audiocraft

for the HI·FI hobbyist

AUGUST 1957

209

35 CENTS

Room acoustics controlled electronically

Install a record player in your car

Tweeter crossover networks

Goodmans ARU Enclosure Kit

PROOF

UNIVERSITY SPEAKERS STAY SOLD!

To insure valid statistics, this tabulation covers the largest selling brands, based on a four-year survey (April 1953 to March 1957) of classified and "Swap or Sell" ads for used high fidelity loudspeakers. All ads authenticated as placed by private individuals in Audio, High Fidelity and Music At Home

PERCENTAGE OF TOTAL INSERTIONS			
SPEAKER "A"	SPEAKER "B"	SPEAKER "C"	UNIVERSITY
46½%	23¼%	16¼%	13%

Fewest number of ads offer University equipment . . . outstanding testimonial of user satisfaction.

We have always believed that the tremendous volume of University speakers sold in the past to hi-fi enthusiasts attested to the genuine listening satisfaction

nd pleasing, but the
power". Does it grow
r . . . or is it obsolete

diophile magazines,
peakers readers out-
eading loudspeakers

aken over a span of
re "for sale" listings
than three times as
average hi-fi users
year after year as a

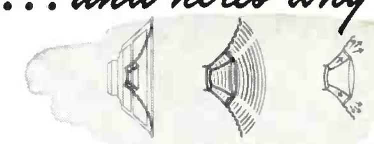
size and budget requirement

ENCLOSURES

nds better

E, WHITE PLAINS, N. Y

. . . and heres why

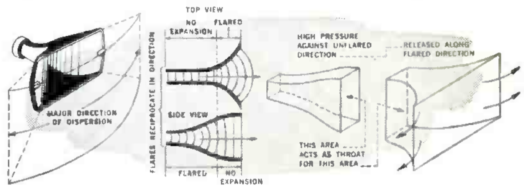


PATENTED DIFFUSICONE PRINCIPLE.

Available only on University Diffaxials. Mid and high frequencies are extended with remarkable efficiency through coaxial dual horn loading at the apex of the loudspeaker cone. A radial projector combined with aperture diffraction provides uniform, wide-angle dispersion, assuring *full fidelity* no matter where off speaker axis you may be listening.

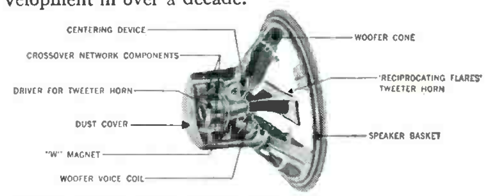
EXCLUSIVE BI-SECTIONAL CONSTRUCTION

Typical of University's advanced design and fabrication techniques is the unique bi-sectional construction of completely independent basket and magnet assemblies. This results in a precision product—vibration and shock-proof in operation, built for trouble-free long life.



PATENTED "RECIPROCATING FLARE" DESIGN

On all University tweeters the compression driver is coupled to a "reciprocating flare" horn designed to provide *maximum* uniformity of wide-angle dispersion in the horizontal plane with optimum vertical coverage. This is the greatest single advance in wide-angle horn development in over a decade.



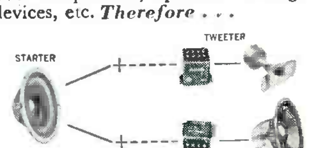
TRUE THRU-THE-AXIS DESIGN

In *true* thru-the-axis design, the tweeter driver unit is fitted to the "reciprocating flare" horn *thru the center* of the woofer magnet assembly. Only with *this* thru-the-axis design is it possible to project high frequencies thru a horn of scientific formula-correct length and configuration . . . and thus achieve highest efficiency, lowest distortion and uniform wide-angle treble reproduction.

MAXIMUM COMPONENT FLEXIBILITY

To meet the ever varying technical needs of expanding aspirations and improvements, University components are designed to provide a maximum of application and operational flexibility, e.g.: woofers with dual impedance voice coils, networks and filters to match all popular impedances and crossover frequencies, speakers having adjustable response devices, etc. ***Therefore . . .***

Only University can offer...

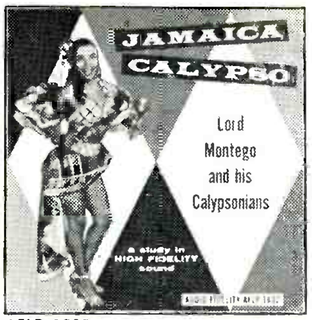


GENUINE PROGRESSIVE SPEAKER EXPANSION

The "Master Blueprint" that prevents your speaker from becoming obsolete, because you can *improve* without discarding existing speakers or systems! You choose from literally dozens of different starter speaker set-ups to suit your present taste and purse. Then, when and as you wish, you integrate these components into *tomorrow's* magnificent deluxe system . . . safeguarded by unmatched engineering flexibility and variety that makes "step-by-step" improvement a wonderful reality.

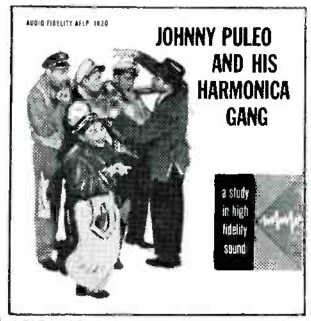
HIGH FIDELITY

These are just a few of the reasons why University assures you superior sound that lives and lasts through the years. As other satisfied purchasers know . . . you might spend more—but you can't equal University.

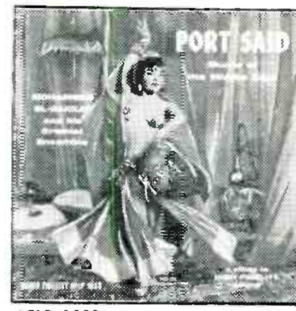


AFLP 1832

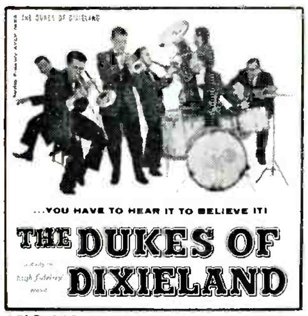
AFLP 1825



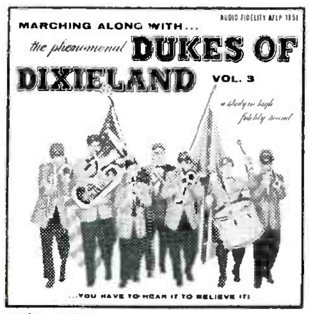
AFLP 1830



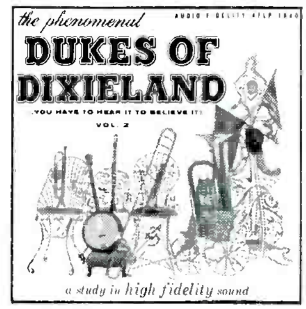
AFLP 1833



AFLP 1823



AFLP 1851

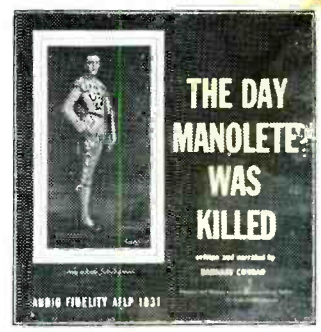


AFLP 1840

the finest in HIGH FIDELITY Sound . . .

AUDIO FIDELITY

TOTAL FREQUENCY RANGE RECORDINGS

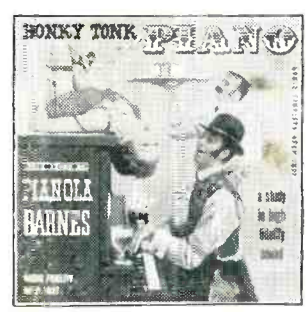


AFLP 1831

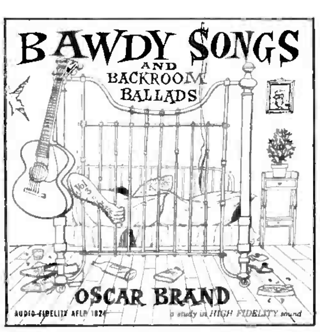
AFLP 1815

AFLP 1810

AFLP 1822



AFLP 1827



AFLP 1824

AFLP 1801

AFLP 1817

in Brilliant
High Fidelity Sound
$5.95 each 12 inch LP

AUDIO FIDELITY
INCORPORATED

Nationally Distributed by:
DAUNTLESS INTERNATIONAL
766 Eleventh Ave., New York 19, N. Y.
Write for FREE Catalog

Save yourself time and trouble by ordering your books directly from us. Just fill in the coupon below.

audiophile's bookshelf

Three recent books by three experts

HANDBOOK OF SOUND REPRODUCTION

By EDGAR VILLCHUR, inventor of AR loudspeaker systems and president of Acoustic Research, Inc.

Here is A-1 information about all aspects of sound reproduction, acoustics, and the necessary components. Written by one of the foremost authorities in the field, the book is organized in a way similar to home training courses. It fully covers a difficult technical subject in a manner which will provide pleasure and profit to the high-fidelity enthusiast. $6.50 **249**

HIGH FIDELITY: THE WHY AND HOW FOR AMATEURS

By G. A. BRIGGS, designer and manufacturer of Wharfedale loudspeakers.

". . . . holds something for everyone. For the amateur, for whom it was written, it holds a bit of everything, in suitably compressed form, and must inevitably leave him with a feeling that he has acquired a general working background to the whole subject. . . . It deserves a wide readership, and I am certain it will secure it." — HI-FI NEWS (England) $2.95 **250**

OLIN DOWNES ON MUSIC

Edited by IRENE DOWNES

A selection of over 170 of Olin Downes's reviews, Sunday columns, and other pieces, written between 1906 and 1955. $5.00 **246**

"The general impression these (reprints) have left on me is that I have been in long and fruitful contact with a fine musical mind, a mind moreover, of fundamental sincerity and integrity." — Ernest Newman in THE NEW YORK TIMES BOOK REVIEW

Now available — the revised edition of Greene & Radcliffe's extremely popular

THE NEW HIGH FIDELITY HANDBOOK

A complete, practical guide for the purchase, assembly, installation, maintenance, and enjoyment of high-fidelity music systems. Includes the latest information on equipment. 250 illustrations, diagrams, and plans. $4.95 **251**

". . . Messrs. Greene and Radcliffe, two gentlemen whose knowledge of hi-fi is only slightly less than awesome. Whoever said that 'reading maketh a full man' was right — at least as concerns this book. Read it through, and you will arise full of knowledge." — Deems Taylor

WHAT TO LISTEN FOR IN MUSIC

By AARON COPLAND. The revised edition of a book which made it possible for thousands to increase their enjoyment of music through creative listening. $3.95 **247**

THE FORMS OF MUSIC

By SIR DONALD TOVEY. Written by one of the most literate and profound of modern interpreters of music, these essays are drawn from those articles which Tovey prepared for the *Encyclopaedia Britannica.* Paper, $1.35 **239**

Continuing best sellers

HIGH FIDELITY RECORD ANNUAL: 1956

Edited by ROLAND GELATT. The second volume of *High Fidelity Record Annuals.* Included in this collection are reviews of classical and semiclassical music and the spoken word which appeared in HIGH FIDELITY Magazine from July 1955 through June 1956. Comparisons with recordings of previous years are emphasized. A performer index is included. $4.50 **237**

HIGH FIDELITY RECORD ANNUAL: 1955 $4.95 **201**

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. The book is clearly written and well indexed. Hard cover, $5.00 **232** Soft, $2.90 **233**

HIGH FIDELITY: A PRACTICAL GUIDE

By CHARLES FOWLER, Publisher, AUDIOCRAFT Magazine

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.

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 chain, explaining their features and specifications so as to provide the most helpful criteria for evaluating, and for selecting and matching components. $4.95 **234**

Book Department
AUDIOCRAFT Magazine
Great Barrington, Mass.

I enclose $........ for which please send me, postpaid, the books indicated by circled numbers below. (No C.O.D.'s or charge orders, please.) Foreign orders sent at buyer's risk. Add 55¢ per book for postage on foreign orders except Canadian.

Binder 1 (holds 14 issues) 223 $3.50
Binder 2 (holds 12 issues) 245 $3.00

	239
201	245
223	246
232	247
233	249
234	250
237	251

NAME ....

ADDRESS ....

....

Charles Fowler
Publisher

Warren B. Syer
Associate Publisher

Roy F. Allison
Editor

Frank R. Wright
Managing Editor

Eleanore B. Wright
Editorial Assistant

Roy Lindstrom
Art Director

Eleanor Gilchrist
Art Assistant

Frances A. Newbury
Manager, Book Division

R. D. Darrell
J. Gordon Holt
Joseph Marshall
Contributing Editors

Claire Eddings
Advertising Sales Manager

Arthur J. Griffin
Circulation Manager

audiocraft

THE MAGAZINE FOR THE HI-FI HOBBYIST

AUGUST 1957

Volume 2 Number 8

A D V E R T I S I N G

Main Office — Claire Eddings, The Publishing House, Great Barrington, Mass. Telephone: Great Barrington 1300.
New York — Frederick H. Wallin, 280 Madison Ave., New York, N.Y. Telephone: Murray Hill 3-4449, 3-4450.
Chicago — John R. Rutherford & Associates, Inc., 230 East Ohio St., Chicago, Ill. Telephone: Whitehall 4-6715.
Los Angeles — Brand & Brand, Inc., 6314 San Vicente Blvd., Los Angeles, Calif. Telephone: Webster 8-3971.

Audiocraft Magazine is published monthly by Audiocom, Inc., in Great Barrington, Mass. Telephone: Great Barrington 1300. Editorial, publication, and circulation offices at: The Publishing House, Great Barrington, Mass. Subscriptions: $4.00 per year in the United States and Canada. Single copies: 35 cents each. Editorial contributions will be welcomed by the editor. Payment for articles accepted will be arranged prior to publication. Unsolicited manuscripts should be accompanied by return postage. Entered as second-class matter October 1, 1955, at the post office, Great Barrington, Mass., under the act of March 3, 1879. Additional entry at the post office, Pittsfield, Mass. Printed in the U. S. A. by the Ben Franklin Press, Pittsfield, Mass.

The Grounded Ear

by Joseph Marshall

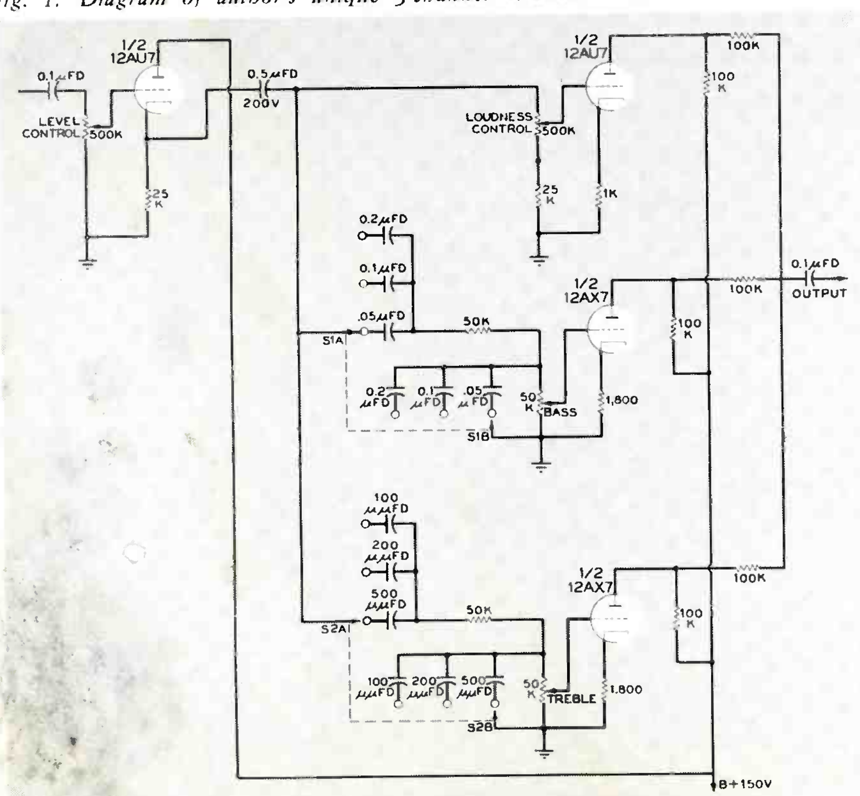
FROM time to time I have reported new developments by others, and I hope I will not be considered presumptuous if I now report one of my own.

One of the most troublesome of unresolved problems in hi-fi design is that presented by the so-called loudness control, which is meant to compensate for the fact that the frequency response of the ear varies with the intensity of the sound. At high intensity levels the response is relatively flat over the whole audible range. But as the intensity level is reduced the response falls off at both the high and low ends until, at very low levels, low bass sounds of the same intensity as the middle-frequency sounds become inaudible. Fletcher and Munson investigated this 25 years ago and prepared the well-known Fletcher-Munson curves from their data.

The Fletcher-Munson curves we see in hi-fi literature are actually abstract curves of several hundred diverse human ears. These abstract curves are extremely helpful in improving our understanding of the processes of hearing, but they are not universal curves applicable to all or even a majority of human ears — any more than the measurements of an average or mean American male are applicable to all or even a majority of American males. And yet, too many engineers, both amateur and professional, have treated the Fletcher-Munson curves as if they could be applied universally. There might be some justification for such use in strictly communication media (such as the telephone) which do not pretend to provide faithful reproduction. But high-fidelity equipment is intended to furnish faithful reproduction, and a universal application of the Fletcher-Munson curves is about as likely to insure faithful reproduction for everyone as a suit tailored to the measurements of the average American male would be likely to make every man well-dressed.

This would be true even if all listeners agreed in their preferences. But as a matter of fact, some listeners prefer a frequency balance approximating that of an orchestra heard very close-up, while others prefer that of an orchestra rather more remote, and this difference requires different degrees of equalization as well as different sound levels.

Fig. 1. Diagram of author's unique 3-channel loudness- and tone-control circuit.



Actually, if we look into the original Fletcher-Munson data and subsequent research efforts in this field, we will find that the one thing they make very clear is that there is a wide variation in the hearing capabilities of individual human ears. If these studies prove anything of value for high fidelity, it is that the loudness-level contours vary so much both with different ears and with different intensity levels that any equipment which hopes to provide the highest degree of faithfulness for the greatest number of people will have to include a means of varying the loudness contours pretty widely.

It is significant that the original attempt to stick closely to the abstract Fletcher-Munson curves on all equipment has been a failure. Only the cheapest and simplest hi-fi equipment today offers a single loudness compensation control. In the better equipment engineers have tried to provide some range of variation. In some instances this takes the form merely of a switch to disable the loudness control entirely; in others, the loudness control is paired with a level control and, when properly operated, the combination can furnish a sufficient variation to suit many and perhaps a majority of ears; in still others, there are contour selector switches or controls which provide a choice of slopes as well as degree of boost. A notably felicitous solution is found in the Marantz control unit in which a LOUDNESS COMPENSATOR control provides some variation of both the slope and the boost, and when used in conjunction with the excellent tone controls can meet a wide variety of requirements or preferences.

Many experts, especially in Great Britain, believe that the best way to handle the problem is by means of the tone controls. Also, many owners of American systems with loudness controls have found that they obtain the most satisfying sound by disabling the loudness control and merely adjusting the tone controls. Actually, this approach has great merit. The only trouble is that

Continued on page 48

by RICHARD D. KELLER

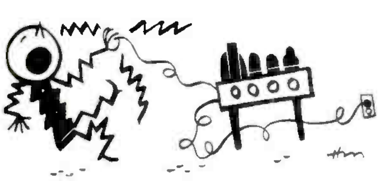
book reviews

The Radio Amateur's Handbook

Pub. by the American Radio Relay League, West Hartford, Conn.; 760 pages; $3.50, paper-bound.

The 34th annual edition of this venerable reference standard has new material added in the light of the numerous changes in technical practice during recent years.

A short section on transistors is included, and an appreciable amount of new equipment and circuitry in all categories appears throughout the book. New receivers and transmitters for the novice as well as for the more experi-



enced amateur, and new material on high-powered VHF and single-sideband equipment and beam antennas help round out the Handbook this year. Ratings and base diagrams of hundreds of receiving and power tubes, semiconductor transistors, and diodes are also included.

It is easy to see why the Handbook has an annual distribution greater than that of any other technical handbook in any field of human activity and is universally used by radio engineers and technicians, as well as by thousands of amateurs and experimenters.

The Electronic Musical Instrument Manual

Alan Douglas, M.I.R.E.; pub. by Pitman Publishing Corp., New York; 250 pages; $7.50.

This 3rd edition of a book originally published in 1949 has been expanded to cover many modern developments in the electronic musical-instrument field. It explains the relationship between acoustical-instrument tone colors and their electrically created counterparts, presenting the basic circuits for achieving the desired tonal results.

Commercial electronic instruments of France, Germany, Britain, and the United States are described, and circuits given for all or part of the Hammond, Solovox, Clavioline, Novachord, and Conn organs, with detailed explanations of their operation.

The Electrical Production of Music

Alan Douglas, M.I.R.E.; pub. by Philosophical Library, New York; 224 pages; $12.00.

The author addresses here primarily the amateur who is interested more in the production rather than the reproduction of music.

Unlike the work reviewed above, which delved extensively into the details of commercial electronic organs, this book deals with the *basic* principles of the electrical production of music. Starting with an interesting description of each of the major types of orchestral instruments, their characteristics, and methods of tone generation, the author proceeds to show just how their respective transients and formants, or harmonic patterns, can most closely be simulated by artificial or electronic means.

A great deal of information is given in this work about musical scales and intervals, and about possible future trends of research in the field. An appendix presents the more involved mathematical approaches to musical formation and filtering.

Handbook of Sound Reproduction

Edgar M. Villchur; pub. by Radio Magazines, Inc., Mineola, N.Y.; 216 pages; $6.50.

Written by a well-known audio researcher, author, and instructor, this book covers rather extensively the engineering principles involved in the reproduction of sound.

The approach to the subject of loudspeakers and enclosures is most noteworthy, although the coverage of the physical basis of mechanical-electrical analogies is also good. A short history of the sound-recording art, and discussions of low- and high-power amplifiers, pickups and tone arms, and testing methods for completed systems are included.

The advanced hi-fi layman should find much of interest in this volume, while the sound engineer or scientist will find it a very useful and wide-ranging handbook.

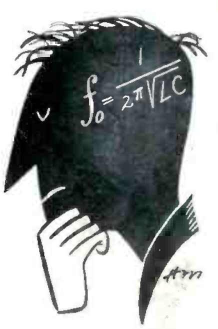
Vacuum-Tube Circuits and Transistors

Lawrence Baker Arguimbau, with transistor contributions by Richard Brooks Adler; pub. by John Wiley & Sons, Inc., New York; 646 pages; $10.25.

A very thorough textbook, this, with emphasis on fundamental principals, yet with formalized mathematics kept to a minimum. The book covers every major phase of electron-tube theory and usage from diodes to television (nothing, however, on gaseous-discharge tubes), and includes new material on frequency modulation, noise, and inverse feedback.

Transistor theory is woven in with the rest of the text. Semiconductor physics is well explained, with transistor circuit theory in linear amplifiers, tuned circuits, and oscillator circuits covered in some detail.

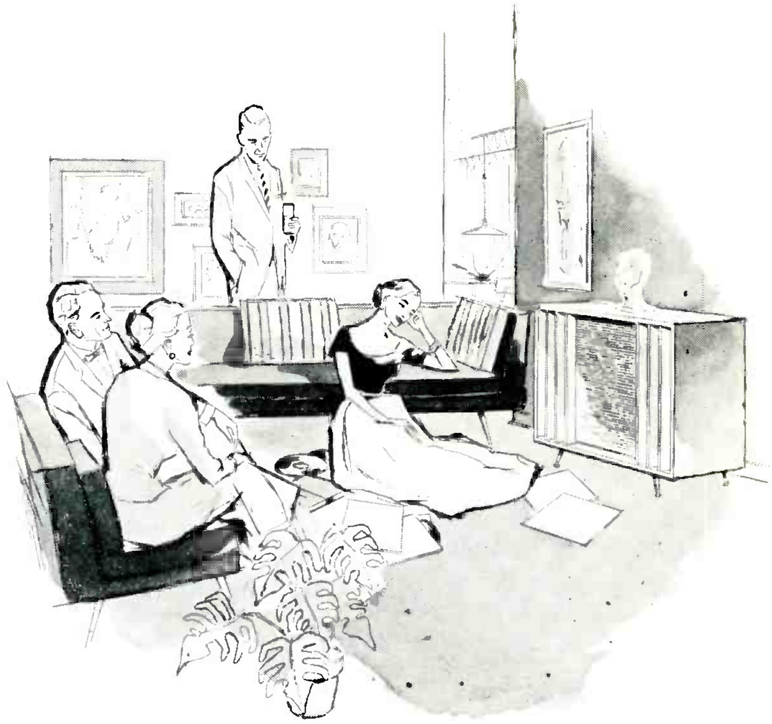
The authors deal here mostly with basic principles and theory rather than



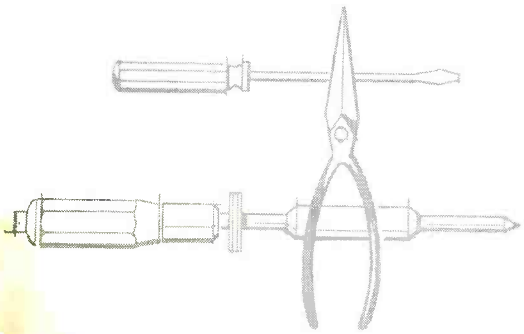
with specifics. Numerous problems are given in each chapter to determine the comprehension of the student as he proceeds.

This brings the original well-known work by Mr. Arguimbau, *Vacuum-Tube Circuits*, written in 1948, up-to-date as of mid-1956, and illustrates dramatically the large new territories discovered and charted in the world of electronics in those eight short years.

treat your family
to all the fun and enjoyment
of fine high fidelity at
one-half the price you
would expect to pay



HERE'S ALL YOU NEED



to build your own HEATHKIT HI-FI

FM TUNER

AM TUNER

PREAMPLIFIER

HEATHKIT HIGH FIDELITY FM TUNER KIT

This FM tuner is your least expensive source of high fidelity material! Stabilized oscillator circuit assures negligible drift after initial warmup. Broadband IF circuits assure full fidelity, and 10 microvolt sensitivity pulls in stations with full volume. High-gain cascode RF amplifier, and automatic gain control. Ratio detector gives high-efficiency demodulation. All tunable components prealigned. Edge-illuminated dial for easy tuning. Here is FM for your home at a price you can afford. Shpg. Wt. 7 lbs.

MODEL FM-3A **$25.95** (with cabinet)

HEATHKIT BROADBAND AM TUNER KIT

This tuner differs from an ordinary AM radio in that it has been designed especially for high fidelity. The detector uses crystal diodes, and the IF circuits are "broadbanded" for low signal distortion. Sensitivity and selectivity are excellent. Quiet performance is assured by 6 db signal-to-noise ratio at 2.5 uv. All tunable components prealigned. Incorporates AVC, two outputs, and two antenna inputs. Edge-lighted glass slide rule dial for easy tuning. Your "best buy" in an AM tuner. Shpg. Wt. 8 lbs.

MODEL BC-1A **$25.95** (with cabinet)

HEATHKIT "MASTER CONTROL" PREAMPLIFIER KIT

This unit is designed to operate as the "master control" for any of the Heathkit Williamson-type amplifiers, and includes features that will do justice to the finest program material. Frequency response within ±1½ db from 15 to 35,000 CPS. Full equalization for LP, RIAA, AES, and early 78's. Five switch-selected inputs with separate level controls. Bass and treble control, and volume control, on front panel. Very attractively styled, and an exceptional dollar value. Shpg. Wt. 7 lbs.

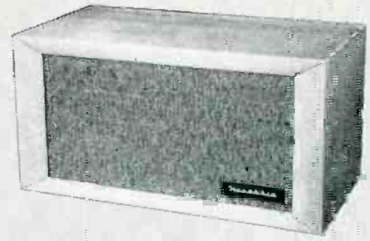
MODEL WA-P2 **$19.75** (with cabinet)

HEATHKIT "BASIC RANGE" HIGH FIDELITY SPEAKER SYSTEM KIT

The very popular model SS-1 Speaker System provides amazing high fidelity performance for its size because it uses high-quality speakers, in an enclosure especially designed to receive them.

It features an 8" mid-range-woofer to cover from 50 to 1600 CPS, and a compression-type tweeter with flared horn to cover from 1600 to 12,000 CPS. Both speakers are by Jensen. The enclosure itself is a ducted-port bass-reflex unit, measuring 11½" H x 23" W x 11¾" D and is constructed of veneer-surfaced plywood, ½" thick. All parts are precut and predrilled for quick assembly.

Total frequency range is 50 to 12,000 CPS, within ±5 db. Impedance is 16 ohms. Operates with the "Range Extending" (SS-1B) speaker system kit later, if greater frequency range is desired. Shpg. Wt. 30 lbs. MODEL SS-1 $39.95

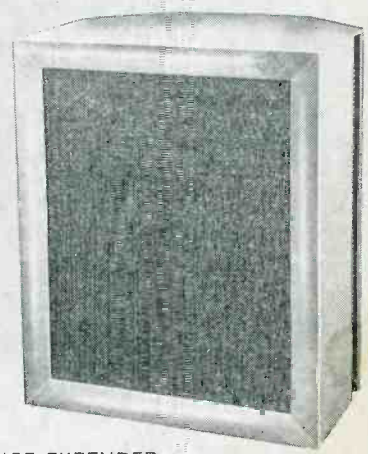


"BASIC" SPEAKER SYSTEM

HEATHKIT "RANGE EXTENDING" HIGH FIDELITY SPEAKER SYSTEM KIT

The SS-1B uses a 15" woofer and a small super-tweeter to supply very high and very low frequencies and fill out the response of the "Basic" (SS-1) speaker system at each end of the audio spectrum. The SS-1 and SS-1B, combined, provide an overall response of ±5 db from 35 to 16,000 CPS. Kit includes circuit for crossover at 600, 1600 and 4000 CPS. Impedance is 16 ohms, and power rating is 35 watts. Measures 29" H x 23" W x 17½" D, and is constructed of veneer-surfaced plywood, ¾" thick. Easy to build! Shpg. Wt. 80 lbs.

MODEL SS-1B $99.95



RANGE EXTENDER

...and save!

HEATHKITS

World's finest electronic equipment in kit form...

HEATHKIT "LEGATO" HIGH FIDELITY SPEAKER SYSTEM KIT

The fine quality of the Legato Speaker System Kit is matched only in the most expensive speaker systems available. The listening experience it can bring to you approaches the ultimate in esthetic satisfaction.

Frequency response is ±5 db 25 to 20,000 CPS. Two 15" theater-type Altec Lansing speakers cover 25 to 500 CPS, and an Altec Lansing high frequency driver with sectoral horn covers 500 to 20,000 CPS. A precise amount of phase shift in the crossover network brings the high-frequency channel into phase with the low-frequency channel to eliminate peaks or valleys at the crossover point. This is one reason for the mid-range "presence" so evident in this system design.

The attractively styled "contemporary" enclosure emphasizes simplicity of line and form to blend with all furnishings. Cabinet parts are precut and predrilled from ¾" veneer-surfaced plywood for easy assembly at home. Impedance is 16 ohms. Power rating is 50 watts for program material. Full, smooth frequency response assures you of outstanding high fidelity performance, and an unforgettable listening experience. Order HH-1-C (birch) for light finishes, or HH-1-CM (mahogany) for dark finishes. Shpg. Wt. 195 lbs.

MODELS HH-1-C or HH-1-CM $325.00 each

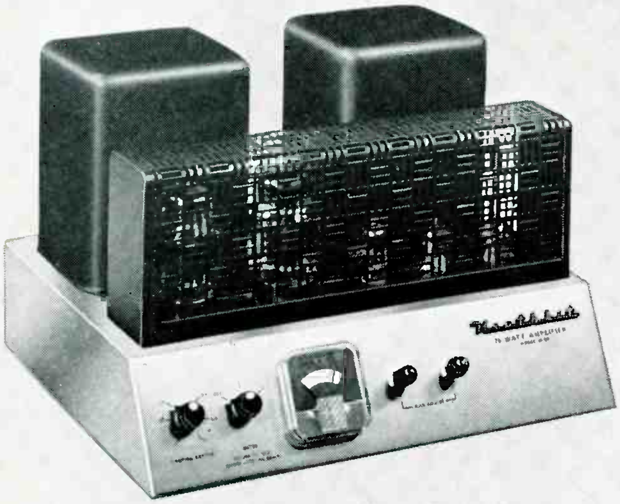
"LEGATO" SPEAKER SYSTEM

Pioneer in "do-it-yourself" electronics

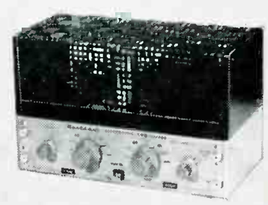
HEATH COMPANY

A subsidiary of Daystrom, Inc.
Benton Harbor 18, Mich.

25-WATT AMPLIFIER



70-WATT AMPLIFIER



ELECTRONIC CROSS-OVER

easy-to-build designs by HEATH *insure*

You get more comprehensive assembly instructions, higher quality circuit components, and more advanced design features, when you buy HEATH hi-fi!

HEATHKIT 70-WATT HIGH FIDELITY AMPLIFIER KIT

This new amplifier features extra power reserve, metered balance circuit, variable damping, and silicon-diode rectifiers, replacing vacuum tube rectifiers. A pair of 6550 tubes produce full 70-watt output with a special-design Peerless output transformer. A quick-change plug selects 4, 8 and 16 ohm or 70 volt output, and the correct feedback resistance. Variable damping optimizes performance for the speaker system of your choice. Frequency response at 1 watt is ±1 db from 5 CPS to 80 KC with controlled HF rolloff above 100 KC. Harmonic distortion at full output less than 2%, 20 to 20,000 CPS, and intermodulation distortion below 1% at this same level. Hum and noise are 88 db below full output. Variable damping from .5 to 10. Designed to use WA-P2 preamplifier. Express only. Shpg. Wt. 50 lbs. **MODEL W-6M $109.95**

HEATHKIT 25-WATT HIGH FIDELITY AMPLIFIER KIT

The 25-watt Heathkit model W-5M is rated "best buy" in its power class by independent critics! Faithful sound reproduction is assured with response of ±1 db from 5 to 160,000 CPS at 1 watt, and harmonic distortion below 1% at 25 watts, and IM distortion below 1% at 20 watts. Hum and noise are 99 db below rated output, assuring quiet, hum-free operation. Output taps are 4, 8 and 16 ohms. Employs KT66 tubes and Peerless output transformer. Designed to use WA-P2 preamplifier. Express only. Shpg. Wt. 31 lbs. **MODEL W-5M $59.75**

HEATHKIT ELECTRONIC CROSS-OVER KIT

This device separates high and low frequencies electronically, so they may be fed through two separate amplifiers driving separate speakers. The XO-1 is used between the preamplifier and the main amplifiers. Separate amplification of high and low frequencies minimizes IM distortion. Crossover frequencies are selectable at 100, 200, 400, 700, 1200, 2000, and 3500 CPS. Separate level controls for high and low frequency channels. Attenuation is 12 db per octave. Shpg. Wt. 6 lbs.

MODEL XO-1 $18.95

HEATHKIT W-3AM HIGH FIDELITY AMPLIFIER KIT

Features of this fine Williamson-type amplifier include the famous Acrosound model TO-300 "ultralinear" transformer, and 5881 tubes for broad frequency response, low distortion, and low hum level. Response is ±1 db from 6 CPS to 150 KC at 1 watt. Harmonic distortion is below 1% and IM distortion below 1.3% at 20 watts. Hum and noise are 88 db below 20 watts. Provides output taps of 4, 8 or 16 ohms impedance. Designed to use WA-P2 preamplifier. Shpg. Wt. 29 lbs. **MODEL W-3AM $49.75**

HEATHKIT W-4AM HIGH FIDELITY AMPLIFIER KIT

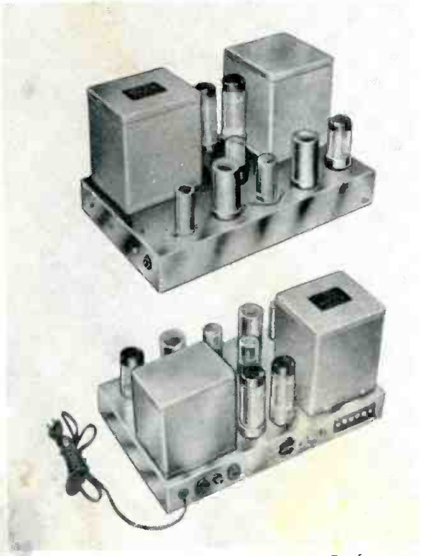
A true Williamson-type circuit, featuring extended frequency response, low distortion, and low hum levels, this amplifier can give you fine listening enjoyment with a minimum investment. Uses 5881 tubes and a Chicago-standard output transformer. Frequency response is ±1 db from 10 CPS to 100 KC at 1 watt. Less than 1.5% harmonic distortion and 2.7% intermodulation at full 20 watt output. Hum and noise are 95 db below full output. Transformer tapped at 4, 8 or 16 ohms. Designed to use WA-P2 preamplifier. Shipped express only. Shpg. Wt. 28 lbs. **MODEL W-4AM $39.75**

LAFAYETTE 60-WATT AMPLIFIER KIT

The latest addition to Lafayette's line of hi-fi kits is a 60-watt ultra-linear power amplifier featuring an Acrosound TO-330 output transformer. The amplifier uses low-noise EF86 voltage-amplifier tubes directly coupled to a cathode-coupled 6SN7GTB phase inverter. Push-pull EL34 output tubes are ultra-linear connected and operated with a fixed bias.

Output of the amplifier is rated at 60 watts (130 watts peak). Frequency response at 60 watts is said to be flat ± 0.1 db from 16 to 90,000 cps. Hum and noise level is 80 db below rated output, according to the manufacturer.

The unit is furnished with input-level, bias, and bias-balance controls. Sockets



High-power amplifier kit from Lafayette.

are provided for remote on/off switching and preamp power take-off. The chrome-plated chassis measures 6 7/8 in. by 14 in. by 7 15/16 in. Lafayette's number is *KT-120.* The kit includes all parts, tubes, diagrams, and instructions. The price is $59.95.

LIVINGSTON TAPE CATALOGUE

A catalogue of all recorded tapes available from Livingston Audio Products Corporation has recently been released. The 48-page booklet lists more than 40 stereophonic and more than 160 monaural titles. Livingston also acts as the exclusive agency for the release of tape material from a number of independent recording companies, such as Boston, Elektra, Empirical, Esoteric, Lyrichord, Oceanic, Riverside, Hack Swain, and Tico. A copy of the new Livingston catalogue will be sent free on request.

SHERWOOD FM-AM TUNER

Sherwood Electronic Laboratories, Inc., recently introduced the *S-2000* FM-AM tuner as an addition to its line of high-fidelity components. The new tuner

S-2000 tuner has FM and AM sections.

features FM sensitivity of 0.95 μv at 20 db quieting, according to the manufacturer.

In the FM circuit, a low-noise, balanced-antenna input transformer feeds a cascode RF amplifier. The FM section also features a Foster-Seeley balanced discriminator, delayed AGC, and AFC.

The superheterodyne AM section has two tuned RF circuits and built-in, directable ferrite-rod antenna.

Additional information about the Sherwood S-2000 FM-AM tuner will be furnished on request.

GROMMES PG AMPLIFIERS

Each unit in the new Grommes *PG* series of high-fidelity amplifiers features advanced feedback circuitry, a full set of controls, and durability. The PG line is finished in charcoal gray with brushed-brass trim.

Three units go to make up the PG series. The 10 PG is a modestly priced 10-watt amplifier. The 15 PG is a 12-

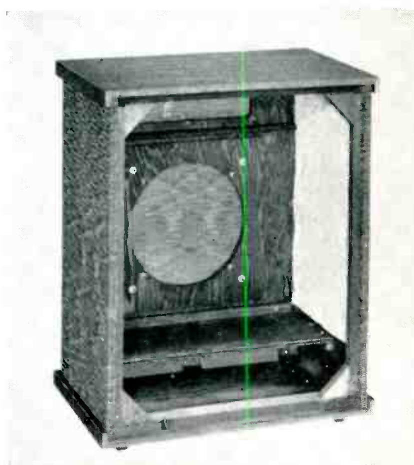
The 20-watt Grommes control amplifier.

watt amplifier featuring a loudness control, wide-range bass and treble controls, rumble and scratch filters, and six inputs, including one for tape head. The 20 PG is a deluxe 20-watt amplifier with all the features of the 15 PG plus higher power in the output stage.

ARGOS SPEAKER ENCLOSURE

The new *Californian* speaker enclosure, manufactured by Argos Products Co., is available factory built or as a prefinished kit. The interior design of the enclosure uses the Jensen Bass Ultraflex principle. The unit is available in two sizes and two colors (blond and mahogany). The top of the cabinet is finished with St. Regis Panelyte which gives the appearance of wood, but is extremely hard. It is said to resist scratches, scuffs, burns, and stains.

Dimensions of the Californian are 24 in. by 29 in. by 15 in. deep. This enclosure is designed for a 12- or 15-inch



Inside view of Argos Californian kit.

speaker. Price of the factory-built unit is $52.50; the prefinished kit is priced at $37.50.

A smaller enclosure, the Californian Jr. for an 8- or 12-inch speaker, is priced at $42 for the factory-built unit, $30 for the prefinished kit. Dimensions of the Californian Jr. are 19½ in. by 23⅜ in. by 13½ in. deep. Prices are the same for mahogany or blond version.

SEMIAUTOMATIC TONE ARM

The new Argonne *AR-34* tone arm starts and stops phono motors when it is used with single-play turntables. Placing the arm in the play position actuates the turntable motor; when the record is concluded, the arm automatically returns to rest and turns the motor off.

The AR-34 semiautomatic tone arm is equipped with a turnover crystal car-

This tone arm controls turntable motor.

tridge and dual sapphire styli. It can be used at all four current phono speeds with equal efficiency, according to the manufacturer.

WEATHERS SPEAKER SYSTEM

Weathers Industries has designed and developed a new speaker system known as the *Barrington.* The new system consists of 12 moving-coil loudspeakers.

Impedance of the system is 4 ohms. Power-handling capacity is said to be 60 watts, and the frequency range is 15 to 20,000 cps, according to the manufacturer. Dimensions of the enclosure are 47½ in. high, 40½ in. wide, and 15½ in. deep. The enclosure is available in blond or mahogany finish.

50-WATT EICO POWER AMPLIFIER

The new EICO *HF-50* 50-watt ultra-linear power amplifier is identical to the HF-60 60-watt amplifier, except that the HF-50 employs the Chicago output transformer. As a kit, the HF-50 is priced at \$57.95; wired, it sells for \$87.95.

An outstanding feature of the HF-50 is the GZ34 rectifier tube with indirectly heated cathode that eliminates high starting voltage on the electrolytic filter

Another model of EICO power amplifier.

capacitor and delays application of the full B+ until the amplifier tubes warm up.

IM distortion of the amplifier is said to be below 1% at 50 watts, and below 0.5% at 45 watts. Harmonic distortion is reported to be less than 0.5% between 20 and 20,000 cps within 1 db of 50 watts. Hum is 90 db below rated output, according to the manufacturer.

Further details about the HF-50 are available and will be furnished on request.

EICO SPEAKER SYSTEM

A bookshelf-size two-way bass-reflex speaker system by EICO features a Jensen heavy-duty 8-inch woofer and matching Jensen compression-driver exponential horn tweeter. Known as the EICO *HFS-1*, the system is contained by a factory-built tuned bass-reflex cabinet. All visible surfaces of the cabinet are smooth-sanded, clear-grained birch. The cabinet is ready for any good furniture-finishing technique.

Frequency response of the woofer is said to be ±4 db maximum variation from 80 to 2,000 cps; response of the tweeter is said to be ±2 db maximum variation from 2,000 to 10,000 cps;

Small speaker system kit from EICO.

over-all response is stated as ±6 db from 70 to 12,000 cps. Power-handling capacity, according to the manufacturer, is 25 watts. Size of the enclosure is 23 in. by 11 in. by 9 in.; wiring time is said to be 15 minutes.

KNIGHT "TRI-FI" SPEAKER

Allied Radio Corporation has announced the release of the Knight *Tri-Fi*, a 12-inch loudspeaker offering 3-way design at moderate cost. The speaker features three concentric radiators, one for reproduction of bass, one for the middle-range frequencies, and one for treble. The Tri-Fi is supplied with a high-frequency level control and a built-in crossover network. Power capacity is said to be 25 watts, and frequency response, 35 to 15,000 cps, ±5 db. Diameter of the Tri-Fi is 12 1/16 in., and the unit is 8 in. deep. Impedance is 16

The Knight Tri-Fi coaxial loudspeaker.

ohms. Binding posts on the frame of the speaker simplify installation by eliminating the need for soldering speaker leads.

This new Knight speaker is available only from Allied Radio Corporation. Stock number of the Tri-Fi is 81 DX 839; its price is \$49.50. Allied guarantees the speaker for one year.

RCA SPEAKER ENCLOSURE

A custom convertible enclosure for 12-inch speakers has been developed by the RCA Components Division. The enclosure is constructed of solid Honduras mahogany and is available in either cherry or blond finish.

A unique feature of the enclosure is its flexibility. It can be used as a bass-reflex, infinite-baffle, or corner-driver housing. When sitting on its legs, it acts as a bass reflex, with tuning carried out by varying the length of the legs. When it rests flush on the floor, it is an infinite baffle. In the corner of a room, a bottom port acts as a diffraction filter to feed extreme low frequencies into the corner apex.

RCA enclosure can be used three ways.

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.

Readers' Forum

Gentlemen:
I dislike your new cover design. It looks cheap, gaudy, and commercialized, and has lost its former dignified appearance.

Eugene I. Cleveland
Troy, N. Y.

Well — we thought it looked pretty good. How do other readers feel about it? If it's voted down, we'll try something else. — Ed.

Gentlemen:
We noticed in the June 1957 issue of AUDIOCRAFT Mr. Marshall's description ["The Grounded Ear," p. 4] of a circuit refinement used by our good friend Dave Hafler, by which distortion is appreciably reduced.

We feel it should be pointed out in fairness to us that we have known of and used this device for over two and a half years. In addition, published circuits of our amplifier prove its public use since the fall of 1955. (Note Mr. Marshall's own review of the Marantz power amplifier in the September 1956 issue of AUDIOCRAFT, showing a circuit with two 30-ohm resistors shunted in normal operation to make 15 ohms. This value was correct only for the first short run of amplifiers starting in November 1955, after which, some time in the spring of 1956, they were changed to 24-ohm resistors shunted to make 12 ohms to ground.)

It's also interesting to note that Dave should suggest the same value we settled on for use with EL34's. In our circuit, we use two 24-ohm precision resistors paralleled during operation to make 12 ohms, their alternate purpose being to indicate balance in our metering circuit. This device has given us a large margin of safety in meeting our specifications on very low distortion (less than 0.1% harmonic distortion at 1,000 cps at 40 watts or better).

We might also add that this has as much or more effect on odd-order harmonics by reducing the excessive final peak currents in class AB-1 operation.

Sidney S. Smith, Chief Engineer
Marantz Company
Long Island City, N. Y.

Gentlemen:
I enjoyed reading George Augspurger's article on loudness controls in the June issue of AUDIOCRAFT. After clearly explaining the problems of designing an

Continued on page 46

EDITORIAL

TWO questions asked very often by readers are phrased like this, with minor variations: "Since yours is supposed to be a how-to-do-it magazine, why don't you ever publish articles showing us how to make new versions of *a*) front-loading bass horns, or *b*) acoustic-suspension speaker systems like the AR models?" A recent communication from Paul Klipsch, designer and manufacturer of the Klipschorn, answers the first question better than we could. Someone wrote to Mr. Klipsch about a very heavy 18-inch driver of field-coil type that he (the writer) had on hand. He proposed to use it in a home-built "Klipsch-type" woofer horn, the design for which had been pubished in a popular magazine without authorization, but which was alleged to be suitable for 18-inch drivers. Extracts from Mr. Klipsch's letter follow:

"Calculation and experience in our laboratory show this horn would peak at 50 cps and its upper cutoff frequency would be 200 cps. The proposed driver could be expected to show a mean impedance of 64 ohms, with trough impedance of 32 ohms and peak of 128 ohms. Power drawn from a nominal 16-ohm amplifier (one designed for a 16-ohm load) would be down 6 db over the two-octave range from 50 to 200 cps, with severe reflection losses outside that narrow spectrum. . . .

"The better approach for utilization of a motor of this type would be to put it in a 10- or 15-cubic-foot closed-back padded box; or, if space does not permit that, then a corner-horn back-loading system like the Shorthorn Model S series or the Rebel III would best be employed. . . .

"This does not mean that a full horn could not be devised, but . . . the design seems hardly worth while for just one obsolete 18-inch driving motor. The recalculations of throat, taper, mouth, and air-chamber sizes would all have to be performed, taking into consideration the driver force factor, suspension compliance, tolerable excursion, etc. Then the whole system would have to be checked by experiment, perhaps through several models. After all, the Klipschorn woofer underwent eleven functional modifications from 1941 to 1957, and the driver, some four major changes and several minor progressions, with Stephens and Electro-Voice co-operating. The conclusion is: the hard way may not be best. . . .

"[Horn] design and execution is intricate, and the adaptation of driver units, a long series of trial, error, and recomputation."

Thank you, Mr. Klipsch. That's why we don't publish extemporaneous front-loading horn designs; they're difficult even for professionals, with extensive experience and laboratory test facilities, to design and build properly. Further, their performance is intimately dependent on the drivers used. And there are few systems that sound worse than bad horns.

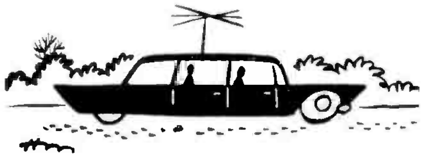
Some reputable manufacturers market loudspeaker-system kits employing front-loading bass horns. We have published kit reports on these, and will continue to do so, for they are virtually sure to be well designed. We will publish also construction articles on other types of enclosures not so dependent on precise design or the driver for proper performance; rear-loading corner horns, for example, are more adaptable, and no one expects them to be the ultimate in enclosures.

Speaker systems utilizing enclosed air as the cone restoring force, such as the AR models, are equally dependent on critical system design for their fine performance. An AR-type system represents an optimal combination of enclosure volume, speaker-cone material, conformance, and weight, magnet size, gap size, and suspension compliance. Changing any of these factors upsets the precise balance of the system, leading to performance deterioration. Since the home builder of such a system must, in effect, make his own driver by altering an existing unit, the successful completion of such a project would require incredibly good luck.

There are other units of audio equipment that are simply not practical for the average home hobbyist to make merely from information in magazine articles, such as tape-transport mechanisms, FM and TV tuners, and pickup cartridges.

Our point is simply that laboratory facilities and a knowledge of how to use them are necessary for building some items of audio equipment successfully, and that we must protect our readers — most of whom do not have such advantages — by not implying that they can do what is impossible.

Perhaps it will be said that we discourage experimentation with such an attitude. We say in reply that do-it-yourself should not be carried beyond sensible bounds, and that we will have no part in encouraging readers to undertake projects that they do not have a good chance of completing successfully, or which will not be useful to them upon completion. — R.A.



turntable on the turnpike

by JOSEPH REBHOLZ

All photos by the author

IN the first article[1] of this series on mobile high fidelity, I showed how the addition of extension speakers in your automobile can make music from any source — radio, tape, or records — far more listenable and pleasant. Installation of a tape player, and the 110-volt AC inverter needed for its power source, was described in the second article.[2] This month (to conclude the series) I'll show you how to obtain music from records to complete your automobile hi-fi system.

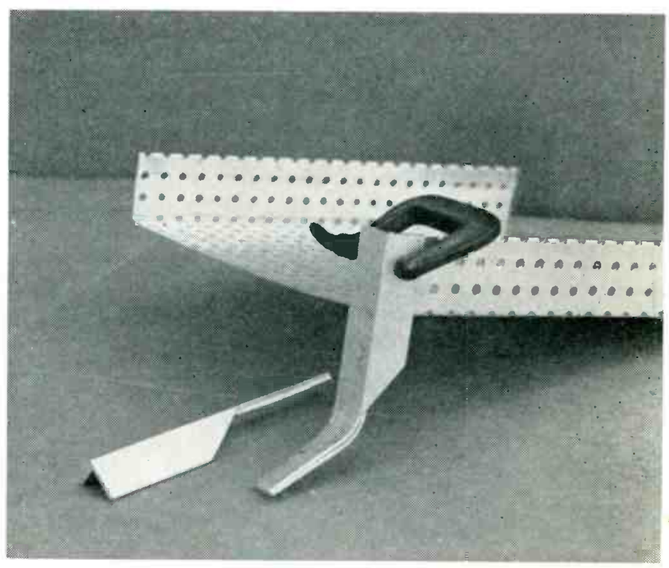
You may install either a tape player or record player without the other, of course, or you may want both. But either or both must be operated from the inverter, and require a minor modification to the car radio if that is to be used as the audio power amplifier for the system. This modification was also described in detail in the preceding article.

"How will it stay in place?" is the first question usually asked by anyone considering a record player in his car. On this score you can cease worrying; a common garden-variety RCA Victor 45-rpm record player will hold its track exceptionally well under all normal driving conditions. Panic stops, kangaroo starts, and tire-squealing corners may dislodge the tone arm; but stop-and-go traffic, the slight hump of streetcar tracks, or the vibration of a washboard road will not disturb the tone arm of a rubber-cushioned player. Besides, you will have better "fi" than even the best auto radio can provide, with no commercials and no static.

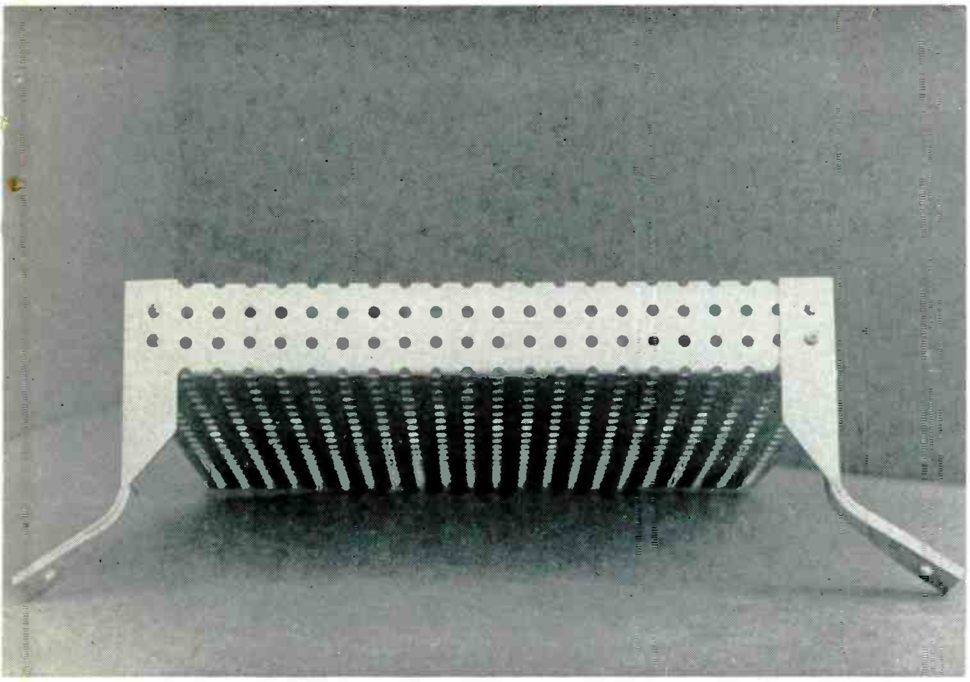
Work, no matter what the reason for it, is not pleasant; but only four hours of weekend tinkering can put a unit like this into your car. The parts required are easy to find and cost very little. The base of our player mount was made of Reynolds "Do-It-Yourself" perforated sheet aluminum; there was enough left for the job after construction of the tape-recorder case described last month. If you have to buy some, the cost is slight (about $2.00), and you will find any leftover material valuable for other household projects. To make the legs for our mount we bought a 6-foot length of aluminum angle stock which cost $1.78. For a cushion against minor vibration and road shocks, a 25¢ piece of foam rubber was obtained from a nearby upholstery shop. When you get the foam rubber, be sure to get the softest available. It comes in many grades of firmness, and the very softest is most desirable for this installation. The 1-inch-thick sheet is adequate, as

[1]Joseph Rebholz, "Fill 'er up — With Music," AUDIOCRAFT, II (June 1957), p. 18.

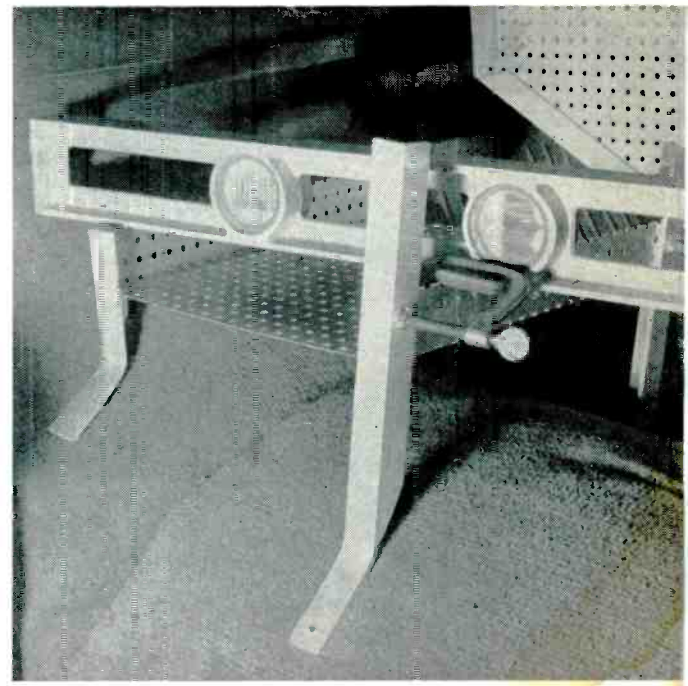
[2]Joseph Rebholz, "Play Your Tapes at 60 mph." AUDIOCRAFT, II (July 1957), p. 14.



Left, record-player installation in your car can be done with easily-worked soft aluminum available at hardware stores. Above, short angle-stock legs are clamped for drilling.



Soft aluminum rivets are used to secure back legs to the base. The base was formed from sheet stock cut to fit record player, with room for foam-rubber padding. Legs are formed as shown for transmission hump contour; see text.



Front legs are cut over-long, then are clamped to base at a height that makes it level when in car. Legs are marked and excess sawed off.

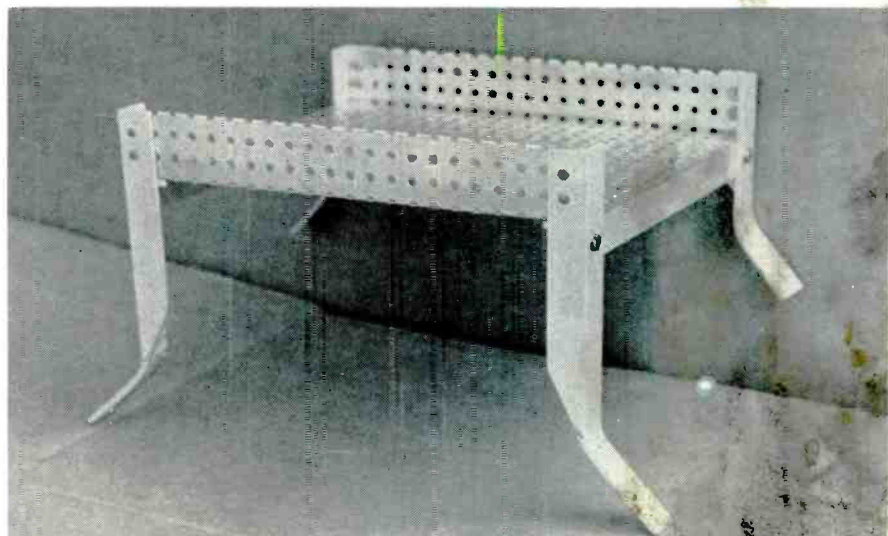
it can be doubled by gluing the layers together. In addition, there were expenditures of 30¢ for rivets and 10¢ for long (at least 1-inch) sheet-metal screws.

Finding the record player for this installation is no problem. A 45-rpm unit is ideal because it is small, inexpensive, uses readily available records, and its short tone arm tracks well. A used RCA Victor 45 player can probably be found in a local radio store for $5.00 or $10.00. Should you buy such a used unit, be sure to purchase (and have installed) a new diamond needle. It will preserve your records and track better than a wornout needle. Sears, Roebuck and Co. sells brand-new 45-rpm changers, complete with amplifier, for $29.50. It should be possible to find this unit, or ones similar to it, in other department stores.

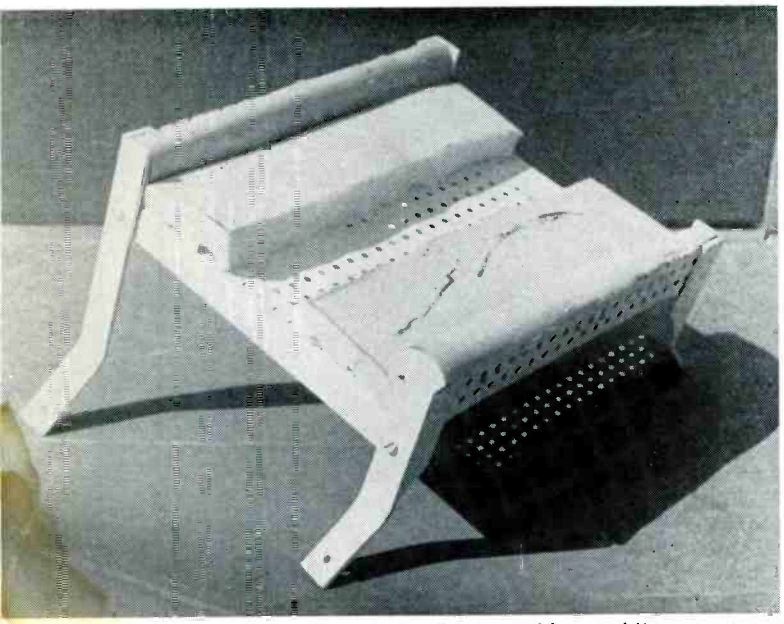
It may be difficult to find a suitable location for the record player in the car. The rear package shelf is a good place for it, if your mother-in-law rides in the back seat often enough to keep the machine loaded with records. In fact, it might be a good idea to mount a dummy player back there just to keep her busy and take her mind off the driving. The glove compartment has been the site of some custom installations. Usually, the cardboard lining is removed from the box and a rack made to support the player. The disadvantages of this installation are the small door through which records must be fitted, and the fact that a glove box, because it is high in the cowl, is subject to more sway than tilt. The car floor qualifies for what might be considered the ideal location. The transmission hump is near the center of all car motion, sidewise and fore and aft. As a result, anything mounted on the hump is in the center of the teeter-totter and is not thrown about so violently by bumps or car vibrations. Then too, it's nice to have the glove compartment as a lockable box in which to keep your records.

Fabricating the installation took something like four hours, not including time for the paint to dry. The first step was to make a base for the mount from perforated Reynolds metal. A rectangle was cut from the stock, long enough to fold up each side plus a half inch more to be bent over as a flange. After the sheet had been burred and the corners rounded, this half-inch flange was bent on each end and flattened out. Then one end was bent upward at a 90° angle, with the flange on the inside. The other end was also bent up at an angle, leaving room between the ends for both the record player and an inch of rubber cushioning.

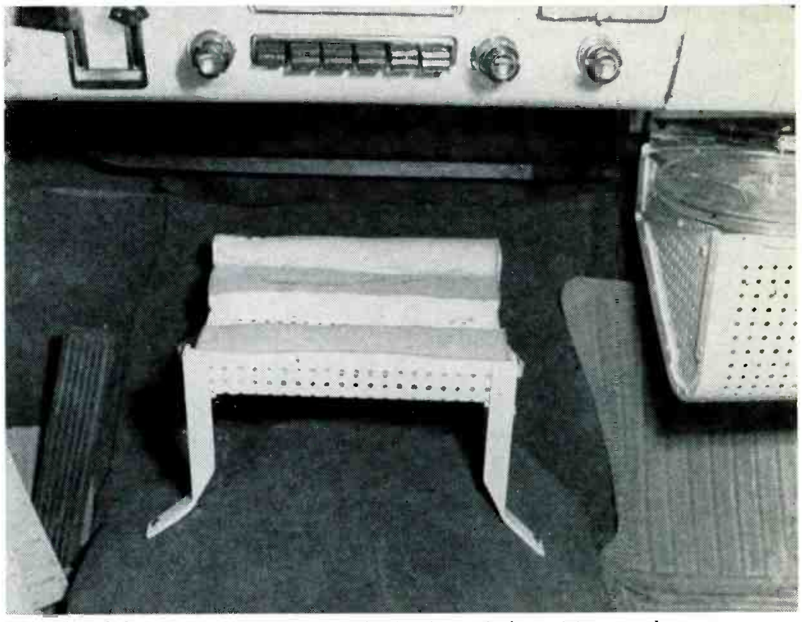
For the rear legs, 5-inch lengths of angle stock were split half way up and the single edge bent outward so the leg would be vertical when fastened to



After front legs are riveted to base, a length of angle stock is cut to fit between front and back leg on each side. These are riveted to legs and to base in order to stiffen entire assembly. Then the unit is painted, and left to dry overnight.



When paint is dry, pieces of foam-rubber padding are cut to fit, leaving a gap in the center section for ventilation of the player's fan-cooled motor. Then pads are cemented down.



Completed base is once more put in its intended position, and holes are drilled into floor using leg holes as drill guides. Then unit is installed securely with long sheet-metal screws.

the driveshaft hump. These legs were riveted to the back corners of the Reynolds-metal base. The base was then propped in location on the transmission hump and a rough estimate of the length of the front legs was made. The front legs were also cut from aluminum angle stock, split, and bent as the rear legs had been, but they were held to the base with C clamps rather than rivets. Then the mounting base was placed on the tunnel and a carpenter's level was used to adjust the base level with the ground. The C clamps were retightened after leveling was completed, and the base was carefully removed so that the front legs could be riveted to it. Two longer pieces of aluminum angle stock were then cut and fitted to each side between the front and rear legs. When screwed in place, they acted to reinforce the base and keep the legs in their proper relationship to each other.

Player fits nicely into the foam-rubber cushions, and plays through auto radio system. Power is obtained from inverter.

Completion of the mount construction brought us to the painting operation. A Binks Model 26 spray gun and portable compressor were put in action with automotive primer-surfacer. The entire mount was carefully sprayed with several coats of this material to fill minor abrasions in the aluminum and provide a good base for the following film of white enamel. Thirty minutes after spraying, the primer-surfacer was dry and the gun had been adjusted to handle the white enamel. By using the Binks syphon-cup gun it was possible to mix both the primer-surfacer and enamel in paper drinking cups and spray directly from the cups. This eliminated the mess and bother of using the standard 1-quart aluminum syphon cup. Regular gloss enamel (of the four-hour variety) was thinned slightly to what was deemed spraying consistency, and a few passes with the gun were made to reach a final adjustment of the air and paint mixture. After this, the entire mounting base was sprayed, top and bottom, with several coats of white enamel. This finish matches the interior (red and white) of the car as well as the previously installed tape recorder. A length of wire was passed through one of the perforations and the mount was hung in the air for the final coat of enamel and subsequent drying.

By the next morning, the enamel had dried thoroughly and we were ready to install the rubber cushion. The rubber was split so it would cover the inside edge of each flange and extend part way across the base without break. This left a central portion of the mount open to give adequate ventilation to the little fan-cooled motor of the record player. After the rubber cushion had been trimmed to size, it was stuck in place with 3M Super Weatherstrip adhesive which dries quickly and holds securely.

Installation of the record player is so simple as to be almost an anticlimax to our other construction work. Set the mounting base on the transmission hump and shift it around until the top is level in both directions. Then drill a hole through the leg down into the metal floor pan. Hold the leg down and use the long sheet-metal screw to screw the leg, carpet, and sound-deadening felt tightly together. We mentioned it earlier, but it's worth repeating: the sheet-metal screws should be at least 1 in. long, otherwise they will never reach the metal floor pan. The record player sets into the rubber (from which it will not slip), leaving from 3 to 5 in. between the top of the player and the base of the dash. Connections from the player are made to the radio and the 110-volt current supply discussed last month.

Now rush to the house, grab a handful of records and start that turntable turning. Perhaps the first thing to do is to drive to the corner service station for gasoline (make sure you have plenty of records) and let the attendants give your new outfit an "awing" over. As nice as music is, it's doubly sweet when there's a vocal chorus of approval in the background.

TAPE NEWS & VIEWS

by J. Gordon Holt

The Tape Standard

THERE is something about the summer months that discourages cerebral activity and creative incentive. Berkshire evenings are comfortably cool, though, so most of our summer cogitation and discussion takes place after hours, when we can relax on the lawn with a gin and tonic. A recent after-hours session produced one of those questions that the inquisitive thrive on and the insecure dread: if a high-fidelity system lacks brilliance when its tuner is playing, has too much brilliance when playing records, and has just the right amount of brilliance when playing tapes, which component has the proper balance?

The answer that immediately comes to mind is, "The tape recorder, of course." But hold on a minute. Turn the speaker system's tweeter level control up higher, and what happens? We have an increase in brilliance from all input sources, so that records are annoyingly bright, and tapes are a trifle too bright, but the tuner is in excellent balance. On the other hand, if we turn the tweeter level control down, we upset the figurative apple cart in the other direction.

Question: which is the best setting of the speaker's level control? Or, conversely, which input source is properly balanced?

The best setting of the speaker's balance control is, by general agreement, that which gives the desired balance. But the desired balance from what? From the tuner? This unbalances it for tapes and records.

All right then, suppose we compromise and set our balance to suit the tape recorder. Now it won't sound too bad on either the record player or the tuner — but the phono pickup may be the best component in the system, while the tape recorder is being used with an out-of-balance microphone and the tuner is picking up a station that uses ten-year-old crystal pickups (without variable equalization) equipped with cactus styli. Is the tape recorder to be trusted more than the pickup? And if so, on what grounds?

This kind of circular thinking really picks away at the Foundations of Faith, and so long as there is no concrete reference point for judging one component against another, the question at hand must remain unanswerable. Fortunately, though, there *is* a reference point, and since I am discussing this knotty problem in a column devoted to tape recording, you have probably guessed by now what the reference point is.

Consider the means at our disposal for testing phono pickup response. That's easy — we use a test record. What test record? There are quite a number of LP test records available, but direct comparisons between them on the same pickup cartridge will show wide differences in high-frequency response. Test record A, on our standard pickup, may show flat response to 20,000 cps, record B may reveal high-frequency roll-off amounting to 15 db at 20,000 cps, while record C may produce a rising response, being up about 8 db at 20,000 cps. Our standard pickup might be said to have flat response if we use test record B as our trusted criterion, but if we have greater faith in test record A or C, then our "standard" pickup does not deserve to be used as a standard.

It is supposedly true that if a test record's pattern of reflected light is of uniform width throughout the high-frequency range, then that record's playback frequency response is flat. It is if the pickup is perfect, but no pickup is. Vinylite has a certain amount of elasticity, so at higher recorded frequencies (where stylus mass begins to enter the picture) the groove will tend to yield to the passing stylus and will produce a loss of output. You have to add treble boost to the test disc to overcome this, but as soon as that disc is played with a cartridge having extremely *low* stylus mass, the boost will show up as boost. A second reason why reflected light patterns can be of dubious value is that stylus abrasion in a groove takes place only at the point of groove contact, leaving the rest of the groove walls undamaged. Hence, a 20,000-cps band on a test disc may have most of its modulation wiped off at the point of stylus contact, but can still have enough unmaimed groove wall to reflect a full-width light pattern. According to the pattern, the disc has flat high-frequency response, but to the playback stylus there is definite high-frequency loss.

The response of a pickup cartridge can be controlled during design and manufacture by varying the amount and the frequency of its mechanical and electrical resonances; and since there are so many ways of varying these factors, the response of any given cartridge will depend almost entirely upon the test records used by its manufacturer. And its sonic balance or coloration from a music recording will depend entirely upon the playback pickup used by each disc recording company to check its own sonic quality. So let's get out of that quagmire as gracefully as we can by examining the possibility for a home standard: tape.

A major advantage of the tape recording medium is that it does not have to be concerned with mechanically vibrating styli and their resonances. A tape-playback head having a pole-piece gap width of a certain magnitude and a coil of a certain inductance and Q, loaded by a fixed external circuit, can be expected to give a certain frequency response from a tape recorded at a given speed by a recording head whose input signal is applied as a constant current through the head. This is just as complicated as it sounds, but the nice thing about it is that the behavior of both the record and playback heads can be predicted with a high degree of accuracy by means of a

Continued on page 44

Goodmans ARU Enclosure

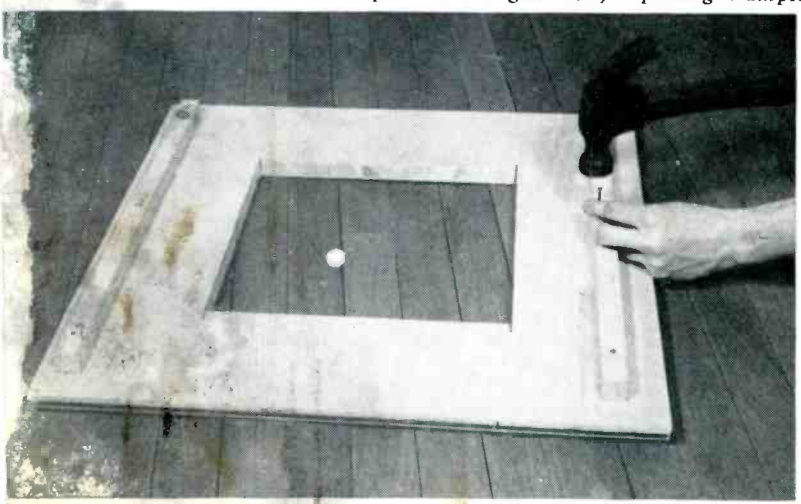
An AUDIOCRAFT *kit report*

ROCKBAR Corporation, the U.S. distributor for Goodmans Industries, Limited, of England, is now marketing a complete line (nine models) of friction-loaded enclosure kits for almost every possible combination of Goodmans speakers in one-, two-, and three-way systems. The enclosures are sold in kit form only and range in price from \$59.25 to \$79.30 without the recommended speakers. Included in each kit is an Acoustical Resistance Unit (ARU) for friction-loading the enclosure, which is mounted in one panel. This replaces the vent or tunnel in a bass-reflex enclosure, and permits use of a smaller cabinet for equivalent results. It also provides excellent damping and smooth response.

For this report, we obtained the Model B-1200 with the Model 172 ARU included. With a 12-inch full-range speaker installed (the Axiom 22, 100, or 150 is recommended), the unit can be used as a single-speaker system. Later it can be converted to a two- or three-way system, retaining the 12-inch speaker as a woofer, with the Midax middle-range driver and horn, and/or the Trebax tweeter. If you're starting right out with a three-way system, the Audiom 70 woofer is recommended. Cover plates are furnished for use on the middle-range unit and tweeter holes in the interim; these and the speaker mounting board are stained black at the factory (one dirty job nicely taken care of for you). The B-1200 is 26 in. high, 20 in. wide, 20 in. deep, and stands 6 in. off the floor on hardwood legs of modern design in keeping with the simplicity of the cabinet. All panels are of ¾-inch plywood; those which will be finished (top, side, and bottom panels) are of birch plywood. Nails, screws, glue, speaker mounting bolts for the woofer, hardware for the legs, Fiberglas insulation, grille cloth, sandpaper, and wood-tape for trimming the front edges of the plywood are all supplied. The leg brackets are made so that the legs may be mounted in either a straight or slanted position. Suit yourself. A screw driver and a hammer are the only tools that are absolutely necessary. Screw holes in the cleats and back panel are all drilled and countersunk, but it is advisable to have a small drill handy to drill screw holes when attaching the leg brackets and the ARU.

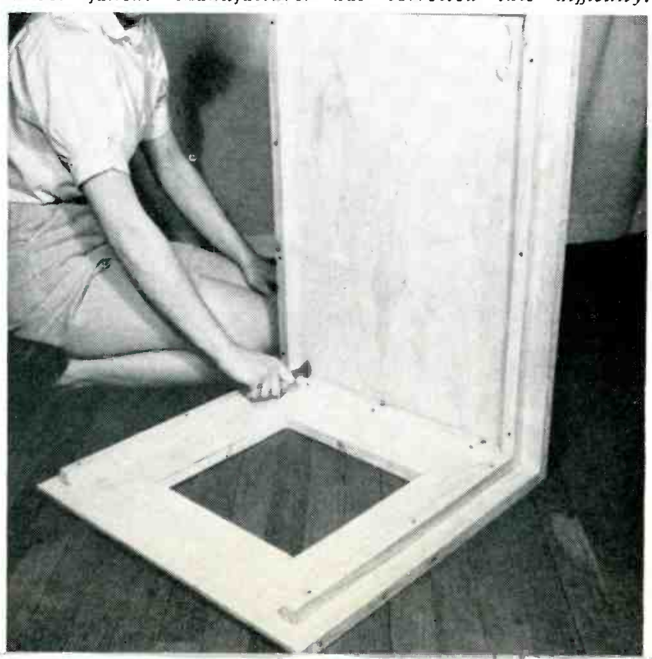
Since it is customary to use the editorial *we* in AUDIOCRAFT kit reports, we will have to admit that in this par-

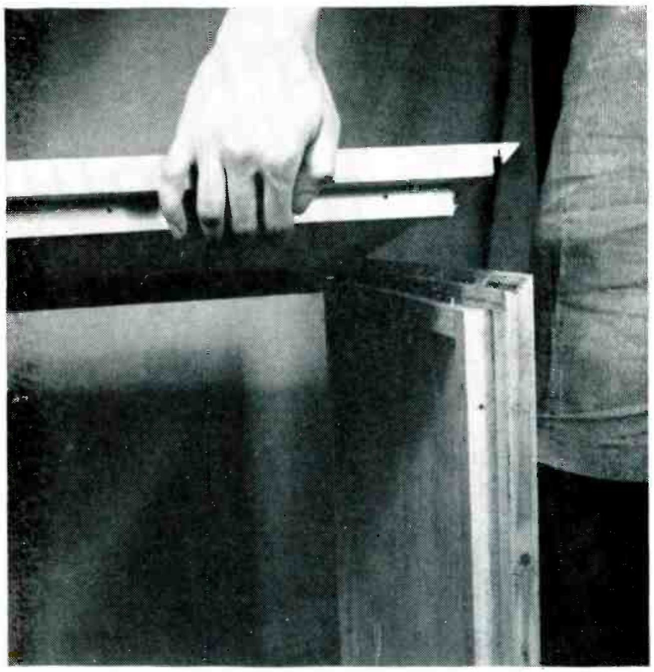
Construction begins with cleat installation on top, bottom, and side panels. These should be positioned carefully. Nails hold the cleats in place while glue sets, replacing clamps.



All photos by Warren Syer

Side panels are then assembled to bottom piece. We resorted to offset screw driver here; direct approach with a straight driver failed. Manufacturer has corrected this difficulty.





Top panel going into place. Note lock-miter joint construction, which provides a good air seal as well as additional sturdiness. Pictures were taken during the trial assembly.

Front panel, which would normally have speakers and grille cloth mounted, is attached from the inside. Note that holes are furnished for a 12-inch cone, Midax and Trebax horns.

ticular project the *we* is a complete novice in the field of hi fi, and that this is the first kit of any kind, sort, or shape which this *we* has ever put together. Actually, this is an asset; we goofed where no one with any experience at all could possibly have gone wrong (we did have a good laugh at ourselves), and we can give a warning or two — just in case.

Construction Notes

As the parts come out of the box, the panels are easy to identify from the diagram that accompanies the instruction sheet, but you'll need a ruler to check the cleats against the parts list. It's a good idea to mark them with the letters corresponding to those on the list for easy recognition later. Everything was in our box that the parts list said there should be, so we were all set to start. If you have the time, we highly recommend assembling the cabinet first without glue (except where the cleats are nailed and can't be taken off again), as we did. Not only does it help to get the lay of the land, but it makes final assembly a lot easier, and less likely to damage anything.

When you nail and glue cleats to their respective panels, make sure that the countersunk screw holes are pointing in the right direction. It will help if you remember that cleats B will screw into the bottom and top panels, E into the front-panel top and bottom, and C into the front-panel sides. We needed about nine extra 1¼-inch nails, using three on short cleats and four on long ones. Some of our cleats were just a shade short and we panicked slightly, but unnecessarily; this can be completely remedied after the box is together with weather-stripping putty. Better a little short than a little long.

We'd like to underline the note in step 11 to the effect that, in joining the sides to the top and bottom, the front edges should be *precisely* flush. Woodtape trim is later cemented onto the grain of the plywood here, and it will be easier to apply and will look more professional if there are no edges jutting out.

In attaching the top and bottom panels to the sides, and the front panel to the rest of the assembly (steps 10, 11, and 17), it is virtually impossible to align a common screw driver with the screws. If you can beg, borrow, or steal 26 1¼-8 phillips-head screws and a phillips screw driver, you'll be all set; we could find nary a one in three neighboring towns and didn't have time to order any. Our solution: use of an offset screw driver, as shown in one of the photographs. Use plenty of glue in steps 10 and 11 so that the joints will be airtight. It will be easier to get a tight fit between the bottom panel and the sides if someone else pushes against the bottom of the side panel after the edge of the bottom is fitted snugly into the slot on the side. Tighten the screws into the top panel only enough to make a perfectly square fit with the side-panel miter. The front panel goes in from the outside and is screwed from the inside; pushing the screws through the cleats (instead of threading them through) will enable you to pull the panel on tightly with the screws.

You may want to touch up spots on the speaker mounting panel and the cover plates with some flat black paint; even if this isn't necessary, don't forget to put a dab on the heads of the speaker mounting bolts. For attaching the grille cloth to the front panel you will need a supply of carpet tacks or a heavy-duty stapler. If the cover plates are to be used attach these *before* installing the front panel; extra 1¼-8 wood screws are necessary if the screws furnished have been used in the rest of the construction.

We decided to finish the enclosure before installing the front panel, the ARU, and the Fiberglas insulation to avoid mixing varnish and steel wool with the grille cloth. Incidentally, the grain of the birch plywood is well worth doing

Back panel fits inside all around, and is held by screws into cleats. No glue is used, since back must be removable.

a good job on so it shows off to its best advantage.

The ARU should be screwed and glued into the aperture cut for it, and twelve 1-6 or 1-8 wood screws will do the job nicely. It may be mounted on either the outside or the inside, but will look better if mounted on the outside and screwed from the inside.

Step 20 specifies that the Fiberglas curtain is to be 6 in. from the rear of the cabinet. The cleat attaching the curtain should be about 6 in. from the rear so that when the curtain is hung, the side that faces the back is 3 in. from the front side of the back panel. We weren't quite sure whether it was necessary to put Fiberglas on the back panel, but since we had enough left over we decided to do so. Luckily, we remembered to trim it 1½ in. shorter each way than the back panel, so that it would not get in the way of the cleats when the panel was attached.

Now that the enclosure is all built and finished, we have to admit what you have probably already noticed from one of the photographs taken during our trial assembly. The front panel *is* upside down, but that was corrected the second time through.

AUDIOCRAFT Test Results

There are several combinations of Goodmans speakers that can be used in this enclosure. Other speakers can be used also, of course, although the woofer should have a cone resonance frequency approximately the same as that of typical Goodmans 12-inch models. Our choice range cone, 5,000-cps crossover network, and Trebax tweeter — seemed representative of medium-priced speaker components that most users would put in the enclosure. It should be pointed out that any enclosure (unless very badly designed) has little effect on middle-range and high-frequency performance of the speakers, so that our results would have been entirely different in these ranges had we used other drivers. This is true at the bass end also, although to a much lesser degree; the ARU friction-loading system* is remarkably tolerant of speaker deviations from design center.

With the Axiom 22 and Trebax installed in our B-1200 enclosure, response

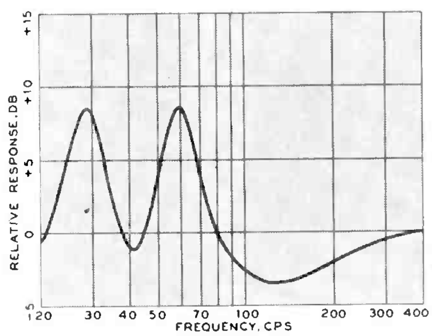


Fig. 1. Impedance at low frequencies, measured as voltage across the voice coil fed by a constant-current source.

in our 15-by-17-foot test room was audibly very smooth throughout the entire bass range, and apparently flat down to just below 40 cps. Below that it simply rolled off with very little harmonic generation.

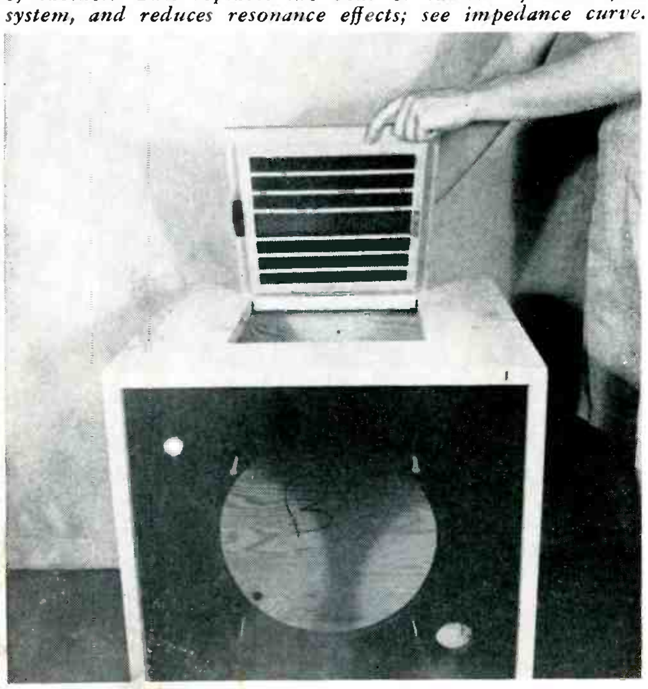
Such performance might be expected upon examination of the impedance curve, shown in Fig. 1. The enclosure is evidently tuned precisely for the speaker, at 41 cps, with equal impedance peaks at 29 and 60 cps. Note that the peaks are quite low in amplitude compared to those of a vented bass-reflex enclosure, which indicates superior damping. Note also that these impedance peaks do *not* correspond to response peaks; they merely furnish an indication of tuning and general response range. It is significant that this admirable impedance curve is obtained with an enclosure of about 3½ cu. ft.; it bears out the manufacturer's claim of equivalent response in a smaller enclosure than a standard bass reflex.

This combination of speakers had no peak in the "presence" range, although there seemed to be a slight, broad bump from 5,000 to 8,000 cps. In our test room (which is quite live) we found that a level control was desirable on the Trebax unit. When this was added, the over-all sound was, in our opinion, excellent. There was no trace whatever of boom and no impression of screech; moreover, cabinet-panel vibration was acceptably low. The system could be driven hard enough to make listeners' eyes glaze before any sign of speaker overload became evident.

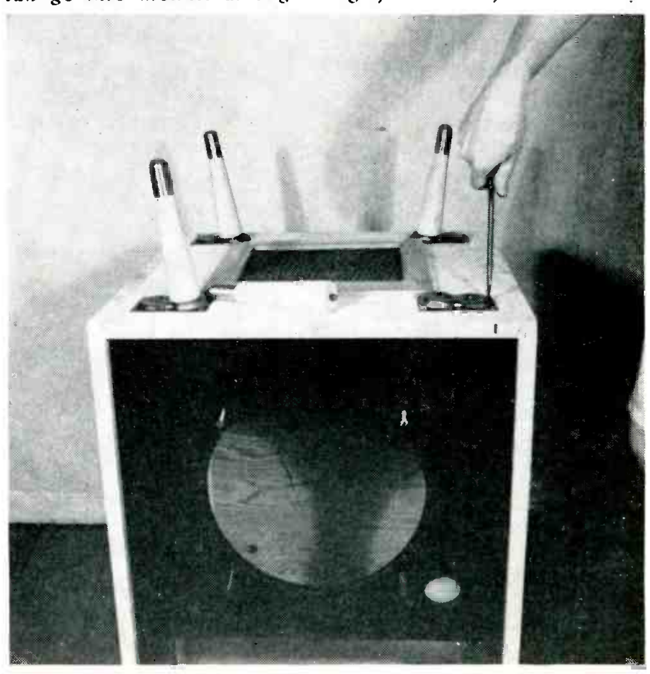
The enclosure itself is not the easiest of kits to assemble, but it isn't difficult either. The fact that a diminutive female member of our staff, totally inexperienced in kit building or woodworking, carried out the task successfully (and did a fine job of both assembly and finishing) should give encouragement to everyone. She now has a speaker system that even the most advanced audiocrafter would be pleased to own.

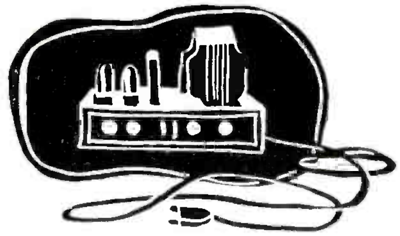
*See Joseph Marshall, "The Grounded Ear," AUDIOCRAFT, I (Nov. 1956), p. 4, for an extended discussion of the ARU enclosure principle.

ARU (Acoustic Resistance Unit) goes into hole in bottom of cabinet. This replaces the vent or tunnel of bass-reflex system, and reduces resonance effects; see impedance curve.



Last step is installation of legs. It is much easier going if pilot holes are drilled first for leg-mount screws. Legs can go into mounts at slight angle, as shown, or vertically.



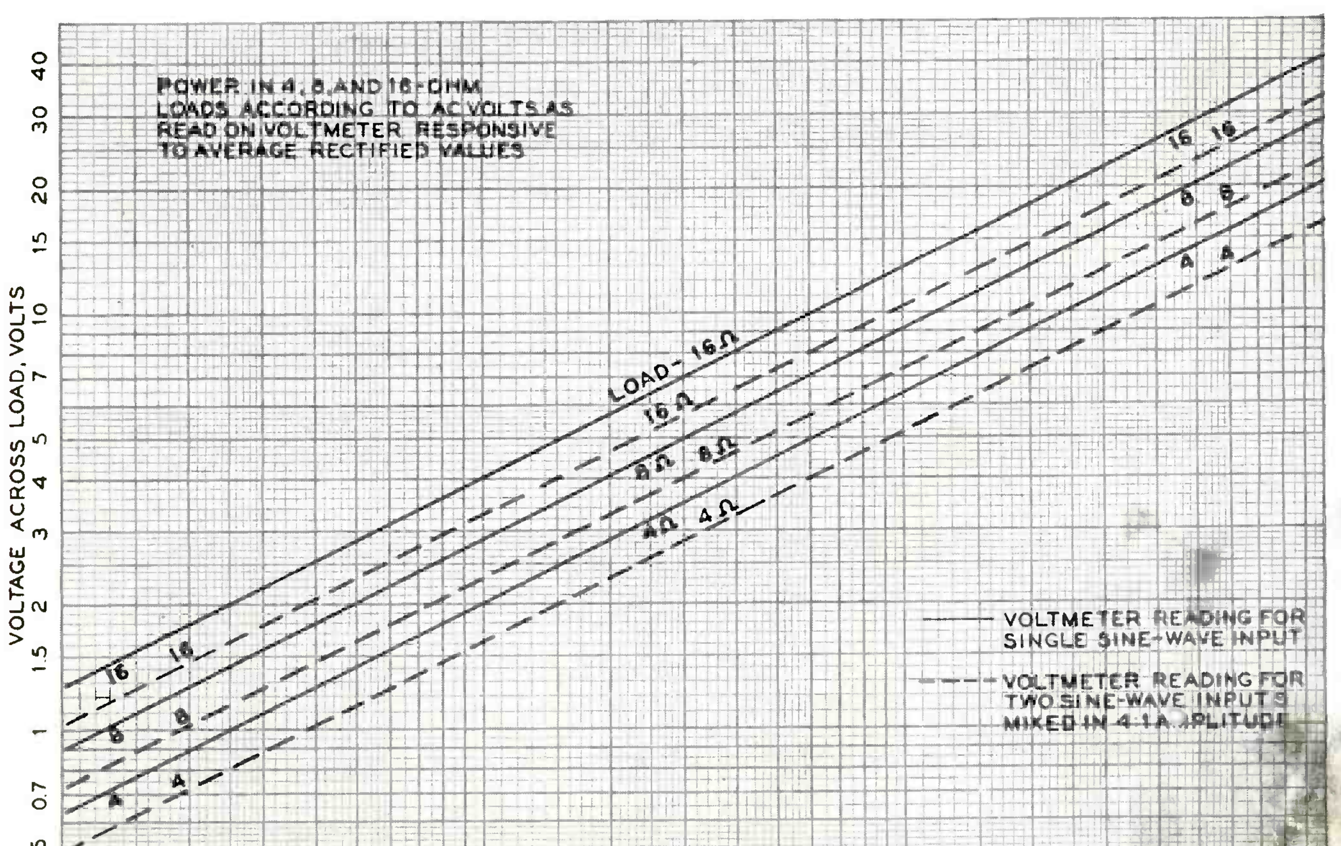


AMPLIFIER POWER CHART

WHEN making measurements and tests on power amplifiers, an audio wattmeter is a convenient and useful instrument to have. Many of us don't have one, though, and must rely on voltmeter readings subsequently converted to power values with the formula $P = E^2/R$.

The accompanying chart is designed to eliminate these simple, but tedious, calculations. Solid lines show the power developed in loads of 4, 8, and 16 ohms by single sine-wave input signals, according to the measured voltage across the load. It is easy to obtain a required power output in the following way: locate the desired power on the horizontal scale at the bottom of the chart; follow the scale line at that point directly upward to the heavy solid line appropriate for the load impedance you're using; follow the scale lines directly to the left, and read the voltage from the vertical scale. When your voltmeter across the load reads the same value, the required power is being developed in the load. To find the power corresponding to a given voltmeter reading, simply reverse the process.

Intermodulation tests are normally made with two sine-wave signals, one four times the voltage amplitude of the other. An ordinary voltmeter will ignore the presence of the smaller signal, since its indication is proportional to average rectified values of the total signal, and that isn't affected by the addition of the second signal. Peak value of the IM signal combination, however, is 1.25 times that of the larger signal alone. Therefore, to obtain the equivalent single-sine-wave value of a two-sine-wave IM signal, the voltmeter reading must be multiplied by 1.25. That's what the dashed lines on the chart are for; these lines are used in exactly the same way as the solid lines. The dashed lines give valid power results *only* for two sine-wave signals mixed in a 4:1 amplitude ratio, the recommended ratio for IM tests. — ALAN FREDERICK



by Dr. JOHN D. SEAGRAVE

A Sequel

MINIMIZING PICKUP TRACKING DISTORTION

THIS article is really an addendum to my two-part paper on pickup tracking which appeared in the December 1956 and January 1957 issues of AUDIOCRAFT. It provides a simplified graphical solution to the rather nasty-looking family of equations (27a, b, and c) for the solution of the problem of determining the "best" overhang to use with a fixed, nonoptimum offset angle and arm length. When the previous paper was written, I could see no way to plot or otherwise simplify Eqns. (27a, b, and c), since they involved L and $\sin \beta$ as two unknowns, as well as R_1 and R_2, and this seemed to imply at least an isometric plot of low accuracy, or a whole set of parametric curves involving interpolation.

Eqns. (27a and b) require calculation of an expression of the form $(a^2 + b^2)^{1/2}$; while this is easy to do on a slide rule,* it is necessary to carry out the calculation in detail, and evaluate m_{max} for the case under consideration to see how much short of optimum the "best" nonoptimum solution is. If β can be changed somewhat, but not to β_o, the calculation has to be done all over again just to see if it is worth all the trouble. Furthermore, if one wants to compare several commercial arms, few of which are very close to optimum for LP's, the calculation program gets rather tedious.

Universal Design Chart

It is an overgeneralization to regard L and $\sin \beta$ as independent variables for purposes of calculation, since for a particular problem they are both known at the same time; they occur in combination as the product $L \sin \beta$ in the right-hand side of Eqns. (27a, b, and c) if those equations are multiplied through by L. The fact that the left-hand side is then LD_1 is a minor disadvantage, because D_1 is easily obtained by dividing the value of LD_1 by L. Since it can be seen that LD_1 is a function of $L \sin \beta$ for all three branches of the solution, it is clear that if we specify R_1 and R_2, *a single curve* of LD_1 vs. $L \sin \beta$ will represent the complete set of design equations (27a, b, and c); moreover, the two-way optimum case appears as a special point on the curve. Such a master design curve is plotted in Fig. 6 in sufficient detail to yield accuracy at least as good as that corresponding to the best measurements of distance and angle it is practicable to make. The curve has a discontinuity in slope at the point corresponding to β_o, because the criteria for optima differ for values of $L \sin \beta$ above and below that point. R_1 and R_2 are those values previously used for 12-inch LP's: 2.40 in. and 5.70 in., respectively.

If we had calculated D_1 with the aid of this master curve, we should then want to calculate m_{max} from the appropriate formula given in Part II. These formulas for m involve L, $\sin \beta$, and D_1. Since we are concerned with the value of the maximum distortion index which would occur if we used the value of D_1 given by the curve for a particular value of $L \sin \beta$, I went a step further and calculated the corresponding values for m for the selected values of $L \sin \beta$ used in plotting the LD_1 curve. Actually, the quantity which can be plotted against $L \sin \beta$ is $mL \cos \beta$, but $\cos \beta$ is a very slowly varying function of β for cases of interest, and has the value of 0.95 for $\beta = 18°$. If it is simply ignored, the value of m is given approximately by dividing the number read from the curve by L, as in the case of D_1. The plotted curve of $mL \cos \beta$ in Fig. 6 shows cusps at both β_1 and β_o, at which points its definition changes. The sharp approach to the "mini-max" value of m at β_o is quite clearly exhibited by this second curve.

Incidentally, note that while we set out to calculate the best D for given β, the converse case of best β for given D, for which equations were not even given in Part II, is also easily solved by reference to Fig. 6, except that D_1 must first be calculated from D by Eqn. (15). For convenience, the inverse relations (15) and (17) are reproduced here.

$$D_1 = D[1 - \tfrac{1}{2}(D/L)] \quad \ldots(15)$$

$$D \approx D_1[1 + \tfrac{1}{2}(D_1/L)] \quad \ldots(17)$$

Use of the Charts

We have seen how the entire practical consequence of the mathematical material developed in Part II for design purposes has been represented in the two universal curves of Fig. 6, even as the tracking equation was represented in Fig. 3 as a universal graph useful for analysis of existing equipment. Such compactness of expression — and it is indeed a major simplification — has a price, but it is the same price paid for the universal analysis curves in Fig. 3: one must divide or multiply the input and output numbers by L for a particular arm in order to use the universal graphs. High accuracy is obtainable from them *because* they are universally applicable. We have thus reduced a physically and mathematically complicated problem to one which requires for its solution only a very low level of mathematical sophistication. Since this is largely multiplication and division, we may eliminate entirely the need for a slide rule or for consulting elaborate tables of trigonometric functions by including here the table of $\sin \beta$ for the angles appropriate to our problem.

Table of Sines

β	$\sin \beta$	β	$\sin \beta$	β	$\sin \beta$
10°	0.1736	17°	0.2924	24°	0.4067
11°	0.1908	18°	0.3090	25°	0.4226
12°	0.2079	19°	0.3256	26°	0.4384
13°	0.2249	20°	0.3420	27°	0.4540
14°	0.2419	21°	0.3584	28°	0.4695
15°	0.2588	22°	0.3746	29°	0.4848
16°	0.2756	23°	0.3907	30°	0.5000

Numerical Examples

Linear interpolation may be used to find intermediate values from the table of sines. Thus, to find the sine of 18¾°, subtract 0.3090 from 0.3256 to obtain the difference, 0.0166; add ¾ of it, which is 0.0125, to 0.3090; the answer is 0.3215.

As a numerical example of the use of the universal charts, consider the problem of a correspondent who wrote for help when he lost his way among the brackets of Eqn. (27a). He had an ESL cartridge in an Audax 16 arm, and had measured L as 12¼ in. and β as 18¾°. Either he found it impossible to change β to β_o, or he wanted to see whether it was worth the trouble by evaluating m_{max} for the "best" overhang with the present offset angle and comparing it with m_o.

We have already interpolated in the table of sines to find the sine of 18¾°, which is 0.3215. Then $L \sin \beta = 12.25$

Text continued on page 42

*Let b be larger than a. If the right end of the slide is set opposite b, the angle whose tangent is a/b may be read on the tangent scale opposite a. With the hairline index set on a, slip the slide until the same angle on the sine scale appears opposite a; the hypotenuse of the right triangle with sides a and b, namely $\sqrt{a^2 + b^2}$ appears opposite the end of the slide.

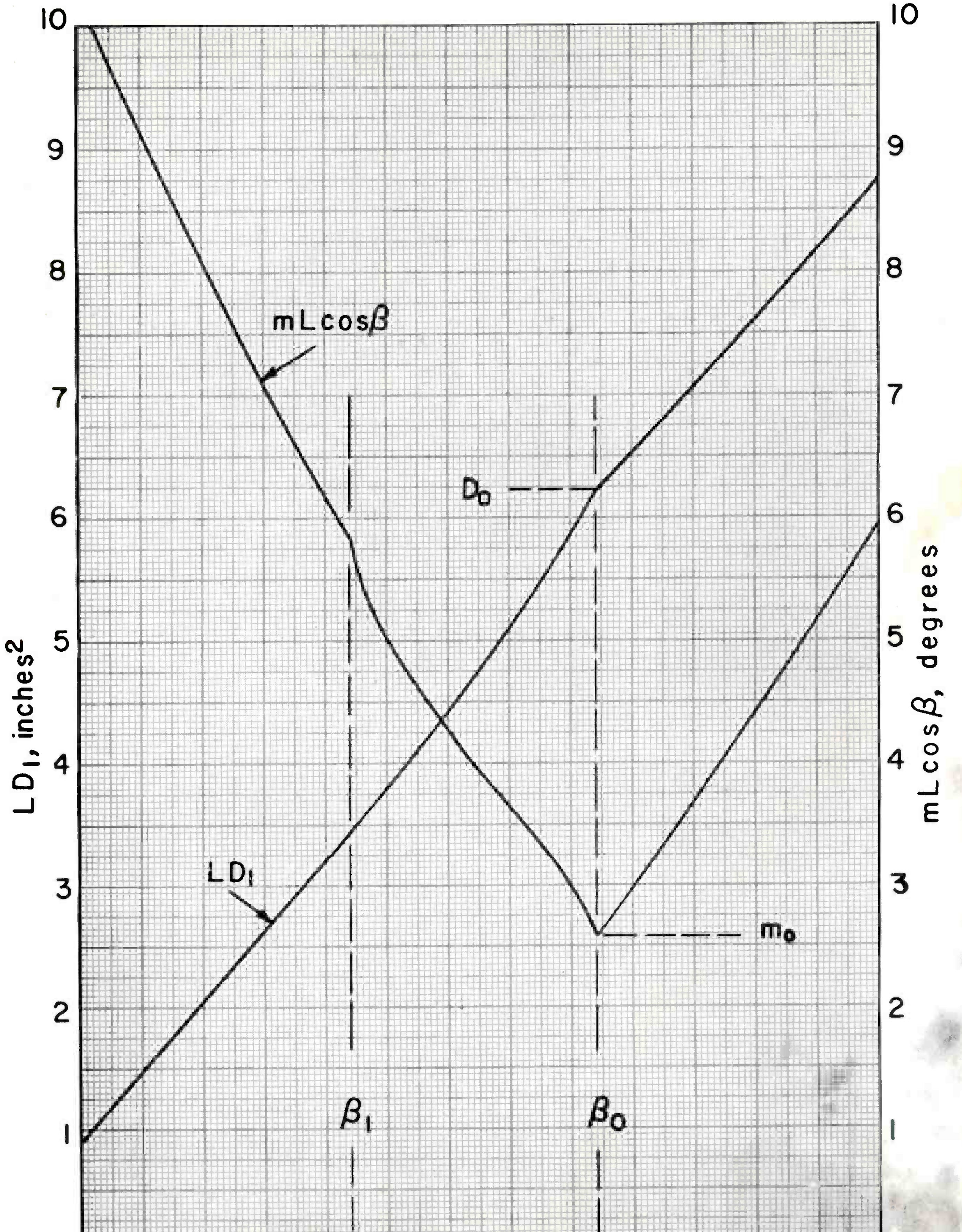
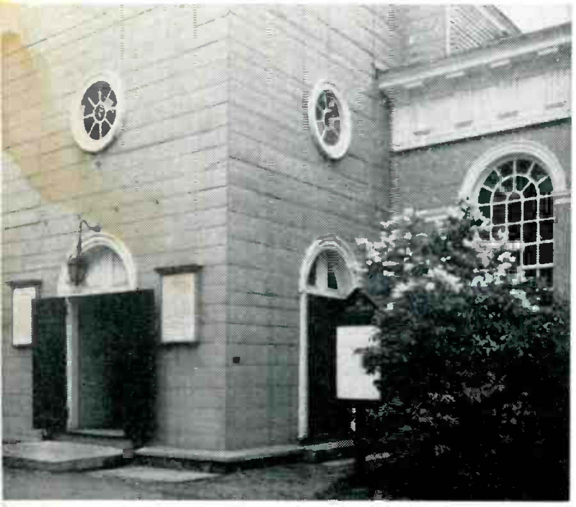


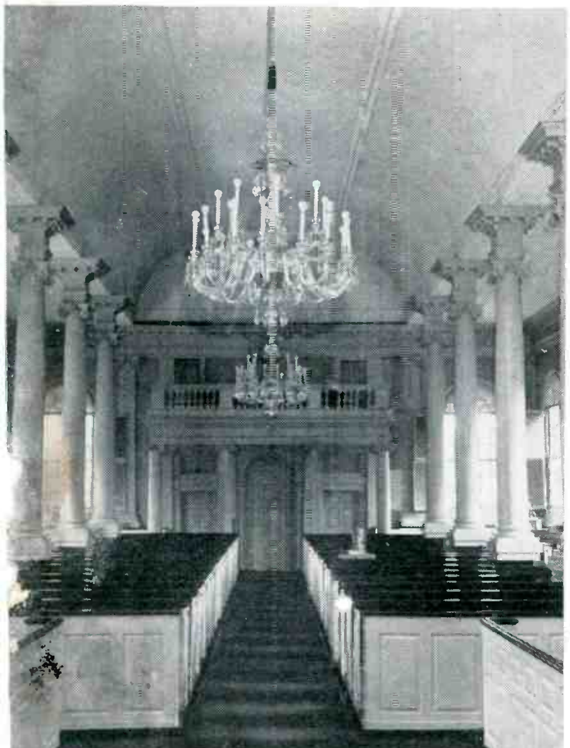
Fig. 6. Universal design curves giving optimum relation between offset angle β and overhang D for any arm of length L, and the corresponding maximum distortion index m. D is related to D_1 by Eqns. (15) and (17). Curves given are for 12-inch LP's.

A Special Report

Electronic Reverberation System



Christ Church, Cambridge, where the electronic reverberation test was made.



Interior of the church. Natural organ sound in here was dry and constricted.

WHEREVER music is played — in a concert hall, a church, an auditorium, or the home — the acoustic properties of the room affect an auditor's subjective reaction to a major degree. Sound that seems alive yet perfectly defined in a good concert hall may, in another, be too dry and dead; in yet another, it may be so muddled as to appear soggy. A lot can be done to improve matters by proper acoustic redesign, but often this is too expensive or impractical for other reasons. And in home listening rooms, no treatment is possible that will permit duplication of the acoustic environment of Carnegie Hall. That fact is probably the most important practical reason why, even with stereo reproduction, a complete illusion of auditorium presence cannot be obtained in the home.

Church acoustics are of special interest to Aeolian-Skinner, manufacturer of pipe organs, because they are so rarely good for organ music. Moreover, extensive alterations to improve matters acoustically are, in most cases, not permissible. The company's recent solution to this problem — electronic control of reverberation — is so effective that, in simplified form, it may someday provide an answer to home listeners' acoustic problems too.

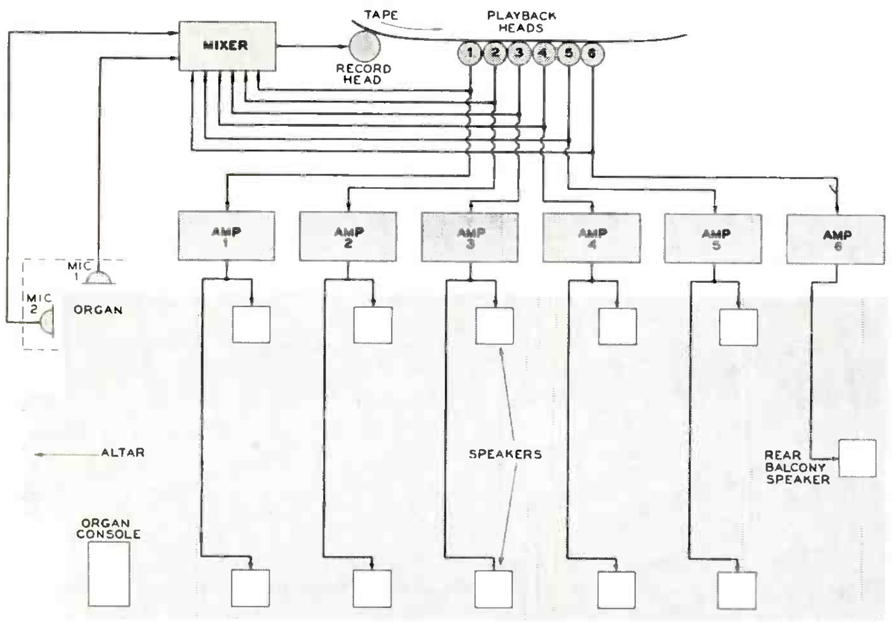
The problem with most American churches is that they are too dead (non-reverberant) acoustically for organ music of the Classical Period. This, and many modern organ works as well, were written for performance in large edifices with hard interior construction of stone or marble. They were written to sound right in a building with a long reverberation time. When played in a typical small American church of wood, with carpeting and plush-lined seats, the music lacks life and vitality; the soft mantle of reverberation for which it was composed is missing, and the loss is distressing. With the revival of interest in classical organs and in the classical organ repertory, which began in this country just before World War II, this unfortunate state of affairs began to receive the attention of organ builders and organists. Not much could be done about it in most instances, however, except when an organ was to be installed in a new building designed with the acoustic requirements in mind.

One of the first classic-revival organs made was installed by Aeolian-Skinner in Christ Church, Cambridge, Massachusetts. Not surprisingly, this church has about the worst possible acoustic character for a classical organ; built in 1761, the construction is of wood and plaster on very flexible laths, with carpeting and seat cushions. The organ is installed in depth, for there was little frontal space for it. Reverberation time of the church when empty is about 0.4 second (extremely low) and is fairly uniform with frequency. The net result is that the live organ sounds as though it were being reproduced through a corner speaker system in a small living room, via a close-up recording. It was here that the electronic reverberation system was tested, and the accompanying photographs were taken.

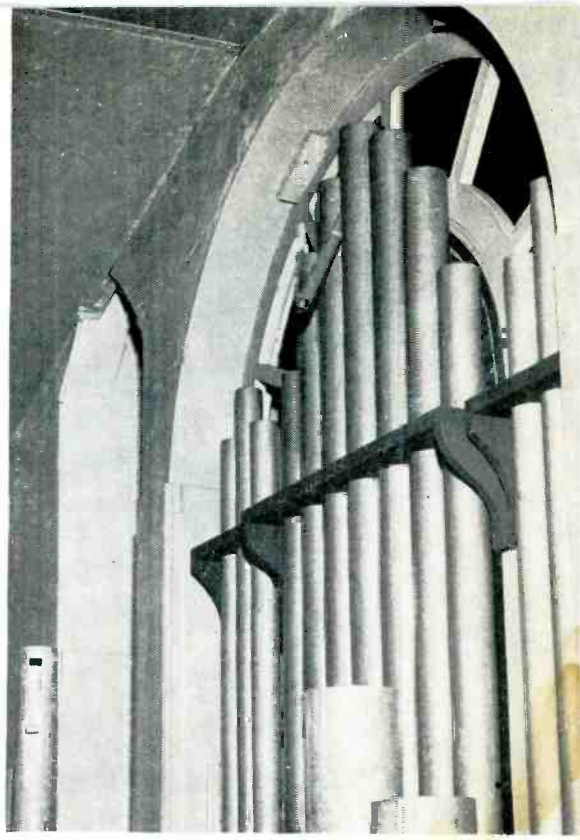
How It Works

A block diagram of this system is given

Joseph S. Whiteford, President of Aeolian-Skinner. The company manufactures organs and developed this system.



Functional diagram of the electronic reverberation system. Playback-head outputs are variable in level and frequency response, so that feedback can be controlled to produce any desired reverberation curve at any frequency. Stability is good.



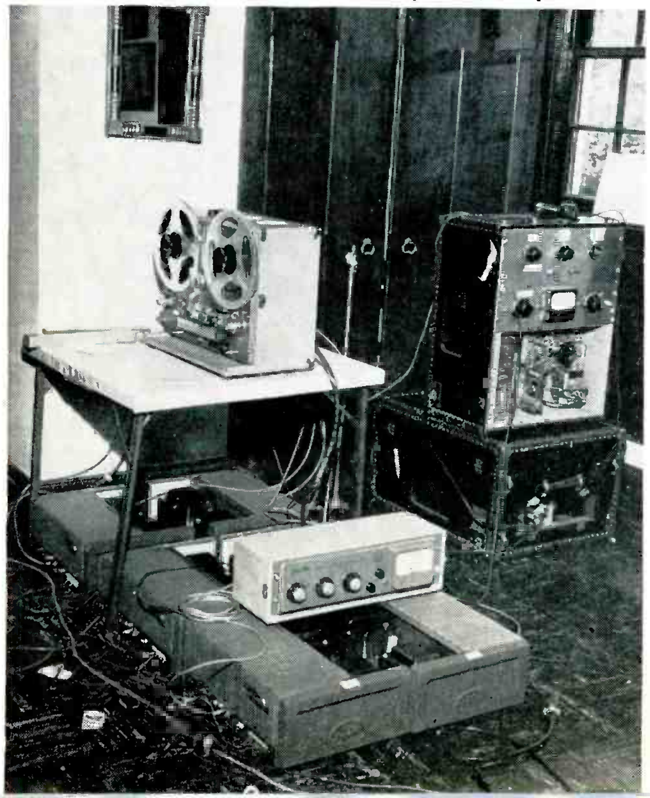
Capps microphone in one of the organ chambers. An Electro-Voice mike was used for pickup in the other chamber.

above. In this particular installation, the organ is divided into two chambers at the front of the church; the swell and great pipes are in one section, with the choir and pedal pipes in the other. Two microphones were used (Capps and Electro-Voice), one in each chamber. The mike outputs were mixed in the electronics section of an Ampex recorder, and fed to the record head of a special Concertone tape machine. This is followed by six closely spaced playback heads, which pick up the signal with varying amounts of time delay. Outputs of the six playback preamplifiers are mixed with the original microphone signals and fed back to the record head; they are also fed to six individual 80-watt power amplifiers (H. H. Scott). The first five amplifiers drive five pairs of speaker systems (Acoustic Research AR-2) spaced at regular intervals from front to back along the sides of the church. An AR-1W/JansZen speaker system in the balcony at the rear is driven by the sixth power amplifier.

According to Joseph S. Whiteford, President and Tonal Director of Aeolian-Skinner, the precisely calculated progressive delay of the sound reinforcement from front to rear of the church which is obtained with this system, and which would be a characteristic of natural reverberation, accounts in large measure for the astounding realism of the results. Each channel has individual level and equalization controls by means of which the shape of the reverberation reinforcement curve at all frequencies can be tailored to suit the installation. The system remains stable when adjusted for reverberation times as long as 7 seconds. In a recent demonstration at Christ Church it was adjusted for about 3 seconds; when the system was turned on gradually while the organ was playing, it gave listeners the uncanny feeling

Continued on page 46

Behind-the-scenes electronic equipment used for the test. On table is altered Concertone recorder with six playback heads. Also used were six Scott 80-watt amplifiers, Ampex mixer.



Ten Acoustic Research AR-2's were distributed along sides, and an AR-1W/Janszen combination was placed in the balcony. Speaker output was delayed progressively from front to rear.

by EDMOND ARIESSOHN

How to add a TWEETER

Part II

Selecting the Right Tweeter

Now let us consider some aspects of integrating a tweeter into an existing loudspeaker system. The first question that must be settled is what tweeter to use. Our discussion of the various types may have provided some basis for selection in terms of performance, but we are still faced with the problem of selecting a tweeter with the proper low-frequency cutoff.

It is possible to obtain tweeters with cutoff frequencies ranging from 250 cps to 3,500 cps or higher. The first and most obvious precaution is making sure that the tweeter of your choice has a low-frequency response which reasonably overlaps the high-end capabilities of the speaker with which it is to be used. For instance, in a two-way system with a woofer that falls off rapidly above 2,000 cps, it would be a mistake to select a tweeter whose frequency response did not extend below 3,500 cps. Clearly, this would leave a gap in the range of the normal ear's greatest sensitivity.

A second criterion exists to guide us in our search for the proper tweeter: that of *off-axis* response. This time, however, the emphasis is not on wide angular response but on compatibility among the various speakers of the system. We have already seen that sound emanating from a cone speaker gradually tightens into a narrow beam along the speaker axis as the frequency rises. Another way of describing this phenomenon is to say that a listener seated directly in front of the speaker will hear whatever high frequencies it is capable of reproducing. As he walks to one side, he will notice a progressive loss of highs. Suppose that a wide-angle tweeter is added to this cone speaker which just overlaps its on-axis frequency response. It is still possible for an off-the-axis listener to hear a gap in the spectrum as a result of the woofer's beaming effect at the upper end of its range. It is clear, therefore, that a tweeter should be chosen whose response extends low enough to operate with a cone speaker *at a frequency for which the directional characteristics of the cone speaker are not yet pronounced.*

One further characteristic should be borne in mind in making a selection: that of voice-coil impedance. It will simplify the task of connecting the tweeter if you choose one whose rated voice-coil impedance is the same as that of the other speaker or speakers in the system. If your present speaker has an 8-ohm voice coil, it simplifies matters to select a tweeter rated at 8 ohms, though we shall see later that it *is* possible to use a tweeter of different impedance.

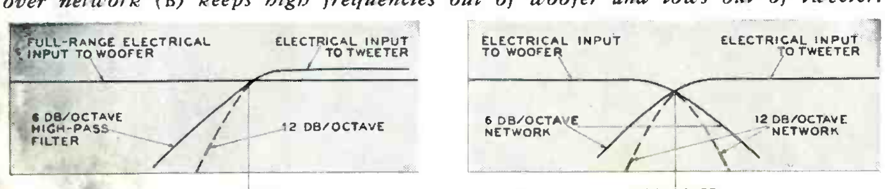
Crossover Networks

Assume now that, having taken all the above factors into consideration, you've bought a tweeter that meets all the requirements for compatibility with your present speaker. Can you simply connect it to the proper terminals on the amplifier, and sit back to enjoy the crisp, bright sound you expected? Not quite yet. If the delicate tweeter were to be connected in this fashion it would almost certainly burn out the voice coil or fracture the diaphragm. Remember, one of the fortunate circumstances which permitted the voice coil to be made of lightweight materials was that it was meant to reproduce only that portion of the sound spectrum which, statistically, contains only a small fraction of the total signal power. If the total frequency spectrum is applied to the voice-coil terminals, the heat generated by low-frequency power would be sufficient to burn out the voice-coil windings. Even if burn-out did not occur, this low-frequency power would cause excessively large motion of the voice-coil structure which would fracture the diaphragm. Low-frequency power must be prevented from reaching the tweeter.

The device employed to effect this separation of frequencies is an electrical filter. A knowledge of how to select and employ the proper filter will insure optimum performance of your system. Filters for use with tweeters are of two types, the high-pass filter and the high-frequency crossover or dividing network. As its name implies, the high-pass filter is a device which permits the passage of high frequencies only and, when connected between the tweeter and the amplifier, effectively bars all frequencies below its nominal cutoff frequency. The high-pass filter has no effect upon the other speakers in the system; hence, it finds its greatest application in cases where only reinforcement of the high-frequency response is desired. Assume

Fig. 9. This basic network provides for a wide choice of crossover frequencies.

Fig. 8. High-pass filter (A) simply keeps low frequencies out of tweeter; crossover network (B) keeps high frequencies out of woofer and lows out of tweeter.



that the present speaker is a coaxial type with integrated woofer and tweeter, but which for some reason has mediocre performance on the high end. A good tweeter with a high-pass filter is the logical addition in this case, since unrestricted operation of the coaxial speaker is beneficial. The same thing might be done to reinforce the middle range for increased "presence."

It should be pointed out that all filters are characterized by what is called their "pass" band and their "attenuation" band. The transition from pass band to attenuation band is never abrupt, but is accomplished at a rate determined by the design of the filter network. Thus, reference is made to "6-db-per-octave" or "12-db-per-octave" networks. These terms describe the rapidity with which signal power is attenuated as its frequency falls outside the nominal cutoff frequency of the network. "Cutoff" is defined as the frequency at which the signal power at the output terminals of the network is half of that at the input terminals, or 3 db lower. The simplest high-pass filter, consisting only of a capacitor in series with the tweeter voice coil, has a maximum attenuation rate of 6 db per octave; a two-element network consisting of a series capacitor and a shunt inductance has a maximum attenuation rate of 12 db per octave (see Fig. 8).

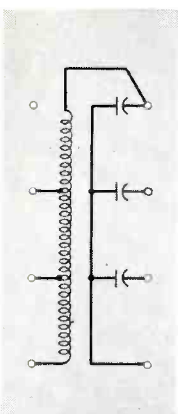


Fig. 10. A tapped inductor and set of capacitors are wired in this way inside a multiple-purpose dividing network, Fig. 9.

A sharp filter cutoff is not always desirable. In addition to the increased complexity of its design and critical nature of its adjustment, the multisection, sharp-cutoff filter or network may exhibit electrical instability in the form of shock excitation or ringing. Subjectively, the sharpness of filter cutoff determines the degree to which the sounds from the individual speakers of the system are kept separated. If a smoothly blended sound is desired from the system, a large amount of frequency overlap will be sought and a 6-db-per-octave filter will achieve this end. If a more distinctly separated sound is wanted, the user will select the sharper 12-db-per-octave filter.

Implicit in our discussion of networks thus far has been the idea of another type of network which does more than simply keep the low frequencies out of the tweeter. This other type actually divides or apportions the entire frequency spectrum between the speakers of the system, and for this reason it is called a dividing or crossover network. The crossover network is a combination high-pass and low-pass filter, each section feeding the appropriate speaker. It finds its greatest application in systems where specialized speakers are employed (woofer, middle-range speaker, and tweeter). By limiting the high-end response of the woofer, for example, the crossover network assists in reducing intermodulation distortion, preserving angular dispersion compatibility, and achieving maximum utilization of the available audio power.

A typical 6-db-per-octave crossover network is shown in Figs. 9 and 10. This network (the University N-2A), consisting of a number of capacitors and a tapped inductor, permits the selection of several crossover frequencies and impedances. Such a network provides a high degree of flexibility for the user. It permits him to experiment with different crossover points and to compare the results. It can be used as a 6- or 12-db-per-octave high- or low-pass filter. It can even be used in pairs for the sharper 12-db-per-octave crossover rate between woofer and tweeter. Finally, it insures the user against obsolescence of his system should he at a future time decide to expand it still further by addition of a third speaker. This is accomplished by employing the companion network, the University N-2B, between the added speaker and the remainder of the system.

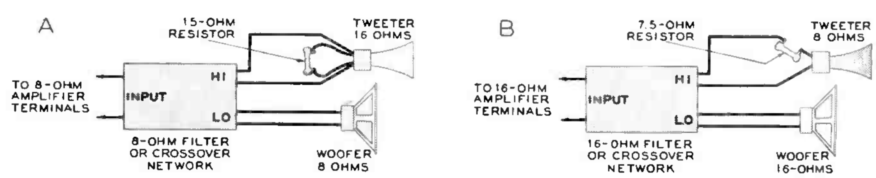


Fig. 11. How to match a tweeter of higher (A) and lower (B) impedance to woofer.

One question remains to be discussed: that of network and speaker impedance matching. Most commercial networks are of the constant-impedance type. This means that when connected to operate at a given impedance and terminated in a resistive load of that value, they will present a constant load to the amplifier independent of frequency. Thus, in adding a tweeter to an existing speaker with an 8-ohm voice coil, one should select a unit with a nominal impedance of 8 ohms and use an 8-ohm crossover network or high-pass filter in order to maintain equal power distribution.

Now this is an idealized statement of a situation which, for several reasons, is not always attainable in practice. In the first place, the voice coil of a speaker is not a pure resistance, and its impedance is not constant with frequency. As a matter of fact, it will be correct over only a small portion of the frequency spectrum. Second, as we have already seen, the tweeter may be much higher in efficiency than the cone-type general-purpose speaker. Hence, equal electrical inputs to the two speakers will result in widely different *acoustic* outputs with a resultant displacement of the *acoustic* crossover point. The over-all balance of the system can be restored by use of a balance control inserted between the network and the tweeter. The balance control is an L or T pad of the same nominal impedance as the remainder of the system; it permits adjustment of the entire sound level of the tweeter. It can be readily appreciated that such a control provides the user with the means of achieving a system balance which is personally suited to his tastes, automatically compensating, in operation, for differences in relative speaker efficiencies and the varying effects of room attenuation and acoustics.

The possibility was mentioned of matching a system with speakers of different voice-coil impedances. This possibility arises from the inherently greater efficiency of the horn-type tweeter. In most cases the speakers are either of 8- or 16-ohm impedance. Suppose you find yourself with an 8-ohm extended-range speaker and a 16-ohm horn-type tweeter. By connecting a 15-ohm resistor in parallel with the tweeter voice coil, Fig. 11, you can accomplish a dual purpose. First, the total impedance of the combination will be corrected to 8 ohms; second, the acoustic balance will probably be improved by this parallel resistor. An 8-ohm crossover network should be used. For a 16-ohm cone speaker and an 8-ohm horn tweeter, the same advantages may be obtained by wiring a 7.5-ohm resistor in series with the tweeter voice coil. This results in a system whose total impedance is 16 ohms.

The same principle may be employed in three-way systems in which one speaker is mismatched. The system input should be matched to the *least* efficient speaker, with suitable series or parallel resistors employed to bring the impedance of the remaining speakers into agreement with it.

With a reasonable amount of care, then, a tweeter can add a new dimension of color and sparkle to a workmanlike, but sometimes drab, all-purpose cone loudspeaker.

TRANSISTORS *in Audio Circuits*

by **PAUL PENFIELD, JR.**

VIb: Single-Stage Analysis

Graphs of the Formulas

Some of the formulas in Tables I, II, and III, given in the June issue, are simple enough, but others are quite complicated — especially the power relationships. To give the reader a good idea of how the properties of transistor stages vary, certain of the formulas in Tables I, II, and III have been plotted.

It was assumed in making these charts that the typical parameter values given in Part 5 described the transistor — that is,

$$\alpha = 0.98 \qquad \ldots(26)$$
$$\beta = 49 \qquad \ldots(27)$$
$$r_c = 2 \text{ Megs} \qquad \ldots(28)$$
$$r_b = 1{,}000\ \Omega \qquad \ldots(29)$$
$$r_e = 40\ \Omega \qquad \ldots(30)$$
$$r_d = 40 \text{ K} \qquad \ldots(31)$$

Thus, the graphs presented here do not apply to all transistors. However, the general features of the graphs — the shapes, etc. — will be the same for any transistor.

Fig. 3 shows the input resistance R_i as a function of load resistance R_l. Note that the resistances are plotted logarithmically, because of the wide variations found in the two. If they had been plotted linearly, most of the detail would have been lost.

Note also that the common-base input resistance is the lowest, the common-emitter value is medium, and the common-collector is the highest. Furthermore, the lowest input resistance for common-collector hookup is just the same as the highest value for common-emitter configuration.

In addition, the grounded-emitter case has a much smaller percentage *variation* in input resistance, varying only in a ratio of about 3:1 between its maximum value and its minimum.

Fig. 4 shows the output resistance R_o vs. the generator resistance R_g. Here again, the common-emitter circuit has a moderate value, varying in a ratio of about 3:1, while the other two take the extreme values — the grounded-base the higher values, and the grounded-collector the lower values.

Voltage gains for all three configurations are shown in Fig. 5. The common-collector-circuit voltage gain is always less than one, while the common-base and common-emitter circuit gains are the same.

Next, in Fig. 6, are pictured the current gains. The common-base circuit has a current gain less than one; the common-emitter current gain is everywhere just 0.98 (or α) times the common-collector value. For most practical purposes, then, they are the same.

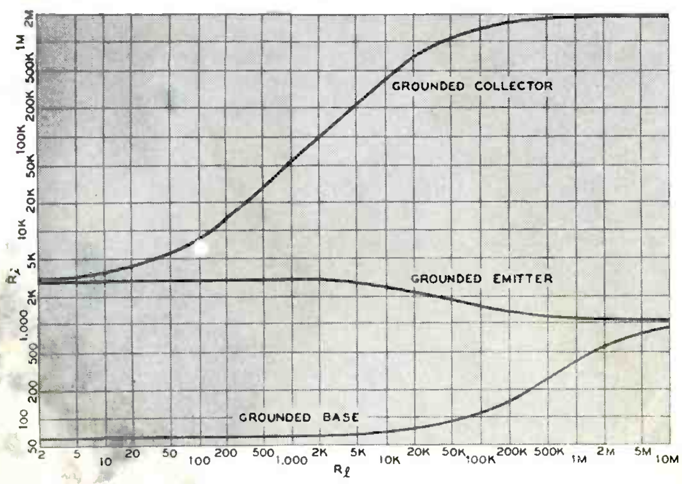
Surprisingly, the same configuration (common-emitter) has simultaneously the highest voltage gain *and* current gain. This explains its wide popularity.

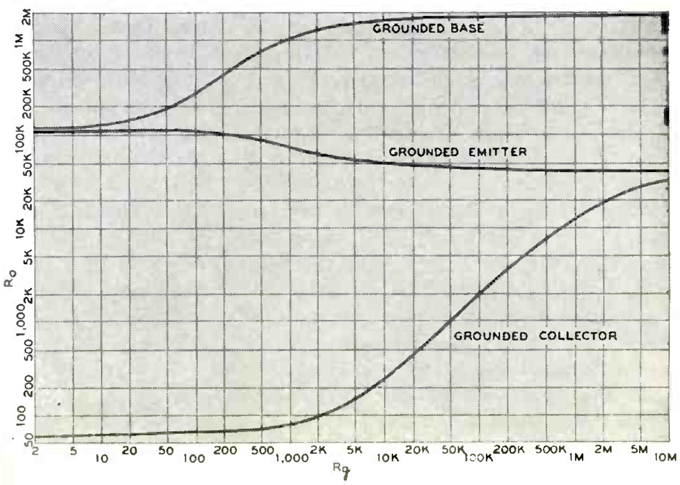
The power gain G is plotted in Fig. 7. It is obvious that the power gain of the common-emitter circuit is much higher than that of the other two for all values of load resistance.

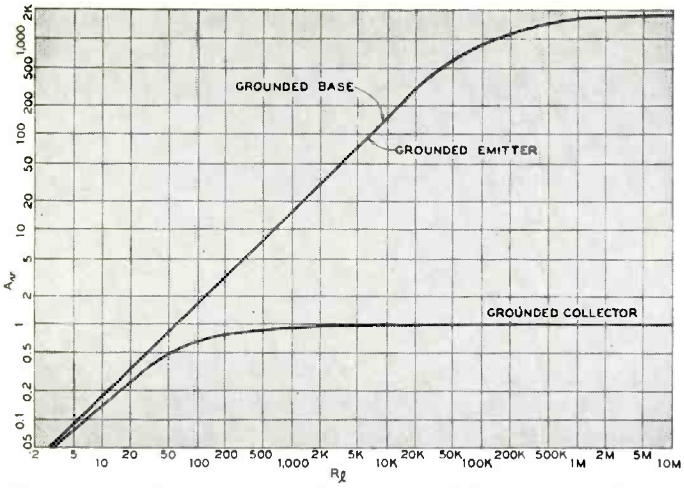
The system transconductance g_s and the transducer gain G_t are not shown plotted, because they depend on *both* the load resistance *and* the generator resistance. A few words might be said about them, however.

First, g_{se}, the common-emitter system transconductance, is higher than either g_{sb} or αg_{sc}. For all types of input devices, therefore, with *any* value of internal resistance R_g, the most current output from the first stage is obtained with the grounded-emitter circuit. The only exception occurs when, with a low load resistance, the grounded-collector circuit

Fig. 3, left. Variation of input resistance with load value. Fig. 4, right. Output resistance vs. the generator resistance.







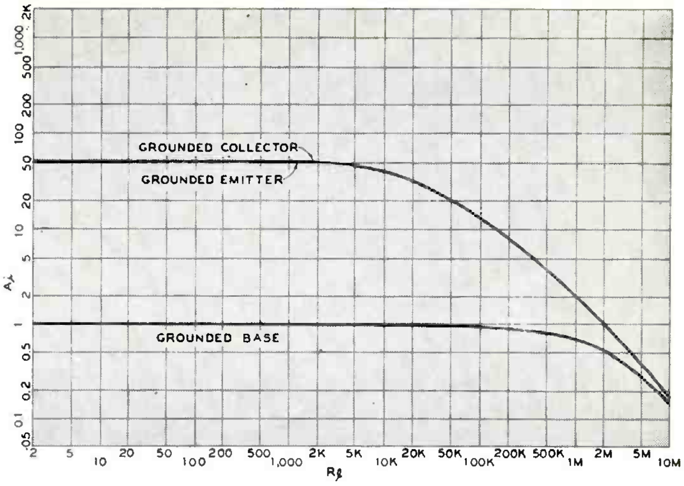


Fig. 5, left. How voltage gains vary with load value. Fig. 6, right. Effect of load resistance on current-gain magnitudes.

may have a very slight advantage. But for virtually all usable values of load and generator resistances, the grounded-emitter circuit has higher system transconductance.

Second, G_{te}, being proportional to the square of the system transconductance g_{se}, is greater than the corresponding transducer gains for the other two configurations.

The fact that the grounded-emitter circuit is virtually unsurpassed in all kinds of gain, and has moderate input and output resistances, accounts for its wide use. When selecting a configuration to use, some designers try to match impedances between stages, or with the input or output devices; however, there is no particular point to this, since the grounded-emitter case virtually always gives the highest gain with or without impedance matching.

The approximate formulas in Tables IV, V, and VI correspond, as can be seen, to special values for the functions. By looking at the graphs, it is evident when these approximations are valid, and when they are not.

The result of our work in Part 6, then, is contained in Tables I, II, and III, or the graphs of these functions, and the approximate formulas in Tables IV, V, and VI.

Simplifying Diagrams

As promised earlier, we'll talk about reducing actual circuit diagrams to the form of Fig. 1. As an example, look at Fig. 8, which shows a two-stage transistor amplifier operating from a dynamic microphone into a resistance load. How do we go about reducing one of the stages to the form of Fig. 1?

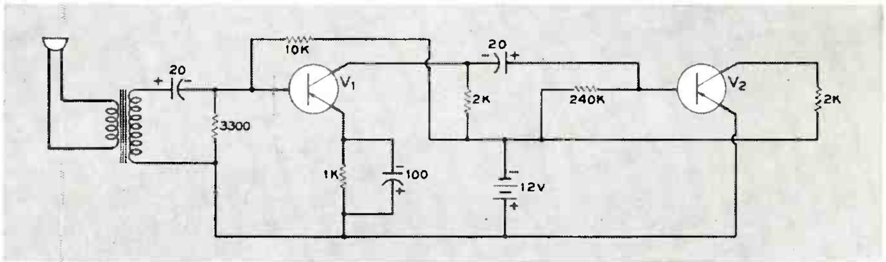
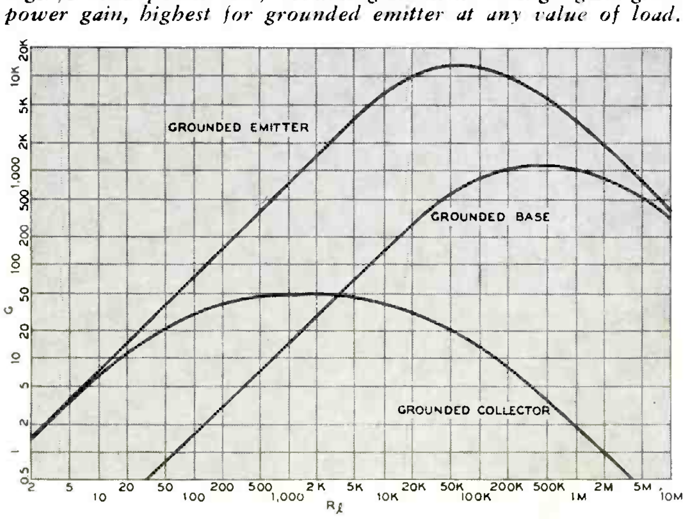


Fig. 8. Complete circuit of a typical two-stage transistor microphone amplifier.

Take the first stage. First, eliminate the DC part of the circuit by taking out the battery, and replacing it with a short circuit. Next, short out all the capacitors which, after all, are supposed to allow AC to pass. This reduces our circuit to that in Fig. 9.

Next, replace the dynamic microphone by a voltage source and an internal resistance — say, 1 mv and 150 ohms. Then, transform this microphone equivalent circuit past the transformer. When doing this, the voltage source is to be multiplied by the turns ratio, and the internal resistance by this ratio squared. Since normally the impedance ratio is given for transformers, find the turns ratio by taking the square root of the impedance ratio. Thus, if this transformer were a 25:1 impedance step-up transformer, the new voltage source would be 5 mv, and the transformed impedance, 3,750 ohms.

Fig. 7. Multiplication of current gain times voltage gain gives power gain, highest for grounded emitter at any value of load.



Now what can we do with the second transistor stage? Merely replace it with its input resistance, as far as the first stage is concerned. If the second transistor V_2 has the parameters given above, this input resistance, 3,000 ohms, can be found from Fig. 3, or Table I, or Table IV (since the second transistor's load of 2 K is small). Fig. 10 is the result.

Finally, resistances at the load and at the input can be combined, as is usually done, giving the final result of Fig. 11. The only circuit element left unchanged is the transistor, so values for current and voltage gain from Table I are still valid for this stage.

It should be evident that the reduced diagram in Fig. 11 contains much less information than the original in Fig. 8.

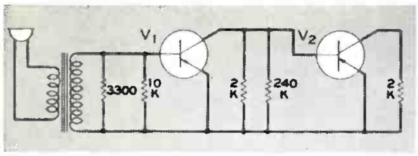


Fig. 9. First simplification of Fig. 8.

As far as AC operation of the first transistor is concerned, however, they are equivalent.

The same thing can be done with the second stage, of course, yielding the gain there also.

Although this treatment has been quick, reducing complex diagrams for each stage to the form of Fig. 1 is merely a matter of calculating the equivalent resistance the transistor "sees" at each end — and, with a little experience, the reader will find it quite easy.

For amplifiers involving more than

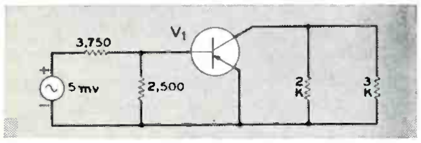


Fig. 10. Second step of simplification.

one stage, the analysis can be handled in a number of ways.

First, each stage can be calculated separately. This is what was done in the first illustration; the first stage was analyzed by substituting for the second stage its input resistance. Then the second stage could have been analyzed in the same way, substituting for the first stage its output resistance, as calculated from Table I. The voltage of the first stage is just equal to the input voltage of the second stage, so the final output voltage is just equal to the product of the two voltage gains times the input voltage, or, alternatively,

$$V_{o2} = A_{v2} R_{l1} g_{s1} \qquad \ldots (32)$$

where R_{l1} is the load resistance seen by the first stage, g_{s1} is the system trans-

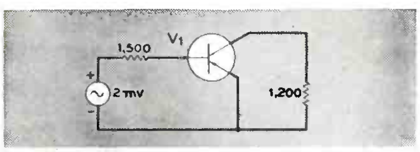


Fig. 11. Final version of first stage.

conductance of the first stage, etc. Note that in both stages the approximation of the load being very small is fulfilled, so that the simplified equations in Table IV can be used.

A second method is to use the equivalent circuits of Part 5 directly. The result seen in Fig. 12 is quite messy, with four fictitious generators. In general, it would be easier to solve the problem stage by stage, as in the last paragraph. However, here we notice that, as far as the first transistor is concerned, the load resistance is small compared to the

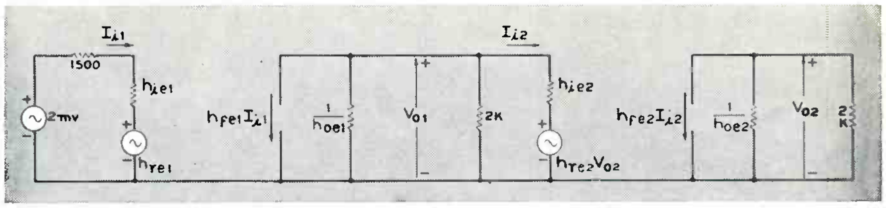


Fig. 12. Equivalent circuit for Fig. 8 obtained by treating both stages together.

quantity $1/h_{oe}$. Since this is true, the current through the resistance $1/h_{oe}$ will be very small, and for practical purposes can be neglected. Similarly, the quantity h_{re} is small, and unless the voltage V_{o1} is large, the fictitious generator on the input can be neglected.

In that case, the circuit is solved almost by inspection. The input current I_{i1} is just equal to 2 mv/(1,500 + h_{ie1}), and the voltage output will be this I_{i1} times h_{fe1} times the load resistance seen. Again, in the second stage, the feedback voltage source $h_{re2}V_{o2}$ can be neglected, so it is a straightforward job to find I_{i2}. Once that is found, the output current (and therefore the output voltage) can be found quite easily.

This process of simplifying the equivalent circuits, when the load resistances are in the correct range, is very useful, because by removing the h_{fe} signal source we are permitted to treat the input and the output of a given stage separately. It is known as "unilateralization," since it makes the amplifiers *unilateral* — meaning the output has no effect on the input. The elimination of the reverse voltage generator does the trick. This is, of course, only possible when the load resistance is low, *or* the generator resistance is high. In the first case, the value of the voltage generator is small compared to the voltage drop across h_{ie}, and in the second it is small compared to the voltage drop across R_g. In these two cases it can be neglected, and we have succeeded in isolating the input from the effects of the output.

It is often not clear in practical cases which of the two methods above is the easier. In case of doubt, it's usually better to do the analysis stage by stage by means of the formulas in Table I. On the other hand, drawing the AC equivalent circuit often helps in understanding the circuit operation as a whole.

It should be emphasized again that these formulas hold only when the actual circuit can be reduced to the form of Fig. 1. In cases where it cannot, the equivalent circuit is the best bet.

These formulas represent the easiest method of calculating important quantities relating to individual stages, and are very important in designing equipment. Having a handy chart of the relations in the tables simplifies much of the design work.

Next month we get down to more practical aspects of circuit design, starting with input stages.

Further Reading

Single Stage Formulas

Cheng, C. C. "Transistor Equations Using h-Parameters." *Electronics*, XXVII (Apr. 1954), p. 191.

Coblenz, A. and Owens, H. L. *Transistors: Theory and Applications*. New York: McGraw-Hill, 1955, pp. 90-145.

Hunter, L. P. *Handbook of Semiconductor Electronics*. New York: McGraw-Hill, 1956, pp. 11-1 — 11-27.

Johnson, L. B. "An Improved System for Calculating the A. F. Performance of Junction Transistors." *Mullard Technical Communications*, I (July 1954), pp. 186-196.

Krugman, L. M. *Fundamentals of Transistors*. New York: John F. Rider Publisher, 1954, pp. 19-67.

Lo, A. W., Endres, R. O., Zawels, J., Waldhauer, F. D., and Cheng, C. C. *Transistor Electronics*. Englewood Cliffs, N.J.: Prentice-Hall, 1955, pp. 81-93, 107, 113-117.

Penn, W. D. "Simplified Transistor Circuit Equations." *Electronic Industries and Tele-Tech*, XIV (Dec. 1955), pp. 76-77, 149, 151, 153, 155.

Shea, R. F. *Principles of Transistor Circuits*. New York: John Wiley, 1953, pp. 50-79.

Shea, R. F. *Transistor Audio Amplifiers*. New York: John Wiley, 1955, pp. 72-95.

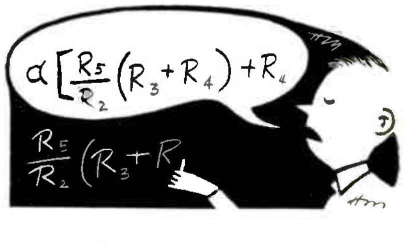
Two-Stage Analysis

Coblenz, A., and Owens, H. L. *Transistors: Theory and Applications*. New York: McGraw-Hill, 1955, pp. 165-201.

Hunter, L. P. *Handbook of Semiconductor Electronics*. New York: McGraw-Hill, 1956, pp. 11-24 — 11-26.

Shea, R. F. *Principles of Transistor Circuits*. New York: John Wiley, 1953, pp. 80-96.

Shea, R. F. *Transistor Audio Amplifiers*. New York: John Wiley, 1955, pp. 101-123.



Tips for the woodcrafter

A New Finish for Old Furniture

by George Bowe

CERTAIN antique cabinet pieces, such as dry sinks and china cupboards, provide excellent housing for some of the components of a home sound system, and, at the same time, preserve the decorating style of the room. Much of an antique's beauty and value lies in the finish which should reveal, rather than conceal, indications of age and use. If the original finish is in fair condition, by all means retain it; if it is not, or if it has been covered by layers of paint and varnish down through the years, refinishing is the obvious solution. If there is any question in your mind as to whether the old finish can be salvaged, try bathing it with the following solution: to a quart of water and mild white soap, add one tablespoonful of turpentine and three tablespoonfuls of boiled linseed oil. Working on one surface at a time, wash the finish with a soft cloth saturated with this mixture; then wipe dry with a clean cloth.

If the finish shows improvement after the washing, it may be possible to improve it still further with a rubdown of powdered pumice stone and oil. Use a thin oil such as No. 10 motor oil, sewing-machine oil, or linseed oil. Mix the powder with the oil until it becomes a light creamy mixture. Apply it to the finish with a soft cloth or piece of felt, rubbing with the grain of the wood. Rub lightly to avoid wearing through the finish, especially near the edges. Clean the surface with a cloth saturated with benzene. It is surprising how well many old, neglected finishes respond to such a washing and rubbing.

Using Paint and Varnish Removers

If a piece does not respond to the cleaning operation, the job takes on a greater magnitude — that of complete refinishing. This is not the easiest of tasks, but, with patience and perseverance, the home craftsman can emerge triumphant and justly proud. Of course, the first step in refinishing is removing the old finish, and this is best left to a commercial paint and varnish remover. Homemade finish removers using lye should not be used, since lye can injure wood surfaces and remain in the wood to damage the new finish. There are many commercial removers on the market today in liquid, semiliquid, and paste forms; the semiliquid and paste varieties are especially suitable for vertical surfaces where a liquid remover would run. Some types of removers require lifting of the finish with a putty knife after it is loosened; others need only to be washed away with water. Here are some general rules applying to most types of paint and varnish removers:

1) Always follow the manufacturer's directions — you'll get maximum results from his research. (At this point I can only think of the old maxim, "When all else fails, read the directions.")

2) Work on one surface at a time. When the remover is applied to too large an area, evaporation may cause the remover to harden before you have had a chance to work on it. If this should happen, apply a second coating to remove the first.

3) When using a remover outdoors, keep the work in the shade to prevent an excessive rate of evaporation.

4) If the finish consists of multiple layers, don't expect to remove all of them with one application. Apply the remover as many times as necessary.

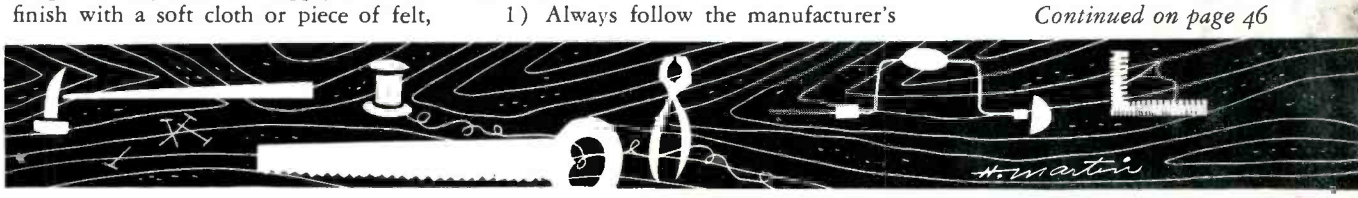
5) Don't rush — allow the maximum time indicated in instructions for the remover to work.

6) Adhere to all safety precautions indicated on the container concerning yourself, your clothing, and the work area. Do not use flammable removers near an open flame or electric heater. Should a drop of remover get into the eye, wash it out immediately with plenty of water.

7) Wear rubber gloves and old work clothes. Cotton gloves have a tendency to pick up the old finish being removed, so they should not be worn.

8) When working indoors, use several layers of newspaper to protect the surrounding area.

Continued on page 46



Multiconductor Cables

Any cable connecting one piece of apparatus to another must be flexible and as breakproof as possible. It is important, when making up cables, to use suitable wire.

Always use stranded wire. Solid wire is not so flexible and will break if it is bent enough. If the cable is going

Incorrect and correct ways of lacing cable. Always use regular lacing cord.

to have to bend sharply, around a corner or next to a clamp holding it down, for example, even normal stranded wire will not be good enough. In such cases special "limp" test-lead wire should be used.

If you make up the cable yourself, hold the wires together with tape or lacing cord. Don't use string, but invest in regular lacing cord; it is specially waxed to hold up under a break. Strong fishing line is a fairly good substitute, except that it is slick.

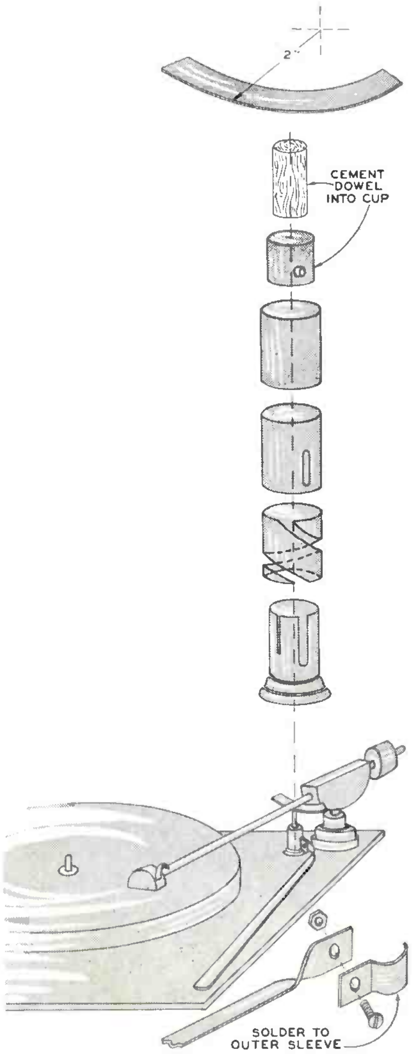
When using lacing cord, be sure to use the correct knots, so that if the cord breaks at any point it will not unravel. The illustration shows the right and wrong ways to tie the cord.

Paul Penfield, Jr.
Brookline, Mass.

Pickup Lifter

One of the penalties of graduating from a record changer to a precision turntable and pickup arm is the nerve strain of putting the pickup down on a record and lifting it off at the end. Every one of us must have been clumsy on some occasion or other and skidded the needle over the grooves. What is needed is a device to raise the arm by remote control so that it can be positioned while clear of the record surface. The solution is at hand in the form of an ordinary lipstick holder.

The drawing shows the idea adapted to suit my Leak pickup arm mounted on a Connoisseur turntable. The lipstick holder was cut down to 7/8 in. high with a fine hack saw. The arm support and operating lever were cut from 1/8-inch Plexiglas. A movement of the 9-inch-long operating lever through 15° or less (it stays within the boundaries of the turntable), lifts the pickup head about 1/4 in. clear of the record surface. Weldwood cement holds the lipstick-holder base to the turntable platform.



How lipstick holder can be fashioned into a device for lifting phono pickup arm. Arm support and operating lever are made from 1/8-inch-thick Plexiglas.

With more clearance available at the side of the turntable, an alternative solution would be to mount a full-size lipstick holder to one side of the pickup base and use a drop arm to do the lifting.

Charles M. Wells
Toronto, Ont.

Chassis Layout

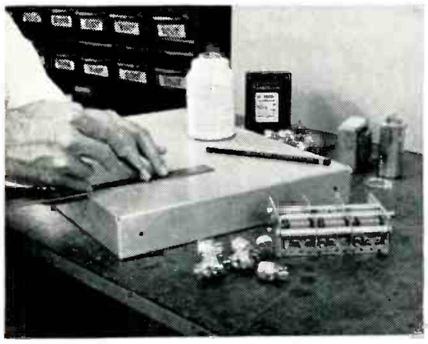
Perhaps the least attractive task which confronts the enthusiast who constructs electronic equipment at home is that of cutting the necessary mounting holes in metal chassis bases. The appearance of hand-operated punches in many sizes and shapes has done much to reduce the work involved. In particular, the advent of commercially fabricated aluminum chassis bases and enclosures has been a special boon to the home constructor. This material is a preferred chassis metal because of its desirable electrical properties, such as good shielding and low resistance, and also because it is so easily worked. It is capable of presenting a neat finished appearance which will not rust or tarnish.

As supplied by the manufacturer, these aluminum bases have a smooth surface finish, and it was with the intention of preserving this finish that my attention was directed toward suitable layout techniques. Some of the ideas evolved may be of interest to others.

While arranging parts in the search for a suitable placement, it is worth while to protect the chassis with a paper covering. Once the proper placement has been determined, however, greatest accuracy in layout can only be achieved by marking holes and cutouts on the chassis itself. The problem resolves itself into one of finding a marking method which will not injure the aluminum surface.

Obviously, layout with a scriber or other means of scratching lines into the chassis must be ruled out because of the damage inflicted on the surface. A logical marking material would seem to be an ordinary lead pencil. Pencil layout has the advantage of producing a sharp, clearly defined line on aluminum, but unfortunately it leaves a graphite deposit which is difficult to remove. It is possible, of course, to remove the graphite by erasure or by polishing the aluminum with steel wool or abrasives, but this defeats our purpose since it alters the surface finish.

The obvious solution to the problem will be found in a marking pencil which will leave a sharply defined line, and yet be more easily removed. The ideal answer presented itself in the form of colored pencils, which are readily available in many brands, including Eberhard



Laying out a chassis: colored pencil will not scratch aluminum surface and lines wash off with soap and water.

Faber's Colorbrite line. The red and blue colors, in particular, make a good contrast with the aluminum. The pencils can be easily sharpened to produce clear layout lines. The deposits left on the chassis after the layout and hole-cutting operations are completed can be removed by washing the chassis with soap and water. After drying, the exterior of the chassis can be sparingly sprayed with clear lacquer, such as that available in convenient aerosol spray bombs. This will protect the chassis surface and provide a finish that is easily dusted and cleaned. The finished chassis will retain all of the neatness and beauty possessed by the original unworked surface.

Maurice P. Johnson (W3TRR)
Baltimore, Md.

Turntable Mounting

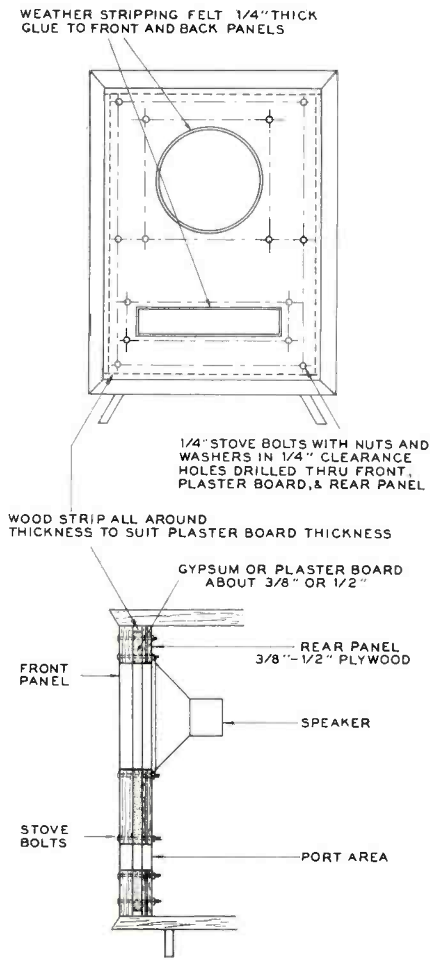
Turntables are often mounted on springs which are supposed to absorb motor vibrations. In some cases this is not particularly effective, especially if the motor is mounted rigidly on the base plate and not suspended from shock-absorbing mountings. In this case, the purpose of the springs may be defeated and the turntable subjected to vibrations which cannot be absorbed (in fact, they are sometimes aggravated) by the springs on which the turntable is supposed to float. These vibrations are then transmitted to the pickup and appear in the speaker as trembling distortion or flutter.

In my experience, the remedy has been to do away with the springs altogether and to mount the record player rigidly on a heavy plywood base of at least ¾-inch thickness. This base should also be supported firmly by substantial mounting strips in its cabinet, possibly even screwed down on them.

John J. Stern, M.D.
Utica, N.Y.

Speaker Panel

The sketch shows a cheap way of making a practically resonance-free front panel for a speaker enclosure. The materials used are common and easily worked. Two things should be kept in



Front panel of gypsum-board-lined loudspeaker enclosure. Entire enclosure can be constructed of same materials.

mind: the wood strips should be installed so that they do not come in contact with the rest of the enclosure, and the same type of construction can be used for the entire enclosure.

A plaster or gypsum-board-lined enclosure will act practically as a sand-filled enclosure. The enclosure will be virtually resonance-free, but not so heavy as a sand-filled unit.

The sketch shows a port area which may or may not be there; in other words, the board should be cut "to suit."

Herbert J. West
New York, N.Y.

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 the Audio Aids editor. No limit on the number of entries.*

Chassis Punch

Reference is made to Lt. Loue Stockwell's "Poor Man's Chassis Punch" in "Audio Aids" last May.

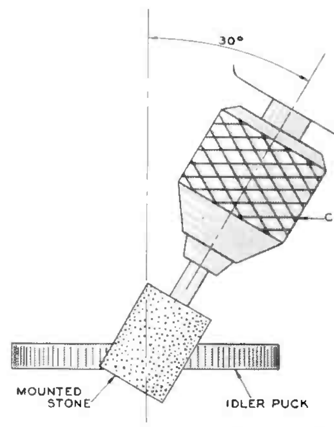
I believe Lt. Stockwell omitted an important point. Most hole cutters have the adjustable cutter mounted at right angles to the vertical, and it is difficult to adjust this to the proper diameter of the hole required. The procedure can be simplified by drawing a circle of the correct size on a block of wood with a compass. Then drill a pilot hole through the block at the center of the circle. It is then simple to adjust the cutter to contact the lead-pencil line on the wood block.

R. H. Watkins
Winona, Minn.

Tape-Recorder Wow

Slowdown and intermittent wow in tape recorders are often caused by the glazing of the rubber tires on the idler pucks. These components should be replaced at the earliest opportunity, but a creditable job of removing the glaze can be accomplished, with the pucks in place, with a cylindrical grinding wheel mounted in a small electric drill.

Remove the panel of the recorder and arrange the pucks so they rotate freely. The trick is to avoid making flat spots on the tires. Hold the grindstone axis at about 30° with reference to the idler's axis. In this way, the idler will be rotated rapidly by the grinder while it cuts away the glaze and leaves a fine-toothed surface. Cut just enough to remove the glaze. Be sure to use the grinder in such a position that the crumbs are thrown away from other components of the drive mechanism.



Glaze on tape-recorder idler pucks can be removed with cylindrical grinding wheel mounted in small electric drill.

R. L. Browning
Texas City, Tex.

BASIC ELECTRONICS

by **Roy F. Allison**

XVIIIb: Triodes

IN the first half of this chapter, published in the preceding issue, the subject of triode amplifying tubes was developed up to the point at which an amplified output signal was obtained at the plate. A 6J5 tube, with an amplification factor of 20, was chosen as an example of a typical triode. With a 360-volt B+ supply, a load resistor of 25 K, and a bias of 4 v, the actual voltage amplification or gain was just over 15.

At least two matters may be puzzling readers at this point. First, we had demonstrated earlier in the chapter (using the 6J5 plate characteristic curves) that, with a fixed 160 v on the plate, a grid voltage of —8 v with respect to the cathode would reduce plate current to less than 1 ma. Under the same conditions, zero grid voltage with respect to the cathode would produce a plate current of 20 ma. In our amplifying-stage circuit used later (Fig. 6, reproduced here) the quiescent plate voltage is also 160 v, since under no-signal conditions there is a voltage drop of 200 v in the plate load resistor. Yet, when the input signal's positive swing

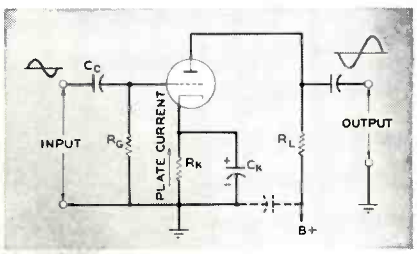


Fig. 6. Amplifier circuit for a triode.

made the grid reach zero v with respect to the cathode, it was stated that the plate current would be only 10.5 ma; and when the input signal's negative peak made the grid 8 v negative with respect to the cathode, we said that the plate current would be 5.6 ma. Why the difference?

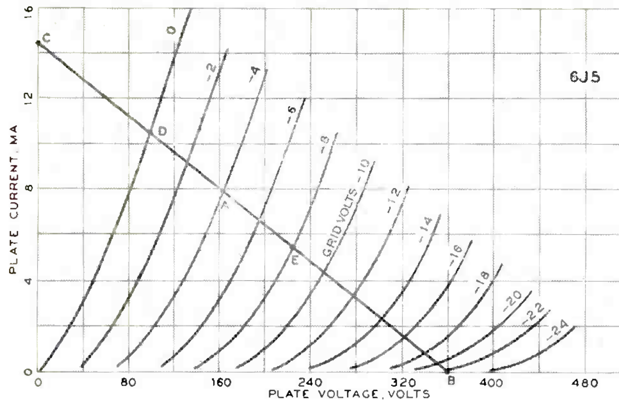
Second, it was pointed out that changes in the grid voltage have 20 times as much effect on plate current as changes in the plate voltage for a 6J5; that is, the amplification factor μ is 20. It is changes in the plate current that produce changes in the voltage drop across the plate load resistor, and these voltage changes represent the output signal. Why, then, was there an actual amplification of only about 15?

These superficial anomalies are really two results of the same process, arising because the tube is not a perfect amplifier. Recall that the plate voltage *does* have an effect on plate current — not so great an effect as grid voltage, to be sure, but still appreciable. Now, when the grid signal goes in a positive direction, it increases plate current; the increased plate current causes a greater voltage drop across the plate load resistor, lowering the plate voltage, and that tends to *reduce* plate current. When the grid signal goes in a negative direction it decreases plate current, which decreases voltage drop across the load resistor; that increases the plate voltage, which tends to *increase* plate current. The presence of the plate load is necessary to develop an output signal, but it is a peculiar fact that its presence also causes the plate voltage to swing in a manner such that it always opposes the effect of the grid-voltage swing. Consequently, plate current does not change nearly so much in the circuit of Fig. 6 as it would if the plate voltage were fixed, for equivalent input-signal swings at the grid. The fact that the grid voltage has *more* effect on plate current than the plate voltage is what permits operation of the tube as a voltage amplifier; if it did not have a greater degree of control, the opposing action of the plate-voltage swings would defeat the grid-swing action entirely.

The moderately complex nature of the plate characteristic curve makes it quite difficult to describe mathematically, with complete accuracy, how a vacuum-tube amplifier circuit will behave. Fortunately, however, graphical solutions and equivalent circuits can provide not only useful design information but assistance in the process of visualizing what actually happens in such circuits. The graphical solution involves a chart of the plate characteristic curves, which we have already encountered, and a *load line*. Fig. 9 repeats the 6J5 plate-voltage plate-current curves seen first in Fig. 5, with a load line superimposed. This load line represents all possible plate-voltage and plate-current values for a B+ supply voltage of a given value and for a load of a given resistance value. For consistency we have plotted this load line to correspond with the conditions of the previous example: 360 v B+ and a 25-K plate load.

The load line could have been obtained in many ways, depending on circumstances. Taking the line of reasoning we adopted previously, we wanted to operate around the 4-volt bias point with 160 v on the plate at that point. This fixes one point (point A) on the load line. We've said that the B+ supply is 360 v. Another point is fixed by considering one extreme condition of plate voltage; that at which the tube is completely cut off, not conducting at all. At this point the plate voltage is 360 v and the plate current is zero, and this is shown as point B on the chart. Drawing a line across the chart through points A and B gives us our desired load line, which (as we calculated previously by other means) corresponds to a plate load of 25 K. To check this, consider the other extreme of plate voltage: that when the entire B voltage would be developed across the load resistor, in which case the plate voltage would be zero. The plate current then would be the same as if the load resistor were directly across B+: 360/25,000, or 14.4 ma. We note that the load line does indeed go through the zero plate-voltage line at 14.4 ma. This is labeled point C on the chart. Then, to calculate the value of bias resistor needed, we note that 8 ma plate current flows at point A, for a bias of 4 v. The cathode resistor must be 4/.008, or 500 ohms.

Alternatively, we might want to try various values of load resistor to see which is best for a given set of circumstances, or we may want to analyze an existing circuit. In either case we should calculate points B and C, and then draw the load line between them. This procedure is valid because the simple equation defining voltage drop across a resistor in terms of current through it is a linear one; that is, it produces a straight line when plotted on a chart such as that in Fig. 9. Any two points



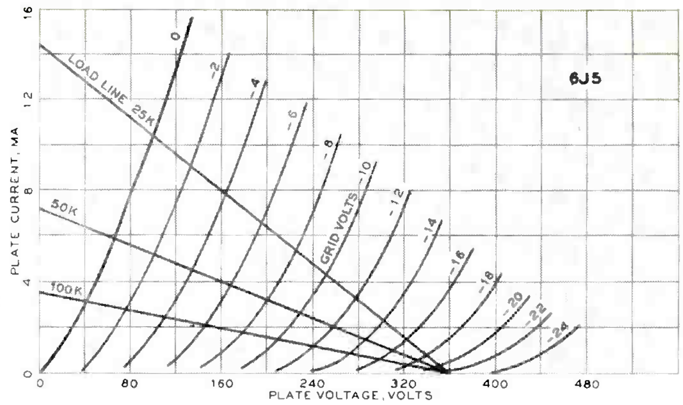


Fig. 9. Load line drawn on plate characteristic chart for a 6J5. Fig. 10. Comparison of load lines for 25 K, 50 K, and 100 K.

on a straight line, of course, are sufficient to define the line.

Now let us look into the significance of this load line. We have seen that the line shows all possible plate-voltage and plate-current values that can exist with that specified load and B supply. The line also crosses the individual curves on the chart at fairly regular intervals which correspond to the various bias values. Thus for any particular voltage between grid and cathode, we can find the corresponding plate voltage and plate current merely by looking at the proper point on the load line. If our bias has been fixed at point A, for example (4 v), the plate voltage must rest at 160 v with no input signal. As an input signal on the grid swings positive, plate current increases and plate voltage decreases along the load line upward and to the left; if it swings as far as 4 v positive, the instantaneous values of plate voltage and plate current are shown at point D, where the zero grid-voltage line crosses the load line. The point is at 10.5 ma plate current and 97 v plate voltage. Swinging 4 v down from A, the input signal would reduce plate current and increase plate voltage to point E on the load line, where the 8-volt bias curve crosses. At that point, plate current would be 5.6 ma, and plate voltage would be 220 v. These are the values obtained previously for our example circuit, and this is the method by which they were found.

Ideally, the load line should cross the incremental grid-voltage curves at precisely equal intervals throughout its length. If it did, the changes in plate voltage would always be exactly proportional to the input signal variations, and the output signal developed at the plate would then be free of distortion. Unfortunately this ideal is never perfectly realized: in our example a 4-volt positive grid swing produced a plate-voltage change of 160 — 97, or 63 v; a 4-volt negative grid swing produced a plate-voltage change of 220 — 160, or 60 v. The imbalance in output represents even-order harmonic distortion. Odd-order distortion shows up as nonproportional amplification on *both* swings. And since the intervals of crossing points generally become more crowded together at both ends of the load line, it is apparent that the distortion will increase as the output signal increases in amplitude.

It is evident from Fig. 9 also that the bias point may not have been well chosen for all purposes; moving it down on the load line would certainly permit a larger signal to be handled, for instance, although that might increase the distortion for small signals. It even appears unlikely that the best possible load has been selected. A 50-K or 100-K plate load resistor, which would yield a load line of less slope, would probably furnish greater voltage gain, lower distortion, and greater signal-handling ability. Fig. 10 shows comparative load lines for 25, 50 and 100-K plate load resistors, with a 360-volt B supply. Another consideration in selection of a load line is that the tube voltage and power ratings must not be exceeded. Crowhurst* gives more detailed discussion to load lines for voltage amplifiers, and their selection for specific applications.

The AC equivalent circuit of an amplifying stage is helpful in explaining its operation in a physical sense as well as mathematically. Consider Fig. 11, the schematic diagram of our familiar circuit, with the parts' values filled in. This has the normal cathode bias resistor and bypass capacitor, which in combination maintain a steady DC bias potential on the cathode regardless of signal variations. So far as the AC signal is concerned, the situation is identical to one in which the cathode is grounded and an equivalent negative DC bias is maintained on the grid, around which the input signal fluctuates. The bypass capacitor is usually made large enough so that this situation is maintained for all signal frequencies of interest.

This part of the circuit, accordingly, can be replaced by a generator producing an AC voltage equal to the input signal voltage times the tube's amplification factor, or μe_g. We know that any voltage source has an internal resistance that is effectively in series with the source; in this case, it is the AC plate resistance of the tube, R_p. The tube and its plate resistance (nominally about 7 K for a 6J5) can be replaced in the AC equivalent circuit by the amplified voltage source μe_g and the 7-K resistor

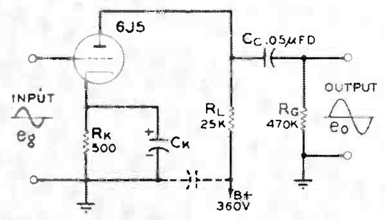


Fig. 11. Single triode amplifier stage. Note that output signal is drawn incorrectly; it should be exactly inverted.

labeled R_p. These appear to the left of the dashed-line box in Fig. 12.

The plate load resistor is connected between the plate and B+, Fig. 11, but so far as AC is concerned, B+ is at ground potential. In our AC equivalent circuit, therefore, we show R_L connected between plate and ground.

The coupling circuit consisting of C_c and R_G is used only to isolate the DC voltage at the tube plate from the output circuit, while passing the AC output signal variations on. For normal AC signal frequencies, then, the coupling capacitor can be considered to be a perfect connection between the two resistors. It follows that in our AC

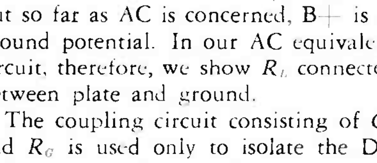
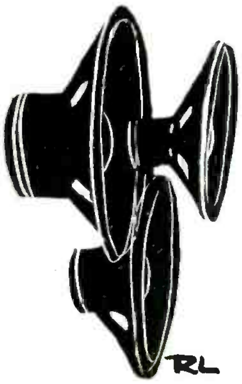


Fig. 12. Equivalent circuit for Fig. 11.

equivalent circuit (Fig. 12), R_G is in parallel with the plate load resistor. And for AC purposes, the output signal is developed across the parallel combination of R_L and R_G. This combination is in series with the source voltage and

Continued on page 45

*Norman H. Crowhurst, "Designing Your Own Amplifier," AUDIOCRAFT, I (March 1956, p. 20; Apr. 1956, p. 25; May 1956, p. 21; Jul. 1956, p. 19; Sept. 1956, p. 28).



a multiwoofer horn system

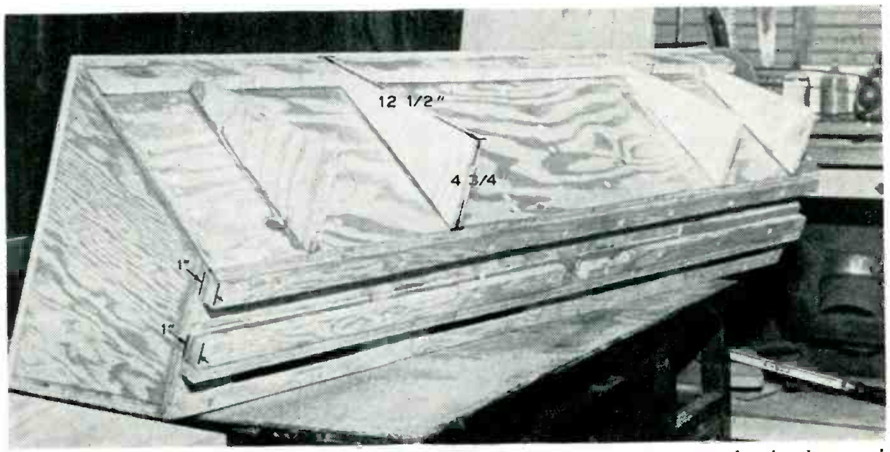
by ED MOTTERSHEAD

ABOUT ten years ago my wife and I were happily listening to regular radio broadcasts of good music and otherwise enjoying ourselves like most people in the pre-TV and pre-hi-fi era. Then one day a newspaper friend of ours brought home a mechanical hand-crank phonograph for his daughter, age seven.

He also bought several albums of Bach, Beethoven, and similar "good" recordings, which he proceeded to play on this monstrosity with vast delight, insisting that all his guests listen to the third movement, the string quartet, or whatever, when the best anyone listening could do was to suffer through an interminable series of strangled sounds and leave the party early.

But we were hooked. Music on records opened up a whole new world to us, so we spent months shopping in music stores. We finally picked out a good commercial make in the slightly over $500 range, with AM and FM, a 78-rpm turntable, and what were euphemistically billed as two 12-inch coaxial speakers. We even got a really good piece of blond oak furniture in the deal.

In the meantime, our other friends were buying various hi-fi components and talking woofers, tweeters, record compensators, preamps, Williamson circuits, chokes, filters, and what not — and building speaker enclosures of all sizes and shapes. Because we had a large basement, table saw, and drill press, we were subjected to construction projects for bass-reflex cabinets, Jensen corner horns (referred to as the potato bin), Karlsons, and, finally, the big Klipschorn. Through all this we patiently drilled holes and screwed screws for our friends, listened to their crossover networks, and played our records on our Magnavox.



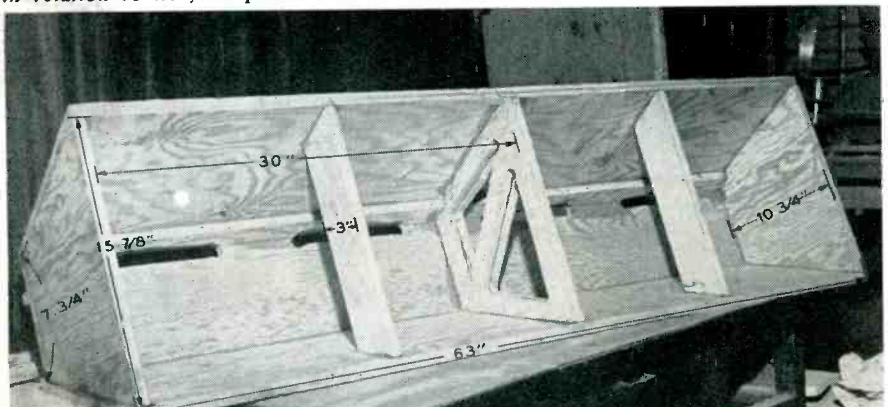
Rear view of coffin in upright position, showing spacer strips on the back panel, glue strip at top front edge, and four triangular braces for enclosure top panel.

In despair, one friend finally forced a $10 record compensator and a $9 preamp on us, together with GE cartridges. Another friend produced a surplus Pickering. Eventually we wound up with two Pickering cartridges with diamond styli, but no fancy amplifiers or fancy speaker enclosures.

In the course of time, several of the outmoded, discarded, or otherwise surplus speaker enclosures came to rest in various corners of the living room, kitchen, and basement. This gave us a wired-for-sound effect, but we were still without hi fi in the proper sense. Finally, I succumbed. My wife and I part company at this point in the story; she has always been content simply to listen to music and enjoy it without worrying about high and low frequencies or anything except too many decibels.

For some months I haunted the several hi-fi salons in Chicago, bought plans for speaker enclosures (none of which got built), attended the audio shows, and behaved in the accepted manner of the neophyte high-fidelity fan. During this period, a spot of horse trading also left us in possession of most of the pieces of a prewar Capehart, complete with unmanageable magic changer, two speak-

The four-speaker resonating chamber, or coffin, fully assembled. This is inverted in relation to its final position in the enclosure. Note double brace in the center.

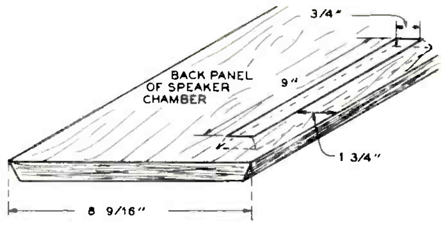


ers, two amplifiers, a nonoperative AM-FM tuner which still baffles us, and assorted loose pieces. Just for kicks I rigged up the two amplifiers and two speakers from the Capehart in a crude lumber frame sitting in the living room on top of the Magnavox. This gave us essentially four 12-inch speakers and sounded twice as good, at least twice as loud. My wife put up with this in the interests of peace in the family and even admitted that it sounded "tremendous" (female talk for too loud).

At this point the old question came up of what to do really to improve the rig so it would sound as I wanted it to sound. Study and examination of various catalogues, plus field study of components on display and in action, brought us to the dreadful total of $1,300 net cost, with no tape or binaural sound, yet. This merely put us where we were with enough improvement so you could hear it instead of talk yourself into it.

The four speakers blaring away in the living room also presented a challenge. If they sounded good now, how would they sound in an enclosure? Where was a multiple-speaker horn?

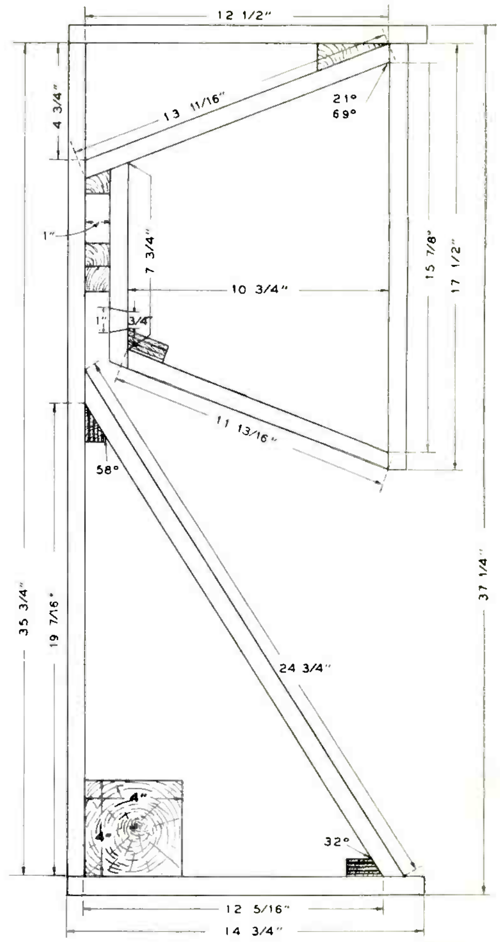
Klipsch had a design for a two-speaker corner horn. Jensen had an old design allowing for one 15 or two 12's. Some 80 to 100 hours of arithmetic, curves, and assorted drawing-board exercises



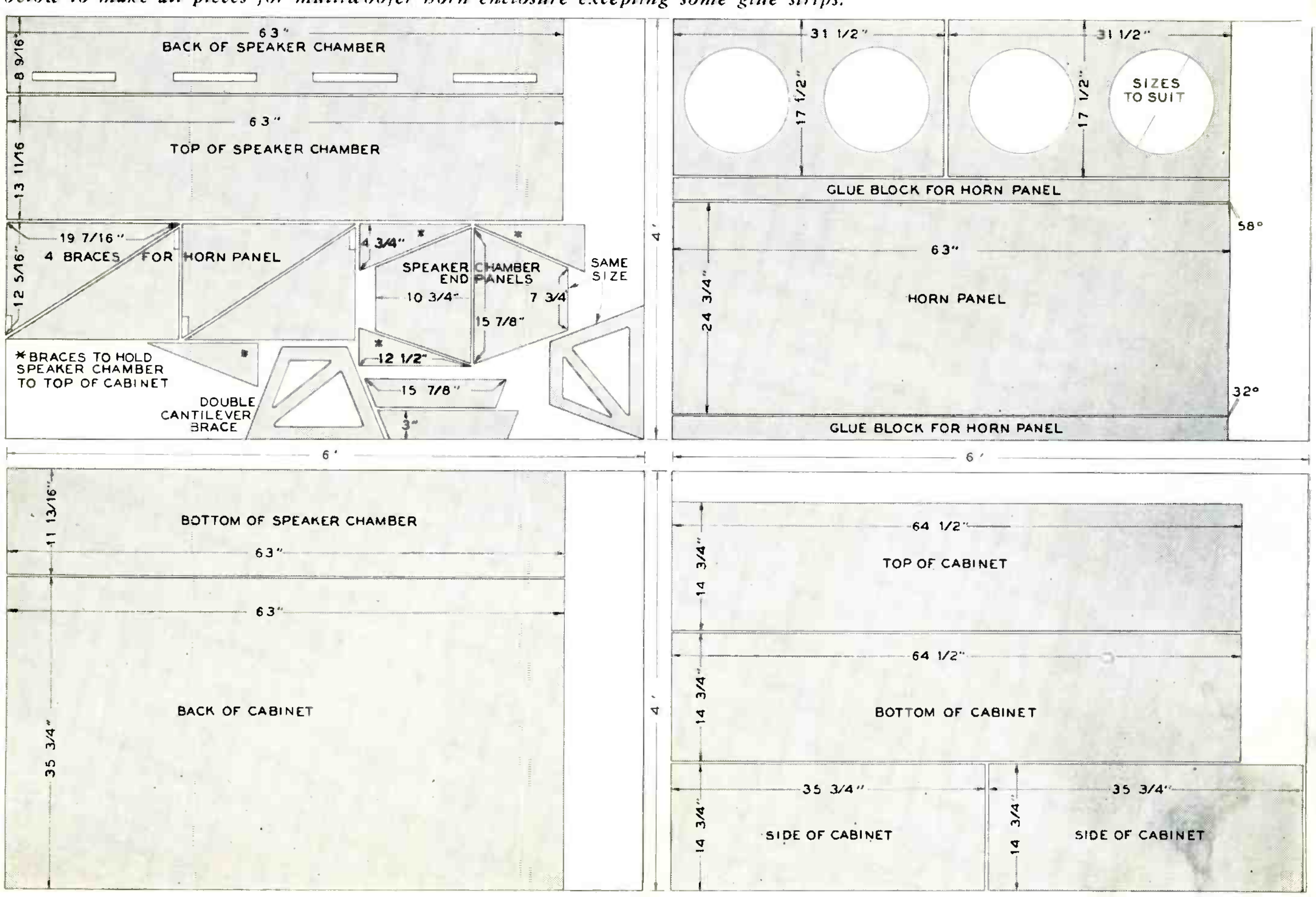
Above, detail of back coffin panel with slot dimensions. Right, a side view of the rear-loading horn assembly, showing interior construction in each section.

produced a design for an enclosure which, checked over by *bonafide* audio engineers, looked as though it would produce acceptable sound using the four available speakers. The only trouble was that the thing used up six 4-by-8 sheets of ¾-inch plywood, and would end up weighing in the neighborhood of 450 lbs. Since we already had four davenports and a piano in our 21-by-33-foot living room, another object the size of a piano seemed too much.

In the Klipsch line there is also a small corner horn for one 12-inch speaker: a box roughly 12 in. from back to front, and about 20 in. high. Having built around a dozen of these with my friends, and knowing that they sounded reasonably good, I thought it might be worth while to try something essentially the same, but with capacity



Four sheets of 4-by-6 plywood, ¾ in. thick, can be cut according to the patterns below to make all pieces for multiwoofer horn enclosure excepting some glue strips.



Resonating chamber and top panel of enclosure glued and screwed together. Strip of plywood was nailed to back edges of triangular braces, and scrap pieces of plywood were attached to each end, to serve as temporary guides in positioning top panel.

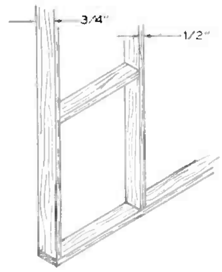
for the four speakers available. The result was the coffin, shown in these drawings and photos.

The original speaker back chamber dimensions were increased to allow for a 15-inch speaker and multiplied by four. This was arbitrarily reduced a bit because the available space in the corner window of the room set an outside limit of 65 in. horizontal length. The result, shown in the plan, provided a gross volume of approximately 7,843 cu. in., with space front-to-back and in width of speaker board to allow for installation of any of the available hi-fi 15-inch speakers.

Slot area in the rear of the back chamber was increased to provide four slots 9½ by ¾ in. on the inside of the chamber, with an outward flare through the rear panel to 10 by 1 in. Travel of sound waves from the rear of the speakers was held to 17 in., the same as the small unit used as the base for the calculations.

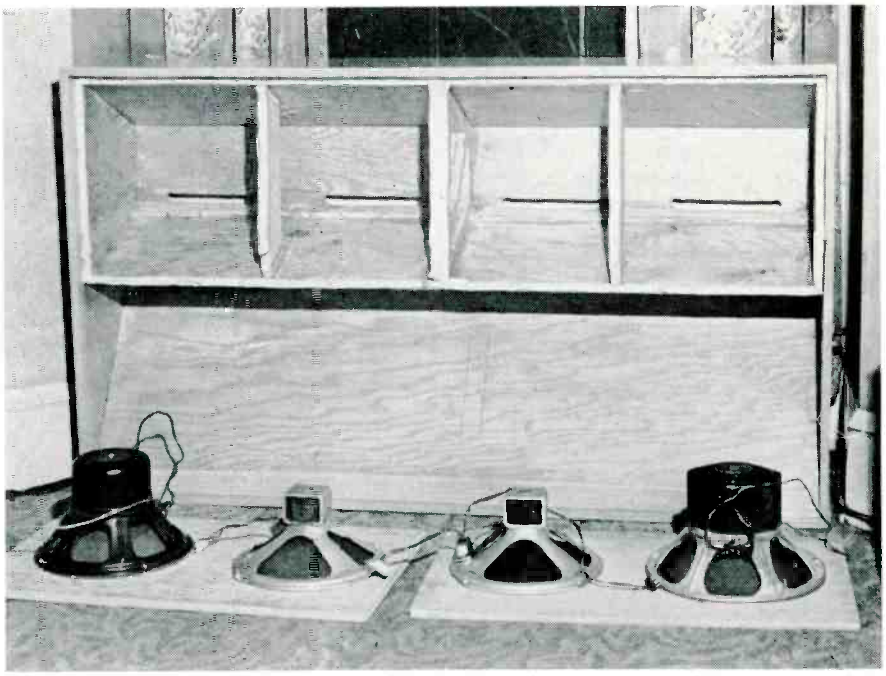
Dimensions of horn flare were taken off one side of the model corner horn, doubled, and the entire horn built on one side. This object is horizontal in design; the four speakers are mounted in a line, and the horn mouth is at the bottom.

The result is a noncorner corner horn sitting in the corner of the room. Total



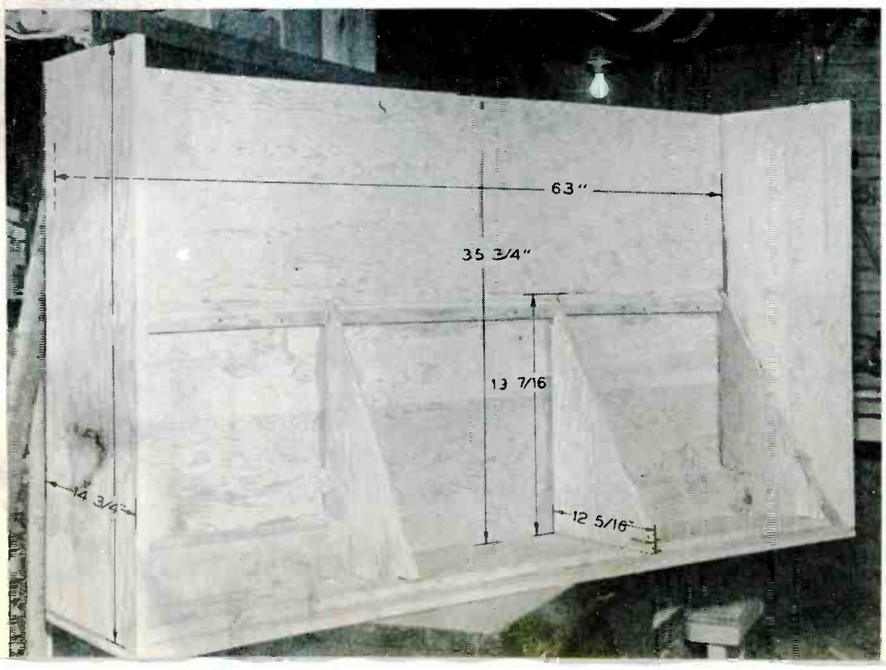
Detail of grille cloth framework.

cost for materials is about $40. This includes four 4-by-6-foot sheets of ¾-inch plywood, 1½- and 1¾-inch screws, casein glue, 2 yards of open-weave drapery material for grille cloth, lengths of ½-by-¾-inch material for the grille frame, etc. A cutting plan for the plywood pieces is included herewith.



The upper and lower assemblies combined. Now the reason for adding top panel to the coffin is apparent: this very heavy unit simply rests in place while it is firmly attached to lower assembly. Two speaker mounting boards simplify installation too.

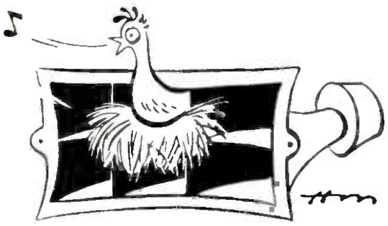
Partially completed lower assembly. The 4-by-4 timber corner supports are in place at each end section, with center section ready for the third. Note glue strips at ends of the horn-panel braces; final step is installation of the large horn panel.



Both speakers from the old Capehart had extremely heavy magnets. The 12-inch speaker scaled around 30 lbs., and the 14-inch speaker weighed in at around 50 lbs. I was a bit worried about the center of gravity, with the speakers in the upper part of the works, so I used a length of 4-by-4-inch timber cut into three sections as rear glue blocks to hold the back and bottom together and to provide some ballast. It also provided a truly square joint at that point, which was helpful in straightening out the built-in warp of the back panel.

AC grade ¾-inch plywood, good one

Continued on page 43



Sound-Fanciers' Guide

by R. D. DARRELL

THE luckiest, if not the most decisive, of my earliest aural experiences was a simultaneous introduction to the electrifying world of symphonic sound and the fascinating, mysterious realms of "new" music. Although it was more years ago than I like to count, I've never forgotten that when I played hooky from high school for my very first Friday afternoon students' rush-line Boston Symphony concert, even the dramatic impacts of Beethoven's *Egmont* Overture and *Emperor* Concerto (with no less a star than Josef Hofmann) made a less overwhelming impression on me than those of Debussy's *Ibéria* and — most of all — Schreker's *Prelude to a Drama*. This last piece, a then-characteristic example of post-World-War-I modernism, post-Straussian and post-Puccinian eclecticism, has long since passed into undoubtedly deserved obscurity, but I shall always cherish its memory as an intoxicating appetizer to the feasts of more substantial contemporary music I was to relish later during the Monteux and Koussevitzky regimes at Symphony Hall.

Of course young listeners of today are still luckier in having easier access to an infinitely wider range of orchestras, conductors, and repertory, all of which may be reheard at will and studied in detail on records at home. Yet I feel that their sonic coming of age is more handicapped than mine was by too thorough, if not exclusive, grounding in the standard masterpieces. For the later in one's musical experience radically new music is encountered, the less readily it is likely to be accepted and the more conscious one is sure to be of its difficulties. By the very nature of things, only a small fraction of any period's compositions achieves genuine stature, and the more discriminating a listener's tastes become, the less patience he has for frankly experimental writing. So it is almost inevitable that even in these days, when contemporary composers are more liberally represented on records than ever before, they still command the intensely interested attention of only a small proportion of the potential audience, while many of the most active record collectors tend to ignore such discs entirely or to sample them only rarely and reluctantly.

Nowadays, indeed, I find myself much less ready than I used to be to tackle the new and unknown, largely because I've learned by experience that many such ventures turn out disappointingly. But what a ridiculous attitude that is! And now that I find myself with several month's accumulation of contemporary-music recordings which I've been timidly postponing listening to, I've resolved to devote an entire column to them — and in so doing relearn for myself the old lesson that shouldering a worthwhile, if unappetizing, duty always has its own rewards as well as its rigors. After all, there should be nothing — absolutely nothing — in organized sound weaving which isn't of some interest to every enthusiastic and open-minded audiophile. This month's listening chores admittedly have been boring at times, but they also have had their great moments of delighted excitement. And if I've emerged with comparatively few works which I can recommend unreservedly, I'm more than ever convinced that the task is well worth attempting, even without the pressure of professional duty; and that even in boredom one's listening horizons may be usefully expanded, while the rare precious discoveries become all the more valuable for one's having had to work for them.

First, the Orange Juice . . .

But if you're as willing to search for challenging music as you are for provocative sounds alone, I suggest that you get off to the easiest possible start by beginning with the most promising or at least the most uncontroversial materials. Since it is assumed that this column is concerned primarily with novel or unusually distinctive sonic qualities and the best of present-day hi-fi recordings, an ideal choice is a pair of *divertissements* in which the music itself isn't new at all (going back, indeed, to Rossini in his most diverting and entertaining veins). The novelty resides in the ingenious orchestrations with which a contemporary British composer has dressed up in gorgeous hues basically simple melodies and rhythms: Britten's *Matinées* and *Soirées musicales*. These have been recorded before with considerable popular success and, in some cases, with perhaps less self-conscious gusto than Boult demonstrates in Westminster's coupling (W-LAB 7055), but never with more glittering, yet unexaggerated, recording or with finer authenticity to the varied percussive timbres exploited here so piquantly by Britten at his most imaginative.

The short Eighth Symphony by Vaughan Williams, for all that it is a brand-new composition making its first recorded appearance in Barbirolli's composer-approved Hallé Orchestra performance (Mercury MG 50115), is scarcely less problematical musically and equally enticing sonically, since the composer here seems less concerned with the intricacies of symphonic form as such than with the combinations and permutations of symphonic tone-color potentialities. His jaunty second-movement Scherzo, for example, is spicily scored for wind instruments alone; the nostalgically lyrical Cavatina, which follows, for strings only; while the final Toccata is a kind of étude on bell motives exploiting a wide variety of percussion instruments. There is nothing unusual, of course, in a present-day composer's making the most of "all the 'phones and 'spiels" he knows, but few younger men have used them more expressively than the 83-year-old Briton. In comparison, the richly impressionistic Bax *Garden of Fand* overside seems static and oversweet, and Butterworth's *Shropshire Lad* a strange mélange of Wagnerian harmonies and English folk idioms. Yet this last tone poem also has a tender poignance which is hard to resist, and throughout the recording is not only impeccably bright and transparent, but happily free from the excessive "spotlighting" characteristic of some earlier releases in the Olympian series.

Still in modern-but-not-modernistic domains are Kodály's lusty *Háry János* Suite and rhapsodic *Galanta Dances*, of particular pertinence here in that their catchy tunefulness is so kaleidoscopically enhanced by the most ingenious of twentieth-century scoring and — in their Rodzinski versions — by some of Westminster's most brilliant recording, especially notable here for the superb cimbalom sonorities in the suite. I called delighted attention to this some months ago in the W-LAB 7034 LP (where it was coupled with *Night on Bald Mountain*), but it is a pleasure to repeat that praise for the every-bit-as-impressive taping (Sonotape SW 3003), in which the Mussorgsky tone poem is more appropriately replaced by the *Galanta Dances* originally issued on W-LAB 7020.

Equally impressive technically (and perhaps even more dramatic from the drum-biased hi-fi fan's point of view) is Bartók's Sonata for Two Pianos and Percussion. While the musical idioms here may be enigmatic to some ears, they are made more attractive than usual both by the fascinating nuances of percussive timbres and the surprisingly expressive reading by British soloists under Richard Austin's direction (Westminster XWN 18425). I miss some of the starker force and harsher impacts of the old Dial LP performance, but the recording here is far superior, and for good measure there is a bonus coupling of the *Contrasts* for clarinet, violin, and piano, less biting but scarcely less rollicking here than in the earlier Peter Bartók 906 LP.

. . . Then, the Cod-Liver Oil!

Another now-standard modern masterpiece, which for many listeners represents one of the most substantial and approachable achievements of contemporary composers, is Hindemith's *Mathis der Maler*. But here is where I fall out of step with the parade, for while there's certainly nothing especially "difficult" about this music, it's far too lugubrious and lacking in humor or grace for my taste. Steinberg and the Pittsburgh Symphony (Capitol P 8364) make more of its monumentalities than do most earlier interpreters (including the composer himself), but for me the added sonority and weight of both the present performance and the notably strong, bold recording merely italicize the work's pretentiousness. Nor can I muster much personal interest in the highly acclaimed Toch Symphony No. 3 overside, which strikes me too as overly ambitious in its treatment of rather inconsequential ideas — although I must admit that strictly as an audiophile I did relish some of the instrumentation innovations, particularly the ingenious bell-like use of the vibraphone and the augmentation of normal symphonic sound effects by a compressed-air "hisser."

Although perhaps no contemporary composer writes in the chamber-music forms with greater craftsmanship (or with more thorough understanding of individual instrumental idiosyncrasies) than Hindemith, again, almost everything of his since the delicious early *Kleine Kammermusik* for wood winds commands only respect without affection from me. Those who feel differently, however, should find much to enjoy in Concert Hall CHS 1250 and Unicorn UNLP 1028, since these two LP's offer a representative cross section of Hindemith's enormous sonata output: four works (for trumpet, clarinet, bassoon, and viola) on the former disc; two more (for English horn and oboe) on the latter, all with piano accompaniment. Each of these is a valuable sonic documentation of its starred instrument's techniques and colorings, but in the first group only the viola sonata is really satisfactorily played (by Tursi and Echaniz) and recorded; the English horn and oboe sonatas are far superior in both respects. Yet even here, I relish the superb playing of Louis Speyer far more in the less serious (indeed, ironically witty) Oboe Sonata by Henri Dutilleux, and most of all in the G-minor Sonata

credited here to Bach. Actually it was written for violin or flute and probably by one of Johann Sebastian's sons — but who cares? In the brightly recorded bittersweet tones of Speyer's oboe and Daniel Pinkham's glittering harpsichord this vivacious music provides a baroque interlude of sheer delight.

Returning to contemporaries: Henry Cowell's obsession with early American hymns and country-dance tunes gives his orchestral works (like those of Virgil Thomson) special appeal for listeners who consider most present-day compositions lacking in sheerly melodic attractions. They should enjoy his Symphony No. 10, *Hymn and Fuguing Tunes* Nos. 2 and 5, and Ballad (played by Adler and the Vienna Orchestral Society, Unicorn UNLP 1045). I certainly do — although I regret that there is not more sonic variety in Cowell's somewhat conservative scoring and more distinction to the present only soso performances and recording. There is also a *Fiddler's Tune* here for strings alone, which is brief, catchy, and sonorous enough to be relished by even so biased a wind-and-percussion sound fancier as myself, but it probably will be only string-orchestra connoisseurs who can find consistent enjoyment in the Zimbler Sinfonietta program, directed by Lucas Foss, on Unicorn UNLP 1037. For here even the fine Bartók *Divertimento*, with all its intense energy and bite, is far from ingratiating, while Milhaud's *Little* Symphony No. 4 is even more nervous and harsh. I liked better the highly concentrated *Little* Suite by the Greek Schoenbergian disciple, Nikos Skalkottas, in which for once the inherent logic of the twelve-tone technique is aurally as well as intellectually apparent. And I was fascinated most of all by the mysteriously atmospheric *Unanswered Question* by Charles Ives, which also gains in sonic interest by the inclusion of four flutes and a trumpet propounding — over the passionless, quietly flowing, *Gymnopédie*-like strings — the insistent, enigmatic question of the eternal riddle of existence.

Another contemporary work for strings alone, this one of a more straightforward neobaroque character, is John Verrall's elegaic Prelude and briskly tuneful Allegro (performed by the MGM Chamber Orchestra under Carlos Surinach, MGM E 3371). It pales by contrast, however, with the less substantial but more colorful Chamber Concerto by Karl-Birger Blomdahl, and still more with the imaginative yet always lyrical explorations of restrained percussive qualities in Richard Donovan's *Soundings* — one distinctively "new" work which I can recommend wholeheartedly for its expressive originality as well as for its deftly delicate nuances of sonic coloring. That flare of responsive enthusiasm, however, was sadly damped when I turned to the first domestic release (Decca DL 9861) drawn from the ambitious German *Musica Nova* series from Deutsche Grammophon, originally sponsored by UNESCO. Werner Egk's *French Suite After Rameau* seems too long a way "after," depending mainly on a brash vivacity to make whatever point it does make; and Karl A. Hartmann's Sixth Symphony is a rather spasmodic reworking of techniques exploited with far greater distinction and drama by Bartók in his great *Concerto for Orchestra*. Nevertheless, there are sonic consolations even here: in both works Fricsay's RIAS Orchestra displays an unusually fine bass drum and the beautifully recorded percussion playing (particularly in the second half of the symphony) provides for me the most arresting moments of aural interest.

Composers as Their Own LP Producers

With the notable exceptions of MGM and Columbia, most of the larger recording companies have made only occasional attempts to give the less well-known contemporary composers (Americans in particular) adequate LP representation.

But far from being daunted by this, a number of them have banded together under the aegis of Composers Recordings, Inc., to secure their own hearings; and, while they can afford to tackle only a few large-scale works (and these only by employing European orchestras of considerably less than the first rank), they have already built up an impressively extensive and varied repertory. Unfortunately, the recordings themselves seldom measure up to the best current technical standards, but if the hi-fi fan can rank most of them no higher than adequate, the student or specialist in contemporary musical activities is likely to be less critical in this respect. At any rate, the CRI series as a whole warrants warm respect and encouragement, even when the individual choices are less than exciting or even far from agreeable to one's personal tastes.

For myself, I found unqualified enjoyment only in Paul Creston's uninhibitedly vivacious *Dance* Overture (Oslo Philharmonic under Antonini, in CRI 111) and the gamelan evocations in Daniel Pinkham's superbly imaginative and poetic Concerto — actually a duo — for Celesta and Harpsichord (Low and Pinkham, in CRI 109). But the former disc also includes Haufrecht's spirited *Square Set* for string orchestra, as well as an even lighter-weight *Summer Holiday* by Hively and a more pretentious, repetitive, post-Rimskian *Macumba* by the Castilian-Cuban composer, Pedro Sanjuan — all performed by the Roman "St. Cecilia" Orchestra under Antonini. And the latter supplements the celesta-harpsichord Concerto by two more Pinkham pieces for violin and harpsichord (a songful *Cantilena* and almost jazzy *Capriccio*), plus a curious Hovhaness *Duo* for the same combination, and a whole batch of Henry Cowell piano pieces (some featuring his once-notorious tone clusters; others his more sonically successful experiments involving a specially prepared piano or direct performances inside the instrument itself). Most of these were first recorded, also by the composer, some years ago by Circle; since that LP is now out of print, it is good to have the new one's characteristic examples of the pre-Cage and pre-*musique-concrète divertissements* by the leprechaun of American composers.

There is further (and more novel) aural stimulation in Henry Brant's singular manipulations of multiple flute sonorities (in CRI 106); and the latest, and eeriest yet, batch of Luening and Ussachevsky tape-derived works (in CRI 112). Although Brant's *Angels and Devils*, for the extraordinary combination of flute solo (Fredrick Wilkins) with three piccolos, two alto, and five more ordinary flutes was written as far back as 1931, it still remains prophetic of later, less daring science-fiction film scores as well as a flutist's all-out holiday. And in the *Poem in Cycles and Bells* for tape recorder and orchestra (Royal Danish Radio under Otto Luening), L. & U. rework, with notably heightened effectiveness, some of the materials first recorded in the Innovation GB 1 or Phonotapes-Sonore PM 5007 reviewed here last November. Their suite from *King Lear* (for tape recorder alone) has perhaps even more striking dramatic qualities, but here one is more conscious of the lack of the visual stage action and situations the music is so ingeniously designed to accompany; while Ussachevsky's solo composition, *Piece for Tape Recorder*, also seems best suited as a background for some imaginary dramatic episode, although even by itself it makes a special appeal to the sound fancier by virtue of its quite incomparable ghostly whispers, explosive twangs, and ominously thundering pedal points.

The overside works on these discs never succeed in commanding a similar degree of interest, at least as far as I'm concerned, although other listeners may find more to enjoy than I do in Irving Fine's polished but precious *Music for Piano* and *Mutability* song cycle (with Eunice Alberts, in CRI 106), and in William Bergsma's evocative but to me interminable *Fortunate Islands* for strings alone (Roman "St. Cecilia" Orchestra under Antonini, in CRI 112). Also, I was frankly bored by what seemed to me the skitterish, synthetically spirited, but basically pointless Symphony No. 1 by Frank Wigglesworth (Vienna Orchestra under Adler); while even the fact that a Pulitzer Prize jury honored Norman Dello Joio's *Meditations on Ecclesiastes* (Oslo Philharmonic under Antonini)

couldn't enliven any personal interest in this highly emotional but for me overintense music (CRI 110).

Composers Recordings' most ambitious project to date is the LP (CRI 108 X) of the one-act opera, based on a famous Balzac tale, *La grande bretèche*, by the group's director, Avery Claflin — who, like many another contemporary musician, has had to turn to other tasks than composition for his livelihood, but who (unlike most of them except Charles Ives) has found his creative instincts no handicap in the business world. He is perhaps not as wholly successful in operatic as in banking domains, yet the present work (sung in English by American soloists with the Vienna Symphony under Adler) is a smoothly effective work even when

Continued on next page

SOUND FANCIER

Continued from preceding page

heard divorced from the stage action. While eclectic in its idioms and scoring, it maintains a consistent individuality as well as genuinely singable vocal lines. The performance is particularly notable for the artistic restraint displayed by Patricia Brinton in the star role of the Wife, and for the fact that, although the other members of the cast are less impressive vocally, all of them enunciate with an intelligibility rare indeed in any previously recorded or broadcast "opera in English."

I HAD hoped to include in this contemporary survey a detailed discussion of the most substantial tribute paid to present-day composers: the specially commissioned compositions and recorded first editions of the Louisville, Kentucky, Philharmonic's subscription series. But my listening time ran out before I had worked my way back from the three 1957 releases issued so far, through the six for 1956, to the no less than twelve in the boxed double albums for 1954-55. Now, space permits preliminary citation of only a single disc: LOU 57-2, which couples the exuberantly zestful *Suite transocéane* by André Jolivet (one of the rare examples of contemporary music in which the composer genuinely seems to be enjoying himself) with a wondrously concise, expressive, and wholly intelligible Symphony in D by John Vincent. I'll return to more of the Louisville works (available only on direct subscription) later, but meanwhile if they had produced nothing else of real consequence, this Vincent Symphony is by itself enough to bolster or restore a shaky or lost faith in the ability of today's musical creators to measure up — at least on some occasions — both as worthy successors of their memorable predecessors and as eloquent spokesman for our own age.

TRACKING ERROR

Continued from page 22

$\times$ 0.3215 = 3.94. Referring now to Fig. 6, we find corresponding to this value of $L \sin \beta$ is a value of LD_i = 6.91, and dividing that result by L gives D_i — 0.565 in. Then, using Eqn. (17), $D = 0.565(1 + 0.565/24.5) = 0.565 \times 1.023 = 0.578$ in. This is the best overhang to use with the given β.

From the other curve in Fig. 6 we may read opposite $L \sin \beta$ (3.94) the value of $mL \cos \beta$, 3.47. If we ignore $\cos \beta$ and divide by L, $m = 0.28$; taking into account $\cos \beta$ (0.947) gives $m = 0.299$ degrees per inch. It is now instructive to compare this value with m_o. From the graph we note that β is greater than β_o, and can calculate $\sin \beta_o$, which is $3.68/12.25 = 0.301$; interpolation in the table of sines gives $\beta_o = 17.5°$. Then, from $m_oL \cos \beta_o$ (2.58), $m_o = 2.58/12.25(0.953) = 0.221°$ per in. Thus the "best" position for a β of 18¾° gives a maximum distortion index about 36% larger than for the optimum condition, but, because of the great length of the arm, the absolute value of m is quite small. Changing β to β_o is probably not justified if major surgery would be required. Note that this comparison would have been unaffected if we had ignored $\cos \beta$ in both cases.

Vertical Tracking Error

There is another form of tracking error which can be quite as serious as that which we have discussed in detail, but fortunately it can be completely eliminated. Owing to the 45° inclination of the record-groove walls, the stylus must move parallel to the plane of the record to avoid generating distortion in much the same manner as in the case of horizontal tracking error. The plane of symmetry of the pickup must be perpendicular to the record. The easiest way to observe any such error is to place the cartridge on its back on a flat surface, and with a try square or similar tool make a vertical mark on the end of the cartridge in line with the stylus, as seen looking along the straightedge. Then with the cartridge mounted in the arm, vertical tracking error is zero when the mark is aligned with its reflection in a record. An actual record is preferable to a mirror, since for arms with a long length for vertical motion, this angle changes with height. For such arms the vertical height should be adjusted at the base until the above condition is met; if this cannot be done without bumping of the record by the arm near its base, longer pickup mounting studs are required, or shims may be added. Small washers are convenient for that purpose.

Warp-Induced Wow

The angle which the cartridge makes with the record in the tangent (fore-and-aft) plane is of little consequence except as it may slightly affect sensitivity to "wow" when tracking warped records. This is fortunate because most arms provide no further adjustment if the previous criterion is met, without redesigning the cartridge mount. For minimum warp-induced-wow sensitivity, the pivot for vertical motion should be in the plane of the record. Arms which have long lengths for vertical motion have distinct advantages in this respect over those which do not, since the pivots of the latter cannot possibly be near the plane of the record, and their shorter lengths aggravate the effect of a given amount of displacement due to warpage.

MULTIWOOFER SYSTEM

Continued from page 38

side was used, and it really isn't anything to brag about as lumber. Anyone who has worked with it is familiar with the splinter problem, so this thing naturally got lots of glue and screws in all directions.

The finished box came out $64\frac{1}{2}$ in. long by $37\frac{1}{4}$ in. wide by $14\frac{3}{4}$ in. deep, which, as seen in the photos, was not such a monster after all. Assembly provided some cute problems. A little forethought resulted in the following schedule, which worked out very nicely.

1) Assemble the three long sections and two trapezoidal end blocks to form the coffin, with the 2-inch glue block inside just below the slot location.

2) Cut two cantilever braces, with the diagonal running from back top to bottom front when mounted. Glue and screw together to make a double center brace. The two center ends of the two-piece speaker mounting board will be screwed into this brace. Make two more $\frac{3}{4}$-inch braces about 3 in. deep and $15\frac{7}{8}$ in. long, which go from top to bottom at the front edge of the coffin. Note that the top panel of the coffin extends to reach the rear panel of the box.

3) Install 1-inch strips plus two heavy 1-inch-thick glue blocks, as shown, on the back of the coffin.

4) Cut out slots as indicated. This is easily done with one of those little bayonet jig-saw attachments for a hand drill.

5) Put a taper on the slots with a file or rasp.

6) Mount the four small triangular braces on the top side of the coffin. These screw to the coffin, top panel, and back panel. Install sections of glue block between these braces along the front edge of the coffin.

7) Attach the top panel. Doing this makes it possible to handle a relatively heavy object easily when it comes time to put it in position in the lower section of the box. It simply sits still while you drill and screw.

8) Attach the front glue-block strip to the bottom panel, and then add the back panel and the two end panels. Two large triangular horn-panel braces can then be installed, one at each end. Put the two outer 4-by-4-inch corner glue blocks in place, then the two central trianglar horn-panel braces, and finally the middle 4-by-4-inch glue block.

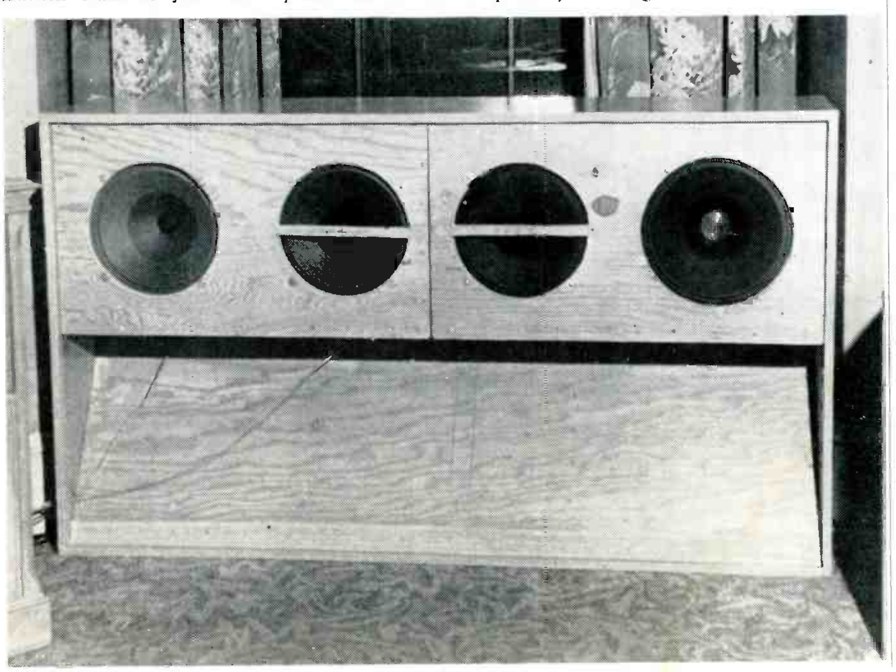
9) After installation of the glue-block strips between the top ends of the horn-panel braces, the horn panel itself can go on.

10) Hang the top unit in place after putting glue on all mating surfaces. Put screws into all glue blocks, through the sides of the box into the coffin end plates, into the edges of the long sections, and into the back. This joining must be exceptionally rigid. The top assembly weighs around 95 lbs. empty. Add roughly 100 lbs. of speakers and speaker boards, and there is a lot of weight not supported from below in any way. This was done deliberately, because I wanted the sound from all the speakers to blend in the horn section.

Incidentally, it was found advisable to preassemble at various stages with nails, then drill all screw holes with pilot bits. The assembly was subsequently knocked down and reassembled with glue and screws. This insured a

Continued on next page

Speakers are in place, and enclosure is completed except for grille cloth on its frame, which fits inside top, bottom, and side panels. The author preferred a dark walnut stain to flat black paint on the inner panels, although either would serve.



MULTIWOOFER SYSTEM

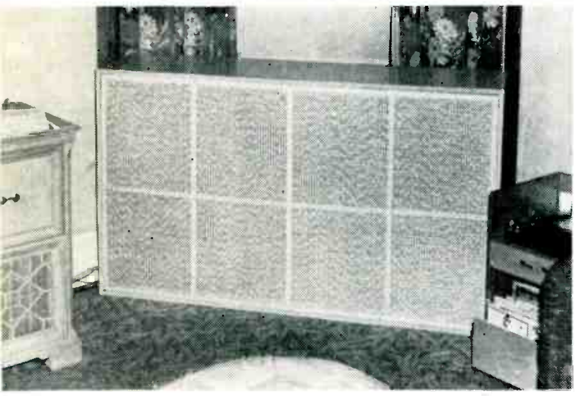
Continued from preceding page

perfect fit of all parts except for such minor bloops as were corrected easily with plastic wood.

You can hit the finished assembly with a hammer and get little more than a dull thud. There was a trace of boom in the bottom cavity, and one friend suggested that I cut some holes in the horn panel and fill the thing with asphalt or sand. I offered to let him then carry it upstairs, and that was the end of the discussion.

As may be seen in the photos, there are two turntables hooked up to this rig. Both are Webster 3-speed changers, using either GE variable-reluctance cartridges with sapphires or Pickerings with diamonds. One is for the 4-year-old child. Mary Ruth wanted a record player of her own so she could "put the arm down all by myself" when she was three.

Finished speaker system doesn't look as large as its dimensions would indicate, probably because of its simple exterior.



After our experience ten years ago with our newspaper friend, I refused to have any child's music machine of any description in the house, and rigged this turntable for her to play through the main system. She's happy, and the children's records even sound good — some of them.

Grille screen presented no problems except that the light strips tended to split out under tension of the cloth, and it took about 3 hours for two people to stretch the thing tightly enough to suit my wife. It's not quite so tight as tennis-racket stringing, but nearly so.

I reduced the amplifiers from the Capehart by one, driving both Capehart speakers with one 20-watt amplifier from a sound signal taken off the Magnavox tuner behind the volume and tone controls. The other speakers came from the original Magnavox, and, to our amazement and amusement, we found that the "coaxial speakers with woofer and tweeter" consisted of two excellent soft-cone, loosely mounted 12-inch speakers with light-weight magnets and, hung on a cross bar of the speaker panel, a couple of thin tin-cup affairs which are apparently acoustical sound diffusers. What function they have as tweeters I can't say. However, they were dutifully hung on the new speaker board "coaxially" with their speakers.

All these speakers, of course, have electromagnetic field coils, with the coils serving as chokes in the amplifier circuits. The bottom of the Magnavox cabinet easily handled both amplifiers, and a reasonably neat rig is the result.

For the technically minded, we ran a signal generator through the unit with the following result: audibly flat response down to 38 cps; some falloff below 38 cps down to 24 cps, where almost everything quits. At 22 cps there is still a flutter, of dubious value.

A handful of new tubes got rid of the tube noises, and we put up with a very low 60-cps hum which you don't hear unless the thing is turned on about half power — which is loud enough to fill an orchestra hall. I like the orchestra in the room, but not in my lap.

Truthfully, I have heard all the big ones, the Jensen, the Klipschorn, the Patrician, and the rest. They may be better, but this one is very good — and look at that $1,300 I *didn't* spend! This isn't an ultimate sound system, but now I have an enclosure that will let me buy better speakers and better electrical equipment piece by piece, and I'll be able to hear an improvement every time.

TAPE STANDARD

Continued from page 17

slide rule and a few formulas. If there are electrical resonances in either head, these can be measured independently of the tape medium itself. When resonances are absent, the playback response from the tape head will conform to its design requirements within a fraction of a db. Thus, if we play a frequency-response test tape recorded to match the NARTB playback curve, and adjust the equalization of the playback preamp for flat response from this tape, we can be confident that the playback will be correct for any NARTB tape. Here, then, is our trustworthy sound standard for the entire high-fidelity system.

Any recorder that will play back a 7½-ips NARTB-recorded tape without frequency deviations can be trusted to play commercial tapes with equal response accuracy. Once a recorder has been tried and found not wanting in this respect, it can be used with a few good commercial tape recordings for adjustment of the rest of the system. From then on, determining the status of other components becomes a fairly easy job

Precise adjustment of playback equalization in a modern professional-type recorder is a relatively simple matter, and even a nonprofessional unit of good quality should be able to reproduce the NARTB standard test tape to within a few db. Bear in mind, though, that a response deviation of 1 db over an octave or more is sufficient to create an audible change in over-all coloration. So if the recorder in question shows, say, a 3-db rise from 2,000 to 7,000 cps, it can be expected to sound quite bright when playing a commercial tape. A phono pickup having truly linear response will thus sound more subdued than the tape recorder, and if this is the case, then the rest of the system may be considered properly adjusted when the brightness is optimized to suit the pickup.

At this point I should inject the observation that many home recorders (and most old professional recorders) are not designed to conform to the NARTB tape-playback curve, and if the playback equalization on one of these machines is gimmicked up to play the NARTB test tape flat, it won't play its own tapes properly. It may be feasible to adjust tone controls until the playback response is within 1 or 2 db of NARTB flat, and then use those control settings for playing commercial recorded tapes, setting up speaker balance controls, and evaluating other components. Alternatively, if the recorder in question has a 15-ips operating speed and a narrow-gap playback head, 7½-ips operation with the *playback equalizer set for 15 ips* will give a very close approximation of the NARTB playback curve. The recorder can thus be run at 7½ ips with 7½-ips equalization for its own tapes, or with the 15-ips equalization for NARTB tapes.

The acme of perfection in a complete high-fidelity system is reached when several discs and good commercially recorded monaural tapes of the same masters sound identical when played on their respective reproducers, and when both sound realistic. Some record manufacturers make "adjustments" in the balance of their discs and tapes, so corresponding releases are rarely found to be identical under even the best conditions. Westminster Sonotapes are excellent for making these comparisons.

When a tape recorder can play NARTB tapes with accurate equalization, the speaker system can then be adjusted to provide proper balance, the phono cartridge can be selected or equalized to match this balance, and then any homemade tapes can be compared with professional discings or with any commercial tapes that are on hand. To reiterate one point, though: if appreciable tone-control adjustment is needed to produce NARTB playback from a recorder, the controls will have to be returned to their original positions when the recorder's own tapes are played, if these are to be reproduced with accurate equalization. If in doubt, set the playback tone controls to match the NARTB tape. Then load a fresh tape on the recorder, set the record level to 10 or 15 db below maximum, and record some test tones from an audio signal generator. Tones of 50, 100, 250, 500, 1,000, 3,000, 5,000, 7,500, and 10,000 cps will be representative of over-all response, while turning the volume down between each tone will enable it to be identified during playback. Now, with the tone controls still in the correct NARTB position, play your own recorded test tape and observe the output levels from the power amplifier. If the recorder uses the NARTB curve, or a good approximation thereof, the measured response will not deviate by more than 2 db in either direction. If there is found to be an appreciable discrepancy in playback, readjust tone controls until there isn't and mark the setting. Don't worry too much about the ranges below 70 cps and above 8,000 cps — they don't have much effect on balance, and it is balance that we're concerned with.

If all goes well, you should now have (a) a system that will play accurately any NARTB tape, for use as a sound standard; (b) an alternative system that will play homemade tapes with the same balance; and (c) a means for adjusting loudspeaker system balance and comparing other components with standard tapes.

BASIC ELECTRONICS

Continued from page 35

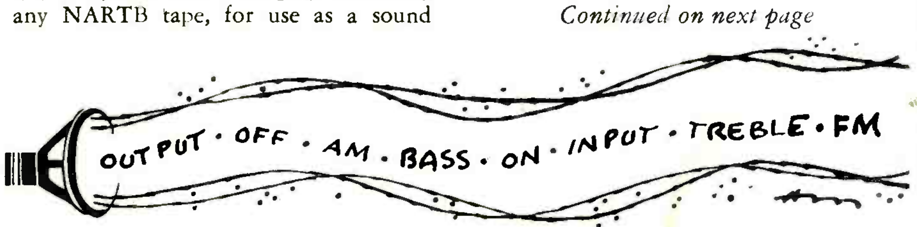
the tube's plate resistance. If we consider the entire voltage developed in this circuit to be the input signal voltage multiplied by the tube's amplification factor (μe_g), it is apparent that some of this voltage will be developed across the plate resistance and the rest across the total resistance of the load (R_T). That is why the gain of a normal amplifying stage can never be so high as its amplification factor: some of the output signal is always lost within the tube itself, in its plate resistance.

Let us see how this equivalent circuit works out for gain calculations, compared to the process used before. We assume the same input signal amplitude: 8 v peak-to-peak. Multiplied by the amplification factor of 20, this gives 160 v as our source generator voltage. That voltage is developed across a 7-K plate resistance in series with the parallel combination of R_L and R_G; since one is nearly 20 times the resistance of the other, the resultant resistance of the two can be taken as the smaller value alone. The total series resistance in the circuit is then 25 K + 7 K, or 32 K. Across the load will be developed 160 v × 25/32, or 125 v. The gain is the output voltage divided by the input voltage: 125/8, or about 15.6. This agrees quite well with previous results.

The agreement is not perfect because, as noted in the definition of plate resistance, R_P changes according to the operating condition of the tube; it is far from constant. In the equivalent circuit it is assumed to be constant, while in the graphical solution its variations are taken into account. Still, results are usually close enough either way for practical purposes.

Gain calculation by means of the equivalent circuit is most convenient in

Continued on next page



BASIC ELECTRONICS

Continued from preceding page

designing, evaluating, and trouble-shooting amplifier circuits. It can be simplified even more than the process just employed, by developing a simple formula for the output voltage in terms of the quantities appearing in Fig. 12, and then dividing it by the input voltage; that yields the gain figure directly. If this is done the following formula is obtained:

$$A = \frac{\mu R_T}{R_P + R_T},$$

where μ is the triode's amplification factor, R_T is the parallel resultant resistance of the load (R_L and R_G), R_P is the tube's plate resistance, and A is the stage gain.

In this particular case, the following grid resistor, R_G, had no appreciable effect on the total resistance of the load. In many practical circuits it does have an effect, however, and when it does it must be taken into account, both in the equivalent circuit with its simplified gain formula and in the graphical solution. For the latter case the plate load resistor alone is used to set up the DC operating conditions; then the AC load line is pivoted around the chosen bias point to alter its slope in correspondence with the total AC load value.

REVERBERATION SYSTEM

Continued from page 25

of being transported to a large cathedral. Turned off again, the natural organ sound became constricted and artificial by comparison! A further remarkable phenomenon occurred at the bass end. In the organ there is plenty of bass from the pedal pipes, but very little of it got out of the pedal chamber into the church. The microphone in the pedal chamber

picked up this bass, of course; and when the electronic reverberation system was turned on, the bass came up to a natural level — but virtually all of it was being reproduced by the speakers.

During this demonstration, the speakers were simply placed in the pews as shown in the photographs. In the final installation they will be attached near the ceiling and painted the same color as the walls. Since they are not audible as speakers anyway, there should be no apparent evidence that the church acoustics are being assisted electronically.

Aeolian-Skinner plans to make these systems available on a custom basis for other churches and auditoriums with similar acoustic problems. Questioned about less elaborate systems for home use, Mr. Whiteford seemed confident that a practical home device operating on the same principle could be marketed. He suggested that one step toward this goal might be the development of a magnetic drum to replace tape reels, with the heads very close to, but not actually touching the drum, so that head cleaning and wear would be eliminated. [This method is used in an artificial reverberation system manufactured by Philips of The Netherlands — ED.]

Robert Breed was the engineer for Aeolian-Skinner on this project. Consultant and codeveloper was Dr. Jordan J. Baruch of Bolt, Beranek and Newman, Inc.

READERS' FORUM

Continued from page 13

adequate control for low-level listening, he came up with a solution which closely resembles that used in the Fairchild Model 240 preamplifier; namely, a function switch for normal or background music. Actually, the 240 has three loudness positions: one is essentially flat, a second is for a setting 15 db down at 1 Kc, and the third is for a setting of 28 db down at 1 Kc.

We found, after extensive listening tests, that it was impossible to get the desired amount of bass boost for proper low-level listening without dropping the gain of the preamplifier. In the LOW position, for example, which is 28 db down at 1 Kc, we provide a bass boost of 22 db at 30 cps, and, as is apparent, such a tremendous boost at normal listening level would be overpowering for both the amplifier and the speaker. In addition, we also found it sounded best to give a slight amount of treble boost at the same time; in the LOW position, we provide a 6-db shelf extending from 5,000 to 12,000 cps.

Those who have listened to the Model 240 have been particularly taken by this arrangement, which we call the Listening Level Control. However, market research has shown that the public is apparently not ready, nor does it appreciate, the advantages of this approach. To the best of our knowledge, complicated multiswitch loudness controls are still desired by the audio public. Perhaps simplicity as a design element will require maturity not now evident in the high-fidelity field.

R. G. Bach, Sales Manager
Fairchild Recording Equipment Co.
Long Island City, N. Y.

Except in AUDIOCRAFT *readers, of course.* — ED.

WOODCRAFTER

Continued from page 31

9) On carvings, use an old tooth brush or a sharpened stick to take out the old finish. A putty knife or a scraper will do the job on flat surfaces where a wash-away type of remover is not used.

10) Wipe away any residue of loosened finish with old rags or burlap.

11) Some removers call for a final rinse of denatured alcohol, naphtha, or turpentine when the old finish is off. Use whichever the instructions suggest to be certain of success with the new finish.

One of the most difficult of the American colonial finishes to remove is a paint made with skim milk or buttermilk and colored pigment, frequently red. Usually found on old pine furniture, this is a stubborn finish that will not be loosened by ordinary paint remover. If paint remover is used, there is a possibility that, as it loosens the surface color, it will cause it to penetrate the wood and stain it. Thus, the honey color that is characteristic of old pine will be lost. One approach to the old skim-milk finish is to keep the surface moist with denatured alcohol while rubbing it with sandpaper or steel wool. This is tedious work and all of the color will not be removed, but the remaining traces will add character to the new finish. Homemade lye removers have been known to take off milk paints, but their use is not recommended for the reasons stated earlier. The manufacturer of one commercial paint remover (Helperize) claims it will do the job, but I have had no opportunity to try it personally.

Sandpapering Tips

Once the old finish is removed, the next step is preparing the surface for the new finish. Since sandpapering plays such an important role here, there are two precautions to be observed: first, avoid oversanding the surface so you won't destroy the *patina*, the mellow tone which age has given the wood; second, eliminate all objectionable scratch marks or they will be amplified and preserved by the new finish. In sanding, use a paper only as coarse as is required to handle the initial job of smoothing out the roughness; use nothing coarser than 1/0 or the wood will be too deeply scratched. Follow this with a rubbing with 2/0 sandpaper until the proper smoothness has been attained. Of course, always sand in the direction of the grain

1) For flat surfaces, fold the sandpaper around a wooden block for smoother results and easier handling.

2) For a curved opening, wrap a piece of sandpaper around a length of dowel or broom handle in order to reach the contour of the surface.

3) For an outside curve, wrap the sandpaper around a scrap piece of linoleum or carpet to give it body to conform to the curve being sanded.

4) When working in small areas, such as carvings, fold the sandpaper over a finger, a pen holder, or a small dowel.

5) To sand turnings on furniture legs, use narrow strips of emery cloth to reach into the grooves and also to smooth the outside round surfaces.

Repairing the Surface

An antique would lose much of its charm and value if it were made to look like a new piece of furniture. Permit it to reflect the charm of age by retaining some of the imprints of wear that have come to it during its long and useful life. However, scars that detract from the appearance of the piece should be mended, and this should be done *after* the sanding has been completed and the wood is otherwise ready for finishing. Where a natural finish is planned, it is not easy to make the patch a good match with the original wood. If a type of wood plastic is used, get it in a color as close to that of the wood as possible — mahogany, oak, pine, etc. If a penetrating stain is to be used on the piece, mix some of the stain with natural-colored wood plastic. A test can be made on a piece of scrap wood to determine if the stained wood plastic and stained wood will match when both have dried. Don't expect a perfect match; a fair match is better than average.

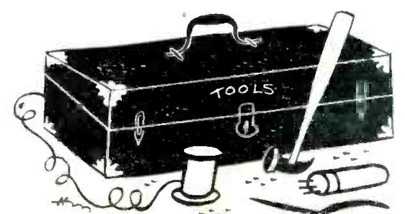
Housing a tuner, amplifier, turntable, etc., in an antique cabinet may require the addition of new wood which does not match the tone of the old. Sometimes pine or walnut oil stains can be used to achieve a compatible color. Since you may want only to tint the new wood, wipe off the stain immediately after applying it; the longer the stain is allowed to remain on the wood, the deeper will be the color. The shade of an oil stain can also be lightened by the addition of a small quantity of turpentine.

If you have a stock of oil colors at hand, it's possible to blend your own oil stain to match the old wood. Pigments such as burnt umber, Vandyke brown, raw sienna, and burnt sienna can be mixed singly or in pairs with the following vehicle: 1 part turpentine, 3 parts boiled linseed oil, ½ part japan drier.

An Easy Finish

In a previous article (AUDIOCRAFT, May 1956, p. 8), the conventional finishes — varnish, shellac, lacquer — were discussed. This time, let's consider a finish of more recent vintage that is easy to apply and maintain, and that can be used without a filler on open-pored woods. It's a penetrating sealer type of finish designed for use on new wood, or old wood from which all the finish has been removed. Apply it with a brush or cloth, let it dry, and rub it lightly with fine steel wool. Follow this procedure for two more coats, rubbing the final coat with steel wool or powdered pumice and oil as described at the beginning of this article. This will produce a rich satin finish. Since penetrating sealer sinks into the wood pores, it does not reflect scratches as noticeably as a surface type of finish. In areas that receive hard wear, it can be spot-patched in the future without the patch's showing. It's an almost foolproof finish and, as I mentioned a moment ago, easy to apply. After stripping an antique of its old finish, sanding it smooth, and repairing it — what man wouldn't settle for a lasting and attractive new finish with a minimum of effort!

This article is the concluding one in George Bowe's series on woodworking, "Tips for the Woodcrafter."



PROFESSIONAL DIRECTORY

TRADERS' MARKETPLACE

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

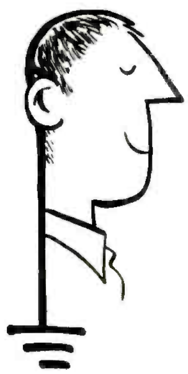
ADVERTISING INDEX

GROUNDED EAR

Continued from page 4

if we desire to maintain a truly perfect balance we must readjust the tone controls every time the volume changes substantially.

I have inclined to this point of view myself, but have been plagued with the problem of removing the disadvantage ever since I first started to fool around with high fidelity many years ago. For five years now I have been experimenting with a circuit which seems to me to come closer to a satisfactory solution than any other method I have tried. This involves providing greater versatility in shaping the response curve of the system to take care of all the factors which necessitate a modification from flat response. These factors include the hearing curves of the listener, the level at which the sound is reproduced, the nature of the listening environment, any deficiencies in the source material, and, finally, the characteristics of the reproducing system, particularly the speaker. To achieve this I use two tone-control channels, each of which provides a choice of peaking points or slopes, and a maximum boost of between 15 and 20 db. This provides a flexibility approaching that of the equalizers used in recording and broadcasting. Among other things it will handle the problem of loudness compensation *at any given volume level* very nicely, since both the slope and the amount of boost can be varied as necessary.



There remains the problem of disposing of the need for readjusting the tone compensation when the volume level is changed, and the circuit provides a means of doing this which is quite satisfactory. There are two gain or volume controls. One of these maintains the equalization as volume is increased or decreased, and the other can be called a LOUDNESS control, although it works in an opposite manner to the usual control. In the conventional loudness control circuit, the system is equalized at a very loud level, and as the volume is reduced with the loudness control, the bass and/or treble are boosted in relation to the middle frequencies. In my circuit, the system is adjusted for a balanced or satisfying response at the *lowest* normal listening level. As the LOUDNESS control is turned to increase volume, the bass and treble boosts are progressively washed out until, at maximum volume, the response is flat. This seems to be a preferable method because the ear is not nearly so sensitive to frequency imbalance at very loud levels as it is at low levels. In any case the big problem in home listening is to compensate at low or moderate levels and this method makes possible a far more precise adjustment.

This is achieved by means of the circuit shown in Fig. 1. There are three parallel channels fed by the same source and tied together at the output. The uppermost channel is the flat channel, the next is the bass channel, and at the bottom is the treble channel. Response of the two lower channels is shaped by networks of the Wien bridge type. All three channels have gain controls. It is obvious that the input to the following stage will be the sum of the outputs of all three stages. The gain control in the flat channel is the LOUDNESS control, and is normally at its minimum position, at which point the stage has no gain or a slight loss. The BASS and TREBLE channels provide a direct boost of 20 db or more. The interesting point is this: increasing the gain on the flat channel will start washing out the boost of the lower channels, and when the flat channel is at maximum the boost cannot be more than 6 db. To provide a choice of response shapes and crossover frequencies, three switch-selected networks are used in the bass and treble channels. The values shown give excellent results both for tone control and loudness control. Increasing the value of the capacitors moves the crossover downward.

This circuit can be incorporated as part of a control unit, replacing both the tone control and loudness circuits; it can also be used as a separate unit to precede or to follow a present control unit. The two 500-K controls can be of the coaxial type to save space. The circuit provides a large versatility in adjustment. The simplest way to set it initially is as follows: 1) put the LOUDNESS control and the two tone controls in their minimum volume position; 2) adjust the LEVEL control to produce the lowest normal listening level; 3) now, with the tone controls, adjust the BASS and TREBLE for a satisfying balance and over-all sound; 4) increase volume with the LOUDNESS control as desired. Increasing this control will progressively wash out the bass and treble boosts to compensate for the increased acuity of hearing at both ends as volume is increased.