead>
<tr>
<th>Frequency Responses:</th>
<th>From 20 to 20,000 cps</th>
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</thead>
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<td>Output Voltage:</td>
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<td>Channel Separation:</td>
<td>more than 22.5 db at 1000 cps</td>
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<td>Recommended Load impedance:</td>
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<td>Compliance:</td>
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CARTRIDGE ASSEMBLY

WRITE FOR DETAILS TO: SHURE BROTHERS, INC., 222 HARTREY AVE., EVANSTON, ILLINOIS

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applications, the 0- or 12-dB/octave, according to the rapidity with which such effects begin, or the margin of protection needed, will be quite adequate.

A question we are often asked relates to the use of differing impedance units in the same system. While this is possible, steps should be taken to achieve correct matching. As the woofer invariably has to work at maximum efficiency and requires maximum damping, it is best to design the crossover at its impedance, and use the appropriate amplifier impedance tap to match, padding the other unit with either series or shunt resistance to give it the same impedance value.

For example, if the woofer is 16 ohms and the tweeter 4 ohms, use a series resistor of 12 ohms in the tweeter circuit. This will result in a 6-dB loss, which means some other method should be used if the tweeter does not have this much spare sensitivity over the woofer. Any speaker transformer with a center tap on the low-impedance winding will serve to achieve this matching (Fig. 2). Alternatively, if the tweeter impedance is higher than that of the woofer, a shunt resistance or a step-up auto-transformer will enable correct matching to be achieved.

Figure 4 shows the family of constant reactance crossover configurations from 6 dB/octave to 24 dB/octave. To achieve better match, where the woofer unit's voice-coil inductance possesses appreciable reactance at crossover, use configurations (A), (D), (E), or (H), where the low-frequency output has a series inductance element; the value of voice-coil inductance can be made part of the output inductance element. Voice-coil inductance is not usually constant, because part of it is due to acoustic radiation effects, as well as the electrical inductance of the coil in the magnetic gap.

A good compromise value may be calculated by finding the frequency where the impedance is just double its minimum value. Assume this value is simple reactance and calculate the equivalent inductance from a reactance chart, or the formula \( L = X_l / 2\pi f \) (in henries, when \( f \) is in cps). Merely subtract the value so obtained from the calculated value for your crossover and get a coil to provide the rest.

The chart of Fig. 3 provides for calculating all the crossover elements, in terms of the reactance coding shown on Fig. 3. Values for networks (A) through (F) use references at the left, while values for (G) and (H) use references at the right of the chart. For example, suppose a 16-ohm horn system uses an 800-ohms crossover of the 24-dB/octave variety and configuration (H). It uses reactance elements \( X_1, X_2, X_3, \) and \( X_4 \). Figure 5 shows how the chart is used to obtain the values shown in the circuit of Fig. 6.

That handles two-way systems in all their varieties. Now we come to the design of crossovers for multi-way (more than two-way). We only show three-way, but systems with more crossovers use the same method, extended. The "end" units—lowest and highest—follow the same design as two-way, while intermediate bands employ band-pass sections. The complete set of three-way configurations is shown in Fig. 7. Here, as well as specifying reactance, we have to specify

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**Fig. 7.** One set of possible configurations for a three-way crossover, corresponding to each of the basic types shown in Fig. 4. Each element is coded with a reactance and frequency; the reactance refers to Fig. 3 and the frequency to Fig. 7.
ladies
and gentlemen,
may we
present
"the beginning
of a
new era"
in listening
pleasure
NEW! THE THORENS TD-224 “Masterpiece”

WORLD’S FIRST TURNTABLE AND AUTOMATIC RECORD CHANGER

The most advanced precision instrument ever developed for the automatic reproduction of all recorded music in the home.
Here is the ultimate in high fidelity quality and convenience — a fine 2-in-1 Swiss instrument that combines all the benefits of a professional turntable with all the conveniences of an automatic record changer. More than five years in development, the TD-224 meets and exceeds the standards of the most ardent and discriminating perfectionist.

**HOW IT WORKS**

Imagine a firm, sure, yet gentle hand removing an individual record from a stack, placing it carefully on a turntable, waiting until the record is played, lifting it gently and placing it on a lower stack, moving to the upper stack of unplayed records, and repeating the process infallibly — all automatically. There you have the principle behind the unique Thorens Masterpiece. It is a turntable that plays records individually, as records should be played, yet changes them automatically, with precision, grace and beauty.

The Thorens TD-224 Turntable and Record Changer overcomes the problems of today's "automatic turntables" and record changers, which must sacrifice quality and create record wear in favor of convenience. Now, for the first time, no compromise has been made in design and performance. This is an instrument of perfection, a true masterpiece, created by brilliant Swiss engineers who are music lovers as well.

**QUALITY WITH CONVENIENCE**

Here are only a few of the benefits that are built into the Thorens TD-224:

**NO RECORD STACK ON TURNTABLE**

The Thorens TD-224 eliminates the problems created by stacking of records on the moving turntable. No distortion, no warping. The record stacking is completely separate from the turntable. No other changer offers this benefit.

**CARTRIDGE QUALITY**

This is the only record changer which can properly utilize the finest professional cartridges with highest lateral and vertical compliances. Because of its features, Thorens engineers recommend that the finest-quality cartridges be used, for maximum re-creation of music.

**SINGLE PLAY OF RECORDS**

The TD-224 plays records as every professional turntable does, individually. You can hear the difference this makes in your enjoyment.

**CONSTANT STYLUS ANGLE**

The angle of the stylus is constant because the tone arm is in a set position, perpendicular to the record surface. Vertical tracking error is as minimal as on professional turntables. The TD-224 is the only present day changer that can make this statement.

**FAMOUS BTD-125 TONE ARM**

The TD-224 incorporates the famous Thorens BTD-125 Tone Arm, a classic of Thorens-Swiss craftsmanship. No other arm offers so many unique benefits: Lowest possible inertia assures accurate tracking even on warped records, minimizes record wear and stylus wear; Precision ball bearings on all axes; All adjustments: precision-calibrated gramophone, stylus positioning slide, balancing counter-weight. Unique vertical pivot keeps stylus vertical at all times, automatically, not by usual critical adjustments. Plug-in shielded cable connector and a complete 5-wire system throughout gives maximum shield from hum. Resonance well below audible frequencies. Less than 0.5"/inch tracking error. Quick-change plug-in shell for all standard and ultra compliance cartridges. No wonder Thorens engineers decided that no other tone arm would do for the TD-224 Masterpiece.

**CONSTANT TORQUE**

The torque on the motor is constant, since there never is more than one record on the turntable at a time. The result is true fidelity from every record you play.

**BUILT-IN RECORD CLEANER**

With the use of present day advanced light-weight tone arms and pick-up cartridges, old-fashioned methods of cleaning records have become obsolete. Thorens had to invent a new way to help you keep your records clean. They incorporated the Cecil E. Watts principles in the TD-224 tone arm brush. A patented continuous record cleaning device is mounted on the record feed-in arm, and cleans the records during play, without interfering in any way with the tone arm. Static charges due to dust are thereby eliminated.

**ILLUMINATED STROBOSCOPE**

Made famous by the Thorens TD-124, one of the most remarkable of all the features of the TD-224 is the built-in stroboscope, illuminated and visible throughout the entire playing cycle. The stroboscope permits control and adjustment of the turntable speed even while the record is being played.

**EXCLUSIVE PITCH CONTROL**

The variable speed control allows you to correct even extremely small differences of speed with slight touch of an adjusting knob, thereby providing true re-creation of music even to the most critical ear. A musician, in fact, can get precisely "on pitch" with any instrument he wishes to play. The strob e, moreover, reveals visually what may be undetectable to the ear. For example, a

1½" variation in speed changes the pitch only 1/6 of a semitone. The strob e, however, indicates even this slight variation, and enables you to maintain the speed at a rate constant to the highest accuracy of 0.1% by adjusting the fine speed knob.

**MANUAL PERFORMANCE**

For transcription turntable performance, the TD-224 can be played manually as well as automatically with the changer.

**MANY OTHER FINE FEATURES**

- 4-Speed operation, with variable speed adjustment control.
- Plays automatically up to eight records (9½ inch stack).
- Intermixes records of any diameter between 7" and 12" provided speed, groove-shape and center hole diameter are alike.
- Automatically shuts off when all records have been played. World famous Thorens drive system and motor, made famous by the Thorens TD-124.
- Level indicator aids in perfect levelling.
- OFF position disengages idler wheel automatically to prevent idler flats.
- Far exceeds NAB specifications for rumble, wow and flutter for transcription turntables.
- Operates at any voltage from 100/250 volts, 50/60 cycles AC.
- FULL ONE-YEAR WARRANTY.

**DIMENSIONS:**

Base measures 27" wide, 14½" deep, 4½" high. Maximum height for operation: 9½".

The superb TD-224 Masterpiece offers features never before available in a single instrument. Its durability and performance specifications far exceed NAB standards for studio equipment. This is an instrument to be cherished as the finest in the world for the re-creation of sound by records.

See the participating franchised dealers listed on next page.
Fig. 8. Chart for deriving modified reference frequencies, $f_1$ and $f_2$, from the actual frequencies, $f_3$ and $f_4$, in a bandpass filter.

Fig. 9. Illustrating how the chart of Fig. 3 is used to calculate values for a three-way crossover of the type shown in (D) of Fig. 7.

frequency, where for the two-way system frequency was all the same.

The configurations shown are one possible form in each case. In the configurations of Fig. 3, where each network provides two-way output, the choice of configuration is fairly simple. In both groups, the configurations identified in (A), (C), (E), and (G) have series input elements for each section and require connecting in parallel at the combined input, while those identified in (B), (D), (F), and (H) have shunt input elements for each section and require connecting in series at the combined input.

For the two-way system, the latter group lead to the logical simplicity of using the tapping point as a common lead. But with three or more ways, there is more than one tapping point. The tapping points can only be common at the input end now, except in the simplest network (B). Providing the configuration of each section of the network is correct, the only requirement for overall constant resistance effect is that the groups in (A), (C), (E), and (G) are connected in parallel and those in (B),

(Continued on page 79)
Following are letters received from readers of this column comments on subjects previously discussed here:

Microphone for Tapping Heartbeats

Share Brothers, which makes microphones as well as other products writes: "This is in reference to your column in the December, 1962 issue of Audio for 'Tapping Heartbeats.' You were asked a question about what microphone to use for recording heart sounds. Share Brothers has recently announced a new heart-sound microphone which will solve this problem exactly." The letter and an accompanying bulletin describe the microphone as follows: 8P-5 series, ranging in price from $97.50 to $147.50, controlled magnetic type, smooth frequency response from below 10 cps to 10000 cps, and about 0.2 mc output for adult normal heart.

Correct Mixing and Miking

Electro-Voice, which also makes microphones as well as other products, writes: "In your January issue, a reader inquired about correct mixing and microphone placement. It is quite true that the professional engineer depends greatly upon the 'cut and try' method, his approach is quite direct and efficient—it is the outgrowth of his general experience, his thorough knowledge of the equipment he is using and its performance, and his understanding of the acoustical environment in which he is operating. All this is considerably less a 'great mystery' than might at first appear to the non-professional.

"Certain fundamentals must be observed for good recording: 1. When more than one microphone is used, it is essential (particularly for stereo) that such microphones have closely matching characteristics. 2. As a general rule, microphones should be used sparingly, i.e., never use two unless you are certain one will not achieve the effect you want. 3. A microphone should not be closer to the sound source than is necessary for control of 'room sound,' i.e., reverberation, and the presence effect you want. 4. Be sure your monitoring equipment is such that it faithfully reproduces the sounds you are recording—it is your basic reference standard.

"Much of the desired information is covered in the 'Microphone Facts' bulletins published by Electro-Voice. Add this to your usual reference books. (Signed, Paul K. Franklin.)" (Readers wishing to receive these bulletins should send request to Editor, Audio.)

Selecto Flutter

A Canadian reader writes: "I was much interested in a letter that appeared in the February, 1963 issue under the heading 'Selecto Flutter.' My tape recorder recently developed a mild case of the difficulty described by your reader. The tape transport mechanism is almost identical to the system used in his machine. I have not yet completely solved my problem but think I am on the right track. A common cause of trouble in mechanical items is loss of spring tension. The shaft of the left-hand tension arm is attached to a small drum, to which is attached a long, very compliant spring. I have experimented with an increase in tension (using rubber bands), and the added tension seems to almost eliminate the difficulty. I suspect the spring should be shortened, having probably lost some of its tension. My trouble is also selective, that is, it starts to happen around the middle of the reel. It also suggests that the angle at which the tape meets the tension arm has something to do with the problem. Around the middle of the reel, the tension arm starts to flutter slightly, perhaps due to mechanical resonance, and this flutter is of course transmitted to the recording. I intend to experiment with 3 parameters: 1. Tension of the tension arm; 2. Tape tension (which can be varied by adjusting the spring under the spring in the voltage supply to the feed and takeup reels); 3. Mass of the tension arm.

Random Clicks

In your May, 1963 column there is a letter about random low-level clicks heard on playback of certain tapes in use. I too had this problem with my tape recorder. In an attempt to solve the problem I had written to the tape manufacturer and to the recorder manufacturer with no results. It finally took me a couple of years to solve the problem, but I did and here is how: I determined that the noise was actually coming from the uncoated side of the tape, not the coated side. I made and placed an extra idler wheel between the supply reel and recording head and had the tape thread in such a way that the outside or uncoated surface had to slide along this wheel. This took off the static charge and the tape became quiet. As soon as I stop the recorder and move the tape off this extra wheel, the noise begins almost immediately. I also had tried various methods of grounding the recorder and the heads but to no avail. I also had replaced the head, but the new one was just the same. (Signed, R. P. Burns.)

VU Meters vs. Eye Tubes

"I disagree with Mr. Allen who says that the VU meter is preferable because it responds logarithmically to the signal. The reason any indicator is used at all is to show the maximum allowable signal. Also I don't go along with Mr. Allen (who prefers the magic eye tube). He seems to imply that he rides gain while recording in order to keep the signal level high. I infer that his excessive tape his is caused by troubles in his tape recorder.

"I must admit that I can find no rational preference for the VU meter, however it is what I have used for years. If I were designing my own tape recorder electronics, I would use magic eye tubes because they are cheaper." Eric R. Weiss, Musical Director, Manchester Recordings.

Double Equalization

Q. I have a record-playback tape machine. The playback amplifier is X dB equalized. If I use the tape-head input of my integrated amplifier, will this combination degrade the signal if the playback equalization is not exactly the same in each component? Or is the double equalization redundant? If the double equalization is necessary, what is the equation in each component?

A. The output of your tape machine should not be fed into the tape head input of your amplifier. If you use a high-level input, such as one marked "tape amplifier" or "auxiliary" or "line," the amplifier provides non-selective equalization. If you were to feed the signal into the tape head input, there would be two bad results: 1. You would have excessive bass boost, something like 30 db too much at 50 cps. You can imagine how this would sound in terms of the audio signal and in terms of magnetic hum. 2. You would probably overload the input tube of your integrated amplifier, resulting in excessive distortion. The input for a tape head is designed to accept a signal on the order of a few millivolts, whereas the input for a tape amplifier will accept a signal of several volts so that overload becomes excessive. Your tape machine probably puts out a signal of 1 volt or more. The tape head input of your amplifier is intended only for a signal taken directly from the playback head of a tape deck. This signal is a few millivolts. In this case your head input should be used to provide the necessary amplification and equalization.

Adding "Echo"

Q. I would like to know how to add an echo effect when making tapes from phonograph records. What I am after is a controllable method of producing a series of echoes, each at a lower volume than the preceding one. I have tried several ideas, but seem to be limited by the time lapse between the record and playback heads, or by a series of uncontrolled echoes. Perhaps a reverberation unit might be the answer.

A. In its simplest form, the echo effect is achieved as follows: As you simultaneously record and play back, the signal from the playback head goes through the playback amplifier and then into the recorder head, where it is mixed with the input signal. I gather that you are probably following this procedure. The sound you recognize, in the time lapse between the record and playback heads, tends to be more of a bouncing echo sound than the reverberation effect you appear to be after.

Better results will be obtained at maximum speed of the tape recorder, for the tape will shorten the time span between the original signal and the echo. Possibly you are feeding in much playback signal into the record amplifier. (Continued on page 78)
You push the button down, the music goes round and round

and it comes out great!

The magnificent Concord 880 (as do all professional tape recorders) has three separate heads—one record, one playback and one erase. To make professional quality stereo tape recordings from F.M. multiplex, stereo records, or live performances, your tape recorder must have three heads!

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CONCORD 880

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CONCORD 550D—tape deck version of transistorized Stereo 550. Priced less than $230!

CONCORD 220—Hi fidelity mono recorder, all push button, three speeds, varisync flutter-free drive motor, dynamic microphone, cue and edit button, magic eye record level indicator, plus Audio-Synctrol accessory for home movie sound. Priced less than $150 plus Audio-Synctrol attachment.

Prices slightly higher in Canada.

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Audio • September, 1963
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DUANE H. COOPER

The widespread use of conservative recording levels accounts for the little distortion actually heard, because of vertical tracking error, in many stereo discs.

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The unique advantages offered by the Acoustech I solid state stereo power amplifier can now be fully realized by using it with the new solid state Acoustech II stereo decade control center. Each unit was designed specifically to complement the other. Together they comprise an amplifying system combining low distortion, superb transient response, high signal-to-noise ratio, and long-term reliability attainable only with solid state circuitry throughout.

The Acoustech II is a decade control center. Never before has equipment designed for the home employed professional stepped level switches as well as stepped tone controls. The far right outside knob (decade level) has 10 db steps, the inside knob (micro) 2 db increments. These step level controls not only provide precise tracking between channels and complete freedom from noise common to conventional volume potentiometers, but also permit identical square wave characteristics (rise time under 1½ μsec) at all level settings.

The decade control and other professional features indicate the bold approaches taken in this first decade control center. The Acoustech II's price ($348, slightly higher West of Rockies) reflects its perfectionist nature. Both solid state Acoustech instruments are available at leading audio dealers. Hear the difference yourself.

The Acoustech I Solid State Stereo Power Amplifier is "... better than the best ...," wrote Julian D. Hirsch in HiFi/Stereo Review, $395.00 (slightly higher West of Rockies).
CLASSIC MARK II

Engineered and styled for those who cannot be content with less than the best—the "big-ticket" system for big sales! Acclaimed by leading audio critics and engineers, including Juian Hirsch of the Hirsch-Houck Laboratories. He gave it an "unqualified top-notch rating"—and proved it in his Hi-Fi/Stereo Review article. Features a 15" high-compliance woofer, super-smooth deluxe mid-range and Sphericon Super Tweeter. Response: uniform and distortion free from 20-40,000 cps. Truly magnificent 35" wide, oiled walnut cabinet. $295.00

CLASSIC DUAL 12

Both visually and acoustically, it approaches the performance and beauty of the Classic Mark II more closely than any other system of its moderate size and cost. Reason? A completely radical approach—instead of the conventional 3-speaker arrangement, it uses two 12" speakers for bass and mid-range reproduction, plus the renowned Sphericon Super Tweeter for phenomenal highs. Response: 25-40,000 cps. Only 233/4" x 311/4" x 151/2" deep. Oiled walnut. $229.95

UNIVERSITY

SENIOR II

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MEDALLION XII A nationwide "best seller"! The 12" three-way system acclaimed by critics as the world's foremost compact system of its kind. Clean, undistorted sound from low bass to beyond the range of audibility. Distinctive styling enhanced by five interchangeable "Select-A-Style" grille frames that snap on and off to match any decor. Response: 28-22,000 cps. 17" x 24" x 11 1/4" deep. $139.95 less grille and base.

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Send for University's colorful, informative catalogs and sales literature covering this outstanding new line of loudspeaker systems.
FM Tuner Characteristics—and Their Relative Importance

DANIEL R. von RECKLINGHAUSEN

Last month this author described the three characteristics he considers most important for a modern FM tuner. This month he continues his description of tuner characteristics and ends up with table which gives his order of importance.

In Two Parts—Part II

We have shown that it is difficult for an FM tuner to reject strong interference from an adjacent FM channel when distortion in the desired channel is to be kept low. But all is not lost, basic FM theory indicates that the stronger signal will predominate at the output of the tuner to a larger degree than at the input; the weaker signal is captured by the stronger one. Even if the adjacent-channel signal is stronger, it may not cause interference. Tuning away from the interfering signal (at the expense of increased distortion) and having it on the slope of the selectivity characteristic will make the weaker signal receivable, although not perfectly.

Since there are only 110 FM channels available with about 1100 FM stations on the air, any one channel will have an average of 11 stations operating on the same frequency. Most of them are separated geographically so that only one station is receivable in an area. However, in highly populated regions it is common to find at least one frequency at which two or even more stations provide adequate signals for most listening purposes. Here, the problem of co-channel interference exists. This is particularly true of the "A" channels which have lower-powered transmitters at fairly close geographical spacings.

Co-channel interference is likely to increase in the future with more FM stations going on the air and the increase in transmitter power permitted by the FCC. Interference will be increased even more due to the FCC's recent ruling permitting wireless microphones to operate in the FM band. The tuner should be able to reduce this interference as much as possible and "capture" is the phenomenon with which this is done.

Anyone who has listened to short wave signals with a communications receiver is familiar with the beat tone which occurs when the local beat-frequency oscillator (BFO) is turned on while listening to a station. As the BFO frequency control is adjusted, the strength of the tone remains exactly the same, varied audibly only by the frequency response of the audio and speaker system of the receiver. With two unmodulated signals at the input of the limiter-detector combination of an FM tuner, exactly the same beat tone occurs. The main difference is that strength of the tone now is strictly proportional to the frequency of the tone. Here, the phase differences between the two signals change 360 deg. per second for every cps difference between the two signals. This is effectively phase modulation of the stronger and originally unmodulated signal. Since phase modulation is the same as frequency modulation increasing in deviation with "modulating" frequency, the voltage amplitude of the beat tone will increase with frequency difference of the two signals.

The de-emphasis network of the tuner will attenuate the beat tone proportional to frequency above the turnover frequency of 2120 cps as determined by the standard 75-microsecond time constant. Then, after de-emphasis, the output voltage of the beat tone will remain constant with frequency at high frequencies and will decrease below 2120 cps. Since 75 kc is the maximum deviation, any beat tone will be attenuated at least 75/2.12 = 35.4, or 31.0 db. This is the basic signal-to-interference improvement of the monophonic broadcasting system.

If it is also assumed that the interference has an equal chance of being
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anywhere in the 150-kc minimum bandwidth and the tuner’s audio response is cut off after 15 kc, a further improvement of 7.7 db results. The total improvement is then 31.0 + 7.7 = 38.7 db.

In stereo operation, the tuner is also sensitive to frequencies up to 15 kc either side of 38 kc away from the carrier. This degrades the 38.7-db figure by 23.3 db to 15.4 db and interference or noise will be considerably worse in stereo than in mono operation.

The FM improvement figure of 38.7 db (in mono, 15.4 db in stereo) holds for all FM tuners as long as the ratio of signal-to-interference is relatively large (for example 10 to 1). With a perfect limiter and detector system, this analysis of capture holds true even if the interference is slightly smaller than the signal. Of course, if the interfering signal becomes any stronger it will “capture” the desired signal.

Perfect things do not exist in this world and the limiter-detector system is no exception. In limiting two signals of similar magnitude, very rapid phase changes occur when the two signals are in opposite phase. This causes a frequency “spike” of very high instantaneous deviation. If the limiter or detector, because of limited bandwidth, cannot accommodate such a “spike,” the interfering signal cannot be captured as well as theory predicts. Figure 8 shows the ratio of desired-to-interfering signal (the capture ratio of the detector system alone) below which the FM improvement becomes degraded.

The response of the I.F. system, if not perfectly flat in the passband, will alter the ratio of signal-to-interference. Here, the interference has a good chance to be on the peak of the response with the desired signal being attenuated by the I.F. filter response elsewhere in the passband.

It has been shown in the analysis of distortion that a flat passband or “near perfect” filter is not the best for FM reception. A low-distortion filter (see Fig. 7) does not have a flat response in the passband. If such a filter should be 2 db down at ± 75 kc, the capture ratio at any one frequency due to that filter alone will vary between 0 and 2 db. With sine-wave modulation of the interfering signal, the capture ratio of this filter alone will then be approximately 1.0 to 1.5 db.

5. Detector Bandwidth

In actual listening to stations, mono or stereo, the interfering and desired signal will be program material other than a sine wave and the average modulation will be considerably less than 100 per cent. This places most signals near the top of the I.F. response. The usual method of capture measurement involves sine-wave modulation; the lowest measured capture ratio of a tuner is not an indication of the tuner’s overall quality because it will involve the sum of the capture ratio contributions of both the I.F. and the limiter-detector system. It is the capture ratio of the detector which is of importance and therefore the detector bandwidth is the next most important specification. The total optimum capture ratio with a 2-mc detector then would be between 2.2 and 3.0 db.

Some limiter-detector systems involve multiple limiters with relatively narrow (compared to wideband detectors) tuned circuits between the limiter stages. They do achieve a good capture ratio for monophonic work but the relatively narrow bandwidth of the tuned limiter circuits with their non-linear phase slopes has a tendency to cause high-frequency distortion. This happens the same way as with non-linear I.F. filter phase shift. No additional limiting or limiters will remove this distortion. Therefore, detector bandwidth is more important than capture ratio even though capture ratio was presented first.

6. AM Rejection

Bandwidth is not the only important specification of the limiter-detector combination. After all, the limiter must be an amplitude limiter and has to remove any residual amplitude modulation from the signal. A perfect limiter, which exists only in theory, has a constant output when its input varies from zero to infinity, or has any value in between from fractions of microvolts to thousands of volts.

As a practical matter, the input signal to a limiter will most often range from tenths of volts to several volts. Also, it is not as important to keep the output voltage of the limiter constant for very slow
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changes in signal strength as it is to remove audible amplitude variations. This means amplitude variations in the range of at least 50 to 53,000 cps in stereo operation (50 to 15,000 in mono) have to be minimized.

These amplitude variations are caused by several factors. For instance the signal will vary in amplitude due to the i.f. response as the transmitter deviates in frequency; or amplitude can vary due to multipath reception; or simultaneous reception of a desired and an interfering signal (be it a station, or random or ignition noise) will also cause rapid amplitude variations which have to be removed by the limiter.

The amount of AM rejection of a limiter-detector circuits can be measured and is often quoted in complete tuner specifications. This, then, is the next most important tuner specification.

7. Pulse Noise Rejection

A tuner which has adequate suppression of amplitude modulation (40 db or more) in general also has good pulse-noise suppression. At the present time, it is very difficult to measure large amounts of AM rejection because all amplitude modulators produce a residual amount of phase or frequency modulation. It is therefore useful to make a further measurement of pulse-noise suppression.

For this purpose, a pulse-noise generator is required. Unfortunately, the available pulse generators produce relatively low energy over the bandwidth of an FM tuner tuned to a signal in the FM broadcast band. Therefore, the pulse generator can be used only for measurements involving low pulse interference. Practically, pulse interference in FM systems is created primarily by electrical equipment such as power-line switches, motor commutators, and ignition systems of automobiles. These sources create a far larger amount of interference than could be generated conveniently by a calibrated laboratory pulse generator. Because of this, the measurements of pulse interference of the various stereo receiving methods during the NSRC field tests were made with an electric razor. This qualitative, practical, but nevertheless useful test was made by the FCC observer in charge of these field tests.

To give an idea of the level of interference to be experienced, field strength values of approximately 1000 microvolts per meter can be created at a distance of 500 feet from a passenger automobile. This is the same level as the field strength of an FM transmitter at the edge of its prime service area.

As any FM listener knows, ignition noise can be heard when tuned to a “medium distance” station. This happens because the noise pulse is stronger than the signal and therefore captures the signal for the length of the pulse. With a strong local signal, ignition noise should be inaudible because here the signal is stronger. Completely off station, ignition noise should again be inaudible. Here, the (vector) sum of random noise of the r.f. amplifier and pulse noise has as its total only the same random phase variation as random noise itself. This will produce the same tuner noise output with or without pulse noise. If increased noise is heard, it is an indication of improper limiting in the tuner.

Therefore, an important characteristic of limiting and a good measure of AM rejection is the reaction of the tuner to pulse noise when tuned off station.

8. Shape of Signal-to-Noise Ratio Curve

Another type of noise the FM tuner has to contend with is random noise. This noise is created partly by the radiation impedance of the antenna and partly by the front end circuit of the tuner itself. Random noise reduces the effect of this noise in the same manner as it reduces interference—by capture. As long as the desired signal is considerably stronger than the noise, then the original signal-to-noise ratio at the limiter input will be higher at the audio output of the tuner. The same improvement of 38.7 db (as for other types of interference) will be found for monophonic operation and 15.4 db for stereo.

Even if the capture ratio of the tuner is quite low, this improvement does not hold when the signal becomes only a little stronger than the noise. Since the noise is random, it varies randomly in amplitude about its normal value and can be both stronger and weaker than its rms value. If the rms value of the desired signal is more than 10 db higher than the rms value of the noise, practically all the noise will have been captured by the signal. Only very occasionally will a noise peak be larger than 10 db above the signal, causing an audio pulse. The common practice is to measure the signal-to-noise ratio at the output of the tuner as the ratio of outputs occurring with 409-eps 100-per-cent modulation and no modulation.

At this 10-db point, a knee occurs in the audio signal-to-noise ratio characteristic. It occurs in both mono and stereo operation respectively at 10 + 38.7 = 48.7 db and 10 + 15.4 = 25.4 db. At higher levels of signal input, each 6 db of signal increase should cause a 6-db increase in audio signal-to-noise ratio. Below the knee, there is more or less frequent capture of the desired signal by the noise and audio signal-to-noise ratio will degrade rapidly. Figure 9 shows a curve of calculated signal-to-noise ratio for a mono FM tuner with a perfect limiter-detector combination. This curve is replotted from data originally computed for a Gaussian i.f. filter 150 kc wide by F.H.L.M. Stumpers of Philips. One particular point worth noting is that an i.f. signal-to-noise ratio of 1.8 or 5.0 db is required to produce an audio signal-to-noise ratio of 30 db.

Only very well designed tuners follow this curve accurately. Others show considerable differences, indicating deficiencies in their performance. For example, less steepness of slope below the knee indicates imperfect limiting for very weak signals. A steeper curve indicates an error in measurement since the amplitude distribution of random noise cannot be altered. The occurrence of the knee at a level higher than 48.7 db indicates an error in frequency response of the tuner. A slope of less than 6-db signal-to-noise ratio increase for every 6-db increase in signal indicates a degradation in front-end sensitivity. This holds as long as the ultimate signal-to-noise ratio of the tuner is not reached, which shows residual tuner and generator noise and hum.

Therefore, the shape of the signal-to-noise ratio curve as determined by actual measurement is an important specification of the tuner.
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The same measurements, but with the tuner operating in the stereo mode, more clearly show the effects of improper limiting or degradation of front end sensitivity. If the two actual signal-to-noise curves are less than 23.3 db apart at their maximum distance from each other, the tuner is not likely to have good separation and/or frequency response when operating in stereo. The location of the “knee” in the stereo signal-to-noise ratio is not easy to pinpoint because of the relative similarity in slope above and below the knee.

In measuring the signal-to-noise ratio, if the 400- cps audio modulation is not turned off at the generator but eliminated instead by the sharp rejection filter of a distortion analyzer, we now have a measurement of the distortion of the audio circuits. To a small degree, residual noise and hum at high signal levels are also measured. At low signal levels “modulation” noise begins to appear. This is the method of measurement prescribed by the IHF tuner standard.

The modulation noise occurs when the desired signal is more or less attenuated by the frequency response of the i.f. filter as the signal varies its frequency during modulation. The random noise coming from the front end of the tuner is not altered since it is not changed by the generator. With any input, for more than 50 per cent of the time, the generator frequency will be in the outer 15 per cent of the tuner bandwidth as shown in Fig. 10. The signal will be attenuated and a higher signal input will be required for an audio signal-to-distortion-plus-noise ratio as for the same signal-to-noise ratio.

9. Difference in Signal Between 30-db S/N and 30-db IHF

Since IHF sensitivity is measured on the steep slope at 30 db of the signal-to-noise ratio curve (in monophonic operation of the tuner) alignment for best sensitivity on this basis for the lowest number of microvolts results in a filter curve with a flat top and with non-linear phase. Here, the filter bandwidth is just barely wider than 150 kc and the average amplitude of the output signal is just barely under the mid-band output of the filter. In this case, the r.f. signal required for a signal-to-distortion-plus-noise ratio is only a little larger than for the same signal-to-noise ratio. When both curves are plotted together, they may be separated by 2.4 ± 0.8 decibels, depending upon accuracy of alignment.

As shown in the section on FM distortion, the filter obtained by alignment for lowest IHF microvolt figure has high-frequency distortion, particularly in stereo operation. Such a filter is generally not phase equalized, causing a further increase in high-frequency distortion. The filter curve shown in (D) of Fig. 5 is typical of this. Furthermore, the inaccuracies in alignment resulting in a slightly lopsided filter, overcoupling peaks, or a still narrower filter, cause a still further increase in high-frequency distortion. Therefore, a tuner with its i.f. section aligned for maximum IHF sensitivity does not have minimum distortion.

When the i.f. system of the tuner is designed and aligned for minimum distortion in stereo operation, the filter response of Fig. 7 will affect the signal output as shown in Fig. 11. Here the output voltage due to signal will vary with modulation more than with a flat top filter. This requires an average signal input 3.5 ± 0.5 db higher for the same signal-to-distortion-plus-noise ratio as for the same signal-to-noise ratio.

As a check on low-distortion operation of the tuner, it is important to know whether the tuner in mono operation has low distortion as found in the IHF test and is this curve separated by 2.5 to 3.5 db from the signal-to-noise ratio curve at r.f. signal levels below 40 db signal-to-noise ratio.

Where does all this noise come from? Part of it may be picked up by the antenna itself. For example, the average peak noise at the antenna terminals may be between 30 microvolts in suburban locations and several hundred microvolts in the city. Even cosmic noise will produce 3 to 4 microvolts. These noises can be reduced by using a more directive antenna than a dipole.

The other main contributor is thermal noise. This exists in any resistance, with the 300-ohm radiation resistance of a folded dipole being no exception. The open-circuit voltage of such a 300-ohm antenna, or the equivalent dummy antenna of a signal generator, is 0.86 microvolt over a 150-ke bandwidth. This noise voltage would increase twice if the bandwidth were quadrupled. A perfect amplifier or tuner which produces no noise itself connected to this 300-ohm resistance would have this voltage as the minimum possible voltage on its input. Also, this tuner would not be permitted to consume any power from the noise or signal power coming from the antenna. This would result in very high signal reflections and standing waves on the antenna lead because such a tuner would not have any resistive component to its input impedance. Such a tuner would have a 0-db noise figure—the best ever attainable.

If a tuner were completely noise-free, but had a resistive 300-ohm input impedance, it would then attenuate the external signal and noise by 6 db. Its in-

![Table 2. The best achievable sensitivity of a monophonic tuner.](image)

![Table 3. The best achievable (monophonic) sensitivity of a tuner aligned for best stereophonic performance.](image)

(Continued on page 81)

52

**AUDIO • SEPTEMBER, 1963**
**PROFESSIONAL** quality. The AR turntable meets NAB specifications for broadcast equipment or wow, flutter, rumble, and speed accuracy. It is belt-driven and synchronous.

**STABLE** performance. The suspension design makes it insensitive to mechanical shocks from the floor or to acoustic feedback.

**FOR BUTTERFINGERS.** This is a picture of the tone arm a second after it has been "accidentally" dropped. It floats down, but when the needle is in the groove the arm is free of restraint.

**complete with arm, oiled walnut base, and dust cover, but less cartridge**

quoted from *HiFi/Stereo Review* (Julian Hirsch)

"The wow and flutter were the lowest I have ever measured on a turntable... The speed was exact... the only rumble that can be heard with the AR turntable, even with the tone controls set for heavy bass boost, is the rumble from the record itself.

"I found that records played on the AR turntable had an unusually clean, clear quality. The complete freedom from acoustic feedback (which can muddy the sound long before audible oscillations occur) was responsible for this."

quoted from *AUDIO*

"The AR turntable does run at exact speed (both speeds), and it introduces as little 'signal' of its own as any turntable we have had occasion to test."

quoted from *Hi-Fi* (John Milder)

"... the best answer so far to the interrelated problems of rumble and acoustic feedback... the only time rumble is audible is when it has previously been engraved on a record by a noisy cutting lathe. Nor is feedback audible... even when the turntable, against customary warnings, is placed directly on top of a wide-range speaker system. There is simply silence."

quoted from *INDUSTRIAL DESIGN*

"... noteworthy for elegant simplicity." (The AR turntable was included in an exhibit staged by Industrial Design Magazine, as an example of functional beauty in product design.)

Literature on AR speakers and turntables, including reprints of the AR turntable reports from HiFi/Stereo Review and Modern Hi-Fi, will be sent on request.

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The price of the one-speed turntable has been increased from the original $58. This price increase, made necessary by manufacturing costs, is the first in AR's nine-year history.

**ACOUSTIC RESEARCH, INC., 24 Thorndike Street, Cambridge 41, Massachusetts**
FISHER SA-1000 STEREO 150-WATT POWER AMPLIFIER AND K-1000 STRATAKIT

Circuit Description

The step-type input attenuator circuit consists of a series of precision resistors, frequency compensated so that response is flat at all steps, which feeds a cathode follower. (The approach is the same as used in instruments such as oscilloscopes.) The cathode-follower input tube is a ECC808/6K8, a new low-noise tube. Next, the signal is fed to a 12AX7 amplifier and direct-coupled cathodyne phase inverter. The out-of-phase signals are then sent to separate sections of the push-pull driver, a twin triode-strapped pentode, the ELL80/6UH8. The output stage utilizes a pair of beam-power pentodes, the 8417, a new tube with an unusual plate structure which tends to reduce secondary emission.

Feedback (17 db) is provided from the secondary of the output transformer to the cathode of the 12AX7 amplifier section. 12 db of feedback is provided by plate-to-cathode coupling in the output stage.

The power supplies for plate, screen, and bias voltages are completely independent of each other and utilize silicon diodes. This rather luxurious power supply ensures top operation in either stereo or mono modes. The quality of the components is quite high and indicates long life at maximum performance level. In this connection, it should be noted that the driver stage is operated at 50 per cent of ratings. (Operating the 6UH8 40 per cent below maximum, in conjunction with its low output impedance, helps to improve transient response.)

Performance of the SA-1000

Figure 2 shows the frequency response of the SA-1000 within the limits of our test equipment. We do not show both channels because the results were so close that drawing uncertainties are usually larger. This is also true for Fig. 3, which indicates the harmonic distortion at rated power. 1.44 distortion (measured with a 16-kHz load, 90 and 7000 cps mixed 4:1), measured a maximum of 0.4 per cent at rated power to a low of 0.2 per cent at 10 watts rms. Ac-

![Fig. 2. Frequency response of the SA-1000.](image)

![Fig. 1. Fisher SA-1000 stereophonic 150-watt amplifier.](image)
THE FISHER K-1000 STRATAKIT

Previously we noted that $50 could be saved by building the kit version of the SA-1000. But that is only part of the profit to be made; there is wealth of information to be culled from this kit, and it is not hard to find. But more of that a little later.

First let us describe what the kit consists of. When we first received it, the K-1000 consisted of two boxes—a heavy one and a small heavy one. Strongly enough, to the uninitiated, the small box (perhaps one-fifth the size of the other) weighed as much if not more than the large one. Of course it contained those massive output transformers. Opening the large box we found the setup shown on Fig. 4; a compartmented parts tray on top and a roughly assembled chassis on the bottom. The parts tray contained 27 numbered parts packets, one spare, and various parts such as tubes and capacitors. The chassis had almost all the mechanical assembly completed and riveted in place. All that remained was electrical assembly, and installing the output transformers. It took us about 14 careful hours to convert these StrataPacks into the equivalent of the SA-1000.

The Instruction Manual

Here's where the wealth of information is located. This manual has taken several strides beyond any manual we have seen to date. First of all we should point out that each one of those numbered parts packets corresponds to an assembly stage, and all the parts necessary for that stage are in there. Thus StrataPack 6 corresponds to Stages 1 and 2 in the manual, and the parts it contains are prepared for that stage—including cut-to-size wires. We also linked the timely warnings which preceded certain lengthy procedures; if we didn't have that much time we were told not to start because it all had to be done at once. Sprinkled throughout were tips and reminders which would save the tired builder from needless mistakes.

We also linked the timely warnings which preceded certain lengthy procedures; if we didn't have that much time we were told not to start because it all had to be done at once. Sprinkled throughout were tips and reminders which would save the tired builder from needless mistakes. It hardly needs saying, but we found the manual accurate in all important aspects.

The only real improvement we could think of would be to include a block diagram and brief description of how the various stages of an amplifier work together, on the neophyte level.

How It Went Together

The K-1000 is an easy kit to assemble, well suited for even the neophyte. We do recommend, however, that the purchase of a pair of long-nose pliers and several appropiate nut drivers will make it so much easier. The pliers are for wrapping wires around lugs and the drivers to get nuts started in places where fingers are too big. There is one place, when the output transformers are mounted, where a 1/8 box wrench will be a lifesaver. Borrow one, you use it only once.

The K-1000 kit is excellently designed, quite an interesting and surprising affair. We also linked the timely warnings which preceded certain lengthy procedures; if we didn't have that much time we were told not to start because it all had to be done at once. Sprinkled throughout were tips and reminders which would save the tired builder from needless mistakes. It hardly needs saying, but we found the manual accurate in all important aspects.

The only real improvement we could think of would be to include a block diagram and brief description of how the various stages of an amplifier work together, on the neophyte level.

Fig. 3. Harmonic distortion of the SA-1000 at 65-watt rms output.

Fig. 4. The Fisher K-1000 Stratakit in its box.

Fig. 5. H. H. Scott FM-Stereo Broadcast Monitor Tuner, Model 4310.

Performance

The question to be answered here is whether we were able to build a unit which performs as well as the factory-built SA-1000. The answer is yes, but for some reason, the kit actually performed better in some areas. For instance, harmonic distortion at rated power never exceeded 0.35 percent at frequencies up to 25,000 cps. In almost all other performance areas the results were close enough to be within typical manufacturing variations.

In sum, the K-1000 is a superb power amplifier kit which is priced $50 less than the factory-assembled version of the identical amplifier—and you can do as good a job as the factory if you take your time and work carefully. Is it worth spending 14-20 hours to save $50? Only you can answer that one.
each channel. In addition there is a stepped master level control which goes down 30 db in 3-db steps. Other controls on the face are: an in-line channel diversity switch, mono/stereo switch, function switch, stereo threshold control, dynaual squeal control, and an a.g.c. partial-full switch. Of course there is the familiar round tuning dial and a tuning meter. Indicator lights are provided to show when the set is receiving stereo or is in standby.

The 4310 will accommodate either a 72-ohm or 300-ohm antenna, balanced or unbalanced. Output impedance is 10,000 ohms. A 72-ohm connection is also provided. There are two convenience outlets.

Fig. 6. Top view of the H. H. Scott Model 4310.

The front end of the 4310 uses the same configuration found on most, if not all, Scott FM tuners: that is, a 6SQ7 cascode r.f. amplifier and a 6US oscillator-mixer. From there the signal goes through four i.f. stages and two limiting stages before it reaches the ratio detector diodes. Then it goes to the well-known Scott multiplex circuitry. Finally it exits through the audio stages and the output attenuator. Of course there are other odd circuits for the diversity function, relay drivers for squeal and stereo threshold, VU meters, and so on. We needn't spend space to describe them because they are relatively straightforward albeit well designed. From the top view, Fig. 6, we can see that the set is carefully laid out. If we could see the bottom view we would discover the usual r.f. rat's nest. Some things never change.

In sum, the 4310 circuit is elaborate but relatively usual for Scott tuners. It does a lot of things.

Performance

Without question, this tuner is one of the finest tuners extant. It pulled in more stations, loud and clear, than any other tuner we have tested. The record now stands at 40 stations.

In performance, the numbers of the 4310 were as follows: Capture ratio, 2 db; rejection of spurious response, 85 db; selectivity, 55 db; AM suppression, 60 db; signal-to-noise ratio, 70 db; sensitivity (mono), 1.95 µv; frequency drift, 0.015 per cent; audio output, 2 volts.

Of course the numbers do not tell the whole story; they certainly do not tell how the 4310 sounds. As we noted before, the set automatically switches to stereo or mono (mono/stereo switch in stereo position) depending on the signal-to-noise ratio, which you set yourself by means of the stereo threshold control. Thus three listening does not become the ordeal it can sometimes be—when the noise rises above your present tolerance, the set automatically switches to mono. Even in mono, if the noise becomes intolerable, the set automatically switches to standby. The tolerable mono level is set by means of the dynaual squeel control. The only problem we encountered with this system was in finding the proper "tolerable" levels which would not have the automatic circuits constantly triggering the relays. Unfortunately the relays create enough noise of their own in the switchovers to be clearly audible. On the other hand, the sound quality, because of the lack of noise and distortion, is just superb.

There was just one minor detail of this excellent tuner which we felt could be improved—the location of the VU meters. We found it rather difficult to track both meters simultaneously because of the space between the meters. We know this doesn't affect sound in any way, but it might make some tired-eyed station engineer much happier if they were placed side-by-side, or one over the other.

To sum it all up, we will state unequivocally that the 4310 is unquestionably the finest FM-stereo tuner H. H. Scott has made to date, which makes it one of the finest tuners around.

K-21

TANNONY 10-INCH MONITOR DUAL-CONCENTRIC

The line of Tannoy Monitor Dual-Concentric loudspeakers was introduced to the readers of AUDIO. We have known about 15-in. and 12-in. units for some time. What we had forgotten was the unusual versatility of these units.

For example, when we first received the ten inchers, we decided to try various enclosures. We mounted them in a 1% cubic foot Tuffix, a 1% cubic foot cotton box, and a small as 1% cubic foot box. Finally we boxed them in a "dummy" box, of course these speakers. Well, to get back, the Dual Concentrics are coaxial units supplied with their own crossover network, as shown in Fig. 7. The basket of the speaker is a heavy die casting, obviously capable of avoiding resonances from this source.

The manufacturer told us that these ten inchers would operate well in a box as small as 1½ cubic feet, so we tried it in such a small box stuffed with cotton waste (the manufacturer told us about that too, only he called it machinists wiper cotton). Frankly we were amazed, it produced the best sound we have ever heard out of a box anywhere near its size. (The cotton waste made a decided difference in the sound end that it smoothed out the midrange. Another absorbent material said to do the same job is Tuffix, which is a special cotton pad.)

The only box we liked, however, was the small one we have described is a horn-loaded unit which is essentially a smaller version of the Dual Concentrics. Well, to get back, the Dual Concentrics are going to market this smaller horn-loaded unit, calling it appropriately enough La Cornetta (the little cornet). One of the many virtue of the box is that the Tannoy people are going to market this smaller horn-loaded system, calling it appropriately enough La Cornetta (the little cornet). We think it is the finest we have heard in a long time. Of course, big brother GR-1 does sound better, but the G-1 is a $1260 as against $385.

Altogether we found the 10-in. Monitor Dual Concentric to be an extremely good loudspeaker which is in the very best category as a sound reproducer. In the 1½ cubic foot enclosure, properly baffled and stuffed, it will take on almost any existing bookshelf and come out on top, at least for our listening taste. By the way, for those who worry about such things, the free air resonance of the speaker is 27 cps, power handling capacity 20 watts, impedance 16 ohms.

K-22

Fig. 7. Tannoy 10-in. Monitor Dual Concentric loudspeaker and crossover network.
The Japan of today is renowned for its quality precision products, created from a harmonious merger of Japan's traditional craftsmanship and modern production line systems. And from this merger comes the renowned line of PIONEER audio components.

For professional applications where large power is a MUST, or for deluxe home applications, choose from PIONEER's two large power models, the 72-watt SM-500 stereophonic amplifier, and the 80-watt SM-600 tuner-amplifier.

Each is designed for maximum versatility, each is designed for easy handling, and above all, each provides the same PIONEER reliability and performance.

The SM-500 provides a full 36 watts of clean and undistorted power from each of its well-designed channels in stereophonic operation, and a total of 72 watts in monophonic operation. Featuring a precision-finished preamplifier using carefully selected noise-free tubes operating off hum-free DC, the SM-500 has a total of 14 inputs to handle all forms of signal inputs.

**SPECIFICATIONS OF THE SM-500**
- Frequency Response: ±1db from 5cps to 100 kc.
- Harmonic Distortion: less than 1%.
- Hum and Noise: Mag. better than 60db, Aux. better than 80db.
- Power Requirements: 115/230 volts, 1.4/0.7 amp., 145 watts (max.), 50/60 cps.
- Dimensions: 11 1/8" (W) x 5 3/8" (H) x 13 1/2" (D) inches.

The SM-600 is a compactly put-together complete stereophonic tuner-amplifier providing 40 watts of noise-free power from each of its efficient channels. In addition to normal AM and FM circuits, its tuner section features a built-in multiplex circuit for the reception of superb FM stereo. Its preamplifier has a total of 10 inputs for full versatility.

**SPECIFICATIONS OF THE SM-600**
- Frequency Response: ±1db from 15 cps to 100 kc.
- Harmonic Distortion: less than 1%.
- Hum and Noise: Mag. better than 55db, Aux. better than 65db.
- Power Requirements: 115/230 volts, 2.1/1.14 amp., 208 watts (max.), 50/60 cps.
- Dimensions: 7 1/8" (W) x 5 3/8" (H) x 17 1/8" (D) inches.
UHER 8000 ROYAL STEREO TAPE RECORDER

We have previously reported on the Uher (pronounced "oo-er") Universal (Oct. 1960) and on the Stereo Record III (Aug. 1960), both of which were then considered rather exciting tape recorders. The Universal had a multitude of features, and only failed as a top-quality home machine in the fact that it was monophonic, its highest tape speed of 3 1/2 ips, and that it was an all-in-one machine. The Stereo Record III provided a number of attractive features, including three speeds and complete stereo performance, and the unit has achieved considerable acceptance as a continuing good performer.

But now comes the Uher 8000 Royal Stereo—4 track stereo and monophonic, four speeds (7 1/2, 3 1/2, 1 3/4, and 1 1/2 ips), and features galore. And it is completely transistorized, except for the motor, which is conventional. Mechanically similar to the Stereo Record III—and that was a good model to follow with its cast aluminum chassis for stability, heavy capstan-shaft flywheel, and long-life sintered bearings—the unit differs electronically in many respects.

In the first place, the 8000 is a three-head machine for monophonic recordings, permitting the recording of what is on tape on the tape. It has built-in echo facilities, built-in sound-on-sound facilities, multiphase mixing control facilities, mixing facilities, end-of-rolloff facilities, and besides all that it can control an automatic slide projector so that once you would accommodate only 5 in. or smaller show, you can subsequently leave it all to the machine.

The upper switch controls the mechanical speed selector and the on/off mode. There are seven positions—four speeds, with three off positions between. Selecting the speed also adjusts equalization for each.

A second switch, together with an interlocked RECORD button, controls all of the electronic functions in its eleven positions, which are marked: 1—mono record or play on upper track; 2—mono record or play on lower track; 3—mono record or play; MULTIPLAY 1—permits recording on the upper track from microphone and mixing with material from lower track; MULTIPLAY 2—permits recording on lower track and mixing material already recorded on upper track; DEAPLOF II—after making recorded commentary on upper track, this position is used to record sub-tonic on lower track at points where a slide is to be changed and for playback with slide projector thereafter, with the slide changing at each point; the tone button was depressed in the second run-through; ECHO 1—permits adding delayed sound to an original recording on upper track, the amount of delay depending on the speed of the tape; ECHO 2—same operation for lower track; SYN-PLAY 1—used for recording one track for later recording another signal in synchronous with the first but on a second track when the switch is turned to the SYN-PLAY II position. Thus practically any trick type of recording can be made with no external interconnecting or switching. Just above the above key START-STOP/Pause keys are two level-indicating meters, one for each channel. To their right are two blue indicator lights—the upper showing when the instrument is set for playback from the upper track and the lower for the second track; both are illuminated for stereo. To the left of the meters are two red lights, showing when each channel is set for recording. Thus for MULTIPLAY 1, for instance, the upper red light is on when the tone button is depressed, and the lower blue light is on; in MULTI-

Fig. 8. The Uher 8000 Royal Stereo Recorder in its attractive simulated leather case.

Fig. 9. Frequency response curves for the Uher 8000.

The two curves at the top show the response from Standard Frequency Tapes 31321-01 and 31321-03 at speeds of 7 1/4 and 3 1/2 ips respectively, while the lower ones show the response at the four speeds.

Fig. 10. The Uher 8000 Royal Stereo Recorder in its attractive simulated leather case.

Performance

Figure 9 shows the frequency response of the Uher 8000 in its various modes of operation. The upper curves show the playback response from Ampex Standard Frequency Tapes 31321-01 and 31321-03 at speeds of 7 1/4 and 3 1/2 ips respectively, while the lower ones show the response at the four speeds. It is seen that the response from the standard tapes that response is within +2 db over the limits of the tape frequencies (from 50 to 15,000 cps at 1 1/2 ips, and from 50 to 10,000 cps at 3 1/2 ips), and on the record/playback curves is within +3 db from 50 to 18,000 at 7 1/4 with the

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Genuine studio PLAYBACK equipment is as superior to conventional "hi fi" components as these components are superior to typical package "hi fi." The reason: PLAYBACK equipment is what the conductors, artists and recording engineers rely on in the studio to accurately compare the realism of a recording with the live rendition.

In professional audio, where no compromise with performance and reliability is tolerated, only genuine PLAYBACK equipment is deemed acceptable. Altec Lansing is synonymous with PLAYBACK, because major professional users — studios, concert halls, theatres — have used Altec equipment predominantly since the beginning of modern sound technology.

The Altec 605A "Duplex" is an outstanding example of such studio equipment and has been judged the finest single-frame speaker in existence. It is the ultimate refinement of Altec's original 604 which had served as the PLAYBACK standard since the birth of long play records.

One hearing will quickly demonstrate why the 605A "Duplex" is supreme. These specifications will explain some of the reasons: The 605A is a 15", two-way speaker system employing a true multicell horn for perfect dispersion of high frequencies throughout the entire audio range. Its guaranteed frequency response is 20-22,000 cycles. The Altec 605A "Duplex" is so free of distortion and false coloration that other speakers sound shrill and constricted by comparison. That's why leading Capitol recording stars such as Judy Garland, Peggy Lee, Nat King Cole and Vic Damone rely on the "Duplex" in studio PLAYBACK for evaluation of their work before the recording is "wrapped-up."

WIDE VARIETY OF WIDE-RANGE SPEAKERS

The 605A is priced at $168.00 including dividing network. At 35 pounds, it is the "heavyweight" of the line. Two other "Duplex" PLAYBACK speakers of exceptional quality are also available. The 605C is a 15" two-way speaker which provides outstanding performance at the modest cost of $132.00. For those who want genuine PLAYBACK sound in comparatively small space, Altec's two-way 601C is the ideal answer at $108.00.

For "starter" systems on a budget, consider Altec full-range, single voice coil "Biflex" speakers: the 15" 415C and the 12" 412C. And, for speakers throughout the home, there's the remarkably smooth 8" 755C "pancake," a popular utility monitor in the broadcast and recording field for many years.

AUDIO'S MOST IMPORTANT FORMULA

Whatever you invest in your system, put major emphasis on the speakers. The speakers are the voice of your system and here, a compromise is most audibly apparent. If, for various reasons, you must compromise with overall quality, it is best not to do so in speaker selection but elsewhere in the audio system. Naturally, you will be assured best results by a stereo system made-up entirely of components of homogeneous quality such as offered by genuine Altec PLAYBACK speakers, amplifiers, and tuners.

Hear Altec speakers, speaker systems and other PLAYBACK components at your nearest Altec Distributor's (see your Yellow Pages). And while you're there, be sure to ask for your courtesy copy of "PLAYBACK" and Speech Input Equipment for Recording and Broadcast Studios. Although prepared specifically for the recording and broadcast industry, it provides the obvious answers to better home listening as well. Or, for your free copy, write Dept. A-9.

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upper limits extending to 13,000, 8500, and 4000 cps respectively at 3%, 1½% and ½ ipa. Obviously one would not expect to use the lowest speed for high-quality music reproduction, but it is quite satisfactory for recording long periods of voice material such as a lecture.

On multi-track recorders, it is important that channel separation be high if monophonic recordings are to be reproduced without interference from other tracks. Separation measured 54 db between channels, and 51 db between adjacent tracks—that is, with a maximum level tone recorded on track 2, the crosstalk into track one measured 51 db. Signal-to-noise ratio measured 53 db on one channel and 51 on the other, and wow and flutter was under 0.2% per second at 7½ ips, increasing as the speed was lowered to a maximum of 0.4% per second at 3½ ips. At 7½ ips, 1X distortion measured 3% per cent at operating level (10 db below 3-per cent harmonic distortion), decreasing to 2% per cent at 10 db below operating level.

The unit has two built-in 5 x 7 in. loudspeakers, one on each side of the case. The output amplifiers—also transistorized—are capable of putting out a signal of 2 watts per channel which is adequate for efficient speaker systems. For optimum quality of sound reproduction, however, the machine would normally be used to feed an external power amplifier and loudspeakers, since the average feedback amplifier does things to the response below 20 cps which have a great effect on the performance. Similarly, response in the range between 100,000 and 200,000 eps becomes important in the very high frequency audio ranges. Thus while the demands of 'scopes—and other measuring equipment—are extended to a top of around 20,000 cps some ten years ago, it is now desirable to extend the range to well over 100,000 cps.

(Continued on page 76)
THE NEW WHARFEDALE W90 — Musical integrity ... effortless realism achieved through a new 6-speaker concept. Low end realized magnificently through two bass speakers. Presence conveyed dramatically through two mid-range speakers. Dispersion achieved panoramically through two high-frequency speakers. Six transducers — superbly matched and integrated with a unique sand-filled enclosure.

**Speaker systems by Wharfedale**

W90 A detailed description follows. All 6 speakers incorporate certain recent refinements which have made possible the task of creating the W90 system.

The chassis (baskets) are exceptionally heavy and manufactured from hardwood. The purpose of this is to preserve absolute rigidity, maintaining the critical relationship between the moving voice coil and the fixed magnet. The stamped baskets found in ordinary loudspeakers are also designed to be rigid. However, this rigidity is often lost as soon as the speaker is mounted firmly against an inexact wooden front baffle. Some speaker designers have even eliminated the basket, weakening the entire speaker structure. Wharfedale baskets are of cast metal. They hold their shape perfectly in mounting, and are strong enough to permit sufficient openings to maintain absolutely correct airloading, essential for the full response of the speaker.

The Cone Surround is an exclusive rolled-rim design, the latest and most effective form of the traditional Wharfedale soft suspension. Earlier surrounds (porous foam or cloth) provided such superior bass damping that they became renowned as an outstanding physical characteristic of Wharfedale speakers. Now, more than ever before, the Wharfedale cone is capable of the long excursions required for true bass energy in a sophisticated tuned dual enclosure. The cone material is special, compounded of long fibrillated wood (traditional to the North of England home of these speakers) and soft pulp! It achieves superior results from the start and its natural resilience assures continuing perfection over the years.

The Magnets are truly impressive, individually and as a family. Because of their natural, and the special design of the magnetic gap, each provides higher total flux in the gap field that has been true of the magnets in any basic speaker system. The six magnets together make the W90 a "high efficiency" speaker, achieving maximum performance at low amplifier power. All-too-many popular speaker systems are starved for power, depending upon exaggerated amounts of amplifier wattage. In the W90, therefore, the all-important transient response is excellent, even at low volume. This clean low end, at reasonable listening levels, is a major reason why all Wharfedales are so pleasant to "live with."

With its six speakers, the W90 is actually a dual 3-way system with all units designed for each other and crossover settings calibrated for undistorted response throughout the audio spectrum. The support effect of the tandem speaker systems results in a sound of exceptional authority, yet in balance over the entire range.

**LOW RANGE.** Two 12½" low frequency drivers handle the sound from 20 to 1,500 cycles. The listener can expect to enjoy the true, fundamental bass notes, so often masked. The two drivers total a cone area of 94 square inches. This is the W90 tandem idea! The Magnets together make the W90 the recognizable key to its satisfying full-throated sound.

**MID-RANGE.** Two 5½" mid-range speakers cover the relatively narrow but vital band of 1,500 to 6,000 cycles. The listener will be startled, for example, by the clarity of the baritone voice and the exceptional resolution of most solo instruments, permitted to stand in correct perspective. The handling of this "MID" range in the W90 is the recognizable key to its satisfying full-throated sound.

**TREBLE.** Two 3" treble speakers are the well-established Super 3'S, much admired for their ability to present the clear treble without strain... making them eminently listenable, unusual for tweeters. This is no accident. It is the result of cone-type rather than horn-type construction, and refinements such as low-mass aluminum voice coils, ultrasonically lined, powered by magnets so large that they are seldom found even in speakers four times the diameter!

**DECOR.** The new W90 is neither a compact, nor a large speaker system. It is a new and highly versatile size, designed from the sound out. Ideally suited to be used in pairs for stereo, the W90 measures 32½" x 27½" x 13½". Housed in a meticulously crafted cabinet built to meet every requirement of perfection in sound, the W90 will fit with ease into the living room, and is elegant enough to join the most distinctive furnishings. Its acoustic design adds versatility... permitting horizontal or vertical use, as desired! The Wharfedale Universal Mounting Base makes it a superb free-standing unit. In oiled or polished Walnut hardwood, $235.00. Utility model in sanded Birch hardwood, without curved molding or dividers, $244.50. Universal Mounting Base to match, $9.95. For illustrated literature, write Dept. WM-35.

Wharfedale • Division of British Industries Corp., Port Washington, N.Y.
when the received signal is above a critical "threshold" the listening quality is very good; below this critical threshold the tolerance is a subjective factor. Fortunately the number, location, and available power of the FM stations broadcasting FM-stereo within the Los Angeles metropolitan area are many, and reception has been good anywhere within the basin area.

with the 38-kc reference during the periods of signal "drop-outs"; or in other words, a "flywheel" effect to carry over during high "flutter" conditions. Such a detector is the phase-locked loop detector (or automatic phase control, APC) principle as employed in color TV sync circuits. These detectors can obtain very narrow effective bandwidths which improves the

ing the local injection signal has the closed-loop phase transfer function for an optimum condition of:

\[ H(s) = \frac{\theta_0}{\theta_1} = B_s e^{\sqrt{2} B_s S} \]

where \( B_s \) = natural undamped resonant frequency, and \( S \) = mathematical variable, complex \( \pm t + js \). Two significant advantages of this reference subcarrier detector are associated with the effective bandwidth and its integration time or memory. The bandwidth of this detector can be expressed by:

\[ 2 B W_{\text{noise}} = \frac{1}{2\pi} \int_{-\infty}^{\infty} |H(jw)|^2 dw, \text{ cps.} \]

This is the equivalent-noise bandwidth of the detector analogous to a narrow-tuned circuit. A narrow bandwidth has the advantage of recreating the reference signal in the proper phase with less influence by noise. The narrow bandwidth is achieved by the configuration and characteristic of the low-pass filter (integrator) used within the loop and is normally an RC network. This network performs the function of storing the phase error (between the received original subcarrier and local reference) information for a period of time for subsequent comparison with the most recent received signal. Hence, during signal "drop-outs" the output phase of the reference signal is maintained at the latest phase relation which is the best estimate of what the input phase of the sync signal was at that time. When the signal is fully restored above the threshold, the signal is updated to equal the incoming signal.

With further quantitative measurements within the receiving system, methods may be determined for additional improvements and such measurements are anticipated in the future.

Areas for Improvement

Until more quantitative measurement and analysis can be made the only comments towards improving reception concerns efficiency and threshold improvements. Obviously an all-transistor system would eliminate the d.c.-d.c. converter increasing the system efficiency and removing the interference associated with these devices. The particular scheme of detecting and providing the local subcarrier reference signal by the locked-oscillator technique is not the optimum method. The most serious disadvantage is that the 38-kc oscillator signal, which must cohere in phase to the 19-kc sync signal and the L-R sidebands for detection, occasionally becomes ambiguous to the transmitted phase due to momentary loss of "lock" to the sync signal or to large phase shifts under conditions of severe propagation factors. A better scheme to employ a detector that employs an integrator of long time constant that would retain the correct phase coherence

"threshold"-to-noise effects. In addition, they can frequency track the sync signal although it was stated early that doppler effects are negligible.

A phase-locked loop that could be used for detecting the pilot and provid-

---


---

Fig. 14. Audio amplifier for second channel.

Fig. 15. Automatic phase-control detector for extracting sync signal.
Matsushita Electric, established world leader in the manufacture of precision electronics, has developed a hi-fidelity sound system of truly remarkable dimension.

Unique achievement, Ultra-Motional utilizes a distortion-feedback technique. The only previous use of feedback was of voltage pickup in the proportion to velocity of speaker cone. But Ultra-Motional feeds back the voltage in proportion to the acceleration determined by the velocity of the speaker movement to the drive stage of the audio amplifier.

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- MIRACORD 4-speed custom changer.
- 15 tubes plus 12 transistors plus 7 diodes plus 5 power rectifiers.
Waldman, sage elderly conductor, imperturbably goes on and on to utter musical absurdity. After all, one gathers, M. Grandjany must have his moment in the stereo sun... I can only repeat that these gentlemen (and their orchestra) are worthy professionals on a very high level. But their efforts are too much on their own behalf, not enough on that of the eminent composers whose music they are interpretation here, whose names are billed in big letters on the record jacket.


The intricate relationships among international record companies bring us many an unexpected release. Here, on U.S. Philips, is the same Grumiaux who played in so many fine Epic Mozart releases when Epic was still the local outlet for Philips of Europe. If I'm right, Epic, a CBS label, is now detourked from Philips, which in the U.S., is a subsidiary of Mercury—which in turn is owned by the larger European Philips. It's similar to the EMI-Capitol-Angel deal. All clear as mud?...

Somewhere, these English Grumiaux recordings seem to me indelibly more lush and fruity than the earlier Epic Mozart with Grumiaux. He is still a first-rate Mozart violinist and no two ways about it. But here the London Symphony sounds too large, plays with too much of a new-world instrumentation; the violin solo is loud, dramatic, and overly big in sound. If my memory is right, Grumiaux himself isn't really as wide-awake and alive here as in the earlier discs on Epic.

Yet the bigger, more dramatic impact is bound to please many who might have found the old Grumiaux Mozart a bit on the chaste side. If so, so much the better; Mozart is still plenty well served.

Schumann: Symphony No. 2 in C Major (Original Orchestration). N. Y. Philharmonic, Bernstein. Columbia MS 6448 stereo

This is a sequel-recording to the Bernstein-Philharmonic versions of the "Rhenish," No. 3 actually recorded in the early "No. 4," also in the original Schumann orchestrations. (MS 6294, 6256). Bernstein had an important role to do, and did it well, without the aid of an orchestra. It is valuable and immensely instructive to have these works in their original forms, even though for a century Schumann has been subject to extensive "improvements" designed to repair the damage to musical sense caused by the composer's notoriously poor understanding of orchestral technique. So it has been said, anyhow. Here you have the evidence for yourself in terms of actual listening.

Yea—-the music is thicker, maladroit, richer, loaded with layers of texture and plastered with ornaments and imitations. The sound is undeniably turdly and the sense notably less clear than in the revised "normal" versions we have always heard. And yet, I ask, isn't that thickness perhaps more precisely intended than we might have supposed? It is of the period—-as Wagner's silk-lined partitions were of the interior decoration of the time!

Frankly, I like the turbidity—and do so does Bernstein, for the best of reasons. It is authentic—both to Schuman himself and to the taste of the period.

But what is best in these three Schumann recordings by Bernstein is his extraordinary feeling for the essence of Romantic expression. This he has developed over the years; he has not remodeled it in his early career. Now, Bernstein does for the inner light of Schumann's expression what the Budapest Boys does for Beethoven's late quartets. I think you can know Schumann only when you have listened to these unusual performances.

Chopin: Mazurkas, complete. Orazio Frugoni, piano. Vox VUX 2017 (2) mono

Orazio Frugoni will be remembered as the fiery-eyed young pianist whom Vox began to promote, if I am right, before the LP era began. I do not recall him offhand as anything of a sensation; yet here, in these Mazurkas, he shows himself one of the most subtle and expressive Chopin pianists in the business.

It isn't easy to reel off literally dozens of these little classical dances, all in the same basic rhythmic pattern. Yet Frugoni plays them so that even after a whole side of Mazurkas one is not tired of the breed. His sense for poetic Romanticism is no less than superb—and far ahead of those much younger pianists of the Neo-Romantic school who have vied with each other to sign and print out Chopin with swim upon their brows! Too often, they quickly become dull; they haven't discovered the means of keeping music alive and Romantic at the same time, as Frugoni has.

Victoria: Four Motets; Missa Quarti Toni. (a) Schola Grand Scholasticae des Pares du Saint-Esprit de Chevilly, (b) Chorale Saint-Jordi de Barcelona. Music Guild 5-41 stereo

What lightly names the French and Spanish can think up for their best choirs! Victoria is the famous late-Renaissance Spanish, whose effective, dramatically mysterious mysteries in choral form have wowed listeners right and left since the early Six- eighties. The four motets, short individual pieces on Latin texts, are sung by a splendid French choir of men, perhaps monks or Catholic students, with fine, non-wobbly voices and an excellent collective ear for blended harmonies. The Mass, occupying Side 2 of the record, is sung in Spain by a more lightly-voiced but still very musical ensemble, this time including sopranos and altos—-boys.

Both of these choirs display an understanding of the free rhythms and expressive word-painting of the Sixteenth century that is unusual in our day of clanging rhythms and rigid beats.

Beethoven: Symphony No. 9. Vyyvan, Carter, Petrock, Bell; BBC Chorus, London Symphony, Krips. Everest 3110 stereo

The Krips "Ninth" is well-liked by many critics and is surely notable for its lack of
**Buyer’s Guide and Condensed Applications Chart—Norelco® ‘Continental’ Tape Recorders**

This condensed guide, prepared by the High Fidelity Products Division of North American Philips Company, Inc., offers the consumer the factual data he needs to select the tape recorder best suited to his specific requirements.

<table>
<thead>
<tr>
<th></th>
<th>Continental '100' Model EL 3585</th>
<th>Continental '200' Model EL 3541</th>
<th>Continental '300' Model EL 3542</th>
<th>Continental '301' Model EL 3549</th>
<th>Continental '401' Model EL 3534</th>
</tr>
</thead>
<tbody>
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<td>Professional musicians, studio recordists, serious music lovers, high fidelity enthusiasts, doctors, dentists, industrial sound installation contractors.</td>
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<td><strong>RECORDING CAPABILITIES</strong></td>
<td>Monophonic 2-Track</td>
<td>Monophonic 4-Track</td>
<td>Monophonic 4-Track</td>
<td>Monophonic 4-Track</td>
<td>Stereo and Mono 4-Track</td>
</tr>
<tr>
<td><strong>PLAYBACK CAPABILITIES</strong></td>
<td>Monophonic 2-Track</td>
<td>Stereo and Mono 4-Track</td>
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<td>Stereo and Mono 4-Track</td>
<td>Stereo and Mono 4-Track</td>
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<td><strong>SPEEDS</strong></td>
<td>1½ ips</td>
<td>7½, 3½, 1½ ips</td>
<td>7½, 3½, 1½ and 15/16 ips</td>
<td>7½, 3½, 1¼ and 15/16 ips</td>
<td>7½, 3½, 1¼ and 15/16 ips</td>
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<td>Up to 32 hrs. on a 7&quot; reel.</td>
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<td>18 lbs.</td>
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For complete technical data and detailed descriptions of Norelco 'Continental' Tape Recorders, write: NORTH AMERICAN PHILIPS COMPANY, INC., High Fidelity Products Division, 100 East 42nd Street, New York 17, New York

*The unit prices stated above are for identification only and are not necessarily the regular or usual retail prices and are not to be represented as such.**
the eccentricities, the over-tensions and vocal outbursts in the middle of the slow movement. (Beethoven is a most unaccommodating composer in this respect!) Westmeister uses three sides, with the fourth given to a rehearsal recording.

SUBLIME TO RIDICULOUS

The Symphonies of Joseph Haydn. Vienna State Opera Orch. Max Goberman. Libraries of Recorded Masterpieces HS 1–10 stereo LPs (with scores included)

This series is a thing of beauty that has been waiting for since the Nineteen Thirties. It has occupied my listening time almost to the exclusion of other LPs for a month or so, on and off, and every moment in this series has been a pleasure. I wish I could anticipate an indelibly familiar, if thoroughly new, Westmeister recording of the entire set. And as for the series itself...it is perhaps for the second half of each work, that is, the last year, and the series is thus terminated, unless another dynamic promoter as dedicated and unassuming as Max Töpler can be found. Truly, Joseph Haydn was the father of the symphony, as all the "appreciation" books will tell you without presenting a trace of evidence. Simple: Nine traits of the "appreciation" writers had never heard of any of this music; they took the idea on faith, and it stuck with them. Now, from Number One right through to Number Ten there isn't a symphony in the enormous series that is not full of life, rhythm, and wit, published, fluent writing consistently far ahead of its time in terms of musical content. Through the interlocks, melodies become bigger, longer, more complex and more profound. And while each movement is different, enough, are just as "good"; for each in its own terms is a complete fulfillment, not merely a rehearsed effort for later thing to come.

The Goberman-Vienna performances are fast, fascinating, fresh, and new to the ears of New Yorkers intensely in touch with the natural kinship of a Viennese orchestra playing music of its own heritage. (The Viennese on their own want to wax a bit stodgy from our point of view.) The recording of these works is a first-rate effort, made on half-inch tape, three-track. (How can such a small company afford it?) And as for the superlative arrival of 4.98, the entire musical score of each work, in miniature, is bound into the album, along with an editorial section. In addition, the second side of each LP disc is replete with mature, well-mixed, orchestral suites, a kind of "appreciation" for each work, perfectly written, readings and norms for the same music today. You wouldn't think that the violin could be subject to such change in the manner of playing, especially in such music as Beethoven; yet even in stereo and hi-fi these Kreisler performances

SCORDATURA


Collections of 63 1811 (2) stereo LPs.

This splendid album kept me busy for a solid evening—it is a one-in-a-blue-moon rarity that, given solid ad- dition, will delight anyone who has a good ear for beautiful playing and a liking for the non-popular Baroque music. "Scordatura" is the key word. It indicated a violin deliberately mistuned, or rather, tuned to some special tuning other than the normal. Each of these fifteen Sonatas by the once-well-known Heinrich Biber (then 40 years before Bach and Handel) is com- posed for a different violin tuning. Sometimes only one string is used, or the violin is de-tuned, up or down; often a thicker or thinner string is substituted, or an A string is used to remind the lower-pitched D string. The result is in every case, first, however, a unique change of tone quality, different for each of the second, a whole series of novel double- and triple-stop passages, entirely impossible with normal violin tuning. In effect we have fifteen different stringed instruments here (Miss Monosoff, in fact, had to string up six violins to enumerate all the pieces) and fifteen different sorts of violin writing, within the straightforward and simple mid-Baroque instrumental style.

What will appall those who know the violin to be the particular technique required—for the written notes in these sonatas do not indicate normal tuning, but, because tablature, that is, merely indicate places where the fingers are to be applied. The soloists are not heard as written but vary according to the tuning of each string.

It is as though for each piece the performer has to play in four different keys simultaneously, one for each hand, Or, if you will, make four different transpositions simultaneously. Under the circumstances, only a violinistic wizard could hope to work up the necessary finger coordination, the eyes, ears, and hands hearing one thing, the ears hearing another.

What is most astounding, then, is that with all this nightmare of finger-twist- ing, the performance is quite superb, with the loveliest phrasing and the most perfect feeling of pitch I ever heard. Very simply, she manages to make unplayable music out of these works, where many another performer would have tested the tuning nightmare, might produce no more than a mechanically correct rendition.

She is wonderfully aided by the varied continuo realizations, accompanying her with a modulated changing harp ensemble, sometimes organ alone (a lovely old one, too) and harp. A variety of instruments are used, with viola da gamba (an instrument actually made for this composer, it seems), or bassoon, or harpsichord (mean-\(\text{toned},\) instead of the usual temperament is tinted yellow) slightly with the organ sound. Excellent stereo recording is the ultimate touch in a very nearly perfect album.
could be spotted at once as already of another age. What differences? Too many—and to tricky—to describe in mere words! Try for yourself: the music here jumps from Schubert-Beethoven and Grieg (with Rachmaninoff at the piano) to Bach (with Zimbalist) and "Mighty Lah" a Rose" (with Farrar). Also some Rachmaninoff songs, with McCormack and without Rachmaninoff. Both acoustic and electrical recordings are included, dating from 1914 to 1928.

So Early in the Morning, Irish Traditional Songs, Rhymes and Games. Collected by Diane Hamilton. Tradition TLP 1034 mono

Anyone who loves folk song, who loves the Irish and the Irish speech and lift, who thinks children are wonderful and who—most important—knows fine music-making when he hears it, will find this record a most pleasant experience.

Diane Hamilton, guiding light of Tradition Records and an old-time Irish enthusiast (she plays the Irish harp herself and sings Irish folk songs to it) made these tapes on various occasions during her stays with the Clancy family, with dozens of assorted children and grandchildren; so this is a home-style disc, made right in the family, though it would seem there are dozens and dozens of different styles.

Short rhymes, longer ballads, songs by kids, songs for kids, sung by the elders, all go into the collection. Many of them are variants of tunes and texts familiar to all of us. Others are new ones in familiar patterns—the "past tense in a near tree" cumulative text, for instance. Lovely stuff for family listening on your own, via hi-fi.

A Double Barrel Blast: The High Cost of Dying; Listening In On Computer Conversations.

Cook 1078 stereo

Emory Cook is the most cryptic engineer in the record business. Sometimes it's hard to know whose leg he's pulling and whether it's an arm or a leg or maybe, just a shotgun trigger. This one is typical and as zany as they come.

Side 1 is a white. We are listening in on a lengthy phone conversation, ostensibly genuine (no one could invent this stuff . . .) between a solid Italian-American citizen and an undertaker, ditto. The first-named's Uncle Willie, or something, has died on him in the front parlor—whaddya do about a funeral? It is quite realistic, matter of fact and wholly delightful, even in bits of language commonly heard everywhere, though not on the air, ever. Goes on interminably, pleasantly—and the fact is that I can't imagine how on earth such an incontrovertible documentary ever got taken down on tape. The surprising lack of correspondence between Mr. Cook's jacket write-up and the actual recorded words merely adds a lift more mystery to an charmingly zany a recording as you'll likely hear anywhere.

This computer stuff! Nobody but Emory Cook could subject me to a whole LP-side of corny humor, as supposedly spoken by two rival computers (one analog, one digital) and leave me at the end still genuinely befuddled as to whether these insane conversations actually are out of computers, or are merely actor-simulated! You try. You guess.

QUARTETS

Haydn: Quartet in D Op. 64, No. 5 ("The Lark"); Quartet in F Op. 77, No. 2 ("Lobkowitz"). Hungarian String Quartet. Vox STGB 512.080 stereo

The Hungarian String Quartet, musicians, coming from Haydn's own background, are the finest players of these Haydn quartets I have yet to hear. Somehow, one feels, this music is to the Hungarian mind so natural, so inevitable of its sort, that the performers scarcely have to play—the music simply appears of its own accord, justly and perfectly, true in style and knowing in expression!

There's no cuteness and self-consciousness of the "Papa Haydn" sort here, nor any false Romanticism; it is all Haydn and very great Haydn. Moreover, the recorded sound is lovely even though the mike pickup is close and with wide spacing of the speakers the instruments may seem to perform in a line straight across the room. No matter; the music is splendid just the same.


Mozart: Quartet in G, K.156; Ravel: Quartet in F. Quartetto Italiano. Angel 35735; 35732 stereo

Few "live" listeners to chamber music have the chance to compare the sounds of different quartets as we do who listen to records. The string quartet, you'll discover, varies much more dramatically from group to group than do the larger symphony orchestras. String quartets are highly individualistic—four individual players, four hand-made instruments (usually very old) and a dynamic unity in performance that makes the quartet relationship a kind of super "family" one, and perhaps even more difficult to maintain over the years than any family ensemble.

The Quartetto Italiano is famed for its precision; and these young people show it easily in these recordings—notably in the Schumann, with its profuse rubato Romantic slurs-down and -up—But what will strike you even more quickly is the florid, wry, sensuous tone color achieved, reproducible with Romantic vibrato. These people are of the neo-Romantic School, it seems, and like other younger performers they seem almost to override the Romantic effort. Yet this sort of ensemble, each player carrying a highly individualistic line yet working precisely with his fellows, offers interesting musical results even in Mozart—not to mention Stravinsky.

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67

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Nothing to appear between album covers so far this year is more worthy of being encored than the anniversary set that introduced the brilliant new Woody Herman band. Requests for a return performance were filled during an appearance at Basin Street West, and the welcome extended by a delighted Los Angeles audience on this impromptu encore revives the demand for more of the same. After giving the band business another lease on life with one of the best groups in twenty-five years as leader, the veteran clarinetist is rolling in good form again and every fan will want to celebrate. By way of topping the festivities, he takes the liberty of bringing back one of his old hits for personal encore and turns out the most riotous reading yet of Catalonia. Under the heavy influence of paying guests, the band is even more thrilling and excitement is far above than before. If a little studio polish rubs off in all the excitement, the loss is restored twice over by the faultless engineering of United Recording's Wally Heider. Each section is allowed to change in its own stereo direction, but soloists never stray far and the blend with the rest of the band remains. Another helpful contributor is Nat Pierce, who arranged five numbers and serves as second in command. Whether churning a popular ballad or the Basie-styled That's Where It Is, his chief concern is that everyone swings constantly. Fancy writing is passed over in favor of imaginative solos from such likely youngsters as Phil Wilson, Billy Hunt, Henry Soutball and Frank Hfiller. Two side trips include Bob Hammer's stirring visit to the gospel world and the tune on which Get It In Your Soul, and Bill Chase puts the technique of running brassy into the bull ring on El Toro Grande.

Clare Fischer: Surfing Ahead

Pacific Jazz Stereo PJS17

Way back when the giants of jazz piano developed original styles and battled into the early morning hours for keyboard supremacy, the term "composer pianist" was coined to distinguish certain nonconformists who served behind the firing line. Lacking the solo impact of the big guns, they planned strategy or kept open supply routes to the front. Jazz is undoubtedly much richer because the Duke Ellington and Thelonious Monk were enabled toourselves such radiators as Art Tatum and Oscar Peterson. But just as nuclear energy perverts the business of peace, so has increased recording activity encouraged some pianists to step out of character, and forced the rest to become more versatile. Even Ellington is making daring sorties of late, while Clare Fischer exemplifies the youngwes who at one moment appear stalking and relentless, only to start toying with dynamite the next. Better known on the coasts for his bop, glide and other jazz noteworthy, Fischer learned about acts as accompanist and arranger with the HI Lo's vocal group. His explosive potential as pianist remained hidden, however, until the recent release of his trio album called First Time Out, which amazed listeners and startled the critics. Among the works performed were five Fischer originals, composed in purely pianistic terms and delivered with the kind of marathoning that a guided missile. This second trio foray for Pacific Jazz is a highpoint in the story of the jazz piano.
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by Edgar Villchur

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ADVERTISING INDEX

Acoustech, Inc. ........................................ 41
Acoustic Research, Inc. ............................ 53
Airex Radio Corporation ............................ 82
Allen, Richard, Speakers .......................... 14
Alltec Lansing Corporation .......................... 59
American Concertone, Inc. ....................... 10
Ampex Corp. .......................................... 7
Audio Bookshelf .................................... 80
Audio Engineering Society ....................... 75
Audio Fidelity Records ............................ 66
Audio Unlimited ..................................... 83
Benjamin Electronic Sound Corp. ............... 69
Bresson .............................................. 30, 31
British Industries Corporation .................... 60, 61
Castor Studios ....................................... 83
Classified ........................................... 82
Concord Electronics Corporation ................ 39
Dukane Corporation .................................. 82
Dynaco, Inc. .......................................... 47
EICD Electronic Instr. Co., Inc. .................. 13
Electro-Voice ......................................... 13
Electro-Voice Sound Systems ...................... 83
Electronic Applications ............................ 71
Elpa Marketing Industries ......................... 33-36
EMI (Scope Electronics Corp.) ..................... 84
Fairchild Recording Equipment Corp. .......... 6, 81
Finney Company .................................... 4
Fisher Radio Corporation ........................... 9, 11
Frazier Incorporated ................................ 74
Garrard Sales Corp. ................................... 5
Goldwin, C. C. (Sales) Ltd. ....................... 83
Gotham Audio Corporation ......................... 67
Harvey Radio Co., Inc. ............................. 5
Heath Company ..................................... 50, 51
Hi Fidelity Center ................................... 83
International Electroacoustics, Inc. .......... 76
Kestling Manufacturing Co. ....................... 83
Key Electronics Company .......................... 84
Lafayette Radio ....................................... 70
Lansing, James B., Sound, Inc. ................... 49
Matsushita Electric Corp. of America .......... 63
Mcintosh Laboratory, Inc. ......................... 73
Murray Carson Corporation ........................ 77
North American Philips Co., Inc. ............... 65
Pikering & Company, Inc. ......................... 19
Pioneer ................................................ 57
RCA Electronic Components and Devices .... 5
Reeves Soundcraft Corp. ........................... 17
Sanwa Electric Instrument Co., Ltd. ........... 70
Scott, H. H., Inc. .................................... 18
Sennheiser Electronic Corp. (N. Y.) ............ 15
Sherwood Electronic Laboratories, Inc. ....... 20
Shure Brothers, Inc. ................................ 29
Sorvino Corp. ....................................... 83
Stuart, Matthew, Co. ................................ 78, 79
Superscope, Inc. .................................... 45
United Audio—Dual ................................. Cov. 111
University Loudspeakers ......................... 42, 43
Wharfedale .......................................... 60, 61
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