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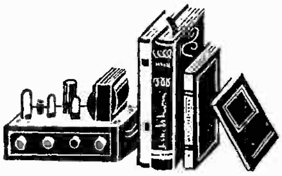


audiophile's bookshelf

How to Make GOOD TAPE RECORDINGS

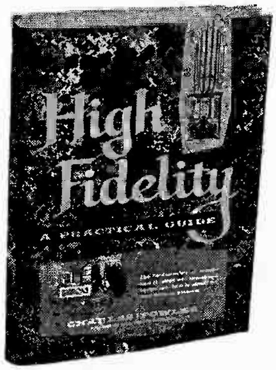
by C. J. LEBEL
Vice President, Audio Devices, Inc.

This completely new handbook on tape recording, by one of the foremost authorities on the subject, contains up-to-the-minute practical help for both the experienced tape recordist and the novice. Written in concise nontechnical language, it can be read and easily understood by the most inexperienced. At the same time, the professional will find a wealth of useful information which could be supplied only by a person of Mr. LeBel's knowledge and experience. All aspects of tape recording are covered.

Cloth-bound Edition, $2.50 **227**
Paper-bound Edition, $1.50 **229**

RECORD RATINGS — Compiled by Kurtz Myers, Chief, Music and Drama Department, Detroit Public Library. Edited by Richard S. Hill, Head, Reference Section, Music Division, Library of Congress.

This book is, without any question, the essential reference for the discriminating buyer of records. It indexes practically all serious music ever recorded on LPs, listing the date and issue of the most important American and European periodicals in which reviews appeared. Symbols indicate what the reviewer thought of that particular release. Full bibliographical information is given for each record. $5.95. **224**



Whether your budget is small or large, whether you are a beginner or a devotee from way back, this complete and definitive guide can help you get the most enjoyment out of your high-fidelity system.

HIGH FIDELITY: A Practical Guide

***by* CHARLES FOWLER**

As publisher of HIGH FIDELITY and AUDIOCRAFT Magazines, and author of many articles on high fidelity, there is little need to introduce Charles Fowler to readers of this magazine, nor to assure them of his ability to tell in clear, nontechnical language just how to evaluate, buy, and operate hi-fi equipment for the optimum in lifelike reproduction.

Gives clear, complete information on:

Loudspeakers, control units and preamplifiers, amplifiers, speaker enclosures, pickups, record changers and turntables, tuners, room acoustics.

Here is the practical, expert advice needed by everyone who has, or expects to have, a high-fidelity system. Starting with an introduction to sound, the author then describes the various links in the hi-fi system, explaining their features and specifications so as to provide the most helpful criteria for evaluating, and for selecting and matching components. **234**

310 pages, 100 illustrations, $4.95

Maintaining HI-FI EQUIPMENT

by JOSEPH MARSHALL

A much needed book on the specialized approach necessary to service high-fidelity equipment. The author discusses not only electronic faults, but the mechanical and acoustical defects which cause a hi-fi system to function less than perfectly.

Hard cover, $5.00 **232**
Soft cover, $2.90 **233**

"For electronics technicians, repairmen, and audio enthusiasts in general, this volume is a veritable audio bible . . . {and} it is truly up-to-date . . . There is so much valuable practical information in this well-indexed work that it should be at the finger tips of everyone who enjoys building or improving home sound systems." — Richard D. Keller in AUDIOCRAFT Magazine.

— AUDIO HANDBOOKS by Norman H. Crowhurst —

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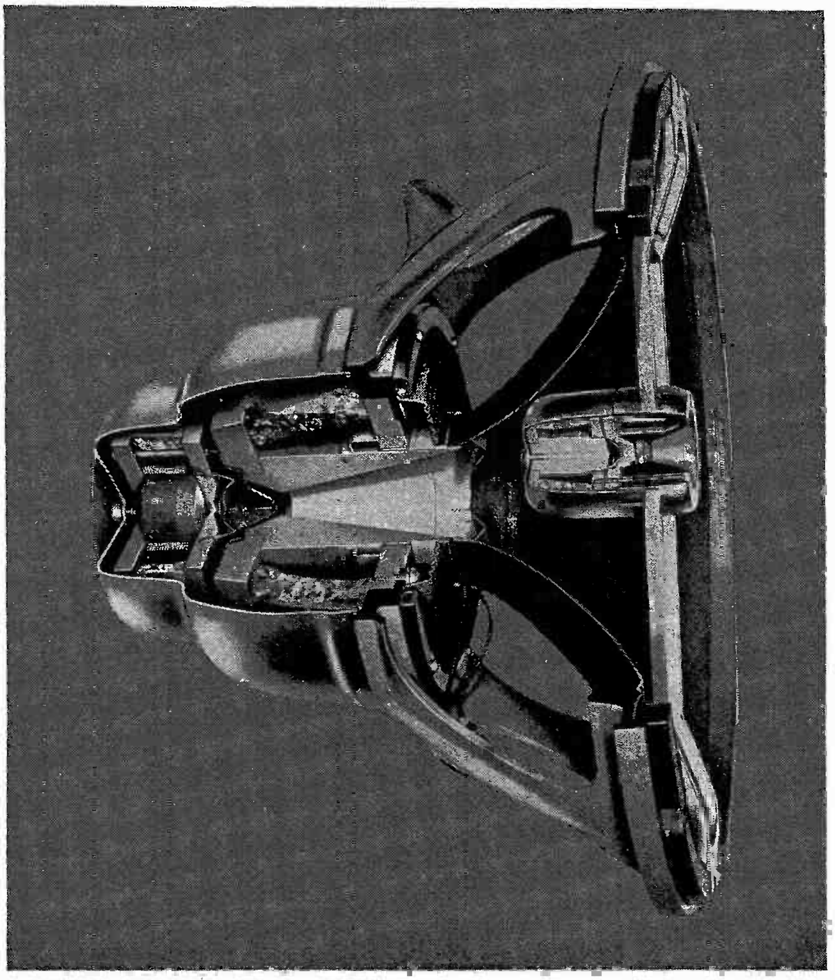

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Six years ago Jensen introduced the TRIAXIAL which combined into one unitary assembly a special "woofer" and two horn-loaded compression-drive "tweeters" to span the audio frequency range with an entirely new smoothness and realism unmatched by any other loudspeaker for listening quality.

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WORLD'S QUALITY STANDARD FOR MORE THAN A QUARTER CENTURY

December 1956

Volume 1 Number 14

audiocraft

THE HOW-TO-DO-IT MAGAZINE OF HOME SOUND REPRODUCTION

John D. Seagrave, whose name appears in the list of AUDIOCRAFT authors for the first time this issue, is an experimental nuclear physicist at the Los Alamos Scientific Laboratory. He is a graduate of Cal Tech with a B.S. in Electrical Engineering and a Ph.D. in Physics. Among his spare-time activities are several forms of "recreational" physics; one of them resulted in his two-part article on pickup-arm tracking, which begins this month.

Although a newcomer to technical audiocraft, Dr. Seagrave is an amateur musician of distinction. He is both Director of Music for the United Church of Los Alamos and Director of the Los Alamos Choral Society.

In "Minimizing Pickup Tracking Error", the nature of tracking distortion is discussed and its dependence on pickup-arm design and mounting is developed quantitatively. Practical graphs and formulas are given both for optimum design of arms and for placement of commercial arms to produce minimum distortion.

The conclusions reached in this paper will cause some furor, because they are not identical with those made in previous studies of the subject. Dr. Seagrave has used more accurate simplifications in deriving design formulas than were applied before, and he has assumed more realistic groove diameter limits — particularly for LP's. His article is a major addition to pickup-arm design literature.

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Advertising

Main Office — Claire Eddings, The Publishing House, Great Barrington, Mass. Telephone: Great Barrington 1300.

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The Grounded Ear

by Joseph Marshall

Tape Quality

In a recent issue of AUDIOCRAFT, J. Gordon Holt devoted his monthly column to answering the question, "Why aren't tape records better?" I don't want to shoe-horn myself into his field, but his remarks have stimulated my own reflections which have convinced me that those interested in exploiting the possibilities of tape reproduction must give this question and its answers some serious consideration soon.

As for tape quality, I haven't heard any large percentage of the available tapes. But I have heard a pretty representative cross section, and I would generalize my own experience with them in the flat statement that the best duplicated tapes available when played back on the best available tape reproducers are no better than the best discs reproduced on the best disc equipment, and the great majority are not as good. Furthermore, there is very little recorded tape material.

Mr. Holt has given some reasons for the seeming paradox of tape quality, and particularly the limitations of the tape-duplicating processes. I might, as a reminder, point out the even more basic fact that the best available tape playback machines cannot cover the frequency range at 7½ ips that almost any good magnetic phono cartridge can at 33 rpm. The Concertone 20/20, for example, which represents an exceptional value at around $500, has a cutoff at around 15,000 cps when in peak operating condition. As for the machines in the $100 to $200 class, their response is scarcely better than that of now-obsolete magnetic pickups and the average ceramic hi-fi cartridges. Although some listeners like the tapes better because, even with the narrower frequency range, they are less noisy and cleaner on most peaks, the fact is that 7½-ips tapes do not have any other clear superiority for the hi-fi listener and do possess the disadvantages of greater expense and awkwardness in use and storage.

This frank criticism is not meant to be an indictment. Tape reproduction is still in its infancy, compared with disc reproduction. I have no doubt that in a very short time the problems of frequency response both in the tapes themselves and in playback equipment will be solved to a degree which will give listeners an opportunity to realize the theoretical advantages of tape recording, at a price comparable with that for disc equipment. But it does explain why the market for tape reproducers and for recorded tape is not bigger than it is. In the high-fidelity field consumers have enough knowledge and discrimination to recognize quality when they hear it. They are not going to invest in tape reproducers or tapes until they can hear superiority in tape reproduction.

And that brings me to the point I principally want to make here. There are few tapes worth listening to from a strictly hi-fi point of view. I will go further and say there are few that do

present standards of tape reproduction real justice. Several times I have asked tape producers to send me samples of their most spectacular tapes. They have complied generously, but in my entire library of tapes I can think of only one or two which I could recommend to a dealer for demonstration purposes. Nobody seems to have given any thought to the matter of producing tapes spectacular enough to *sell* tape reproduction. Indeed, I have had to produce tapes of my own — dubbed from various disc recordings — to use for demonstration. Although these homemade tapes fall far short of demonstrating the quality possible on tape today, nevertheless they are better in over-all impact on the listener.

It seems to me that if tape producers are serious about exploiting the high-fidelity market for recorded tape, the first thing they should do is put out some tapes good enough and spectacular enough to show off the capabilities of the medium. I am aware that several manufacturers of tape reproducers have demonstration tapes, but — without exception — those I have heard don't serve their intended purpose. I don't mean we should have trick demonstration records with snatches of triangle, drums, and organ. I mean complete recordings of music worth hearing as music, in brilliant performances and with brilliant sound quality. There are hundreds of discs that may be used for such purposes. I presume that masters of some are available for duplication in tape. One reason high-fidelity disc recording has found such a wide audience (and market) is that there is an abundance of spectacular recordings which show off the superiority of high fidelity most persuasively. The absence of similar tape recordings is handicapping the tape field by understating its capabilities. As long as discs are judged by playing spectacular examples of discs, and tapes are judged by run-of-the-mill examples both of music and of sound quality, the disc will seem even more superior than it is in fact.

Disc Recordings

I'll probably seem inconsistent when I present some thoughts stimulated by one of my readers, who commends me for my comments on overcut recordings. He makes this observation: most recordings today are meant to reproduce the listening experience of the concert hall, but are actually played back in the home where the dynamic range of the concert hall is more a nuisance than a virtue. He puts his finger, of course, on the paradox which faces the whole field of musical reproduction. We want reproduction which duplicates as nearly as possible the original sound which exists in the concert hall; but it is a patent impossibility to expect, in a 3,000-cubic foot living room, to duplicate the acoustic conditions which exist in a 300,000-cubic foot (or larger) auditorium. The task of the recording engineer is to try to work out a compromise which gives an acceptable illusion; some of these attempts are better than others, but none solves the paradox and it is highly doubtful that anyone ever will. On the other hand, my reader has a point when he complains that recording engineers do not seem to be as aware of the limitations of the home listening environment as they ought to be and that, in consequence, some recordings, particularly those with a very wide dynamic range, are more painful than exciting when played back in the average home.

I will have to agree with that. I love recordings with a wide dynamic range *when I'm in a high-fidelity mood.* But I must concede that, when I'm trying to enjoy the music as music, the extreme dynamic range is often more distracting than helpful. One has two choices: either to set the volume controls so the peaks do *not* blast you out of the room — and stimulate the neighbors to call the cops — in which case the diminuendos and quiet passages disappear into the room background noise; or to adjust volume so that low and average levels are comfortable, at the risk of inviting the objection of wife, child, and neighbors to the blast of the peaks and crescendos. It is of no use for anyone to tell me that if I can't tolerate those peaks I don't really appreciate music as it should be played. I respond that nobody should pay for his love of music with the sacrifice of his own peace of mind, let alone that of his family; further, I point out that the loudest peak in the auditorium is by no means as shocking to the ear of the listener in the auditorium as a 5-watt peak may be in a living room.

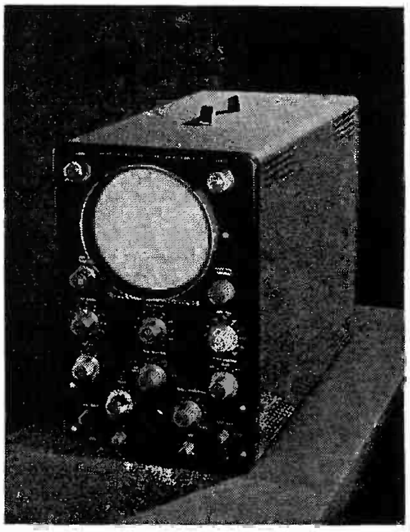
I don't know the answer for this paradox. Back in the old days of 78-rpm shellacs the records were tailored for home reproduction. Although they seldom annoyed the listener because of wide dynamics, they sound awfully flat today. And, for all its annoyance potential, the wide dynamic range of today's recordings has an undeniable brilliance and stimulation the old ones couldn't hint at. But my reader's complaint is by no means an isolated one. If you will check your acquaintances, especially those who don't care about high-fidelity sound, you will find it echoed time and again. My reader appears to think that we ought to have two parallel series of records: those of wide dynamics for the high-fidelity people, and those with the peaks compressed for people who are willing to sacrifice dynamic range to avoid the distraction of blasting. I rather doubt that this is feasible or advisable. There is at present, among the different labels, a sufficient variety of reproduction so that one can usually be found to suit one category or the other of listener. But I do think that there may be a tendency on the part of recording engineers to overlook this angle. Possibly, it might be well for them to audition recordings in a reasonably representative or typical living room rather than in a studio or the concert hall itself and, without returning to the extreme flatness of the old days, minimize those excursions in dynamic range which are not reasonably tolerable in the home. In any event,

Continued on page 37

Audionews

ETCHED-CIRCUIT OSCILLOSCOPE KIT

The new Heathkit *Model OM-2* etched-circuit 5-inch oscilloscope kit is reported to be an improvement over the preceding model by providing wider verti-



Latest Heathkit etched-circuit scope.

cal frequency response, extended sweep-generator coverage, and increased stability.

Vertical frequency response is said to be essentially flat to over 1 Mc, and down only 1½ db at 500 Kc. The sweep-generator multivibrator functions reliably from 30 to 200,000 cps, almost twice the coverage provided by the previous model, according to the manufacturer. Deflection amplifiers are push-pull, and etched circuits are employed in critical parts of the design. A 5BP1 cathode-ray tube is used.

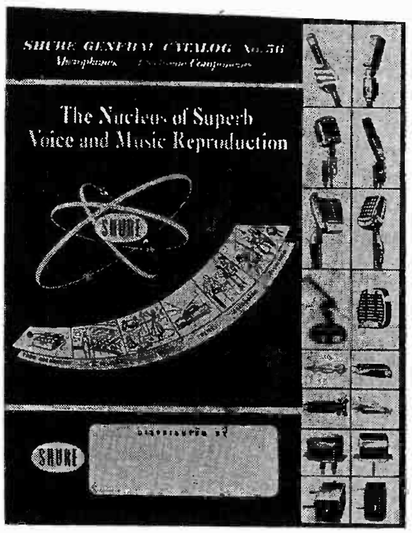
The scope features external or internal sweep and sync., one-volt peak-to-peak reference voltage, 3-position step-attenuated input, and adjustable spot-shape control. A calibrated grid screen is also provided for the face of the CRT, allowing more precise observation of wave shapes displayed.

The new Model OM-2 is designed for general application wherever a reliable instrument with good response characteristics may be required. Additional information will be furnished on request.

SHURE GENERAL CATALOGUE

Shure Brothers, Inc., manufacturers of microphones and electronic components, have announced a new General Catalogue *No. 56* covering microphones, microphone cartridges, microphone accessories, phono-pickup cartridges, and magnetic recording heads. The technical data and general information in the catalogue have been prepared with the customer in mind; questions have been anticipated so that persons buying the products described will find the kind of information they need to evaluate the usefulness of a given model.

To those persons engaged in buying, selling, and installing the products de-



New Shure catalogue, free on request.

scribed, Catalogue No. 56 will be a source of general and technical data that will help them in recommending a particular model. The catalogue can be obtained free from any Authorized Shure Distributor or directly from the manufacturer.

For more information about any of the products mentioned in Audionews, we suggest that you make use of the Product Information Cards bound in at the back of the magazine. Simply fill out the card, giving the name of the product in which you're interested, the manufacturer's name, and the page reference. Be sure to put down your name and address too. Send the cards to us and we'll send them along to the manufacturers. Use this service; save postage and the trouble of making individual inquiries to a number of different addresses.

FM-ANTENNA BOOKLET

A booklet, *All About FM Antennae and Their Installation*, by L. F. B. Carini, is being offered for sale by the Apparatus Development Company of Wethersfield, Conn.

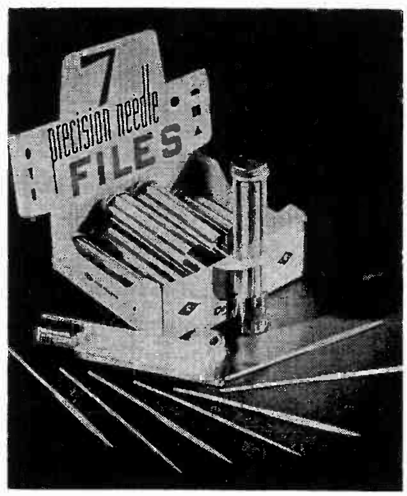
The booklet covers such subjects as "Why an FM Antenna?", "What Constitutes a Good FM Antenna", "Choosing the Correct Antenna for your Installation", "Antenna for Fringe Reception", and "Long Distance FM Reception". Also included is an FM station directory.

The price of the booklet is 25¢.

PRECISION NEEDLE FILE KIT

A kit of precision needle files has been introduced by Centralab. Made in Switzerland, these high-grade carbon-steel files are 5½ in. long. There are seven individual shapes: round, half-round, flat, square, oval, triangular, and knife edge. All have a No. 0 cutting surface.

The files are packaged in a sturdy



Centralab set of No. 0 needle files.

plastic tube, and are said to be a great aid to servicemen, hams, and the do-it-yourself hobbyist.

JENSEN DO-IT-YOURSELF DESIGNS

The Jensen Manufacturing Company has recently published a booklet of do-it-yourself designs for speaker systems.

The booklet, *Technical Manual 1060*, contains 18 simplified plans and complete instructions for building self-contained or built-in single speaker and 2- and 3-way speaker systems. It includes complete parts lists and speaker data for all types of enclosures mentioned.

Persons interested in constructing a speaker system will find the booklet a guide to the space, structural, component, and assembly requirements of modern speaker systems. The reader is assisted in the choice of a speaker system by discussion of the relative performance of various combinations of Jensen speakers and speaker-system kits in the enclosures suggested.

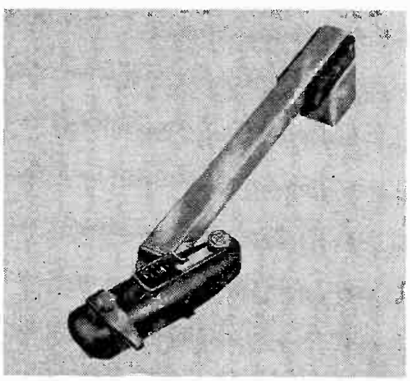
The booklet is available from local Jensen distributors or directly from the Jensen Manufacturing Company. Price is 50¢.

WRIST-ACTION PICKUP ARM

The Metzner Engineering Corporation of Hollywood, Calif., manufacturers of the Starlight turntable, have announced a new *Starlight Transcription Arm* featuring an exclusive "double-wrist action" head which is counterbalanced and has weight adjustment from 4 to 14 grams. The retail price is under $25.00, less cartridge.

According to the manufacturer the counterbalanced, double-wrist action head provides minimum mass and assures prefect tracking and reduced record wear. Resonance is said to be outside the audible range. The arm lifts to a vertical position for cartridge replacement, is 12 in. long, and plays all record sizes up to and including 16-inch records.

An illustrated brochure showing both the Starlight turntable and the new transcription arm is available by writing



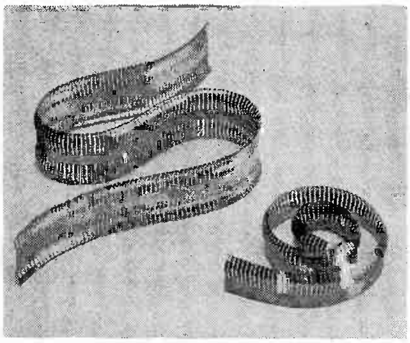
Metzner Starlight transcription arm.

to the Metzner Engineering Corporation, Department 29, 1041 North Sycamore Ave., Hollywood 38, Calif.

EIMAC PREFORMED CONTACT FINGER STOCK

Eimac *Preformed Contact Finger Stock* is a prepared strip of spring material slotted and formed into a series of fingers designed to make sliding contact.

Eimac Finger Stock is said to be an excellent means of providing good circuit continuity when using components with adjustable or moving contact surfaces. It is especially suitable for making connections to tubes with coaxial terminals; or to moving parts, such

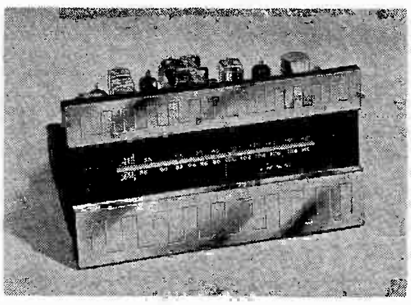


Eimac finger stock for sliding contacts.

as long-line and cavity-type circuits; and it is also useful in acting as an electrical "weather-strip" around access doors to equipment cabinets.

LAFAYETTE FM-AM TUNER KIT

Lafayette's new FM-AM tuner kit incorporates an Armstrong FM circuit with limiter and Foster-Seeley discriminator. AFC can be disabled to allow tuning weak stations. The front end consists of a grounded-grid triode amplifier and separate mixer and oscillator. The AM superheterodyne section fea-



Lafayette KT-100 FM-AM tuner kit.

tures AVC, a ferrite-core antenna, and a high-impedance terminal for external antenna. Tuning is flywheel counterweighted. The kit includes all parts and easy-to-follow instructions. The Lafayette stock number is *KT-100*; the price is $32.50.

CLIMATITE PHONO CARTRIDGE

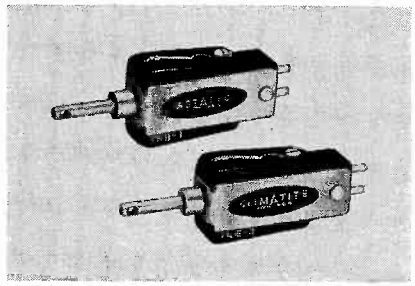
The *Climatite* series of phono cartridges was announced recently by the Astatic Corporation. The new series is designed to meet all requirements of the phonograph industry, and is said to be ideal for use in areas of extreme cold, heat, or humidity.

Currently available is the Climatite Model 420ts, reported to be a high-output, high-compliance, wide-range turnover unit containing separate, removable, 1- and 3-mil synthetic sapphire styli. Unique design simplifies stylus replacement, and quick replacement of the cartridge can be accomplished without use of special tools.

Other basic Climatite models, with their specifications as supplied by the manufacturer, are:

The Model 310T: 3 volts output; compliance of 0.7×10^{-6} cm/dyne; frequency response from 50 to 12,000 cps. Turnover cartridge contains separate 1- and 3-mil synthetic sapphire-tipped needles.

The Model 312T: 0.8 volts output; compliance of 2×10^{-6} cm/dyne; fre-



Astatic ceramic phono pickup cartridges.

quency response from 30 to 15,000 cps. Cartridge is turnover type, containing separate 1- and 3-mil synthetic sapphire-tipped needles.

The Model 414-1 for 45 rpm changers: same specifications as Model 310T, but has single 1-mil sapphire-tipped needle.

Climatite cartridges are delivered ready for direct miniature-cartridge replacement, and they can be supplied with brackets, spindles, and mountings for all original equipment applications.

MASCO FM-AM TUNER AND AMPLIFIER

Mark Simpson Manufacturing Co., Inc., has announced the Masco *Music Master, Model AFR*, a single-chassis FM-AM tuner and 10-watt amplifier. Only a speaker and a record changer are required to complete a home music system. The Music Master also incorporates a preamplifier; it is equalized for LP records, as well as 78's, and has separate bass and treble controls.

The FM section utilizes the Armstrong circuit, with limiter and Foster-

Complete FM-AM receiver by Masco.

Seeley discriminator. The superheterodyne AM circuit has been designed for sensitivity and selectivity.

The unit is rated at 10 watts audio output, and is said to have a frequency range of 20 to 20,000 cps with less than 1% distortion.

Heathkit Model FM-3A High Fidelity FM Tuner Kit
Features A.G.C., and stabilized, temperature-compensated oscillator. Ten uv sensitivity for 20 DB of quieting. Covers standard FM band from 88 to 108 mc. Ratio detector for efficient hi-fi performance. Power supply built in. Illuminated slide rule dial. Pre-aligned coils and front end tuning unit.

$26.95* (With Cabinet) *Shpg. Wt. 7 Lbs.*

Heathkit Model BC-1 Broadband AM Tuner Kit
Special AM tuner circuit features broad band width, high sensitivity and good selectivity. Employs special detector for minimum signal distortion. Covers 550 to 1600 kc. RF and IF coils pre-aligned. Power supply is built in.

$26.95* (With Cabinet) *Shpg. Wt. 8 Lbs.*

Heathkit Model WA-P2 High Fidelity Preamplifier Kit
Provides 5 inputs, each with individual level controls. Tone controls provide 18 DB boost and 12 DB cut at 50 CPS and 15 DB boost and 20 DB cut at 15,000 CPS. Features four-position turnover and roll-off controls. Derives operating power from the main amplifier, requiring only 6.3 VAC at 1 a. and 300 VDC at 10 ma.

$21.75* (With Cabinet) *Shpg. Wt. 7 Lbs.*

Heathkit Model W-5M Advanced-Design High Fidelity Amplifier Kit
This 25-watt unit is our finest high-fidelity amplifier. Employs KT-66 output tubes and a Peerless output transformer. Frequency response ± 1 DB from 5 to 160,000 CPS at one watt. Harmonic distortion less than 1% at 25 watts, and IM distortion less than 1% at 20 watts. Hum and noise are 99 DB below 25 watts. Output impedance is 4, 8 or 16 ohms. Must be heard to be fully appreciated.

$59.75 *Shpg. Wt. 31 Lbs. Express Only*

MODEL W-5: Consists of Model W-5M above *plus* Model WA-P2 preamplifier. $81.50* *Shpg. Wt. 38 Lbs. Express only*

Heathkit Model W-3M Dual-Chassis High Fidelity Amplifier Kit
This 20-watt Williamson Type amplifier employs the famous Acrosound Model TO-300 "ultra linear" output transformer and uses 5881 output tubes. Two-chassis construction provides additional flexibility in mounting. Frequency response is ± 1 DB from 6 CPS to 150 kc at 1 watt. Harmonic distortion only 1% at 21 watts, and IM distortion only 1.3% at 20 watts. Output impedance is 4, 8 or 16 ohms. Hum and noise are 88 DB below 20 watts.

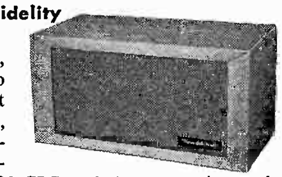
$49.75 *Shpg. Wt. 29 Lbs. Express only*

MODEL W-3: Consists of Model W-3M above *plus* Model WA-P2 preamplifier. $71.50* *Shpg. Wt. 37 Lbs. Express only*

HEATHKIT SPEAKER SYSTEM KITS

These speaker systems are a very vocal demonstration of what can be done with high-quality speakers in enclosures that are designed especially to receive them. Notice, too, that these two enclosures are designed to work together, as your high-fidelity system expands.

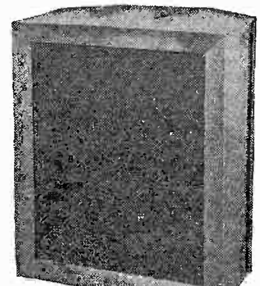
Heathkit Model SS-1 High Fidelity Speaker System Kit



Employing two Jensen speakers, the Model SS-1 covers 50 to 12,000 CPS within ± 5 DB. It can fulfill your present needs, and still provide for future expansion through use of the SS-1B. Cross-over frequency is 1600 CPS and the system is rated at 25 watts. Impedance is 16 ohms. Cabinet is a ducted-port bass-reflex type, and is most attractively styled. Kit includes all components, pre-cut and pre-drilled, for assembly.

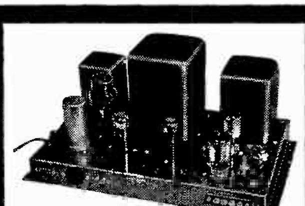
$39.95 *Shpg. Wt. 30 Lbs.*

Heathkit Model SS-1B Range Extending Speaker System Kit

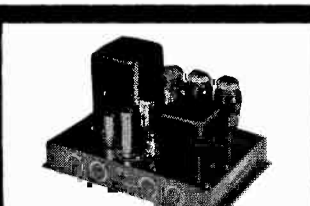


This range extending unit uses a 15″ woofer and a super-tweeter to cover 35 to 600 CPS and 4000 to 16,000 CPS. Used with the Model SS-1, it completes the audio spectrum for combined coverage of 35 to 16,000 CPS within ± 5 DB. Made of top-quality furniture-grade plywood. All parts are pre-cut and pre-drilled, ready for assembly and the finish of your choice. Components for cross-over circuit included with kit. Power rating is 35 watts, impedance is 16 ohms.

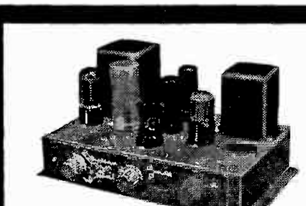
$99.95 *Shpg. Wt. 80 Lbs.*



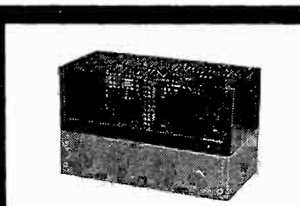
MODEL W-4AM



MODEL A-9B



MODEL A-7D



MODEL XO-1

Heathkit Model W-4AM Single-Chassis High Fidelity Amplifier Kit
The 20-watt Model W-4AM Williamson type amplifier combines high performance with economy. Employs special-design output transformer by Chicago Standard, and 5881 output tubes. Frequency response is ± 1 DB from 10 CPS to 100 kc at 1 watt. Harmonic distortion only 1.5%, and IM distortion only 2.7% at this same level. Output impedance 4, 8 or 16 ohms. Hum and noise 95 DB below 20 watts.

$39.75 *Shpg. Wt. 28 Lbs.*

MODEL W-4A: Consists of Model W-4AM above *plus* Model WA-P2 preamplifier. $61.50* *Shpg. Wt. 35 Lbs. Express only*

Heathkit Model A-9B 20-Watt High Fidelity Amplifier Kit
Features full 20 watt output using push-pull 6L6 tubes. Built-in preamplifier provides four separate inputs. Separate bass and treble tone controls provided, and output transformer is tapped at 4, 8, 16 and 500 ohms. Designed for home use, but also fine for public address work. Response is ± 1 DB from 20 to 20,000 CPS. Harmonic distortion less than 1% at 3 DB below rated output.

$35.50 *Shpg. Wt. 23 Lbs.*

Heathkit Model A-7D 7-Watt High Fidelity Amplifier Kit
Qualifies for high-fidelity even though more limited in power than other Heathkit models. Frequency response is ± 1½ DB from 20 to 20,000 CPS. Push-pull output, and separate bass and treble tone controls.

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MODEL A-7E: Same, except that a 12SL7 permits preamplification, two inputs, RIAA compensation, and extra gain. $20.35* *Shpg. Wt. 10 Lbs.*

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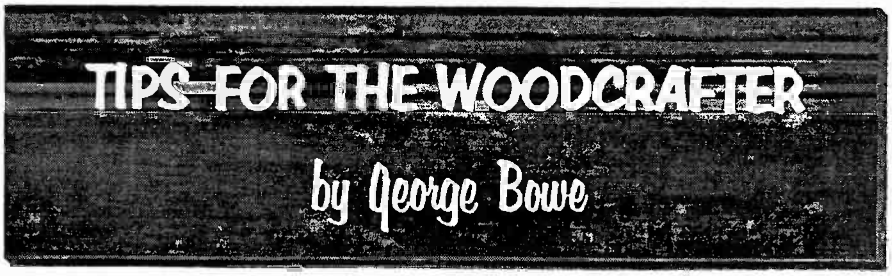

Sharpening Power Tools

Although the objective is the same — safety, accuracy, quality — the force of a rapidly turning motor makes sharpness in power tools even more necessary than sharpness in hand tools. So, from last month's discussion of putting an edge on hand tools, let's tackle the job of keeping the cutting edges of machine tools as keen as they should be.

The Circular Saw: Sharpening a circular saw is very similar to sharpening a hand saw. I believe it is best for the beginner to entrust the operation to a professional, but the craftsman who has been using the saw should have enough

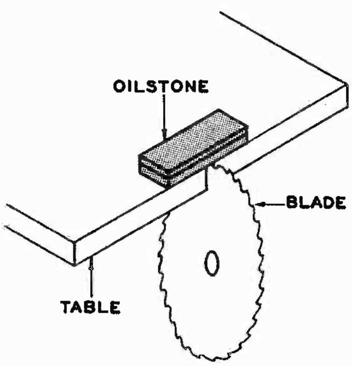

Fig. 1. Jointing a circular saw blade.

understanding of the blade to tackle the job. Four operations are involved — jointing, gumming, setting, and filing.

To joint the saw (make the teeth uniform in height), reverse the blade on the arbor, raise the table above the center of the opening in the table at right angles to the blade (Fig. 1). Start the motor and slowly lower the table until the saw teeth barely touch the oilstone, causing sparks to fly. Shut off the motor and examine the blade to see if all the teeth have been touched by the stone. If they have, your saw is perfectly round; if not, repeat the process.

After a saw has received many filings, the gullets between the teeth become shallow and frequently clog up with sawdust or resin. This gumming can be removed with a thin emery wheel or a file, but a simpler method is to soak the blade in turpentine overnight.

As with a handsaw, setting the teeth makes the kerf wide enough to prevent the saw from binding in the wood. An 8-inch blade can be set with the same tool used for a handsaw: a saw set, following the manufacturer's directions. However, blades of from 10 to 16 in. in diameter are set with a hammer and a special setting device (Fig. 2) that

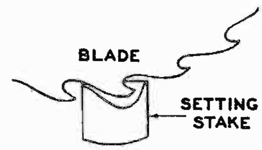

Fig. 2. Setting teeth of a large blade.

assures accuracy. Mark a starting point and set the first tooth bent away from you, followed by alternate teeth. When the starting point is reached, reverse the blade and repeat the process.

Crosscut, rip, and combination saws are filed with the existing bevel setting the pattern. The blade should be held in a clamp to prevent vibration. Mark a starting point and, using a flat mill file with rounded edges, take light strokes as you file the teeth bent away from you (Fig. 3). Be sure to use the same bevel as a guide. The rounded edges of the file will keep the gullets round; square gullets might cause the blade to crack. When you have circled the blade, reverse it in the clamp and proceed as before.

Jointer Blades: When jointer blades need sharpening by grinding, it is wise

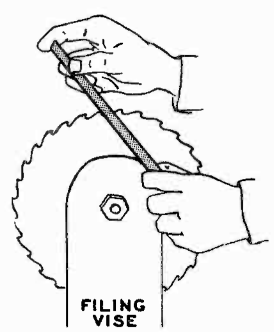

Fig. 3. Filing teeth with a mill file.

to take them to a professional. However, there is much the amateur can do to keep them in condition before such action is necessary. Before feeding any stock through the jointer be certain that the wood is free of any surface grime or imbedded matter which will damage the blades. When they seem to have dulled, they can often be restored by honing without removing them from the machine. Honing is indicated whenever the jointed surface comes out slightly rough or fuzzy. The process can be accomplished while the machine is stationary or in motion.

Stationary honing (Fig. 4) requires wrapping a fine oilstone in wax paper, leaving about a third of the stone exposed. The paper will prevent the stone from scratching the jointer table. Place the oilstone on the front table with the exposed end over the blade opening and lower the table until the stone lies flat on the beveled side of the blade. Wedge the cutter head rigidly in this position and stroke the stone back and forth across the blade until it is sharpened. Repeat the process on the other blades, using the same number of strokes.

To hone while the machine is running (Fig. 5), front and rear tables should be level with each other at the highest point of the cutting arc. Clamp a wooden stop block across the front

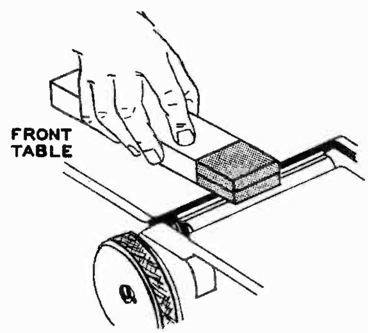

Fig. 4. Stationary honing of a jointer.

table immediately in front of the blades. With paper wrapped around the oilstone, place it on the table over the blade opening and against the stop block. Holding the oilstone securely, lower both tables until the blades lightly touch the stone. Slide the stone back and forth across the full width of the opening several times. Shut off the motor and check the edges of the blades. You will notice that a new narrow bevel has been formed. It should not be more than 1/32 in. in width, or the machine will not operate smoothly.

Shaper Cutters: Hone only the flat side (the face) of a shaper cutter by working it back and forth, first on the coarse side of an oilstone, and then on the fine side (Fig. 6). To finish, stroke the beveled edge very lightly with a fine oilstone to remove the wire edge, but use extreme caution not to change the shape of the cutter.

Mortising Chisel: The mortising chisel, which adds so much to the versatility of a drill press, can rely upon the drill press to keep it in topnotch cutting condition. The mortising, or hollow, chisel is comprised of four cutting edges forming a perfect square — actually four chisels in one. To simplify sharpening and assure a uniform bevel, fasten a cone-shaped grinding wheel

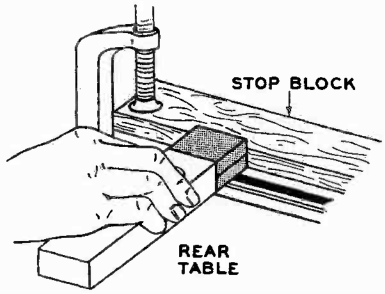

Fig. 5. Honing revolving jointer blades.

in the chuck of the drill press. Using a machinist vise or a clamp, secure the chisel in an inverted position directly beneath the point of the stone (Fig 7). Be certain that the chisel is at an angle of exactly 90°, then lower the revolving grinding wheel slowly and sharpen the four inside cutting edges in one operation. Since the cone cannot reach into the extreme corners of the chisel, they should be finished afterward with a square file. As a final touch, hone the outside surfaces very lightly with a fine oilstone. Bits used with a hollow chisel are sharpened by the same method as explained last month for regular woodworking bits. Using a small, flat augerbit file, sharpen the inside of the spurs following the arc of the edge; file the

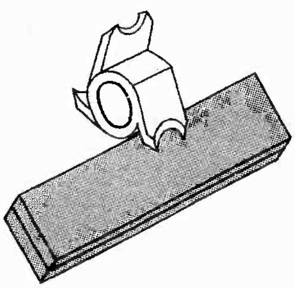

Fig. 6. How to sharpen a shaper cutter.

cutting edge of the lips on the side toward the shank of the bit.

The Oilstone: Because so much responsibility rests upon the common oilstone in keeping both hand and power tools razor sharp, let's give a thought to getting the most from that valuable, but inexpensive, implement. The best type of stone for all-around home-workshop

Continued on page 43

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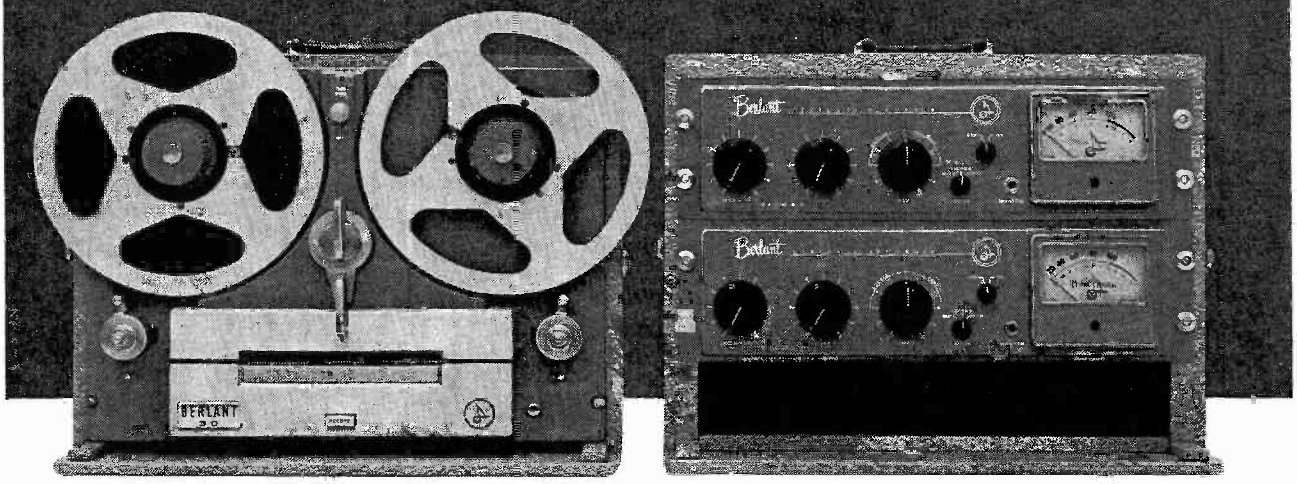

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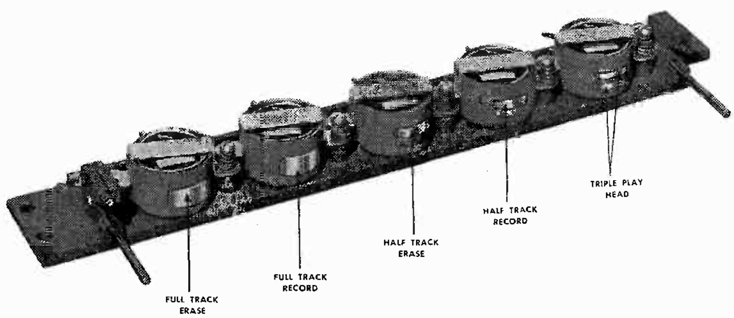

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TAPE NEWS & VIEWS

by J. Gordon Holt

Testing Recording Tape

To hear the differences between two loudspeaker systems it is only necessary to switch back and forth between them while playing some appropriate program material. Assuming the speakers to be of similar efficiency, the differences heard will represent accurately the differences between the speakers.

But comparing two brands of recording tape is another matter altogether. Even though it is simple enough to A-B two brands of tape by splicing a length of tape A to a length of tape B, and then recording through the splice, the audible difference between them is not likely to give any indication as to the relative quality of each tape. It is, instead, likely to indicate only that the recorder is more closely adjusted to the characteristics of one tape than to those of the other.

So far as magnetic properties of the oxide coating are concerned, there is really very little difference between the potential quality of one recording tape and another competing brand. Advertising claims of vastly improved high-frequency response and lower distortion should be viewed with some suspicion, because there have been few radical developments in oxide formulation during the past 5 years. With the outstanding exception of Scotch No. 120 high-output tape[1] (which is unlike anything else currently available), nearly all brands of recording tape are essentially the same in high-frequency response, distortion, and output characteristics.

This is not to be construed as meaning that they are identical in characteristics under the same conditions, for the magnetic properties of the coating oxides used are quite different from one brand to another, and the physical characteristics of competing brands differ significantly also.

All recordists who have looked into the theory of tape recording know that a tape's output level, distortion, and frequency response are intimately related to the bias current supplied to the record head. But it is not often realized that the critical bias-current setting is what accounts for most of the observable differences between recording tapes. For instance, if a recorder has its bias current adjusted to obtain maximum output at 400 cps from an average oxide formulation, the tape will be found to require about 23 db treble boost at 15,000 cps to obtain the NARTB tape-recording characteristic. With the record equalization so set, a narrow-gap playback head will give flat high-frequency response from that tape with the 3,000-cps NARTB playback curve. But if we record on a tape that requires a higher bias current than this, the result will be a considerable rise in high-frequency output, at slightly

higher-than-normal distortion and with slightly lower-than-normal output. On direct comparison the second tape could be said to have "vastly improved high-frequency response", but in view of the resulting loss of output and increase in distortion, this could hardly be considered an unalloyed advantage.

Several tape manufacturers have taken advantage of the fact that their tapes require higher than average bias current, and have touted the rising high end as evidence of a superior product. This is unfortunate because some of them have been proven outstandingly good in all respects when used with the *correct* bias current. There is really no need for indulgence in such misleading comparisons.

This does serve to show, however, that the choice of recording tape for home use can be important in terms of performance. If the tape recorder is equipped with a variable bias control, it can be matched to any tape, so the proper choice of a tape will depend mostly upon its physical quality (which will be discussed later). If the bias current is nonvariable or is not easily adjusted, though, the tape's magnetic properties will determine its suitability for the recorder.

The physical characteristics of a tape (as distinguished from its magnetic properties) will affect its performance only indirectly, in dependability, smoothness of motion, and durability in use. It might be well to consider them for a moment before getting to the matter of performance testing.

The ideal recording tape is impervious to breakage in normal use. This is self-explanatory, and in practice requires only that the tape's tensile strength be greater than the most severe pull that is likely to be encountered when braking from the fast-forward or rewind mode of operation.

A tape should not assume a permanent stretch before snapping under tension. All tapes will stretch to some extent, but the less permanent deformation that takes place before a break occurs, the easier it is to repair a break perfectly. A break can be spliced, but a decrease in pitch because of tape elongation cannot be corrected.

Ideally, a tape should be unaffected by extremes of temperature and humidity. This refers to physical changes in the tape, such as loss of tensile strength or tendency toward cupping when humidity increases. All tape will print through from layer to layer under extreme climatic conditions, but if the tape remains physically unchanged it can at least be used again.

The ideal tape has uniform coating thickness and base thickness throughout an entire reel, and from one reel to another. Variations in base thickness can cause uneven winding at high speeds and tend to reduce the tensile strength of the tape. Varying thickness of the coating will cause changes of output level and variations in frequency response within a reel or between different reels.

Further, the ideal tape has edges that are perfectly smooth and perfectly straight. Small nicks or rough spots along the edges of a tape provide easy starting points for breakage under tension, while a tape which is not cut straight will wind unevenly and scrape on the reel flanges.

Another qualification of the ideal tape is standard width throughout the entire

Continued on page 35

[1]Scotch No. 120 has a slightly lower bias requirement and produces 8 to 12 db more output (with no increase in noise level) for a given input signal than do other varieties of tape. Consequently somewhat different test procedures must be used when comparing it with competing varieties.

Readers' Forum

Gentlemen:

J. Gordon Holt seems to have a talent for hitting on topics to which I have particular sensitivity. In this instance I have no complaint with what he has said; I only wish he had said more.

In his column starting on page 12 of the June issue of AUDIOCRAFT, he wrote about a subject of particular interest to those of us who broadcast "good" music on a commercial basis. Our programs are made up principally of commercial disc and tape recordings, plus those tape recordings which we can make ourselves. Generally speaking, we obtain the commercial recordings directly from the manufacturers or their agents with the understanding that they are solely for broadcast use with label and/or artist credit suitably given. Our own recordings usually are even more restricted in use — perhaps we agree only to use them a limited number of times, or not to use them commercially, or perhaps they are subject to performance fees. It is difficult to make a general statement. Then too, we pay substantial fees regularly to ASCAP, BMI, and SESAC for the right to broadcast copyright musical material.

The question Mr. Holt has raised is that of the tape-recorder owner who records our broadcasts. With modern tuners and recorders, it is possible for the home hi-fi enthusiast to make excellent recordings of our transmissions. But what is actually the home recordist's right in such matters? Mr. Holt has clearly stated that a home recordist would be asking for trouble in putting out commercial recordings based on material picked up off the air. We think that the cautioning to your tape-recorder-operating readers should go further than this. It is very likely that a listener can tape record anything that comes from his tuner, provided the taping is done for his own personal enjoyment, without getting into serious trouble. Even here, though, if one were to tape just the music from a recording with the intention of avoiding the purchase of the recording, it is my impression that the record company, if it ever found out about the unauthorized taping, could and possibly would sue the offending recordist. A tape recording taken from a broadcast and used commercially in any manner (such as background music in a restaurant or for another radio broadcast) certainly could involve the recordist in legal

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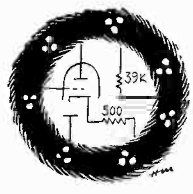
EDITORIAL

At the back of this issue will be found a comprehensive index for Volume 1 of AUDIOCRAFT Magazine. Vol. 1 consists of the first 14 issues, from November 1955 to December 1956 inclusive; future volumes will be composed of 12 issues each, from January through December of each year.

Even we were surprised, as we proofread the index, at the amount of valuable reference material it represents. We have extra copies of only a few issues; it would be wise, then, to protect your file of AUDIOCRAFT. Possibly the best way to accomplish this is to bind it by volumes. It happens that sturdy, good-looking binders are available for Vol. 1, at $3.50; ordering information is given on page 1 of this issue.



This is being written in the middle of the Audio Show season, just after the New York and Boston shows. Attendance records are being broken now with almost monotonous regularity. It seems to be unimportant whether an admission fee is charged or not; in New York, where the four-day show was held this year at the new Trade Show Building, 31,000 paid 50¢ or 75¢ to push their ways through the jammed halls. Total attendance was said to be 38,000. Estimated attendance at the three-day Boston show was 10,000 — also up substantially from last year. Obviously, hi-fi interest in the major cities is still increasing, even though it has existed there for many years.

Far more important than record-breaking attendance at the major shows, in our opinion, is the work being done to promote high fidelity in the secondary metropolitan areas. There have been several one-evening demonstrations and lectures in various cities which have achieved notable success. Unfortunately, they have been necessarily limited in effect because of sponsorship by a single dealer, manufacturer, or manufacturer's agent, or by a very small group of them. It is manifestly impossible to produce an expensive full-scale audio show under such circumstances. Every one of these affairs helps, but promotion on a grander scale is needed.

It is being provided now by an independent organization known as Rigo Enterprises, Inc., producers of High Fidelity Music Shows. These are actually full-size audio shows done in the conventional manner: one or more floors of a major hotel are taken over by the show management for the duration of each show; rooms on these floors are rented to all manufacturer-exhibitors on a first-come first-served basis; adequate publicity is obtained before and during the show. Each show is open for three days from 1:00 to 10:00 P.M., giving everyone a chance to attend. One additional idea worth noting is that, while each show is in progress, exhibiting manufacturers may participate in lecture-demonstrations of complete sound systems given periodically in a nearby auditorium.

Seven Rigo shows were held (in Columbus, Cincinnati, Atlanta, Miami, New Orleans, Dallas, and St. Louis) during the latter part of 1956. Although manufacturers were reluctant to participate at first, the enthusiastic approval — and heavy attendance — with which the public responded changed their minds, and many are now taking part. There seems to be little doubt that the enterprise will succeed. There are eleven shows scheduled for the first half of 1957: Milwaukee, January 4-6; Minneapolis, January 18-20; Seattle, February 1-3; Portland, February 15-17; Kansas City, March 1-3; Omaha, March 15-17; Denver, March 29-31; Salt Lake City, April 5-7; Pittsburgh, April 19-21; Cleveland, April 26-28; and Detroit, May 3-5.

These are not small markets in any sense. It is simply inexcusable that efforts have never before been made to reach them and others like them. Each show ought to leave a spark of interest large enough to grow healthily, forming the nucleus of a local hi-fi boom. It will take only a few dozen such expanding circles of interest to make awareness of high-fidelity sound truly nationwide. We believe that Rigo and the manufacturers co-operating with them should be congratulated on their enterprise and vision. We wish them increasing success. Finally, we hope that all readers living in or near one of these scheduled show areas will spread the word among their friends, and will attend the show themselves; even long-time audiophiles will find an audio show a unique experience. — R.A.

by JOHN J. STERN, M.D.

. . . build an AM crystal tuner

THE schematic diagram for the AM crystal tuner described here was first published in a Sylvania booklet, *40 Uses for Germanium Diodes.* It seemed to be the answer to a problem which has plagued many music lovers depending on AM radio — the relatively poor design of AC-DC AM table radios which are so frequently used as AM tuners in otherwise high-fidelity music systems. Since the chassis is usually

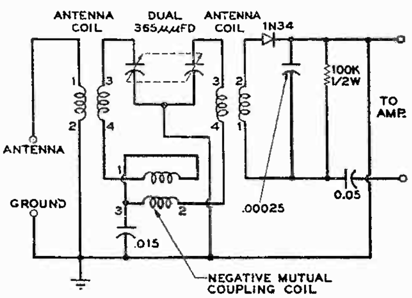


Fig. 1. Circuit of diode tuner is simple.

above AC ground potential, using such an AM radio as a tuner introduces hum into the system which can become annoying, even when the radio is not used but the record player or tape recorder is operating. It can be dangerous as well. Careful polarization of AC power plugs can reduce the hum, but with AM tuner, FM tuner, record player, tape recorder, and amplifier plugged into the same outlet, the probability of correctly positioning each plug in relation to all the others, and keeping it that way, is almost negligible.

A crystal tuner is independent of 60-cps AC current, since it contains no tubes that require a power supply, and it was anticipated that its use would eliminate hum. It did. Not anticipated, but welcome, was the improvement in over-all performance to a remarkable degree.

It seems that even a good AM table model is so designed that the high frequencies are attenuated. This intentional restriction compensates for the necessarily poor low-frequency response in a small set with a small speaker, producing better balance, and also hides the severe distortion. But when the detector section of the radio is used as a tuner driving a good amplifier and speaker, the poor frequency response becomes a serious drawback. The crystal tuner provides a remarkable improvement in the quality of AM reception.

Selectivity of the tuner is excellent; the volume, while not sufficient for headphones, is more than ample to drive an amplifier; and a careful listening test will reveal a beautifully smooth, crisp, wide-range quality which, with a good station, comes close to the character of FM. The tuner is, of course, only capable of bringing in stations within a radius of about 25 miles, and an antenna is needed. I used one lead of the FM antenna, and no ground was necessary; the amplifier seems to act as an efficient ground. Faint reception of some stations 50 miles away promises satisfactory pickup with a correct antenna.

Parts List

2 shielded antenna coils, Miller type 242-A.
1 negative mutual coupling coil, Miller type EL-56.
1 365-μμfd two-gang variable capacitor, Miller type 2112 or equivalent.
1 .01-μfd mica capacitor.
1 .005-μfd mica capacitor.
1 .00025-μfd mica capacitor.
1 .05-μfd paper capacitor.
1 100-K ½-w resistor.
1 1N34A germanium diode.
2 phono jacks.
1 ground lug.
6-32 screws and nuts.
Hook-up wire.
Chassis, 2 by 9½ by 5 in.

Construction Notes

An AM tuner of this sort is quite simple in design, as the schematic diagram in Fig. 1 shows. It consists only of a tuning section, to pass a desired station frequency and reject all others, and a detector circuit. A germanium diode ("crystal") is used as a detector; this, with an RC filter, removes the radio-frequency component of the desired signal passed by the tuning section, and the remaining audio modulation is fed to the output jack.

The circuit's simplicity is possible because no amplification is provided either for the radio frequency or for the detected audio signal. Accordingly it is inexpensive (total cost for parts, including chassis, is less than $9) and easy to build. Further, because it does not tune sharply, no high audio frequencies are lost; the full range of

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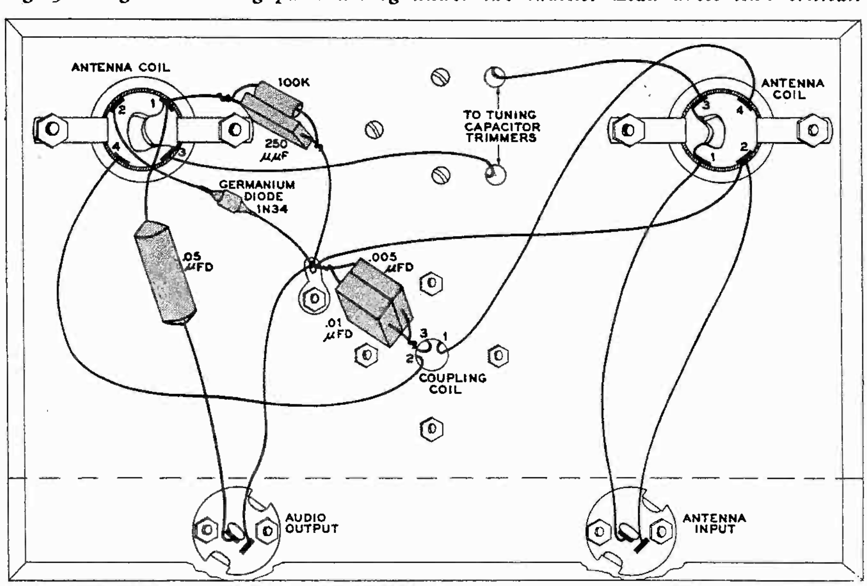


Fig. 3. Diagram showing parts wiring under the chassis. Lead dress isn't critical.

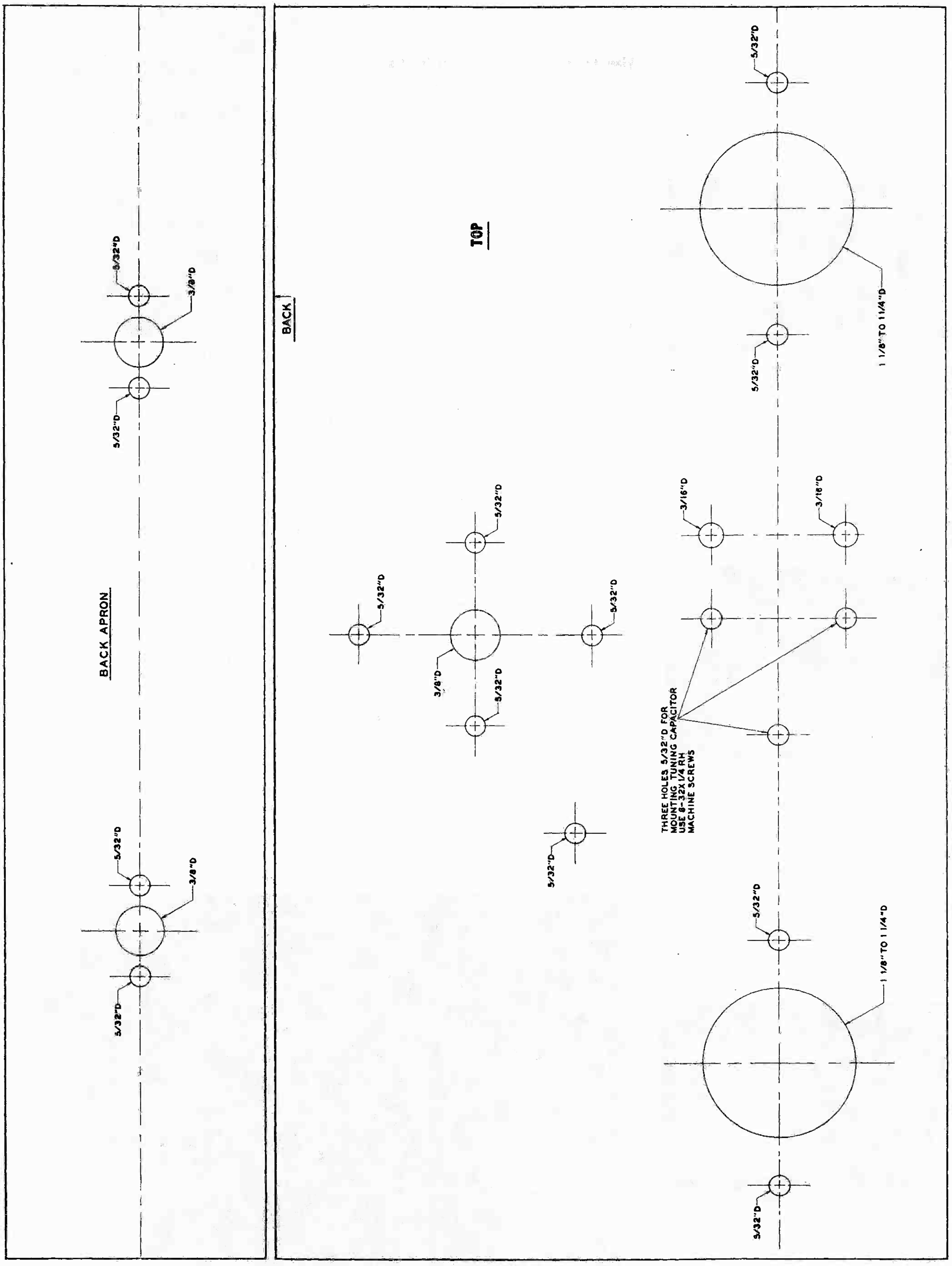


Fig. 2. Chassis punching template for Dr. Stern's tuner. This is full-size, so that no scaling or layout work is necessary.

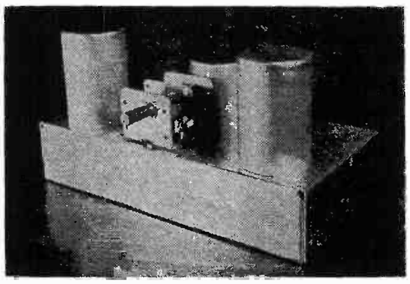
Continued from page 16

the station's modulation is retained. There is nothing in the tuner likely to wear out or become defective, so it should last indefinitely without maintenance.

There are some disadvantages too, as must be expected. The very lack of

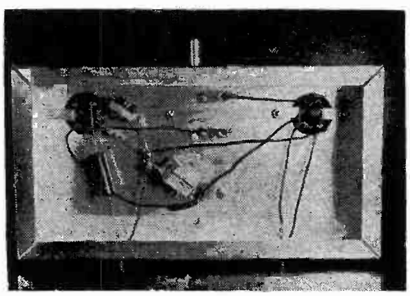
Antenna and output jacks on rear apron.

amplification makes the tuner useless in fringe areas, say beyond 25 miles from stations of average strength and 40 miles from high-power stations. Even within these areas a long outside antenna must be used, and the tuner's output must be fed to a high-gain amplifier or the microphone input of a preamp-control unit. A crystal tuner is



Coil cans and tuning gang mount on top.

not free of the usual AM troubles — static, fading after dark, and beat whistles — and may, indeed, be more susceptible to them than standard tuners. Still, if its distance limitation does not affect you, a crystal tuner offers a most inexpensive way to obtain AM fidelity better than that provided by any converted radio, and at least as good as that of most hi-fi AM tuners. A high-fidelity AM tuner having an infinite-impedance



This corresponds to pictorial, Fig. 3.

detector, however, will probably have lower distortion.

It is possible to make your own chassis of fairly thin sheet aluminum, since none of the parts to be mounted is heavy. This will shave another dollar off the price. We used a commercial chassis base 2 by 9½ by 5 in.; a full-size chassis punching template is given in Fig. 2 for those who use the same size chassis.

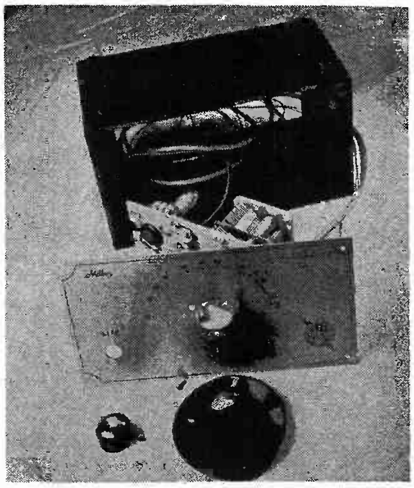
Parts are mounted as shown in the photographs, with the two large antenna-coil cans at each end and the small coupling-coil can behind the tuning capacitor in the center. A standard phono jack is used for the antenna connection, but a lug-type terminal board may be substituted with an appropriate change in the punching template. Both this and the audio-output phono jack are insulated from the chassis, all ground connections being made at a single point by means of a ground lug. The wiring is shown clearly in the pictorial diagram, Fig. 3.

It took us 3½ hours to lay out, scribe, and cut the chassis holes, mount the parts, and do the wiring. If the template (Fig. 2) is used, the job should be shortened considerably. We didn't attempt to add a dial, dial pointer and knob, but it could be done easily; dial assemblies are available at nominal cost.

AUDIOCRAFT Test Results

Here in Great Barrington there are no local stations on which the tuner could be tested. Taken to a few nearby cities, however, it worked perfectly well. Stations located in any given area are usually well separated in frequency, and the tuner had no difficulty in discriminating between them. Sound was wide-range (how wide depended on the station), clear, and free of hum and buzz.

Alignment is quite simple. If no dial is used, the tuning capacitor is adjusted to receive a station at the



Final assembly of the Miller 565 kit.

high-frequency end of the broadcast band, and the small trimmer screw at the back end of the tuning-capacitor assembly is adjusted for greatest sound volume. If a dial *is* used, the pointer is turned to read the frequency of a local station (at the upper end of the band, preferably); the trimmer screw at the front end of the tuning-capacitor assembly is adjusted until the station is heard with greatest volume, and then the rear trimmer is adjusted for greatest sound volume.

The Miller 565 Kit

The tuner described by Dr. Stern worked so well that we became curious about the Miller model 565 AM tuner kit, which is priced at $14.70. It is available completely wired and ready to operate, as the Model 595, for $19.50. We obtained the kit and built it also.

Examination of the schematic diagram for the 565 showed it to be almost

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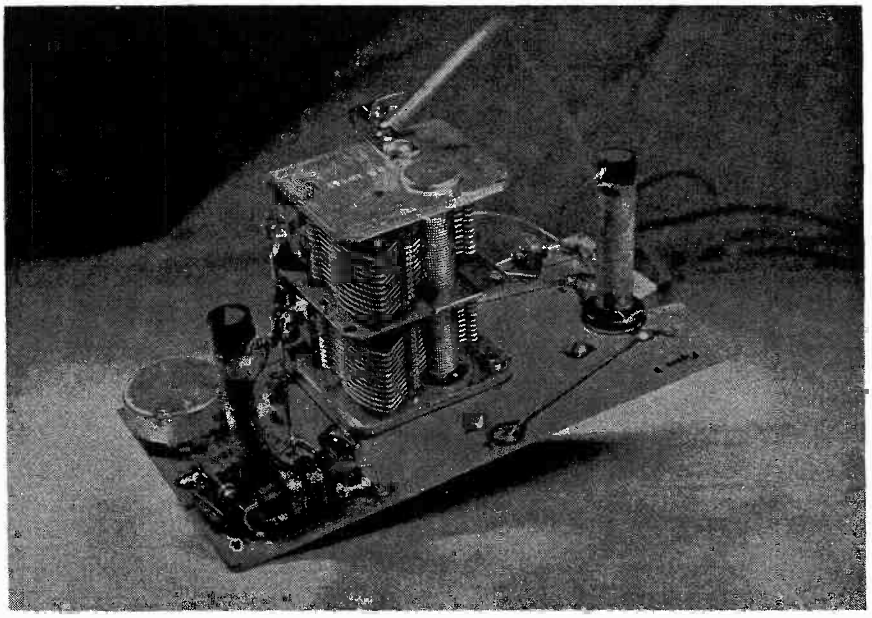
Detail of parts on back side of laminated wiring panel in the 565 AM tuner kit.



by Dr. JOHN D. SEAGRAVE

Part I

MINIMIZING PICKUP TRACKING ERROR

THE serious audiophile has been warned by discussions of the problems of pickup design to recognize the importance of minimizing "tracing" distortion in playback — failure of the stylus to trace all the details recorded in the groove — by proper choice of stylus force, and leveling or balancing of the pickup arm. He also knows that for minimum nonlinear electrical output from the pickup, the stylus tip and damping material must be in good condition and the magnetic circuit clean and symmetrical. It seems to be widely assumed that if he parts with another thirty dollars or so for a piece of hardware known as a "tone arm" in which to plug the pickup, and solemly observes the suggested ritual for mounting the arm, his worries about "tracking error" (failure of the pickup axis to be tangent to the record groove) are at an end. Hear, then, the sad facts[1]: few of the commercially available arms are designed to give minimum tracking distortion on the largest LP's they are supposed to handle! Distortion arising from tracking error can run up to 10% on loud passages with certain combinations of popular arms and cartridges, or more if they are carelessly mounted. It is the purpose of this article to show how optimally designed (or modified) arms can give less than 1% tracking distortion, or how a commercial arm can best be mounted to give the least distortion possible for its nonoptimum offset angle.

Nature of the Distortion

The distortion of a *single-frequency* recording arising from tracking error is almost entirely second harmonic, or frequency doubling, even for very large tracking errors. It will be shown that it arises kinematically as an alternating advance and retard of the reproduced signal with respect to the recorded signal, which amounts to a frequency-modulation of the signal by itself. Since it will be our object to develop means to minimize this source of distortion, we may treat the problem as "almost linear", so that we may regard other nonlinear effects as superposable, and the various linear playback losses as having already taken place. In short, we will assume that the stylus perfectly *traces* the groove. The groove can then be treated as a mathematical curve. The problem may be stated simply: if s is the distance along the groove axis, and $y(s)$ the displacement of the groove at s, what is the displacement $Y(s)$ of a stylus constrained to move in a line making an angle α (*alpha*) with the y-axis?

The general problem just stated will now be illustrated for the simple case of a recorded sine wave. In Fig. 1 the solid curve is such a sine wave of amplitude a constructed geometrically in terms of an angle Θ (*theta*), which we may identify with $2\pi s/\lambda$ if λ (*lambda*) is the wave length of a full cycle. Mathematically,

$$y(s) = a\,sin(\Theta = 2\pi s/\lambda). \quad \ldots(1)$$

Now if we draw through the point s a line making an angle α with $y(s)$, it will intersect the curve at a point s'. The displacement $Y(s)$ along the inclined line is plotted as a function of s for the deliberately exaggerated case of a tracking error $\alpha = 30°$. Its maximum amplitude is $a/cos\alpha$, and its distorted shape may be recognized as differing from $y(s)$ by a predominant second harmonic term, in phase with $y(s)$. It can be seen from Fig. 1 that

$$Y(s)\ cos\alpha = y(s')\ \text{and}$$
$$s' - s = y(s')\ tan\alpha. \quad \ldots(2)$$

Since $Y(s)$ has maximum amplitude $a/cos\alpha$ and the same period as $y(s)$, we might describe it in terms of an artificial phase angle Θ':

$$Y(s) = (a/cos\alpha)\ sin\Theta'(s). \quad \ldots(3)$$

This angle Θ' advances and retards with respect to Θ. With the aid of Eqns. (1) and (2), we can rewrite Eqn. (3) as

$$a\ sin\Theta' = Y(s)\ cos\alpha = y(s') =$$
$$(s' - s)\ cot\alpha = (\lambda/2\pi)(\Theta' - \Theta)\ cot\alpha \quad \ldots(4)$$

and finally as

$$\Theta = \Theta' - \epsilon\,sin\Theta',$$
$$\text{where } \epsilon = (2\pi/\lambda)\ a\ tan\alpha. \quad \ldots(5)$$

Eqn. (5) is *exact*, although we have derived it with reference to an illustration of a simple sine wave. It is, however, an *implicit* equation giving Θ as a function of Θ', while we want to find Θ' as a function of Θ. Higher mathematics is required for its exact solution, but fortunately an extremely good approximate solution will serve our purpose. An exact solution of Eqn. (5) for a sine wave is available[2] in terms of a series of Bessel functions, but for the small distortions we are considering (ϵ less than 0.1), the exact solution differs by less than one part in a thousand from the very much simpler expression,

$$Y(\Theta) = (a/cos\alpha)(sin\Theta + ½\epsilon\ sin2\Theta). \quad \ldots(6)$$

The Distortion Index

Let us rewrite the distortion parameter ϵ (epsilon) in more convenient terms. The wave length $\lambda = V/f$, where V is the groove velocity and f the frequency. $2\pi f = \omega$ (*omega*), and $\omega a = v$ is the transverse recorded velocity. If Ω (capital omega) is the turntable angular velocity and R the radius of the groove, $V = R\Omega$. Noting finally that $tan\alpha \doteq \alpha$ for small angles, we may write

$$\epsilon \doteq \frac{2\pi\ a\ \alpha}{\lambda} = \frac{\omega\ a\ \alpha}{V} = \left(\frac{v}{V}\right)\alpha =$$
$$\left(\frac{\omega a}{\Omega}\right)\left(\frac{\alpha}{R}\right) = \left(\frac{v}{\Omega}\right)\left(\frac{\alpha}{R}\right), \quad \ldots(7)$$

and, since $s = R\Omega t$ and $\Theta = \omega t$, Eqn. (6) becomes

$$Y(t) =$$
$$\frac{a}{cos\alpha}\left[sin\,\omega t + ½\left(\frac{a\omega}{\Omega}\right)\left(\frac{a}{R}\right)sin2\,\omega t\right], \quad \ldots(8)$$

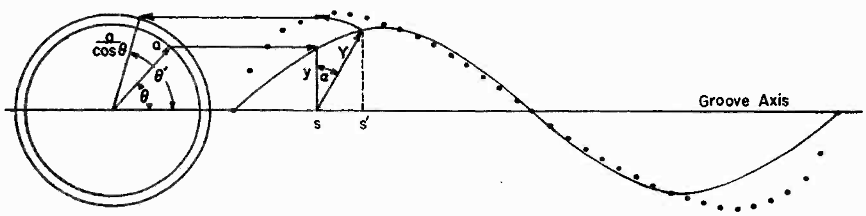


Fig. 1. Graphical construction of a sine wave, and the corresponding distorted wave generated by a tracking error of 30°.

[1] "Hi-Fi Pickup Arms", *Consumer Reports* 21, 245-251 (May, 1956).

[2] H. G. Baerwald, *Jour. Soc. Motion Picture Eng.*, 37, 591 (1941). Our Eqn. (5) is mathematically identical with the two-body problem of celestial mechanics, in which it is desired to describe the motion of a planet in terms of the phase of its "year". The parameter ϵ is then the eccentricity of the elliptical orbits. The solution of the astronomical problem was given by Lagrange in 1770, and more completely by Bessel in 1816.

for the amplitude of stylus motion. The velocity of stylus motion is the rate of change of $Y(t)$, designated dY/dt:

$$\frac{dY}{dt} = \frac{a\omega}{\cos\alpha}\left[\cos\omega t + \left(\frac{\omega a}{\Omega}\right)\left(\frac{\alpha}{R}\right)\cos 2\omega t\right]. \quad \ldots(9)$$

By comparing the second term with the first in equations (8) and (9), we see that *second harmonic distortion*=

$$\frac{1}{2}\frac{\omega a}{\Omega}\left(\frac{\alpha}{R}\right) \text{ or } \frac{\omega a}{\Omega}\left(\frac{\alpha}{R}\right), \quad \ldots(10\text{ ab})$$

for an amplitude pickup or a velocity pickup, respectively. For either case, the distortion depends on the instantaneous recorded velocity ωa, on the inverse of the record rpm Ω, and on the tracking error α divided by the groove radius R. As we shall see, α is a function of R, and for a given distortion α must be smaller for the inner grooves. Designing for minimum distortion is obviously a very different matter from simply minimizing the variation of α. If we put in Eqn. (10b) the values $\omega a =$ 10 cm/sec, $\Omega = 33.3$ rpm, and $\alpha/R =$ 1 degree/inch, we find 1.97% second harmonic distortion. Then, for any other values,

$$\%\ 2nd = 1.97 \times \left(\frac{\omega a}{10\ cm/sec}\right)\left(\frac{33.3\ rpm}{\Omega}\right)\left(\frac{\alpha/R}{deg/inch}\right). \quad \ldots(11)$$

Thus, to keep this kind of distortion below 2% on a 33.3-rpm record with recorded velocities over 10 cm/sec, the quantity (α/R), which we will call *the distortion index*, must be less than one degree per inch of radius.

We have confined our discussion so far to the distortion of a single sine wave of angular frequency ω. If there are two components of frequency ω_1 and ω_2, there will be distortion products $2\omega_1$, $2\omega_2$, $\omega_1 + \omega_2$, and $|\omega_1 - \omega_2|$, as in second-order distortion arising from nonlinearities, but with the important difference that the terms of tracking distortion are *weighted by their individual frequencies*, or, for a velocity pickup, by the squares of their frequencies. It is fortunate that records are made with a pre-emphasis requiring rolloff in playback, but in general the frequency-weighted character of the distortion terms will lead to a form of intermodulation distortion much larger than the single-frequency harmonics we have calculated, with a correspondingly larger nuisance value. Two percent second harmonic distortion in loud passages may go unnoticed, but the associated intermodulation of complex signals may be quite serious. It is for this reason that the distortion index (α/R), to which the IM as well as the harmonic distortion is proportional, must be kept as small as possible.

The Tracking Equation

In Fig. 2 is shown an arm of pivot-to-stylus length L, with the stylus in a groove at a radius R from the center of the record. The pivot is mounted at a distance $L - D$ less than the arm length from the center so there is an *overhang* D. The *tracking angle* ϕ (phi) is the angle between the line from pivot to stylus and the tangent to the groove. If the axis of the pickup makes the *offset angle* β (beta) with the same line, the difference $\phi - \beta = \alpha$, the *tracking error*, which is of course then the angle by which the pickup fails to lie along the tangent to the groove.

In the triangle SPC formed by the stylus, pivot, and table center, the included angle at the pivot is $90° - \phi$, and we may write the *Law of Cosines*

$$2RL\cos(90° - \phi) = R^2 + L^2 - (L - D)^2,$$

which is simply transformed to read

$$\sin\phi = \frac{R}{2L} + \frac{D}{R}\left(1 - \frac{D}{2L}\right). \quad \ldots(12)$$

This is *The Tracking Equation*. It gives the tracking angle ϕ as a function of groove radius R for an arm of length L

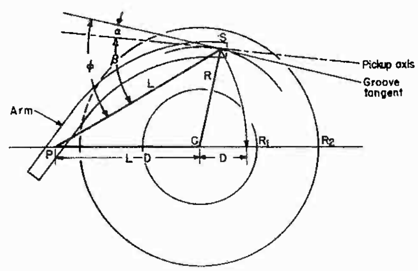


***Fig. 2. Geometry of record tracking. Arm of length* L *from pivot* P *to stylus* S *is shown mounted with an overhang* D *with respect to the turntable center* C. *Groove being tracked has a radius* R.**

and overhang D. For a fixed β, the tracking error $\alpha = \phi - \beta$. If the numerator and denominator of the second term in Eqn. (12) are divided by L, it is clear that ϕ can be expressed as a function of R/L and D/L, which means that it is possible to construct a *universal graph* of Eqn. (12), applicable to any arm. In Fig. 3, ϕ is plotted in degrees as a function of the ratio R/L for various values of D/L. The range of values plotted is appropriate to all ostensibly "high-fidelity" arms, and many other forms of record-player. Fig. 3 is reproduced in fine detail since it is a universal family of curves and can be used to find the distortion index variation of any arm it is desired to analyse. The plots are accurate to within 0.1 degree, and linear interpolation may be made for intermediate values of D/L. The universal curves are of course the same as the specific curves for a 10-inch arm, if the decimal points are moved over one digit to read R and D in inches.

Interpreting Distortion Index

If we choose an arbitrary value of β as our offset angle, then the tracking error $\alpha = \phi - \beta$ is the distance along the ϕ-scale between the line $\phi = \beta =$ *constant* and the curve of ϕ as a function of R for a particular value of D. For appropriate values of D with fixed β, portions of the curve for fixed D will pass on either side of the line $\phi = \beta$ and both negative and positive values of the tracking error will occur. Recall that it is α/R, not α, which is the index of distortion. In our graphical representation this is the *slope* of a straight line drawn from $\phi = \beta$ when $R = 0$ (the point $\phi = \beta$ on the ϕ-axis) and the point on the curve under consideration. For simplicity in illustrating the use of Fig. 3, let us assume that our hypothetical arm has $L = 10$ in. and that we are talking about an LP record with inside radius $R_1 = 2$ in., and outside radius $R_2 = 6$ in. Then we will be interested in the region of the family of curves between $R/L = 0.2$ and 0.6. First suppose we had no overhang, or $D = 0$. Though the curve for $D = 0$ isn't all on the graph, it is nearly a straight line and $\phi(0.2) = 5.7°$ and $\phi(0.6) = 17.5°$. If we were merely to minimize α, we would choose $\beta = 11.6°$. Then the value of α/R at $R = 6$ would be just under 1°/in., which is not bad, but at $R = 2$ it would be $-3°$/in. However, if we took $\beta = 8.6°$, the value of α/R at both extremes would be approximately 1.5°/in., of opposite sign, and numerically less at all points in between.

We can do rather better than 1.5°/in. if we use somewhat larger values of β and D. In the example worked above α was zero only once, but if β and D are properly chosen, we can make α positive near R_1 and R_2, negative between, and zero twice. Since the sign of the tracking error is of no consequence, this will result in smaller maximum values. The tracking error at $R_1 = 2$ should be about three times smaller than at $R_2 = 6$, if α/R is to be about the same. Suppose now we had $\beta = 21°$, and $D = 0.6$ in. Then $\alpha = 2°$ at $R_1 = 2$, $\alpha = -1°$ at $R = 3.2$, and $\alpha = 2.4°$ at $R_2 = 6$, and the corresponding values of α/R are 1, -0.3, and $+0.4°$/in. If β were larger or D smaller we could reduce the largest of these at the expense of the smaller, and continue by trial and error until all three extremes had the same numerical value, the middle one of opposite sign. Anticipating one of the results of a later section, where this "optimum" condition is calculated, let $\beta = 20.1°$ and $D = 0.53$ in. Interpolating a curve for $D = 0.53$, we find $\alpha = 0.9$, -1.4, and 2.7° at $R = 2$, 3.1, and 6, respectively. *All three* maximum values of α/R are numerically equal to 0.45°/in.,

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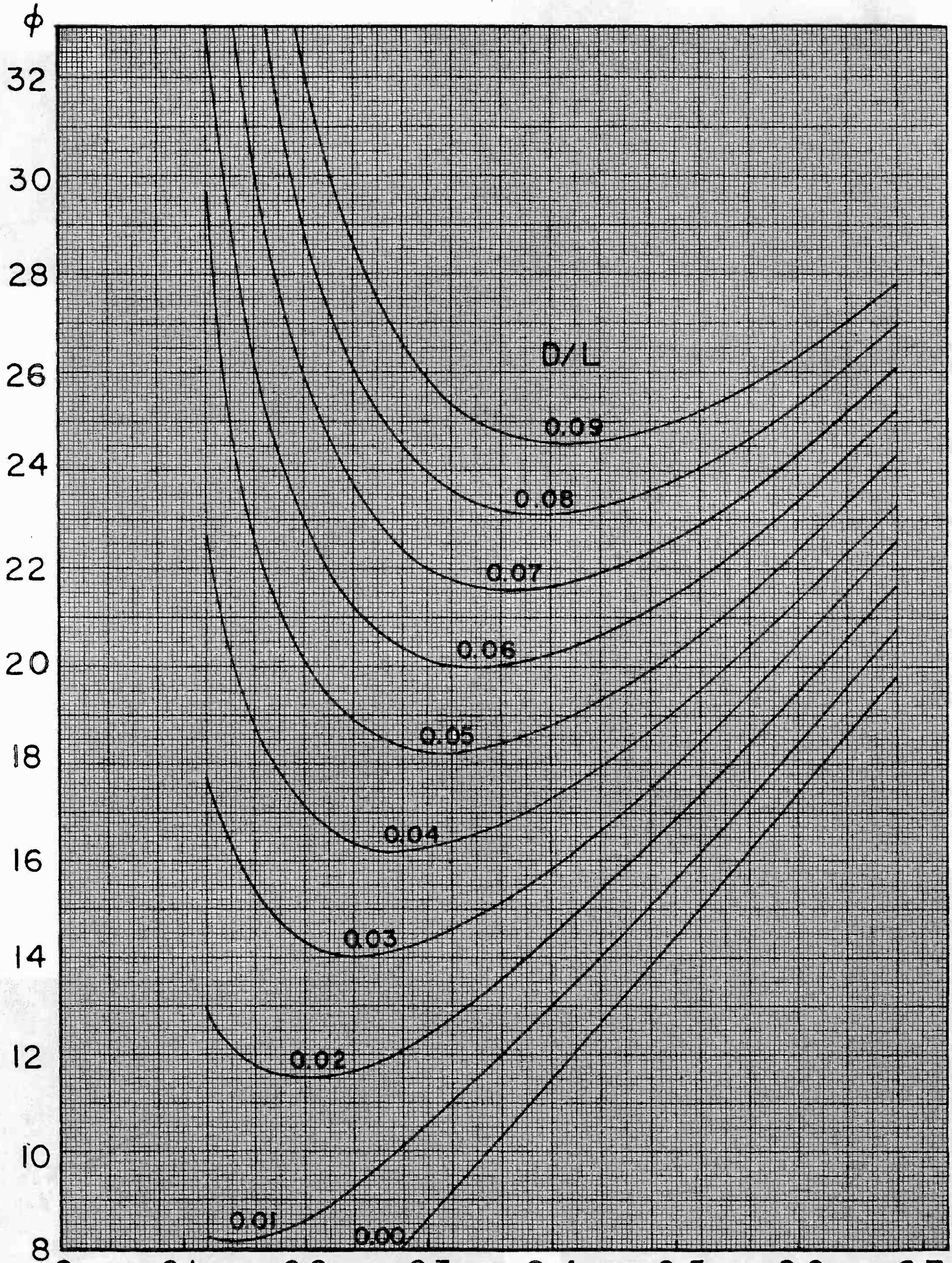
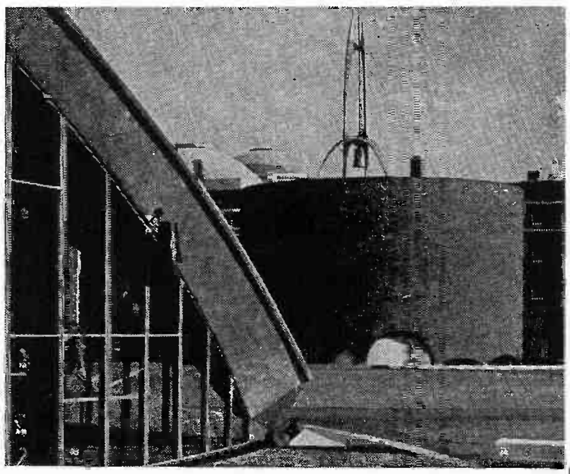


Fig. 3. Universal graph of the Tracking Equation. The tracking angle φ is given in degrees as a function of R/L *for various values of* D/L. *The distortion index* m *is the slope of a straight line connecting the point* $\phi = \beta$ *on the* φ*-axis with a point on the curve corresponding to the overhang* D.

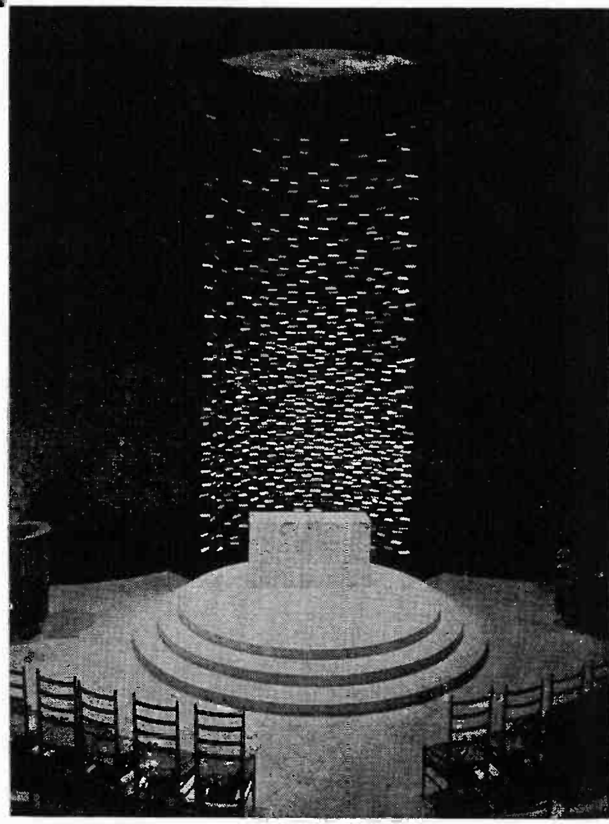


The MIT Chapel is a windowless brick cylinder-shaped building with a surrounding moat. Photos below show interior construction.

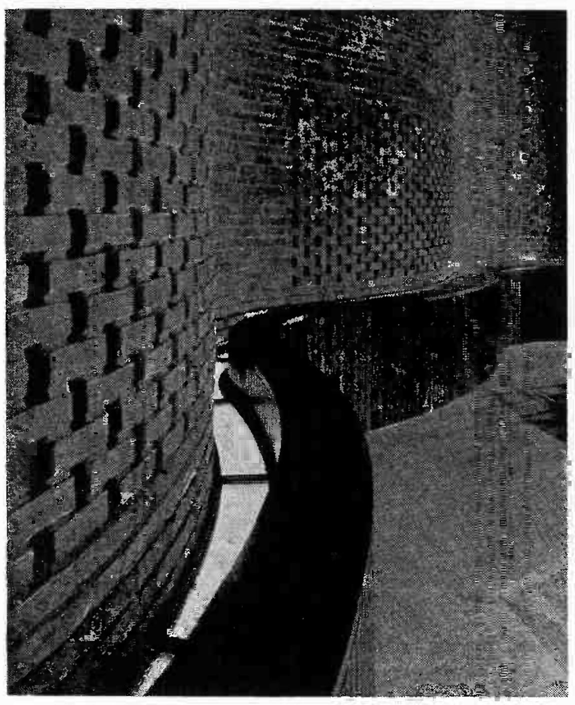
Recording at MIT

WHEN Kresge Auditorium and the MIT Chapel were completed in the spring of 1955, it was demonstrated beyond doubt that the fascinating study of acoustics is now more science than guesswork, and more than ever art. Both buildings are renowned for their simple beauty, which reflects the atmosphere of Massachusetts Institute of Technology in the finest of modern architectural techniques. Moreover, both were designed specifically to provide the excellent acoustical characteristics that have been obtained. Designers were Bolt, Beranek, and Newman.

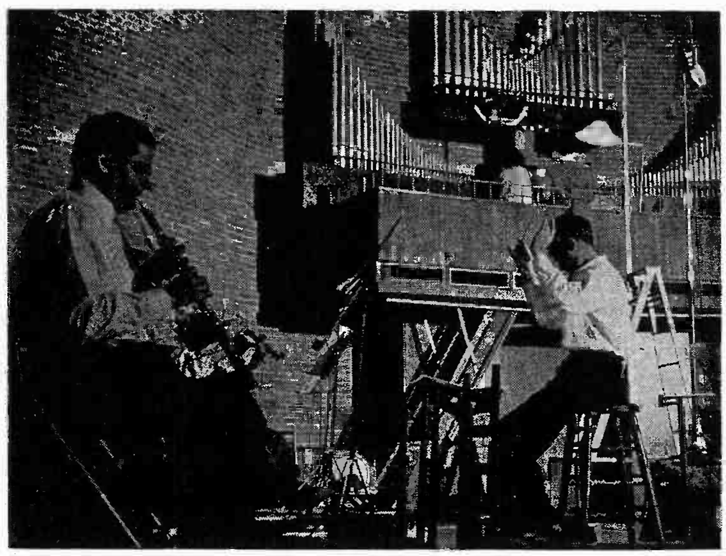
Kresge Auditorium is a domed structure of about 350,000 cu. ft., wood-paneled over much of its interior. About 1,000 sq. ft. of the rear wall is covered by a 6-inch layer of glass fiber which is faced by woven plastic. Reflective "cloud" panels below the ceiling are adjustable, and affect sound quality to some extent. *Continued on page 34*



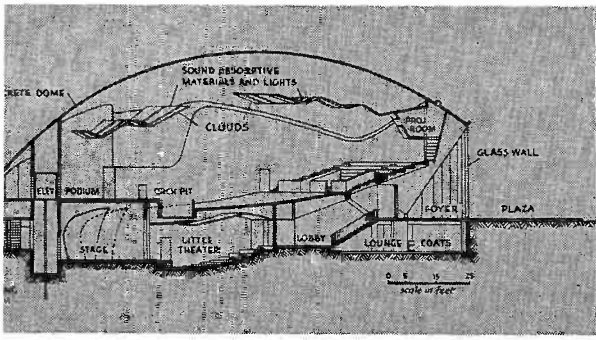
View of the chapel altar, backed by toplighted screen. The ceiling is shaped like an inverted cone mounted off-center, and brick walls are curved irregularly to diffuse sound.

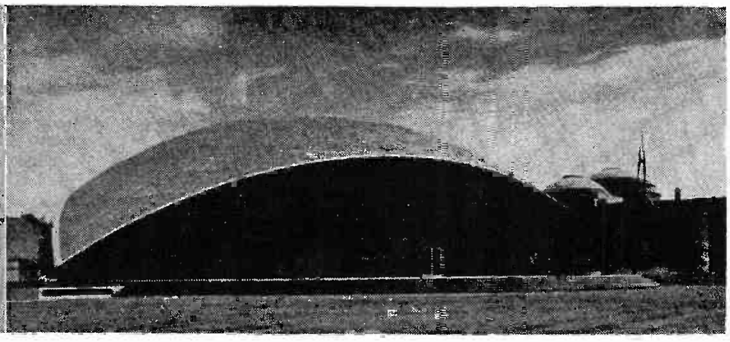


Sound-absorbent material is behind grilles in the wall.

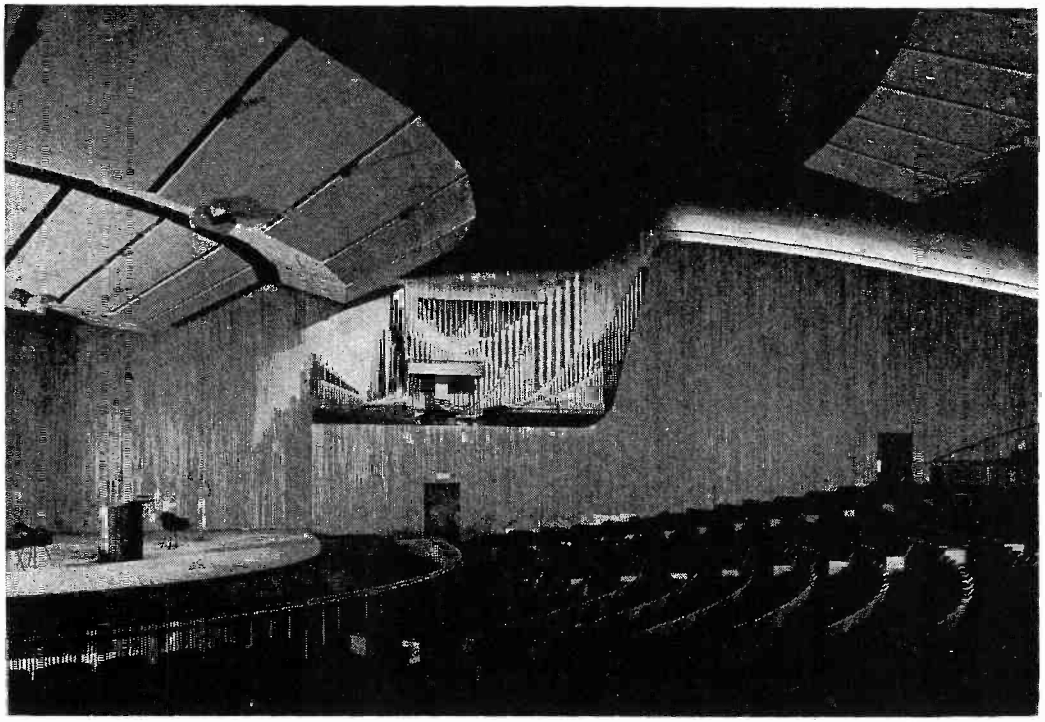


Recording Handel organ concertos in chapel; Lawrence Moe is organist.

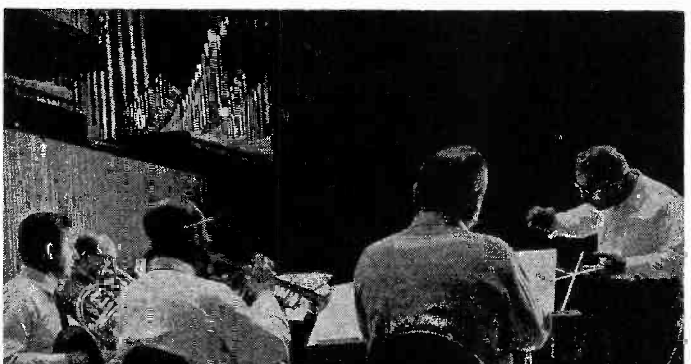




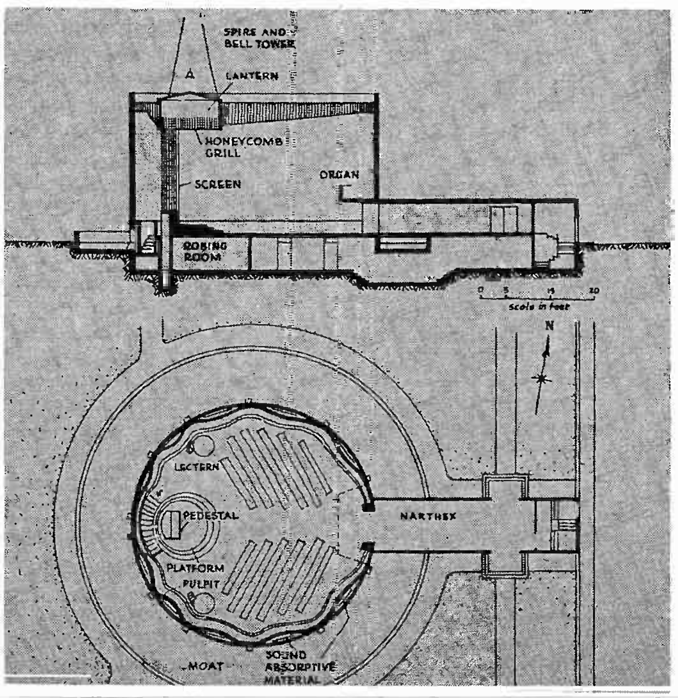
Cross-section of Kresge Auditorium, with an exterior view at the right. Concrete dome has three primary suspension points.



Interior of Kresge Auditorium. Holtkamp organ has positiv, great, and pedal pipes entirely open to view; only swell pipes are enclosed. Auditorium and chapel are virtually ideal for recording, and served for recent Music at MIT *series of Unicorn releases. Below at right are chapel layout plans.*



Roger Voisin and his brass ensemble recording in the Auditorium.



by George L. Augspurger

LOUDSPEAKERS and ENCLOSURES

IV: Horns and Horn Enclosures

IN this series of articles so far we have discussed two basic types of loudspeaker enclosure: the infinite baffle and the tuned-cavity (bass-reflex) system. Provision is made in each system to offset the loss of lower frequencies, which is an inevitable property of fairly small sources of sound, by means of resonance. The infinite baffle depends on increased cone amplitude at resonance to even out its frequency curve, while bass-reflex enclosures effectively add radiating area to the speaker over a limited range of bass frequencies.

We have also mentioned that the efficiency of cone speakers is quite low — on the order of 3% to 4%. Part of the bass loss and the generally low efficiency can be traced to an acoustic mismatch between the speaker system and the surrounding air. As P. G. A. H. Voigt explains, "Most people concerned with speakers think only of the four major items: magnet, voice coil, diaphragm, and some means of baffling the sound pressure in its efforts to take a short cut from one side of the diaphragm to the other. They overlook the fifth item, which is just as im-

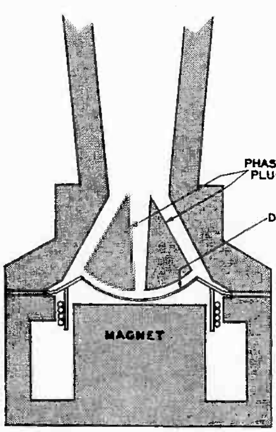


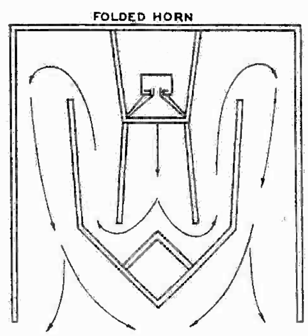
Fig. 1. Throat of high-frequency horn.

portant: namely, the air between the operative face of the diaphragm and the listener."

Mr. Voigt found the answer in experimenting with horns. In the August issue of AUDIOCRAFT we credited much of the original work in twin-cone loudspeakers to Mr. Voigt. The present acceptance of horn-type systems can also be traced, in part, to this British designer. Voigt and others discovered that a properly designed horn acts (over a limited frequency range) as an acoustic transformer to correct the impedance mismatch between a cone-type loudspeaker and the surrounding air. More properly, a horn couples sound energy from high pressure and low velocity at its throat to low pressure and high velocity at the mouth.

Basically, a horn is a tapered tube of some sort with a sound source at the smaller end. The manner in which cross-sectional area increases from throat to mouth is called the flare; and the flare, together with throat area and horn length, determines the operating characteristics of any particular horn, whether used for hi-fi reproduction or calling sheep.

Most theoretical considerations of horn design assume an infinite horn, and in this case the flare alone is the controlling factor. Two variables are involved: the shape of the flare (that is, the formula which regulates the expanding cross section), and the flare constant. For those readers who resent this sort of simplification, full mathematical treatment can be found in Olson's *Elements of Acoustical Engineering* or any other good acoustic-engineering text. In this article, however, I will continue to talk about shape and flare constant since these terms seem to indicate well enough the distinction between the two elements.



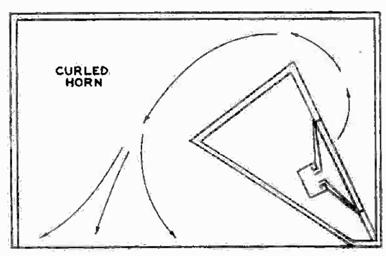


Fig. 2. Two variations of low-frequency horn.

The flare shape affects the acoustic impedance at the throat of the horn. Various shapes may be used, but the most common in high-fidelity design is the exponential curve. The reason is that the exponential horn loads a speaker quite uniformly over the entire range of frequencies which the horn is designed to handle. The standard formula for an exponential horn is

$$S = S_0 \varepsilon^{mx},$$

where S is the cross-sectional area at point x along the axis of the horn; S_0 is the cross-sectional area at the throat (small end) of the horn; ε is the quantity 2.718, the base of natural logarithms; m is the flare constant; and x is the distance from the throat along the axis. It is more easily explained as a horn in which the cross-sectional area doubles at equal distances along the length of the horn. The distance in which this doubling occurs determines the low frequency limit of the horn's impedance-transforming properties, and is determined by the flare constant.

Low-frequency cutoff can be quite accurately determined with more complicated formulas, but a good rule of thumb to remember is that a horn which doubles its area every foot cuts off at about 60 cps. Similarly, one which doubles every 2 ft. will have a 30-cps cutoff, and a horn whose cross section doubles every 6 in. will have a lower limit of about 120 cps. Above the cut-off frequency thus determined, the load on the speaker will be almost purely resistive. At frequencies below that for which it was designed, a horn acts as an inductive load — it is as though an additional mass had been attached to the driver cone. In some horn designs this inductive reactance is used to extend the frequency response below the natural cutoff of the horn, as will be explained a little later on.

Courtesy Jensen Mfg. Co.

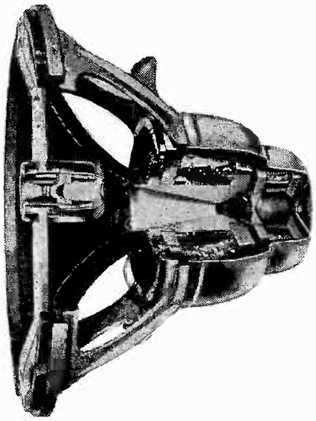


Fig. 3. Unitary three-way loudspeaker.

The formulas for theoretical response of an infinite horn apply for a finite one, provided that the mouth diameter (for a circular horn) is at least one third the wave length of the lowest frequency to be reproduced. This means a horn mouth almost 10 ft. across for a 40-cps horn. No commercial horn-type speaker has ever been marketed in this country with a cutoff frequency lower than 40 cps, and it is easy to see why.

Before we continue to the more interesting considerations of practical horn design, there is one more basic problem that should be mentioned. It would seem common sense to couple a loudspeaker to a horn simply by designing the horn throat to have the same area as the speaker cone, and then screwing the two together. However, higher efficiency can be obtained if the horn throat is smaller than the driver diaphragm and this necessitates some sort of coupling chamber. Since the distance from the horn throat to the source of sound is different at various points on the diaphragm, phasing plugs have been designed to minimize high-frequency losses in the coupling chamber (Fig. 1). This is mainly a problem in public-address units and horn-type tweeters.

Low-frequency units are not so critical in this respect. A plain box may be used as a coupling chamber, since high frequencies are not meant to be reproduced by the bass horn at all. Such designs are also commonly coiled or folded to conserve as much space as possible, Fig. 2, and this again is possible only because the lower frequencies are quite insensitive to minor discontinuities. Folds and bends do all sorts of

Courtesy James B. Lansing Sound, Inc.

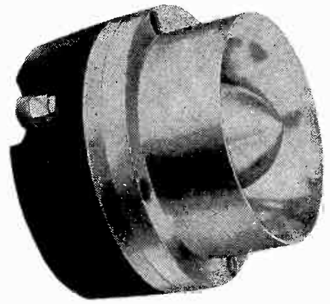


Fig. 4. Driver-horn for extreme highs.

discouraging things to higher frequencies; that is why the reflex configuration common in PA horns is so seldom used in high-quality tweeter horns.

A properly designed horn not only raises the efficiency of the speaker system, but the uniform acoustic load it provides damps the driver quite heavily, and so reduces resonances and distortion. As Mr. Voigt puts it, "For life-like reproduction, good transient response is even more important than the far extremes of frequency scale. Damping improves a diaphragm's ability to follow transients accurately, and air loading is an excellent way of providing damping. By using a horn, it is possible to extend downward the frequency range over which reasonable matching, and therefore air loading, is maintained. Unfortunately, just 'any old horn' will not do, for a bad horn may sound worse than the trouble one is trying to minimize."

The fact is that it is easier to design a bad horn than a good one. Perhaps the best method of illustrating how these considerations of horn design

Courtesy Klipsch & Associates

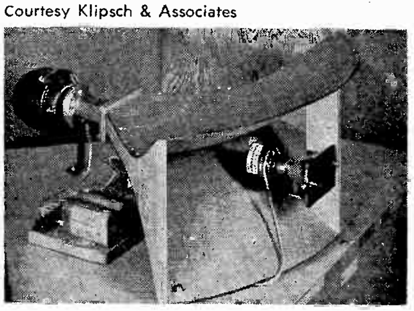


Fig. 5. Squawker & tweeter horn array.

apply to *good* speaker systems is to take a look at a few commercial horn-type systems.

High-Frequency Horns

Fig. 3 is an excellent cutaway photo of the Jensen G-610 Triaxial speaker, which is actually a cone-type bass driver and two higher-frequency horns combined in one assembly. The middle-frequency horn is mounted inside the center pole of the bass unit's magnet, so that the curved speaker cone serves as part of the horn flare. The coupling chamber and phasing plug show quite clearly. A separate superhigh-frequency horn is mounted at the front of the unit; all three drivers have completely separate electrical and magnetic circuits.

A novel tweeter design recently marketed by James B. Lansing is the Ring Radiator illustrated in Fig. 4. Instead of a circular diaphragm, with its attendant resonance and phasing problems, the sound source is a light ring driven by a fairly large voice coil. This annular sound source feeds a sort of doughnut-shaped horn and the whole thing winds up in what is virtually a circular mouth.

The middle- and high-frequency sections of the famous Klipschorn are shown in Fig. 5. The squawker horn is made by Klipsch from his own design — the peculiar duckbill shape is especially plotted to give uniform dispersion over a 90° angle. The high-frequency unit mounted in the mouth of the larger horn is the University 4401 tweeter. In spite of its modest price, the 4401 compares with many more pretentious tweeters, and what Klipsch especially likes is that its efficiency corresponds to that of the rest of the system. Many high-frequency horns are so efficient

Courtesy Altec-Lansing Corp.

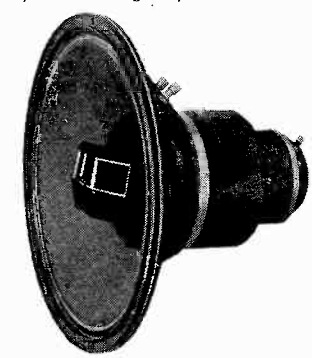


Fig. 6. A coaxial (2-way) combination.

that a pad has to be used to balance their output with associated speakers. Mr. Klipsch considers it rather simple-minded to spend money for an amplifier with a high damping factor, and throw away all the benefits of electrical damping by inserting a constant impedance pad between the amplifier and the speaker. Regulating brilliance with tone controls does not affect speaker damping, but putting a control on the speaker itself upsets the electrical coupling between the amplifier and the speaker system.

In the Klipschorn, both middle- and high-frequency units employ special

Continued on page 38

TRANSISTORS *in Audio Circuits*

by PAUL PENFIELD, JR.

IIa: Junction Transistor Characteristics

THE preceding two installments in this series stressed the physical nature of the junction transistor, and discussed a few other types of transistors and semiconductor devices. A phys-

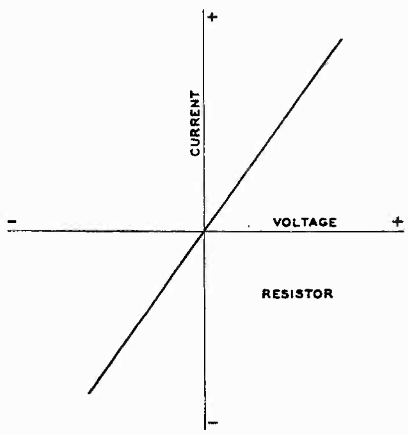


Fig. 1. Volt-ampere curve for resistor.

ical picture of the transistor, and of transistor action, is not directly useful in designing transistor circuits. However, it is very important in the long run, for while a designer can get by without this intuitive understanding, he cannot do his best, and is often at a loss to explain unexpected effects. Furthermore, it is easier to remember the electrical properties when they are related to a good knowledge of transistor action. Finally, the abnormalities and unusual characteristics of transistors are most easily explained by referring to the physical picture of the transistor at work.

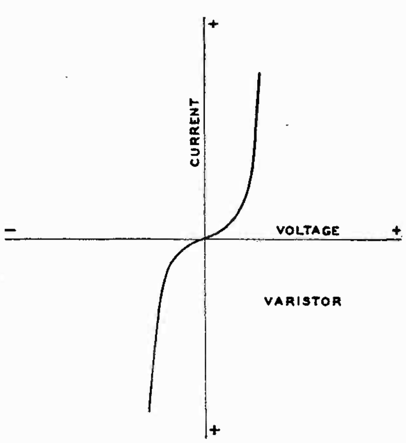


Fig. 2. Varistor has a nonlinear curve.

But it is necessary also to be familiar with the electrical properties of transistors. This installment deals with the electrical characteristics of common junction transistors, and the way these vary under different conditions. I will discuss the common curve families in terms of nonlinearities, and maximum ratings, and then talk about transistor noise and high-frequency response.

The Collector Family

For any electrical device the most interesting information is usually found in its *volt-ampere characteristic*. This is a plot of the current in the unit *vs.*

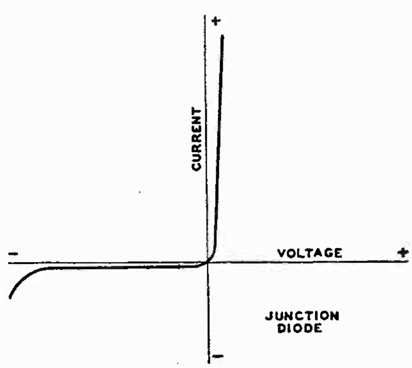


Fig. 3. Diode curve is unsymmetrical.

the voltage across it. With a resistor, for example, a straight line tells the whole story; see Fig. 1. A varistor, a junction diode, and a neon light all require more complicated graphs, as in Figs. 2, 3, and 4. Note that the neon light even has two lines at some voltages — indicating lighted and not-lighted conditions. For some devices such as a capacitor, no volt-ampere plot is possible; instead, as in Fig. 5, voltage may be charted *vs.* charge.

For a three-terminal device such as a transistor, several such plots are pos-

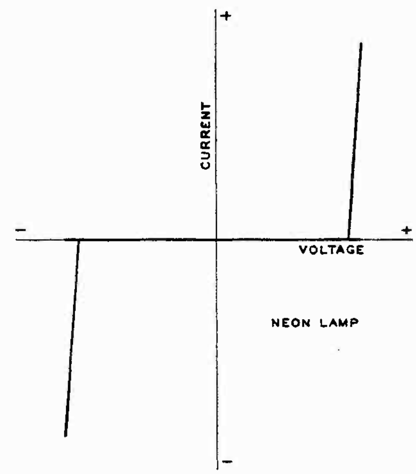


Fig. 4. Multi-valued volt-ampere curve.

sible. Usually the current into (or out of) one terminal is plotted for changing values of the voltage between that terminal and one of the other two, with a number of different fixed conditions of the third terminal.

The most useful *family plot* like this is shown in Fig. 6. Here the collector current I_c is plotted against the collector-to-emitter voltage V_{ec}, for a number of different values of base current I_b. Base current is here called the *running parameter*. This graph is known as the ground-emitter collector family.

Fig. 6 does not apply to any given transistor; rather, it shows all the characteristics of junction transistors as a class, and indicates clearly the limited region in which transistors usually operate. Fig. 7 shows the circuit which produced (or could have produced) the curve family of Fig. 6.

First, look at the so-called *linear* region — where the lines of constant base current are roughly horizontal. It is here that most people use the transistor. Here the distortion is the lowest, and the amplification the highest. If we fix the collector-to-emitter voltage at some constant value (as, for example, by connecting a battery between the collector and emitter) and vary the base current, we find ourselves going straight up and down on the graph, along such

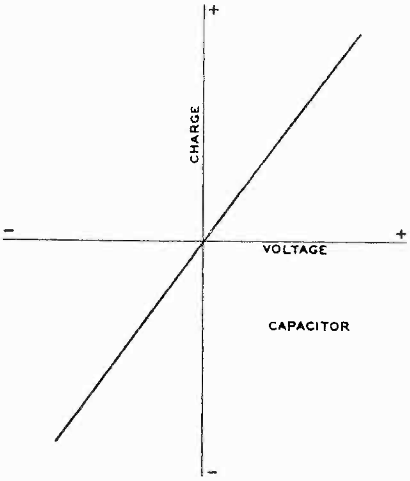


Fig. 5. Capacitor charge vs. *voltage.*

a line as CD in Fig. 8. If the base current varies, say, between points A and B in Fig. 8, the collector current will vary also, and considerably more than the base current. In this example it varies about 49 times as much. This is merely transistor action at work, and the explanation in Part I of this series would predict this sort of behavior.

It was remarked before that the value of collector voltage had little effect on the collector current. This holds true in the linear region: the lines of constant base current are almost horizontal, indicating that the collector current is indeed independent of the collector voltage to a large degree.

Lines in the linear region are nearly equally spaced and parallel; if the device were truly linear, they would be exactly equally spaced and parallel. Some distortion-causing nonlinearities occur even inside the commonly used "linear" region.

That region to the left of the linear area (shown enlarged in Fig. 9) is known as *saturation*. Here all the collector current that can flow is flowing, and a further increase in base current can increase the collector current very little. It happens in many transistors that the minimum collector voltage for any given collector saturation current is proportional to that saturation current, at least approximately. Consequently, the saturation line behaves like a resistance — hence the saturation characteristics of a junction transistor can be almost completely specified by giving its *saturation resistance*. In Fig. 9 this is about 20 ohms.

For certain types of nonlinear operations (such as power switching) it is important to have as low a saturation resistance as possible, although for normal low-power audio work it doesn't much matter.

Saturation is the high-current, low-voltage region. The linear region is limited also on the low-current, high-voltage end — this time by the cutoff current.

Remember that a reverse-biased collector junction does allow a little current to flow through it, current that is caused by thermal effects. This cutoff current depends on the temperature, and only slightly on the junction voltage. Remember further that the transistor, when biased in the normal direction, with the base floating, amplifies this cutoff current by means of the hook multiplier.

Now refer to Fig. 6 again, or the enlarged view shown in Fig. 10. Here

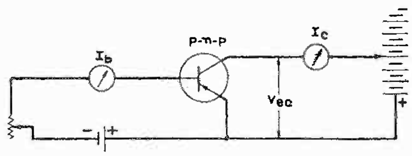


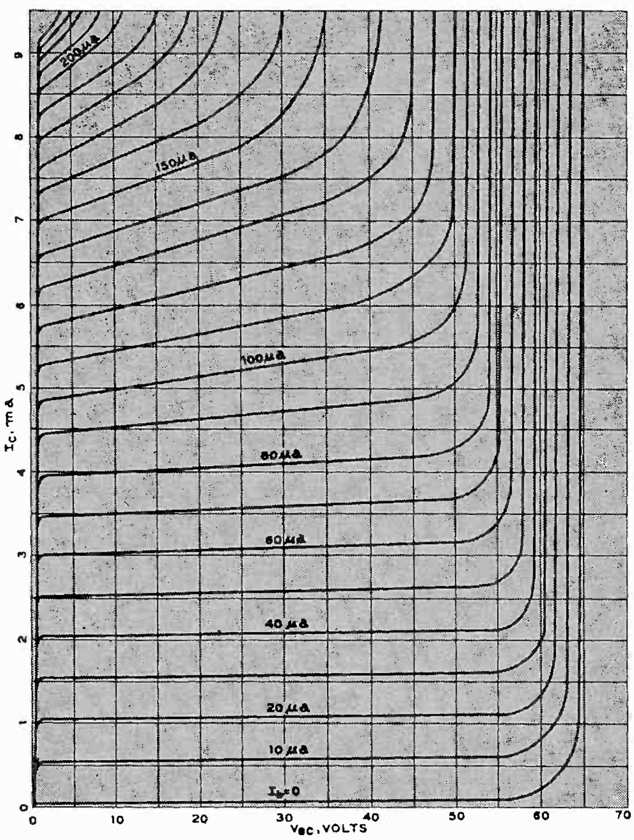
Fig. 7. Circuit used for Fig. 6 curves.

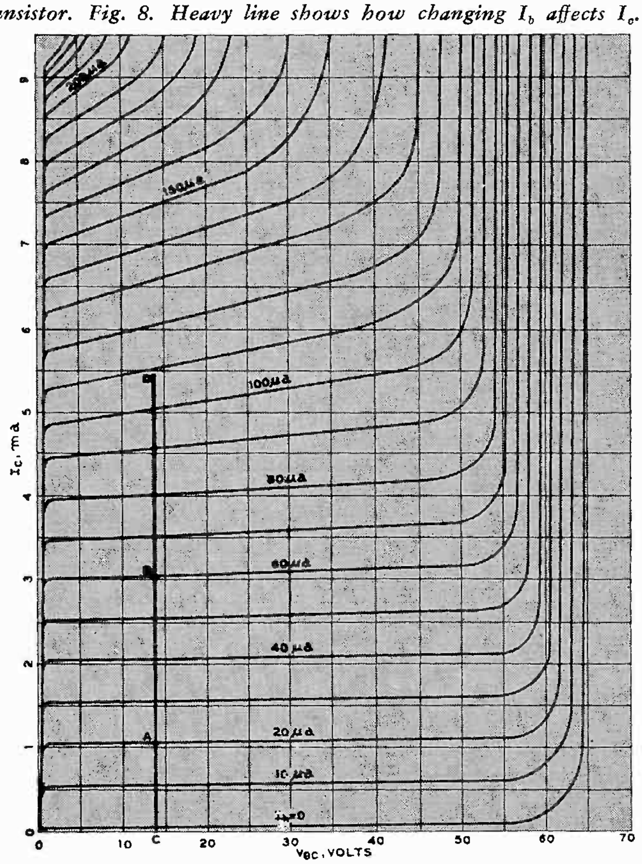
the line of zero base current is at about fifty microamperes collector current — that's one microampere cutoff current multiplied by the hook mechanism fifty times.

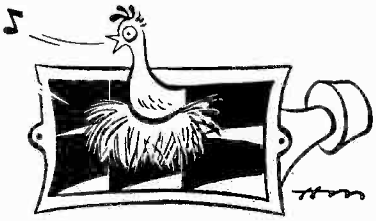
As far as the transistor is concerned, there is nothing particularly significant about the value zero for base current. It is possible to make the base current reverse a little bit and still remain inside the linear region. In fact, the base current can go negative as much as the normal cutoff current I_{co}, at which point the emitter current becomes zero. The

Continued on page 32

Fig. 6. Volt-ampere curves for collector of grounded-emitter transistor. Fig. 8. Heavy line shows how changing I_b affects I_c.







Sound-Fanciers' Guide

by R. D. DARRELL

TRADITIONALLY, the December installment of most record-review columns is devoted, at least in part, to the outstanding new releases of pertinently "seasonal" music: a tradition which has become increasingly irksome to maintain in recent years, since copy must be prepared before many holiday-scheduled records actually arrive, and by the time that copy appears in print a great many listener-readers are completely fed up with the excessive commercial exploitation of Christmas in sound — as well as in almost every other way. Moreover, few recordings of the appropriate musical materials are technically notable enough to warrant extended discussion in this particular column.

Yet by sheer chance, two of this year's Christmas specials are not only already well known (in other forms) to me, but are so exceptional in their sonic as well as musical appeals that it's a joy to commend them to your attention — even if you think you never want to hear another carol again, and even if you steadfastly refuse to countenance any compromise in technical standards.

The first, which has been around since 1952, now is scheduled to reappear under the same number (RCA Victor LM 1711) in what I hope is merely a reprint, for I can't imagine how any re-recording or reprocessing, however skillful, could capture any more transparently some of the outstanding examples of unaccompanied small-ensemble singing on discs. The Robert Shaw Chorale has made many fine records, but no other quite approaches the beautifully restrained yet infectious expressiveness, combined with the characteristic Shavian rhythmic precision and verve, of the *Christmas Hymns and Carols*, Vol. 2. And the conventionality of the title gives no true index to the refreshing choice of materials, which includes (in addition to several old favorites, topped by the best performance of the *The Twelve Days of Christmas* you can hear anywhere) many less familiar airs of Spanish, French, and Italian — as well as of English and American — origin. They are precious additions to the orthodox carol repertory, and the whole wonderful program is crowned by what to my mind is one of the most magnificent examples of "vocal chamber music", Victoria's motet, *O Magnum Mysterium*. There is perhaps no other disc in my permanent library which I have replayed more often or with more consistent delight, at any time of the year, than the original version of this LM 1711.

The second, dating in disc form from last year (Vox VX 25.010) and now scheduled for November or December tape release by Phonotapes-Sonore, is just about as different as it could be — for it is devoted to wholly familiar tunes (not excluding such pops as Berlin's *White Christmas* and Anderson's *Sleighride*), played by a nightclub pianist with rhythm accompaniment. But that pianist is Georges Feyer, and he doubles here as a harpsichordist; anyone who knows the best of his long "Echoes" series will need no further prompting to investigate, on disc or

tape, the present *Echoes of Christmas*. It may not be great musical art (although I'm not so sure about that, since many a more famous serious artist might learn something about deftness and tastefulness from Feyer), but it certainly is immense — and immensely satisfying — fun. Like the Shaw disc, this offers no apparent problems in reproduction and sounds effective on almost any kind of equipment. But in both cases, hearing these works on a really first-rate system will be a revelation of *timbre* purity, transient cleanness, and sonority naturalness, for which the casual listener on run-of-the-mill playback gear will be quite unprepared.

Indeed it is perhaps recordings like these, whose music and performances keenly sensitize one's whole emotional responsiveness, which in the long run actually may educate and refine one's sense of aural discrimination more effectively than even the most brilliant of sensational showpiece discs and tapes.

Go For Baroque

I have written before — in the booklet for *An Adventure in High Fidelity* — about wide-range reproduction's quieter virtues: that is, the advantages minimum distortion and maximum tonal authenticity hold for comparatively simple scores, as well as for complex symphonic orchestrations. Yet probably I've never appreciated their full worth as gratefully as I do now when, after my orgy with out-of-this-world demonstration recordings of last month (and the almost-as-loud but far more confusing pandemonium of the live Hi-Fi Show in New York), I turn back to the gentle old favorites above, and then — so as to preserve my contemplative, low-tension mood — to a batch of new releases drawn from what I have long found to be the most completely personally satisfying of all musical repertories: those stemming from the baroque era.

Two of these releases (which, although not specifically associated with Christmas, are nevertheless eminently well suited for relaxed year-end listening contentment) provide new chapters in the running story on organ recordings which I began some months ago: Vol. 2 of the complete Buxtehude series by Alf Linder (Westminster WN 18149) and the six trio-sonatas in Helmut Walcha's complete Bach series for Deutsche Grammophon (Archive 3013-4). Each reveals new insights into baroque composers' and organ builders' fascination with unmixed tone-color contrasts, and new testimony to present day engineers' ability to reproduce these often strange and raw sonic palettes in their authentic vividness. They present, too, a special challenge to listeners, for even the most fanatical of hi-fi addicts, who would never dream of letting the most delicate triangle tinkle or *pianissimo* timpano tap escape his alerted ears, will have to develop further aural sensibilities if he wishes to discriminate properly among the subtle tone tints and nuances of these performances.

Linder plays the same Varfrukyrka organ in Skänninge, Sweden, first brought to American audiophiles' attention by Carl Weinrich's Bach series, but he is a more lyrical, if less dramatically exciting, interpreter, and the music here is in marked contrast with Bach's monumental masterpieces. Except for the bold Toccata and Fugue in F major, the pieces in the new set represent facets of Buxtehude with which even most specialists may be none too

Continued on page 41

Book Reviews

by Richard D. Keller

Transistor Electronics

Arthur W. Lo, Richard O. Endres, Jakob Zawels, Fred D. Waldhauer, and Chung-Chih Cheng; pub. by Prentice Hall, Inc., Englewood Cliffs, N. J.; 521 pages; $12.00.

In this integrated volume on transistor theory and its applications, five RCA authorities have combined their work in an authoritative and highly useful reference book. It is written for advanced undergraduate and graduate students in electrical engineering and associated fields, but has value as well for the industrial electronics engineer.

The book begins with a fine qualitative treatment of the physical bases of transistor operation. Concepts of hole and electron diffusion, Fermi level energy states and junction potential hills are clearly developed and explained. Device characteristics and parameters are then presented in the y, z, and h parameter systems respectively, with major emphasis on the now generally accepted h parameter system. Four-terminal network theory is also introduced, together with a complete table of equivalent circuits for each of three possible device connections — the common-base, common-emitter, and common-collector configurations.

Especially valuable and informative are the chapters on biasing and stabilization, and low-frequency (audio) operation. These are of particular interest to the audio engineer or specialist; they contain probably the best presentation of the subject now available in book form. Although specific circuit values and transistors are not given, the design information and special considerations for transistor audio applications are unusually well presented.

The final half of the book is concerned with high-frequency operation of the transistor in such forms as amplifiers, oscillators, modulators, demodulators, and pulse circuits. A good part of this information deals with point-contact transistors which have just about disappeared from the market picture, although the underlying basic theory can, of course, be applied to the newer junction types as well.

The junction transistor symbols used throughout the book are rather surprising since they resemble the symbol of a tube with an arrow for a cathode. The reasoning behind this seems logical enough — merely to avoid confusion with the familiar symbol for the point-contact transistor — except that the point-contact type has now virtually faded from view and the industry-wide standard for *all* transistors is still the original point-contact symbol. Also, the use of α_{CB} instead of β for the grounded-emitter forward current gain causes a bit of confusion when interspersed with α_{CE}, the standardized α denoting grounded-base current gain. Such small confusions are to be expected in a fast-growing field.

Tape Recorders and Tape Recording

Harold D. Weiler; pub. by Radio Magazine, Inc., Mineola, N. Y.; 190 pages; $3.95, Cloth-bound; $2.95, paperbound.

For the amateur and semiprofessional recordist this book contains a wealth of practical information. To begin with, an excellent (and nonmathematical) treatise is given on the nature of sound and its various aspects in differing environments. This leads to the sections (which are among the best in the available literature) on microphone techniques in relation to room and location acoustics. Full discussions of reverberation and microphone-directivity patterns and their effects on the over-all mood and clarity of a recording are presented in a lucid and easily understood manner.

Mr. Weiler covers the entire gamut of sound recording. Instrumental recordings from solo guitars to full orchestras, voice recording from speeches to whole operatic groups, recordings made in small acoustically "dead" studios to those made in large auditoriums and churches impose individual problems which he surveys and discusses in detail.

Not only are live microphone tech-

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270 pounds of plywood, 350 pounds of sand, and the best bass you ever heard!

Amplifier Construction

Working at the bottom of a three-inch deep chassis, especially in the corners, can be hard on one's temper and the insulation of surrounding wires. The use of a shallower chassis is not possible if vector sockets are used. However, the corners will no longer exist if the amplifier is built on a sheet of aluminum or steel, or the proper size of bottom plate. The sheet of metal should be cut to the proper size and the original chassis can be used as a cover. Besides ease of working, another advantage is being able to use a cheaper steel chassis without having the hole-cutting job that steel usually brings.

When laying out the chassis, make paper outlines of transformers, chokes, can condensers, and tubes, shuffling them around until you're satisfied. Then measure the outline and buy your chassis. The average chassis flange is just under ½ in., so allow this much for clearance when laying out.

The only disadvantage of this method is that it is necessary either to have all connectors and controls on the top of the unit, or to use leads long enough to allow opening the unit.

Arthur M. Day
Venice, Calif.

FM/TV Lead-In

Other FM addicts may have found, as I did, that the best method of taking a high-frequency lead-in through an apartment house window is by means of Window-Thru lead-in discs, which were described and recommended in a "Tested in the Home" report in the January 1955 issue of HIGH FIDELITY Magazine. For those who do not have that report, it should be mentioned that this is a capacitive device in which small aluminum discs are cemented to each side of the window glass to form coupling condensers. Thus, there is no need to drill *verboten* holes, or to squeeze the lead-in through metal window frames, which are apt to weaken the signal.

In preparing to use my discs, however (two sets; one for FM and one for TV), I found that the glue supplied by the manufacturer had hardened in the tiny capsules and was useless. A visit to the local quarter store convinced me that a Goodyear product called Pliobond was probably an adequate adhesive, if not identical with the original. I used it, following the original instructions for the disc adhesive, and found it to be entirely satisfactory. It is therefore recommended to anyone who encounters this same problem.

Incidentally, the little discs have an additional advantage which is mentioned neither in the magazine nor by the manufacturer; they isolate the receiver from the lead-in, preventing DC or sizable values of AC from getting through. If a power line should fall across the antenna, or if the mast should become grounded while used with a hot-chassis receiver of any sort, the ac-

cident will not damage the receiver nor burn down the house. On the other hand, a window pane is not likely to deter a lightning bolt that gets past your arrester.

Harry L. Wynn
Derry, Pa.

First Aid for Loudspeakers

A lot of literature has been written about loudspeakers, but, when one goes sour, it's hard to find a step-by-step listing of a few simple things the audiophile can do to restore the instrument to service. Many writers simply advise sending the speaker to an expert. Here are a few suggestions, accumulated over the years, which may save some reader the loss of a speaker to a repair shop for several weeks.

First, to check warping, loosen all the bolts or screws securing the speaker to the baffle. Three-quarter-inch plywood should not warp, but green framing material can pull it out of shape. Slight warpage of the speaker frame can cause considerable distortion, and, for this reason, it is not advisable to fasten the speaker too tightly to the baffle. Wing nuts made finger tight on lock washers are a good fastening medium.

High humidity, such as that produced by a three-day rain when the home heating plant is not in service, can inject a tubby sound into the system. A 100- or 150-watt electric bulb placed near the speaker will restore those crisp transients.

Next, inspect the two braided wires, leading from the speaker terminals to the cone, for fraying. With the power on, wiggle them in an effort to detect a loose or cold-soldered joint.

If the trouble has not yet been uncovered and there are no obvious defects in the cone, the fault is probably under the dust cap. If it is in the voice coil, it is a job for an expert; but, in that case, the speaker is usually inoperative. H. A. Hartley says that the action of the cone will prevent dust from collecting. Moving the cone in and out with the fingers may cause a scraping noise, indicating the presence of foreign material such as a metal filing. After carefully removing the dust cap with solvent, this foreign matter can be fished out with a folded piece of Scotch tape.

Finally, those experimenters making use of AUDIOCRAFT woodworking articles should have an extension speaker in the workshop. For this, any cheap speaker for which a replacement cone is readily available will do. On this they can try all the suggestions made for doping the edges, packing and unpacking the cabinet with acoustical material, and so on. Meanwhile, the living-room speaker will remain undisturbed.

C. A. Robertson
Mamaroneck, N. Y.

Bathing Records

Fingerprints, dust, and grime can become so thoroughly hardened in the grooves of microgroove records as to defy the cleaning action of dust cloths or antistatic devices. Most audiophiles have a few recordings in this condition, and hesitate to play them anymore for fear of damaging the reproducer stylus. If these recordings are not mechanically ruined (if they do not have "hang-repeat" points or severe scratches), they can be salvaged for more hours of enjoyable listening. Here's how to go about it.

Prepare a concentrated solution of ordinary detergent and lukewarm water and wash the record surfaces with a wad of absorbent cotton. Don't be afraid to bear down on the record surface; cotton is soft enough so it won't damage the grooves, and the detergent solution will not attack the vinyl record material.

After washing both sides, rinse the record in tepid water. Shake off as many water globules as possible. Place the record face down on an absorbent cloth.

Of course, during the washing and rinsing process try not to get the record label wet. Even if a few drops of water do land on it, no great harm will be done. Record labels are practically molded into the surface of the record, and they will not pucker or peel off unless soaked to saturation.

A record thus cleaned has a noticeably lower surface noise; it's easier to *keep* clean too.

Norman V. Becker
Hollywood, Calif.

Tape Storage

Living, as I do, in a very small city in a rural area, it is not possible for me to purchase audio equipment locally. I'm willing to bet that one couldn't buy a reel of tape within a radius of 50 miles. The point is that audio equipment is difficult to come by and it is often necessary to improvise.

For a long time I was unable to obtain the metal cans in which reels of magnetic recording tape should be stored. Here's what I did before I was able to get these cans. First I wrapped the reels of tape in a plastic wrap, such as Saran wrap, and then in several layers of aluminum foil. I found that this type of wrapping preserved the tape about as well as metal cans do and, although it doesn't look as neat, it makes a good substitute wrapping when cans are not available.

James R. Garrett
New Boston, Ill.

Hum Reduction

Magnetic pickups, particularly ones with a low-level output, are very sensitive to stray magnetic fields and the resulting hum in the speaker can be annoying. The power supply of virtually all high-grade amplifiers is so well filtered that 60-cps hum is reduced practically to inaudibility. Consequently, any hum output in the speaker can usually be attributed to stray magnetic fields in the vicinity of the pickup.

My own unit is equipped with both a GE variable-reluctance unit and a Ferranti ribbon pickup. The no-signal output from the GE pickup was good, but for several weeks I was unable to reduce the hum level from the Ferranti to my satisfaction. Of course, I attended to all routine matters such as proper orientation of the matching transformer, placement of the leads from the transformer to the arm, a check of the dress of the filament leads in both the preamplifier and the power amplifier, and adjustment of the hum balance control. Finally, to my jubilation, I discovered that connecting a lead between the common lug of the speaker output terminal block and ground (the faceplate screw on the wall receptacle) resulted in significant reduction in hum. In my amplifier (Heathkit Model W-5), the common terminal is connected to the ground bus. This lead, then, provides a low-resistance path to ground from the amplifier and, because the pickup lead shield is connected via the preamp to the amplifier ground, for the pickup as well.

John E. Turner
Twin Falls, Idaho

Stylus-and-Record Brush

Keeping a stylus clean and free of dust always pays off in better reproduction and longer record life. A stylus brush can be made easily and inexpensively from a one-inch camel's-hair brush which can be purchased at most dime stores for about 40¢. Cut off the brush handle at the metal ferrule and you have an excellent stylus-and-record brush.

To clean a record, place it on the turntable and, while it is turning, hold the brush lightly on the record, working from the outside toward the center. The camel's hair is fine enough to clean the grooves thoroughly.

A bracket to hold the brush can be made from a piece of brass rod 1/8 in. in diameter. Allow enough on each end to make "eyes", and then wrap two turns around the brush. The bracket can be attached to a convenient place on the phonograph.

Terry McConnell
Petoskey, Mich.

AUDIO AIDS WANTED

That's right — we'll pay $5.00 or more for any short cut, suggestion, or new idea that may make life easier for other AUDIOCRAFT *readers, and which gets published in our Audio Aids department. Entries should be at least 75 words in length, and addressed to Audio Aids editor. No limit on the number of entries.*

TRANSISTORS

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collector current then is equal to I_{co}, a value below which it cannot go unless the collector voltage is reduced to a very low value. In this case, I_{co} is equal to one microampere.

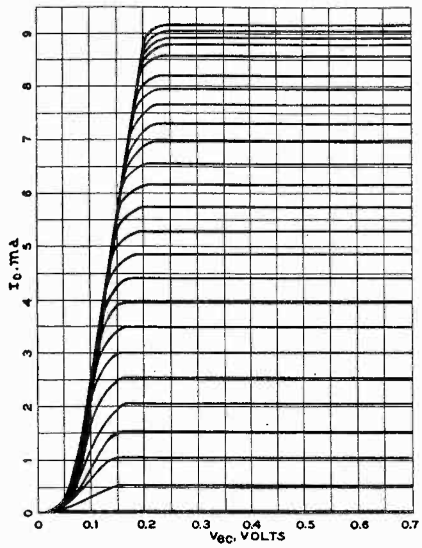


Fig. 9. The saturation region enlarged.

Right from a collector current of I_{co} on up, the transistor is in the linear region — even when the base current is slightly negative. The change from the linear region to the cutoff region is very abrupt — even more abrupt than the change into saturation.

The linear region is limited on the right-hand side of Fig. 6, at high collector voltages, by a breakdown phenomenon. It is natural, after all, that the material cannot withstand very high voltages without breaking down. Breakdown occurs when electrons or holes passing through the collector junction get speeded up fast enough so that they knock covalent bonds apart, forming new current carriers. When each carrier, on the average, knocks one covalent bond apart, then a sort of "chain reaction" occurs and the current becomes very high; it is limited mainly by the bulk resistance of the germanium itself. The junction no longer acts as a rectifier, and transistor action stops.

Formerly this breakdown phenomenon was called the Zener effect, because of similarities thought to exist between semiconductors and dielectrics, whose breakdown characteristics are different but were first explained by Zener. However, the simple breakdown "chain reaction" mentioned earlier was found to be correct. The name Zener seems to have stuck, though, and the breakdown voltage is still called the Zener voltage.

The voltage at which breakdown occurs can to some extent be determined by the manufacturer, and normally a voltage somewhat lower will be specified as the *maximum operating voltage* for the transistor. Since transistor action ceases in the breakdown region, transistors are not normally operated here. However, it is not impossible that use could be made of it in some applications.

The linear region of the transistor is limited on the high collector current side by a crowding of the lines of constant base current. Fig. 6 shows clearly how the lines crowd and become less horizontal at higher currents. The crowding of the lines indicates a loss of gain; eventually, if we go out far enough without burning out the transistor, a power *loss* will occur, instead of a power gain.

In looking back at Fig. 6 again, we can see that the linear region is bounded on all four sides by nonlinearities. On the bottom and the left, there are the relatively sharp transitions to cutoff and saturation. On the right, the junction breaks down and passes excessive current; on the top, there is a gradual lowering of gain indicated by the alpha crowding. The region in the middle is of most use to us in designing transistor circuits; however, it is essential to know the characteristics of the other regions, both to learn to exploit them well, and to learn to avoid them when they are not wanted.

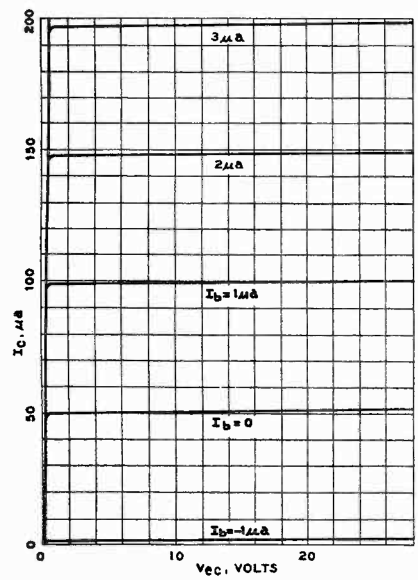


Fig. 10. Expanded view of cutoff region.

Maximum Ratings

At first glance the preceding material might appear as if the transistor could be operated anywhere in the linear region. There are certain *maximum ratings*, however, which should not be exceeded in normal operation. These are usually set by the manufacturer a little on the conservative side, and operation within maximum ratings will virtually never burn out a transistor.

The three maximum ratings — voltage, current, and power — are determined differently, and for different reasons. They are not meant to be applied simultaneously; that is, the maximum rated voltage times the maximum rated current is usually far greater than the maximum rated power dissipation.

A power dissipation rating is specified by the manufacturer from a knowledge of the damage excessive temperature does to the transistor. In power transistors this is a subject of paramount importance, and will be covered in a later installment. For low-power transistors, fortunately, the problem is less severe.

Germanium transistors cannot in general withstand temperatures higher than about 90° C. without suffering at least temporary damage, so care must be taken to keep the power dissipation within the transistor low enough that this temperature is not exceeded. Silicon units are better in this respect, and some compound semiconductors will produce transistors considerably more tolerant of heating.

The manufacturer states as a rating the *maximum permissible peak power dissipation.* If the transistor is to operate in an ambient temperature higher than normal, say in the hot sun, then it cannot lose heat as rapidly, and must be operated at a reduced dissipation. A safe rule of thumb for germanium is to reduce the power rating by 10% for each 10° F. ambient above normal 70° F. temperature. This *temperature derating* is fundamental to the operation of power transistors, but even for low-power units it is important.

The maximum collector-to-base voltage is specified by the manufacturer from a knowledge of the breakdown voltage for the junction. This breakdown increases the current to several times its normal value, and accordingly increases the power dissipation excessively. Excess voltage on a junction in itself does no harm, but once it breaks down, much power will be dissipated, and the transistor will heat up and burn out. Because it is virtually impossible to prevent excessive dissipation above the breakdown voltage, this effectively places an upper limit, or rating, on the collector junction voltage.

Normally the voltage from base to emitter in a transistor stage will be small compared to the voltage rating for the collector junction, so the collector-to-base voltage rating can be thought of as applying equally well from collector to emitter.

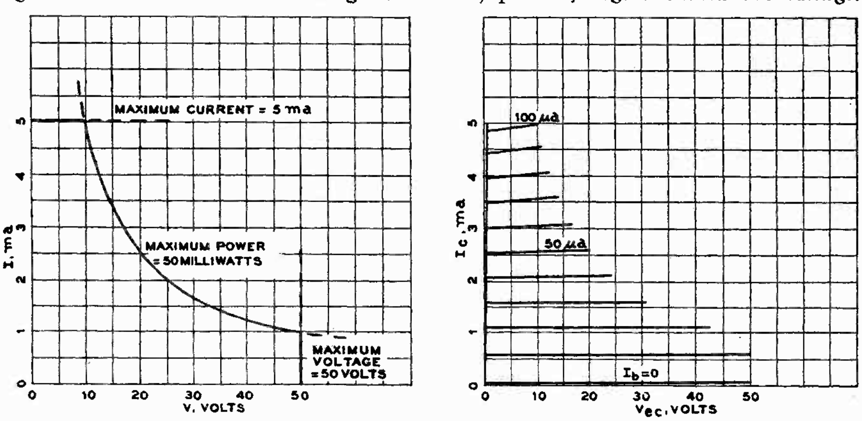
A third rating given by transistor manufacturers is *maximum collector current* or *maximum emitter current.* Since the two are so nearly the same, it makes little difference to which the rating applies.

High current in a transistor will not, as such, do any harm. But at high currents the gain begins to drop off, and the linearity decreases. Furthermore, at higher currents it becomes very difficult to stay within the power rating. Because of these factors, manufacturers frequently specify a maximum current. While it is well to stay within this rating, experienced circuit designers often disregard it altogether, and form their own judgment as to the maximum safe current, on the basis of the operation of the particular circuit they are using at the time. But since determining ratings is a very tricky business, requiring experience and judgment, the beginner is advised to stay within the manufacturer's stated rating.

Fig. 11 shows the permissible region of operation. This is defined by the maximum voltage (here 50 volts), the maximum power rating (50 mw) and the maximum current rating (5 ma in our example). Note that this permissible region does not correspond exactly with the linear region discussed before; indeed, Fig. 12 shows Fig. 6 and Fig. 11 superimposed. Because of power limitations, not all the linear region is available for use.

Part IIIb, next issue, will discuss other curve families, curve variations, transistor noise characteristics, and high-frequency operation.

Figs. 11 and 12. Maximum rating boundaries; parts of Fig. 6 within the ratings.



TRACKING ERROR

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and this is indeed the optimum solution.

There is very little variation in the outer radii of records of the same nominal size, and the results are not very sensitive to it. The average value of R_2 for a number of records in the author's collection is 5.70 in. for 12-in. and 4.74 for 10-in. records. The inner radius depends on the length of the selection and the groove spacing. The author's collection of LP's seems to have only one case with R_1 less than 2.49 in. It will be noted that α/R increases very rapidly for decreasing R, and passes through zero at a radius not much larger than R_1. It is prudent therefore to design for the smallest R_1 likely to be encountered. The value $R_1 = 2.40$ in. will be used in numerical examples below. That is for 10- or 12-inch 33.3-rpm records. 78-rpm records are recorded down to $R = 1.875$ in., but if the arm is nearly optimum for LP's the distortion on inner grooves of a 78 will be comparable to that on inner grooves of an LP, because of the inverse dependence of distortion on record rpm as shown in Eqn. (11). Since $78/33.3 = 2.35$, a distortion index 2.35 times greater can be tolerated at 78 rpm.

The graphical method of analysis outlined above is very useful for evaluating existing arms and comparing their performance, but the trial-and-error approach to the optimum is rather tedious. The conditions for optimum design and for best placement of a non-optimum arm are easily obtained with simple mathematics.

In the second and concluding part of this article, the author develops simple formulas and charts showing optimum offset angle and overhang for any given arm length, and gives examples of compromise adjustments.

MIT

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The most important acoustical treatment, however, is the cushioned seats in the auditorium. Reverberation time is quite small at low frequencies — 2.2 seconds at 100 cps — decreasing to 1.6

seconds at middle frequencies and 1.4 seconds at 4,000 cps.

The MIT Chapel is much smaller, about 40,000 cu. ft., and is roughly cylindrical in shape. A serpentine-curved brick inner wall and an inverted-cone ceiling serve to diffuse reflected sound, so that there are no important focal points. Absorptive material consists of about 300 sq. ft. of glass fiber behind brickwork grilles. Reverberation time is 2.5 to 3 seconds for lower frequencies, 3 seconds at middle-range frequencies, and 1.5 seconds at 4,000 cps. Each building has a striking organ designed by Walter Holtkamp.

Such characteristics are ideal for recording purposes, producing crisp yet massive sound with phenomenal definition. Unicorn Records has taken advantage of this already in a series of six *Music at MIT* releases: *The Modern Age of Brass* (UNLP 1031), four contemporary chamber compositions for brass, performed by Roger Voisin and his Brass Ensemble; Concertos for Organ and Orchestra (UNLP 1032), four Handel concertos from Op. 4 and 7, with Lawrence Moe, organist, and Klaus Liepmann conducting the Unicorn Concert Orchestra; Beethoven Sonatas for Piano, Op. 109 and 110 (UNLP 1033), Op. 57 and 111 (UNLP 1034); Liszt Sonata in B Minor, Op. 178, and *Bénédiction de Dieu dans la Solitude* from Op. 173 (UNLP 1035); and Haydn Sonatas for Piano, Nos. 32, 46, 50, and 51 (UNLP 1036). All the piano works are performed by Ernst Levy, a noted composer-pianist.

A single microphone, suspended 20 ft. in front of the performers and 20 ft. above the stage, was used for the brass recording. One microphone in the organ loft and another 10 ft. above the chapel floor were used for the Handel concertos. For the piano works a single microphone was hung 10 ft. above the piano. Recording and disc mastering was done by Peter Bartók, long respected in the industry for his excellent work in both fields. These records have all been released except for 1036, which is scheduled for February; all should be heard for their unique technical quality as well as the fine performances.

BOOK REVIEWS

Continued from page 29

niques covered, but also techniques for re-recording and actually improving the sound from old shellac and cracked records, and for building libraries of music from AM and FM radio broadcasts. Several chapters of suggestions for improving slide and home-movie shows with the addition of appropriate musical backgrounds and commentary, and a chapter on producing realistic sound effects, will be of special interest to photographers. The importance of having continuous "background noise" in edited tape and of the overlap of sound effects for true naturalness are well emphasized.

All in all, modest as it is in appearance, this book is highly recommended to all who enjoy the art and science of capturing the sounds around them.

Maintaining Hi-Fi Equipment

Joseph Marshall; pub. by Gernsback Library, Inc., New York; 224 pages; No. 58; $5.00, hard cover; $2.90, soft cover.

For electronics technicians, repairmen, and audio enthusiasts in general, this volume is a veritable audio bible. It was published in the middle of 1956 and much of the contents must have been written at the last minute, for it is truly up-to-date.

The very latest commerical high-fidelity circuits, such as the Unity-Coupled Horizon (National) and the Circlotron (Electro-Voice) are explained and analyzed, as well as the Baxendall negative feedback tone-control circuit and several systems for variable-damping control.

There is a handy topical division for using the book as a reference for all sorts of general and specific troubles in high-fidelity systems. At the beginning, high-fidelity standards and terminology are presented, followed by an excellent treatise on types of test instruments and their preferred specifications for adequate checking and maintenance of high-fidelity equipment. The best of the test records, with explanations for their use in checking such conditions as proper equalization and distortion, are listed.

The heart of the book deals with distortion in all its many forms, and how to diagnose and eliminate it. Proper techniques for balancing push-pull stages, obtaining feedback stabilization, using decoupling networks, and matching speakers to enclosures are among the many subjects thoroughly covered. In addition, diagnosing and locating hum; eliminating ground loops; testing for stylus distortion, phonograph-arm friction and turntable rumble and wow; and minimizing distortion in AM and FM amplifiers, limiters, and detectors may be added to the list.

There is so much valuable practical information in this well indexed work that it should be at the finger tips of everyone who enjoys building or improving home sound systems.

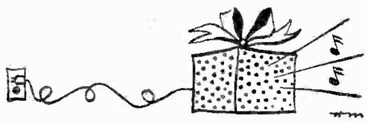
TAPE NEWS

Continued from page 14

length and from reel to reel. Tapes that are too narrow will tend to ride up and down on the heads, and will not work properly with certain types of editing jigs. Tapes too wide will tend to stick in precision-machined tape guides or on heads which have slight shoulders worn into them by standard-width tapes.

The ideal tape also has no tendency to cup, curl, or twist when winding. These are defects that develop after the tape has been used for a while; they contribute to poor handling at high speeds and, in extreme cases, to poor head contact.

Tape should not shed its coating, binder, or lubricant. Peeling of the magnetic coating is obviously an unforgivable flaw, but this has fortunately been eliminated by modern bonding processes. Shedding of oxide particles or formulation additives will tend to cause fouling of the heads (with drop out or loss of highs) and dirty tape



guides, necessitating frequent cleaning and possibly spoiling valuable recordings.

Finally, the ideal tape is frictionless. This is clearly the most idealistic requirement of the lot, but the ultimate aim remains. A low coefficient of friction reduces head wear and minimizes the stickiness which produces high-frequency flutter or squealing on recorder heads. Low friction is obtained by a very smooth oxide surface or an added dry lubricant, or a combination of both.

This is a long list of exacting requirements, and the majority of them are unmeasurable by the user. There are, however, several tests that a recordist can make to determine the over-all quality of a new brand of tape.

First, clean the tape recorder's tape guides, heads, and capstan thoroughly with alcohol. Then thread the new reel of tape on the recorder and run it through in the fast forward mode all the way to the end of the reel. Note whether it pulls smoothly from the reel or whether its layers seem to be sticking together. Stickiness between layers of a new reel of tape may mean that its edges are not smoothly cut or that its coating binder or lubricant is sticky. Either may endanger future recordings by introducing irregular speed variations.

After the tape has been wound on the takeup reel, note how evenly it has wound. If the tape wandered randomly from side to side, it may be the fault of the recorder. But, if the recorder usually winds evenly on fast forward, and the test tape did not, it is a sign that the tape may be unevenly cut. Also, a

Continued on next page

TAPE NEWS

Continued from preceding page

tendency for the tape to wind in bands, with alternate bands lying firmly against the upper and lower flanges of the reel, suggests twists or crooked cuts within the length of the tape. These are minor matters as far as the home recordist is concerned, but where tapes are to be used for commercial purposes it is best to avoid those brands which wind unevenly.

Now rewind the tape onto the feed reel, noting again how it unwinds from the takeup reel. If there is still a tendency for layers to stick together, the tape may be expected to give serious trouble in this respect, and should not be used if dependability is important.

After rewinding, carefully examine all the surfaces that the tape came in contact with while traveling. There will probably be small amounts of residue left from the tape, but if there is enough to form large bunches that can be chipped off with the fingernail, the tape probably has too great a tendency to lose its coating, binder, or lubricant.

Before making up your mind about this, though, wait until it has been tested in the record mode, as follows.

Thread the tape again, and feed a continuous 400-cps tone from an oscillator into the recorder at normal record level (zero db on recorders having a db level indicator), and record through the entire length of the tape. When the end of the reel approaches, note the exact volume control setting and turn the record volume all the way down before stopping the recorder. (Failure to turn down the volume first may magnetize the record head.) Rewind the tape, set the volume control at its original setting, and connect a sensitive AC voltmeter (0-5-volt range) to the output of the recorder. Then play the tape and observe the output reading from one end of the tape to the other.[2] Observed fluctuations should not exceed 1 db in either direction if the tape is intended for professional applications; otherwise, a 2-db variation is permissible. Larger fluctuations may indicate either that the oxide coating lacks homogeneity or is of varying thickness, or that the recorder's bias supply is poorly regulated. To check for the latter possibility, try the same test on some other brands of tape, or put a grease pencil mark on the test tape at one spot where a large change occurred and then re-record through that spot. If the same change occurs at the same spot, the tape is the offender.

Remove the tape from the transport mechanism, and examine the heads and guides for deposits of coating or binder. If this has accumulated to any degree on the polished surfaces of the heads, and if it was found that the tape shed when winding and rewinding (as determined previously), the tape coating is poorly bonded. Deposition of a noticeable coating with a single play indicates an intolerable amount of shedding, particularly if the accumulations have lodged on the active surfaces of the heads. Small accumulations to one side of the head gaps are to be expected after several plays, but deposition on the gaps is fatal to quality recording.

Now take another tape of the same variety as the first sample but chosen from a different production batch. (One purchased from a different store should fill this requirement.) Using the same volume settings as before, run off about a minute of the 400-cps tone onto the second sample, and play it back. Its output level should be within 2 db of that of the first sample if the tape is to be used for professional applications, or within 4 db if nonpro use is envisioned.

Now comes the most critical test of the new tape; its performance test. Reduce the record level to about 20 db below normal recording level, and record a series of test tones at, say, 1,000, 30, 50, 70, 100, 500, 2,000, 5,000, 8,000, 10,000, and 15,000 cps. Thirty seconds duration will be plenty for each tone.[3] Rewind the tape, set the playback level to give a mid-scale reading at 1,000 cps on the voltmeter, and then play back all the tones, noting the readings obtained. For the time being, it doesn't matter whether the response seems to deviate all over the place; the purpose of this test is to check the variability of the tape being tested.

When all readings have been noted as accurately as possible, remove that reel of tape and repeat the frequency-response test on several other reels of identical tape, choosing if possible tapes from other production batches. The results should not vary by more than 3 db at the highest frequency for which the recorder is rated in its published specifications. If there are wide differences between them (of, say 6 db at the high-frequency limit), it is fairly safe to assume that the uniformity is inadequately controlled. When running

[2] On a recorder having an A-B switch which compares input to the tape and output from a separate playback head, variations in output can be observed while recording, thus obviating the need for playing the tape through a second time.

[3] If the recorder utilizes a separate playback head for monitoring from the tape while recording, input/output response comparisons can be made while recording, by flipping back and forth from A to B on the output selector switch and reading directly the db response deviations. For two-headed tape recorders, a short pause introduced between the tones will aid in identifying them during playback.

these tests make sure that all the samples used are specifically identified by the manufacturer as the same type. Many variations in oxide formulation exist between different types of the same brand of tape, and these differences must be considered when making direct comparisons.

This about completes the quality and uniformity tests on the tape itself. The next step consists of checking out the tape's performance on the recorder it is to be used with. Since, as it was pointed out earlier, the suitability of a tape for a recorder will depend largely upon whether the latter has a variable bias adjustment, it will be more convenient for us to consider separately the two types of recorder.

The professional recorder, with variable bias, can be matched to any tape. When a new tape is being tested, the bias (and equalization, if adjustable) should be adjusted for that tape, according to the recorder's instructions. Then the instructions should be followed in carrying out the frequency-response test on the tape. Unless the tape is unusually bad (or the recorder is out of order) its high-frequency response should fall well within published specs at the test speed. It is also a good idea at this time to rig up some form of comparator that will allow you to flip from the playback of the tape to the output from the test oscillator, so that an immediate A-B comparison can be made between the original and the recording for an audible distortion check. Note particularly how the tape sounds when reproducing the 30-cps recorded tone, because some brands of tape introduce serious modulation noise (an annoying hiss that varies with the signal) at low frequencies. Assuming that the tape does not introduce any serious response aberrations or undue distortion (some of the latter is inevitable), the choice of tape for the recorder with variable bias will depend mainly on how closely the tape measures up to the list of ideal physical requirements enumerated earlier.

With the nonvariable-bias recorder, however, the differences in bias requirements for different tapes can be used to serve the function of the lacking bias control; if the bias can't be matched to the tape, the tape can be matched to the bias. The procedure here is fairly self-evident; try several brands of tape on the recorder until a few are found which give the best reproduction when their playback is compared directly with the original. Recording part of a record onto a sample of tape will provide the ideal comparison basis; once the closest match has been established, that is the time to start considering the tape in terms of the physical requirements.

It should be remembered — at least as an afterthought — that the less ambitious the recorder, the less important become most of the idealized requirements that were listed, and that the most important thing in this case is to find the brand of tape which gives the closest replica of the original sound on that recorder. It should also be emphasized that the foregoing discussion of magnetic characteristics pertains mostly to the slower tape speeds, 7.5 and 3.75 ips. The effects of magnetic differences between tapes decrease significantly at 15 ips and practically disappear at 30 ips. It is thus possible to obtain optimum results from practically any brand of tape on a recorder operating at 15 ips without making any adjustments to suit specific brands. This interchangeability does not, however, exist at slower speeds, so most of us have to match our tapes to our recorders, or vice versa.

GROUNDED EAR

Continued from page 5

this dilemma points out that we still have a long way to go before we solve the problem of reproduction of music in the home with sufficient success to satisfy all listeners.

Screen Feedback

I'm afraid I gave my readers a bad steer when, in the September issue, I suggested the use of older-type output transformers with 10% tertiary windings for screen feedback. Though I have not yet received complaints, I am keeping my fingers crossed. It is possible that some of these old transformers, or cheap transformers with such windings, may work. But David Hafler (of the Dyna Company) rushed me a note of caution. Although so far there has been very little work on this scheme, his experience indicates that it is probable that the use of a transformer not specifically designed for screen feedback will produce a multivibrator oscillator instead of a feedback amplifier. If there is capacitive transfer between plate and screen sections of the transformer, the circuit will oscillate. Mr. Hafler has had to work out a new method of winding transformers to balance and cancel out capacitive transfer of signals in his Dyna A-440 transformers. May I caution readers, then, not to invest any money in trying this idea, and to be prepared for trouble. To those who may have tried it and run into trouble, my apologies. I can suggest, as a possible way of salvaging the situation, using the tertiary for feedback to the cathodes of 6CA7's. As pentodes these tubes have enough sensitivity so that the increase in driving voltage should not cause any difficulty, while the cathode feedback will be of real benefit.

LOUDSPEAKERS

Continued from page 25

dispersion. Another familiar method of distributing treble tones is the multicellular horn. The impressive Altec Lansing 604C Duplex speaker (Fig. 6) uses an array of six identical high-frequency horns all driven from a single diaphragm. The mouths of these horns are spread out in a fan-shaped arrangement which spreads out the high frequencies.

Bass Horns

Where treble horns demand close tolerances and delicate workmanship, the biggest drawback to the use of horn coupling for bass frequencies is sheer

Courtesy Klipsch & Associates

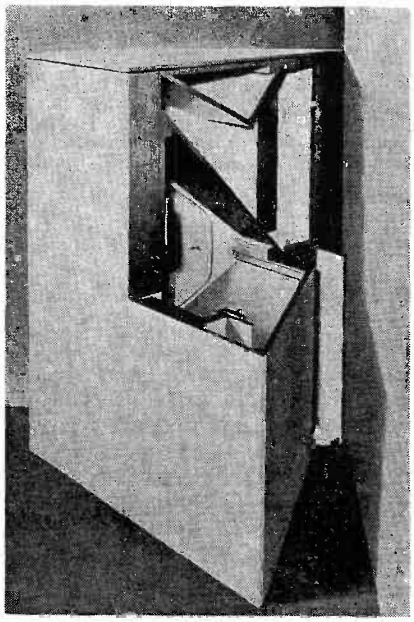


Fig. 7. Inner partitions of Klipschorn.

size. The *only* satisfactory method of retaining fully effective horn loading to reasonably low frequencies, without building another room on the house, is to take advantage of corner placement for the speaker system. Any other attempt to lessen the mouth area will inevitably result in tuned column effects due to mouth reflections at low frequencies.

Although corner horns have become popular only in the last decade, they are not new. P. G. A. H. Voigt recalls, "Corner horns go back to the early days of the cylinder phonograph. I used the principle in 1934, and at the annual Radio Exhibition in Britain that year, the corner horn exhibited by my company was the only one at the show. In the years since then, the advantages of combining corner operation and horn loading have been fully recognized, and many famous designs now use the technique. The special advantage of corner working is that for a given response curve the volume can be greatly reduced, for the sound expands into a quarter or eighth sphere instead of into a nominal hemisphere."

Realizing that many people do not have an available corner for their speaker systems, some manufacturers advertise horn-type enclosures with

Courtesy Electro-Voice, Inc.

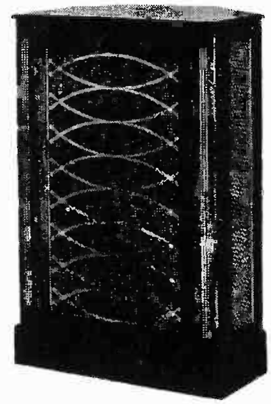


Fig. 8. The Patrician four-way system.

"built-in" corners which can be placed anywhere. But the advantages of corner location for frequencies no lower than 60 cps requires intersecting surfaces extending *at least 5 ft. in all three directions* from the speaker, and it is difficult to imagine how a structure this size can be built into a small cabinet.

In this country the progenitor of most good corner horn designs is the Klipschorn, by Paul W. Klipsch. Although a trihedrally symmetrical design (a sort of pyramidlike affair) had been previously described by Sandemann, and Weil had done work on corner units, Klipsch was convinced that he could design a corner-loaded bass horn which didn't occupy so much floor space. You may (or may not) be able to follow

Courtesy James B. Lansing Sound, Inc.

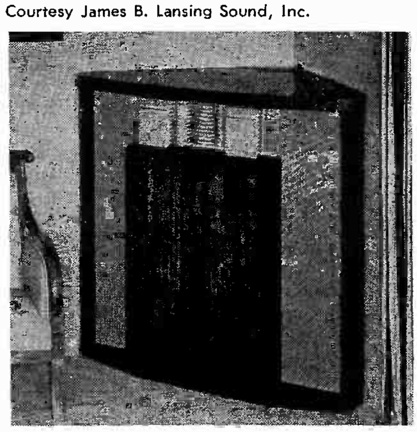


Fig. 9. Hartsfield two-way horn speaker.

the horn path from the cutaway view in Fig. 7. The driver faces forward and is joined to the horn through a small coupling chamber. The horn splits vertically, folds around the speaker chamber, reunites, splits laterally, and emerges in the final section formed between the sides of the cabinet and the room walls.

It may come as a surprise that the Klipschorn, long lauded as the ultimate in reproduction of deep bass notes, has

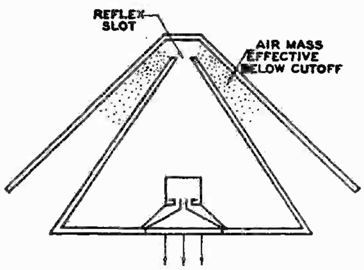


Fig. 10. Simple rear-loading bass horn.

a low-frequency horn cutoff of about 40 cps! How can this be reconciled with the claims of the little cigar boxes which purportedly allow you to "hear all those bass tones to *16 cps?*" This contradiction can, I think, be explained by three facts:

1) The cigar box claims are exaggerated. There is not a commercial speaker system made which will reproduce an audible horn-loaded 16-cps tone.

2) The Klipschorn will produce 50 cps at good volume and negligible (less than 5%) distortion. You would have to search the entire frequency range of most cigar-box units to find any frequencies approaching this distortion figure. There are some quite small units for which this isn't true, but they aren't horn-loaded.

3) The Klipschorn uses a special

Courtesy Electro-Voice, Inc.

Fig. 11. The Baronet rear-loading horn.

trick to reproduce frequencies *below* the cutoff of the horn.

We have already said that below cutoff, a horn acts as though an additional mass had been added to the speaker cone. In the Klipschorn this total reactance is designed to resonate with the acoustic capacitance of the enclosed back chamber at about 40 cps. Audible fundamental tones are therefore reproduced down to 30 or 35 cps, even though horn loading is lost for all practical purposes half an octave above this frequency.

Jensen employs a similar idea except that, instead of using acoustic capacitance, the compliance of the cone suspension is used to resonate with the mass characteristic of the horn. In the Klipschorn, the bass driver must have a suspension resonance much lower than the horn cutoff while in Jensen's "reactance-annulling" design, a cone resonance *higher* than horn cutoff is employed.

We have described the Klipschorn at some length because almost every other corner horn manufactured is based on Klipsch patents. The Electro-Voice Patrician (Fig. 8) and the James B.

Courtesy Audio Research Lab.

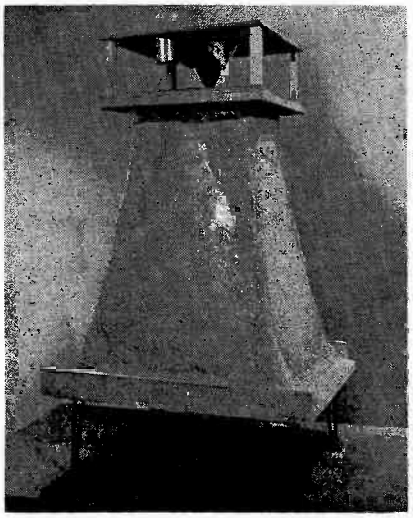


Fig. 12. Ceramex horn out of cabinet.

Lansing Hartsfield (Fig. 9) are both examples of deluxe Klipsch-inspired designs. Klipsch has also experimented with the idea of using a back-loaded horn to boost the bass response of an ordinary cone speaker. Fig. 10 diagrams the system — it looks very much like a bass-reflex cabinet with a horn attached to the port, and that is precisely what it is.

The loading effect of the horn makes the cabinet act as an infinite baffle over most of its frequency range. At progressively lower frequencies the mass effect of the short horn, acting with the acoustic capacity of the rear chamber, introduces increasing phase shift. The small amount of radiation above resonance in this enclosure is more efficiently put to use than in a reflex cabinet, since the horn increases port efficiency somewhat.

At resonance, the system behaves exactly as a bass-reflex cabinet with the port and the speaker operating out of phase with each other to increase the

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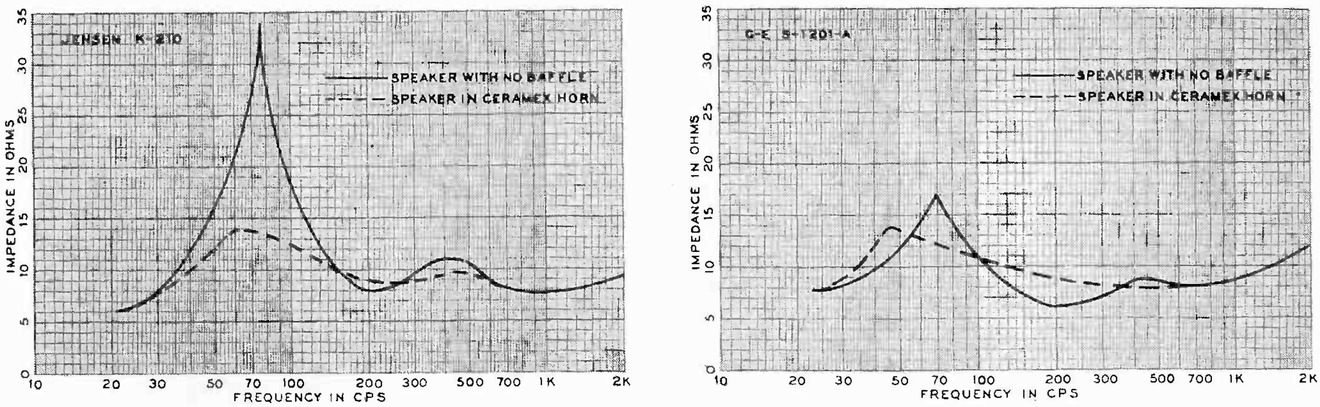


Fig. 13. Impedance curves of two typical loudspeakers, when unmounted and when mounted in the author's horn enclosure.

LOUDSPEAKERS

Continued from preceding page

effective radiating area. But *above* the resonant frequency of the system, the similarity to a bass-reflex cabinet ends. Whereas the mass of air in the port of a Helmholtz resonator remains constant regardless of frequency, a horn has a mass characteristic *only below cutoff.* Above its cutoff frequency, the short horn acts as a resistive load on the port; by thus utilizing this peculiar property of horns, very smooth bass response can be achieved.

Exactly how the enclosure volume, horn length, and rate of flare are juggled around to achieve best results is far better left to Mr. Klipsch than to you or me, and the fact is he has done it quite effectively with at least three speaker enclosures smaller than the full-sized Klipschorn. Fig. 11 shows the Electro-Voice Baronet which utilizes a back-load design in an extremely compact unit.

In the September issue of AUDIOCRAFT we discussed the relationship of cone motion to speaker impedance at low frequencies, and found that the two were directly related. If a horn actually offers a resistive load to its driver, this should therefore be reflected in the impedance curve below 500 cps. Since the speaker is loaded acoustically we would expect impedance variations due to cone resonances to be evened out. So long as the horn operates as a horn, this is just what happens. In most commercial systems, however, some sort of acoustic resonance is employed to revive the drooping bass notes and this introduces new peaks in the impedance characteristics. These are not necessarily related to the acoustic output of the system, although they do indicate that damping is practically nonexistent at certain points.

A system which illustrates the smoothing effect of horn loading without any additional acoustic dodges is shown (without the exterior cabinet) in Fig. 12. The unit is my own Ceramex speaker system — simply a vertical horn having a radial mouth at floor level. A 12-inch speaker is unity-coupled to the throat of the horn, and the whole affair is made of vermiculite-impregnated concrete to eliminate spurious panel resonances. A full description and construction details of the system have already been given elsewhere.* The reason I bring it up in this connection is that it is about as simple a horn-type enclosure as is possible to design, and its impedance curves consequently reflect the effects of horn loading and little else. The curves in Fig. 13 indicate that the horn does provide resistive loading to the speaker diaphragm and smooths out impedance variations to a surprising degree.

One of the interesting things about such a resistive-loaded speaker system is the lack of bass distortion and doubling. Below the cutoff of the horn (60 cps) the response simply disappears, with no usable reproduction below 50 cps. But have you ever heard 50 cps uncluttered with the hoots and rattles of panel resonances, hang-over effects, and frequency doubling? The bass response of such a speaker *sounds* more impressive than many other en-

*Augspurger, George. "A Horn-Type Speaker for Golden Ears." *Radio-Electronics*, XXVII (Apr. 1956), 34-35.

closures which measure up far better on a frequency graph.

The more expensive horn-type systems, such as the Klipschorn, Patrician, and Hartsfield, have special bass drivers designed specifically for use in their particular enclosures. The mere addition of a jerry-rigged horn to an ordinary speaker is not the same as an integrated system, and some designers have been unjustly skeptical of horn design for quality reproduction. In answer to such views, we can do no better than heed one last warning from Voigt: "The experimenter should bear in mind that speakers developed for use with normal baffles or enclosures are not necessarily suitable for use with horns. In an ideal arrangement, the drive unit and the horn are designed as a matching pair, and if this is done properly, results can be breathtakingly lifelike."

SOUND FANCIER

Continued from page 28

familiar. These three canzonettas and six canzonas reveal that the great pre-Bach virtuoso had a gift for melodic charm and pungent humor that is no less distinctive than the intricate architecture in tone for which he is most famous. They happen to be historically important little pieces for the light they throw on the development of this fugue, but luckily you don't have to be a musicologist to relish immediately such delights as the cool loveliness of the elegiac E minor Canzonetta (to cite a single example only) or the enchanting coloring of Linder's poetically devised registrations, caught to perfection in spaciously open acoustics and recording.

Talking with a number of organ connoisseurs about the works reviewed here earlier (the serious ones, that is; I'm trying to forget the sore subject of theater organs at least for a while!), every one of them ended up by demanding, "But have you heard the magnificent Walcha Archive series?" I hadn't then, and knew the blind German player only by some of his Decca releases of several years ago, which were pleasant enough, but hardly especially impressive. But when specialists who seldom if ever rave ecstatically about any record seemed so excited, I felt that something new must have been added to Walcha's work — and my first encounter with the new series is more than enough to confirm that feeling. For Walcha now is surely one of the warmest and most endearing of all Bach interpreters and, as heard here on the 1695 Schnitger organ at Cappel and the even more ancient small organ of St. Jacobi's at Lübeck, he provides perhaps the most ingratiating and persuasive of all possible introductions to the sonic spells of the baroque. The only drawback to these discs (and that only for the special purposes of this department) is that the immaculate recording tends to be entirely overlooked as one succumbs to the sheer magic of expressive organ tone and Bach's incomparably zestful contrapuntal textures.

I have never been able to understand why these particular works aren't heard more often and are not far more enthusiastically acclaimed; teaching pieces though they may be by intent, they seem to me to distill much of the quintessence of Bach's most distinctive art. Listen to the now-jubilant, now-eloquent Fifth Sonata for a starter, and I can't imagine your ever again passing over or belittling the Bachian trio-sonatas.

Bowed Strings and Twanged Continuo

In attempting to turn some hi-fi *aficionados* at least temporarily from big display orchestrations to the very different yet no less kaleidoscopic tone painting of the baroque organ literature, I feel I have a fair chance of success. But I'm doubtful about the stringed music of the same era. For here the sonic colors are less immediately novel and even more subtle, and to the unalerted or unsympathetic ear many of these works sound much alike. It takes close familiarity with the characteristic idioms and sonorities to recognize the actually highly differentiated individualities of style. That comes easily enough if you're willing to make the effort, but meanwhile perhaps the best first approach is merely to develop an appreciation of the distinctive combination of smooth string and twangy harpsichord (*continuo*) tones.

One way is to study performances which compromise to some extent with baroque ideals by blending *timbres* more suavely and phrasing more expressively, thus making them resemble more closely the later strings-only ensemble playing with which we are most familiar. A good example is the extremely skillful *I Musici* group's playing of five *concerti grossi,* including, appropriately enough for this month, the so-called *Christmas* Concerto, No. 6 in G minor (Epic LC 3217). Yet although the music is ingratiating and the recording admirably clean, I never get what seem to me the essential baroque characteristics, especially the bite and ring of the harpsicord's supporting role — here far too discreetly integrated into the tonal fabric.

Going directly to stylistically more authentic, even if less polished, performances is by far the better way — provided only that you refuse to be discouraged or repelled by what may seem like thinness and brittleness at

Continued on next page

AUDIOCRAFT
Sound Sales Directory

Following is a list of dealers who state that they carry the products specified.

KEY TO PRODUCTS HANDLED

1 Audio system components
2 Speakers and enclosures
3 Records and record accessories
4 Tape recorders
5 Pre-recorded tape
6 Radio hardware
7 Tools, wood
8 Audio parts
9 Microphones
10 Books
11 Test equipment

A series of items numbered consecutively is identified by a hyphen between the first and last numbers. Thus, 1-6 indicates 1 through 6; 8-11 indicates 8, 9, 10, and 11.

CALIFORNIA

Beverly Hills

Minthorne Music of Beverly Hills
230 N. Beverly Dr.
BR. 2-7676; CR. 6-4793 — **1-5, 9**

Hollywood

Hollywood Electronics
7460 Melrose Ave.
Webster 3-8208 — **1, 2, 4, 5**

CONNECTICUT

West Hartford

Audio Workshop, Inc.
1 South Main St.
Adams 3-5041 — **1-5, 9, 10**

DELAWARE

Newark

Delaware Music House
20 Academy St.
Endicott 8-3258 — **1-5, 8, 9**

GEORGIA

Atlanta

Baker Fidelity Corp.
1140 Peachtree St., N. E.
TRinity 5-2156 — **1-6, 8, 9**

ILLINOIS

Chicago

Allied Radio Corp.
100 N. Western Ave.
HAymarket 1-6800 — **1-11**

Evergreen Allied High Fidelity, Inc.
2025 W. 95th St.
BEverly 8-1067 — **1-11**

Evanston

Allied High Fidelity Stores, Inc.
602 Davis St.
DAvis 8-8822 — **1-11**

Oak Park

West Suburban Allied High Fidelity, Inc.
7055 W. North Ave.
EStebrook 9-4281 — **1-11**

LOUISIANA

New Orleans

The Music Shop, Inc.
4215 South Claiborne Ave.
TW. 1-5871 — **1-5**

MASSACHUSETTS

Boston

The Listening Post, Inc.
161 Newbury St.
COpley 7-7530 — **1, 2, 4, 5, 8-10**

MISSOURI

St. Louis

The High Fidelity Showroom
6383 Clayton Rd.
Parkview 1-6500 — **1-5, 9**

NEW JERSEY

New Brunswick

Monmouth Music House
215 Bevier Road
CHarter 9-5130 — **1, 2, 4, 5, 9**

NEW YORK

Albany

Audio-Video Corporation
324 Central Ave.
3-1167 — **1-5, 8-10**

Amsterdam

Adirondack Radio Supply
185-191 West Main St.
VI. 2-8350 — **1, 2, 4, 8**

Buffalo

Frontier Electronics, Inc.
1507 Main St.
GA. 5727 — **1-5, 8-10**

New York City

Arrow Audio Center
65 Cortlandt St.
DIgby 9-4730 — **1, 2, 4-6, 8-11**

PENNSYLVANIA

Philadelphia

Danby Radio Corp.
19 South 21st St.
Rittenhouse 6-5686 — **1-5, 8-10**

Radio Electric Ser. Co. of Pa., Inc.
7th & Arch Sts.
LO. 3-5840 — **1-11**

Ten Cate Associates
6128 Morton St.
Germantown 8-5448 — **1-5, 8-10**

WASHINGTON

Seattle

High Fidelity Headquarters
603 Broadway North
CApitol 2266 — **1-4, 8, 10**

WEST VIRGINIA

Charleston

Electronic Specialty Co.
Virginia Street W., At Park Avenue
3-5656 — **1-11**

CANADA

Montreal

Payette Radio Limited
730 St. James West
UNiversity 6-6681 — **1-11**

SOUND FANCIER

Continued from preceding page

first acquaintance. I experienced this feeling, too, when I first started to play the Cambridge Society for Early Music disc (Unicorn 1030) starring violinists Ruth Posselt and Richard Burgin in concertos by Vivaldi and Torelli (one not included in the Epic record above) and sonatas by Dall' Abaco, Veracini, and Albinoni. For this is the first recording I know to have been made in my favorite auditorium for concert listening, Sanders Theater in Memorial Hall at Cambridge, Massachusetts, which I remember best for its incomparably live acoustics as excited by the Boston Symphony in full blast. But the initial impression of thinness quickly disappeared as my ears became accustomed to the very different demands of this music. And long before it was finished I had been persuaded that I'd never heard the combination of a few strings and harpsichord (here played as boldly as it should be, in freely extemporaneous fashion, by Erwin Bodky) captured more authentically. Peter Bartók has made many more sensational and obviously brilliant recordings than this, but I doubt whether even he has ever achieved a more candidly honest one. And at least one of the works included here ranks among those no one, whatever his tastes, should miss; if Albinoni has been only a name to you before, once you hear his Trio-Sonata in A major, Op. 1, No. 3, you'll esteem him forevermore among the most captivating of musical personalities!

Plucked Strings Solo

If you've been exposed to so much hi-fi percussion indoctrination that the ictus of harpsichord tone attack and the gut bite of a rosined bow don't pack enough kick for your overstimulated aural appetites, I still have the means (I hope!) to win you over to baroque strings. Just give me — or rather, Michel Podolski's *Bach Works for the Lute* (Period SPL 724) — a fair chance! But first relax, turn the volume control down (for the tiny-voiced lute is considerably enlarged here, if miraculously quite without distortion), and prepare to enter a strange, but wholly bewitching, new world of sound. In their own ways, these two suites (one usually heard in an unaccompanied cello version) and a Prelude and Fugue in E Flat offer sonic enticements, and even excitements, which are in microcosm quite comparable to those commanded, on an infinitely larger scale, by, say, Ravel's *Daphnis et Chloé.*

(Well, maybe I'm exaggerating just a bit, but [boy scout's oath!] that's the way I feel while I'm hypnotized by some of the most novel, refreshing, and expressive *timbres* I've ever encountered on records or off.)

However, if you're a bit timid about jumping cold, at it were, from more romantic music and instruments directly into what you may fear are the too remote baroque lutenist domains, there are convenient stepping stones in the form of solo Spanish guitar recordings, whose brighter, bolder, more incisive tonal qualities well may be more exciting at first hearing, if scarcely as deeply satisfying in the long run. Two particularly good ones I've heard recently are Laurindo Almeida's *Guitar Music of Spain* (transcriptions of Albéniz and Falla, plus originals by Sor, Segovia, Tárrega, and Tórroba; Capitol P 8295), and Mario Escudero's *Flamenco* (Phototapes-Sonore PM 5008, or Folkways LP 920). The former is perhaps the more immediately appealing for its warmly expressive playing of highly atmospheric Iberian mood music, but the latter, with its more scintillating tonal qualities and electrifying Gypsy passion, is likely to make a more dramatic impact on hi-fi ears, as well as provide an even sterner test of hi-fi systems' transient responses.

WOODCRAFTER

Continued from page 11

use is the combination stone, coarse on one side and fine on the other. Before using it for the first time, soak the stone overnight in a mixture of equal parts of machine oil and kerosene. Thereafter, lubricate the surface with the same mixture each time the stone is used, and make certain that it is free of dust and grime. Before putting the stone away, wipe it clean with a cloth and store it in a dust-free container. If the surface becomes gummy, warm the stone in an oven and it will wipe clean easily.

When honing, utilize the entire face of the stone to avoid wearing it unevenly and forming hollows. Should the stone become hollowed, it can be made level again by several methods: rub it flat on a smooth iron surface using kerosene and emery powder as an abrasive; rub it on a piece of glass using 80-grit silicon-carbide powder and water; or grind it flat on coarse garnet paper.

The Power Grinder: When cutting edges of tools are damaged, or worn beyond restoration by an oilstone, a power grinder can often come to the rescue. In a workshop equipped with hand tools or power tools, the grinder serves a variety of purposes: sharpening, buffing, polishing, wire brushing, and other tasks, all performed by various accessories. In some machines the motor is part of the main assembly, while in others the motor is separate, driving the grinder by a belt. With the latter, the side of the motor shaft which is not turning the belt can be fitted to take the accessory wheels thereby making it unnecessary to remove the abrasive

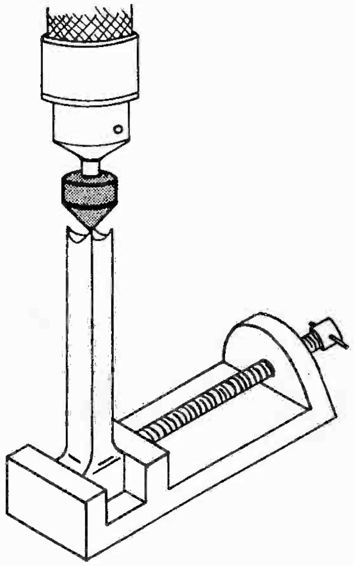


Fig. 7. Sharpening a mortising chisel.

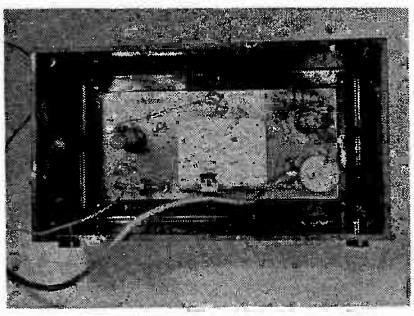
wheel in order to polish or buff or brush.

Though most grinders come equipped with wheel guards or special shields to protect the operator from flying sparks and particles, the wise craftsman will always wear approved safety goggles when using the machine.

AM CRYSTAL TUNER

Continued from page 18

identical to that for the previous tuner. Circuit values differ slightly in some respects, and a volume control has been added. The physical arrangement of parts is, however, quite different; for example, components grouped together



Wiring board in place inside cabinet.

in the coil cans of Dr. Stern's tuner are separated in the 565 kit.

All electrical parts are mounted on a wiring board that is inscribed on both sides with picture outlines of each part where it is to be placed, and with lines showing where interconnecting wires are to go. The board is punched at appro-

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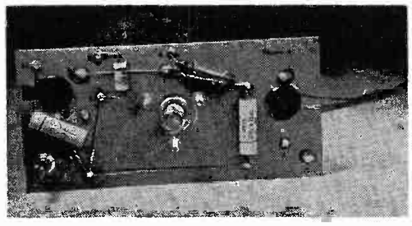
AM CRYSTAL TUNER

Continued from preceding page

priate places and metal eyelets are already inserted in the holes; these eyelets serve as easily soldered connecting terminals, as can be seen in the photographs. When the wiring is completed according to the step-by-step instructions furnished, the board is attached inside the front panel of the 3½ by 4 by 7-inch cabinet with the tuning-capacitor and volume-control shafts projecting through. The brass escutcheon

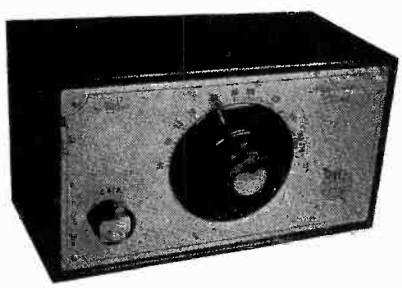


Front side of the wiring board assembly.

is attached at the same time. Then the control knobs and dial indicator are slipped on the shafts; the job is finished. It took us 2¼ hours for everything.

We found that the 565 had slightly greater sensitivity and selectivity than the other tuner. Sound quality was identical, as nearly as we could judge. Other advantages: it isn't necessary to order the parts individually, then scribe and cut the chassis; the 565 is more compact and better looking; it is almost impossible to make a mistake in its assembly; an audio-output cable is supplied; the tuning dial is vernier-driven, so that it is smoother and more precise in operation. The volume control may not be so advantageous because, over much of its operating range, it can produce a sloping high-frequency response — it is safer to leave it turned all the way on.

The 565, although a little more expensive than the other tuner, is still



Appearance of the finished 565 tuner.

an excellent buy because of its far better appearance, additional convenience features, and ease of assembly. If you delight in doing *all* your own work (even to chassis-cutting), or if the lower cost appeals to you, then Dr. Stern's tuner offers virtually as good performance at an even smaller investment.

PROFESSIONAL DIRECTORY

TRADERS' MARKETPLACE

Here's the place to buy, swap, or sell audio equipment. Rates are only 20¢ a word (including address) and your advertisement will reach 20,000 to 35,000 readers. Remittance must accompany copy and insertion instructions.

READERS' FORUM

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trouble, particularly if the music were copyrighted. The only possible exception would be the use of such a recording to demonstrate the capabilities of receiving or recording gear, and even in such instances the recordist would do well to avoid making or using tapes of complete musical selections.

There remains the question of tape recordings from broadcasts which are

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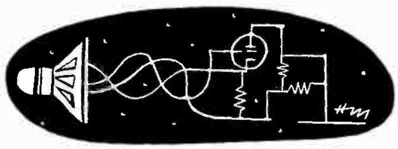
used by the home recordist for the public or private entertainment of groups of people, where there is no commercial intention on the part of the recordist. If the home tape is a copy of the music only from a commercial recording and contains complete musical selections and the recordist's tape were made with the intention of avoiding the use or purchase of the commercial recording, I should think he could get into serious trouble. If the recording is of special material broadcast by the station, not ordinarily available on commercial recording, my suggestion to the recordist would be to get in touch with the responsible executive (usually the Program Director) of the station recorded to see whether permission to use the tape can be obtained. This can take quite a bit of doing, for chances are that the station cannot give the permission itself, but can only tell one whom to ask. And, of course, this implies that the recordist is telling the station and others that he has made the recording, which could be enough to get him into trouble by itself. The best policy, though, is openly and clearly to obtain permission before playing a tape obtained from a broadcast before any group of people (and, I suppose, particularly before any group of people not likely to have heard the original broadcast).

All this may sound very strict and unencouraging, especially when one considers the amount of such taping going on. The situation is somewhat analogous to speeding on the highway: it's



against the law; nobody seriously recommends the infraction; violators are often severely punished, although just as often they get off quite lightly; and the bulk of the infractions remain undetected and unpunished.

Speaking officially for WCRB, I should like it to be clearly known that we take a dim view of most of such recording. We shall co-operate with any recording company which may wish to take action against any of our listeners who copy commercial recorded material broadcast by the station, and we shall take prompt action against those who record our own material and attempt to use it in any way without our prior permission.

Broadcast musical programs are intended for *one time* enjoyment in listeners' homes; commercial recordings are made and sold to provide repeated hearings in the listeners' homes. We work

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READERS' FORUM

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closely with many of the record companies; it is neither their intention nor ours that our broadcasting should cut into possible record sales. Contrariwise, our broadcasting generally stimulates record sales. Should the tape recording of their material by listeners as it is broadcast cut their expected sales of recordings, then it is quite apparent that the record companies will try to make it more difficult for broadcasters to use their materials. This can only result in the curtailment of such broadcasting; thus it is that we must oppose such recording.

Finally, it must be pointed out that any such recording taken at home, even if a $600 FM tuner and a $2,000 tape recorder are used, must necessarily suffer some degradation in quality from the recording used by the broadcaster (and if this is a commercial recording, then from the quality you could probably obtain by buying the recording yourself). Incidentally, costs being what they are, you cannot hope to amortize the cost of your recording and receiving equipment in the trifling savings to be made by taking music down off the air rather than purchasing long-playing records.

Richard L. Kaye
WCRB
Boston, Mass.

Briefly, I think Mr. Kaye has his points, but in the words of the sages, what can be done about it? It would take an efficient police state to do away with recording off the air, and I for one would rather accept the situation as it now exists.

J. Gordon Holt

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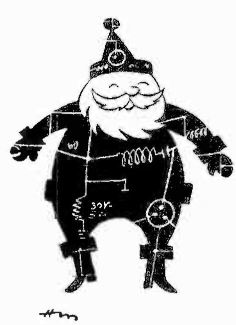

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