THIS MONTH'S COVER: Two young audiophiles ponder the final steps in the construction of their Patrician IV enclosure.
Photo by Phil Geraci

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The Grounded Ear

by Joseph Marshall

Servo Hi-Fi System

Whatever the hi-fi shows may produce in the way of new developments (this is written a week before the New York show), I am pretty sure they will show nothing more provocative than the new servo amplifier/speaker system recently announced by the Integrand Corporation.

Very briefly, this is a three-channel speaker system (woofer, middle-range speaker, and tweeter) in which the speakers are direct-coupled to their amplifiers. Each speaker has a special sensing (or feedback) winding through which feedback is applied to the amplifier input. The illustration shows a simplified block diagram of the system. Because the feedback reflects the motional performance of the speakers, this is a true servo amplifier system like those used to control mechanical processes where any change in the movement one is attempting to control is immediately sensed and corrected. The feedback of the conventional hi-fi system, on the other hand, does not directly reflect or correct the movement of the speaker; it merely offers a certain indirect resistance (or damping) to the movement.

It has long been recognized that this servo-type action would be a wonderful way to control speaker performance. Experimenters have produced special speakers with feedback coils to achieve such a result, or have modified conventional speakers to permit such feedback. It has long been known that such a system would provide a means of controlling the distortion of the speaker, whereas conventional feedback is largely limited to controlling the distortion of the amplifier.

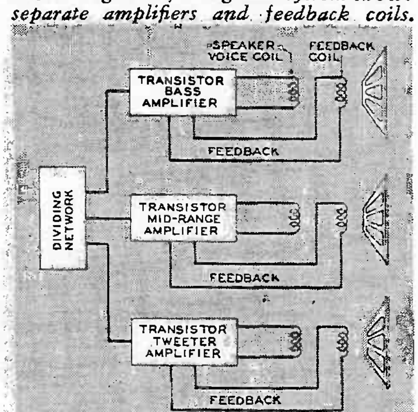
The servo feedback would correct for a nonlinearity in the suspension or magnetic field of the speaker; any nonlinearity in the movement of the speaker would change the feedback and bring a change in amplification to compensate for it. If, for example, the suspension began to resist movement at wide excursions, this would be reflected in the feedback; gain would be increased to deliver a higher voltage to overcome the resistance, and the movement of the air would be held to greater uniformity — as if the resistance remained constant and linear.

It would also correct for frequency nonlinearity, assuming piston action of the cone. If the cone movement at some frequencies were less than at other frequencies, the feedback would be decreased, the gain of the amplifier increased to provide more driving voltage, and this, in turn, would increase cone movement, resulting in increased output. Not only that, it would tend to overcome many kinds of nonlinearity produced by the speaker enclosure. If cabinet resonance tended to make the cone move more freely and produce a higher output, feedback would be increased, amplifier gain decreased, drive reduced, and the movement of the cone reduced also. Even standing waves in a room — which have a tendency to increase or reduce air resistance to the movement of the cone — would be corrected to some degree.

In short, a true servo system embracing the speaker cone itself would clearly provide an ideal method of controlling the production of sound by a speaker, by extending the benefits of feedback to the transducer itself. In such a system the amplifier is not only the driving element, but also the controlling and balancing element, making up through changes in its own performance for any inadequacy or aberration in the performance of the speaker. This assumes no cone breakup, which can be minimized in multiway systems.

There is nothing new about the servo idea. It has been widely applied to control all sorts of mechanical processes, even those involving thousands of tons of mass. Modern ships and planes are held on course automatically by such servomechanisms. They are, to a large extent, constructed by processes in which servomechanisms play a controlling part. Why the commercial application of servomechanisms to high fidelity has been so long delayed is rather puzzling, but there is no doubt in my mind that we shall be seeing and hearing a lot more about this kind of high fidelity in the future.

Block diagram of Integrand system shows separate amplifiers and feedback coils.



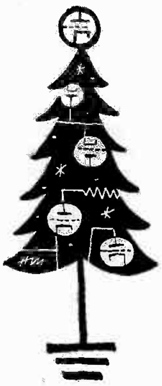
The Integrand system combines the speakers and amplifiers. Preamplifiers, control units, and input sources may be any of the conventional units currently available. The target price for the monaural model is $395. If the claimed response of ±3 db between 30 and 16,000 cps (mind you, that is "acoustic" response) and useful response from 20 to 20,000 cps is realized, this price will represent one of the biggest bargains in hi fi.

The Integrand system is apparently intended to compete in the field of genuine hi fi against the proven fine performance of highly refined conventional speakers and amplifiers. Whether it will actually deliver performance that will satisfy the critical listeners who form this market remains to be seen, but the possibility that servo-type systems are capable of high-quality performance with low-cost components, is certain to strike those elements of the industry mass producing packaged hi fi. The most obvious advantage of servo operation is that it can provide very high compensation for basically poor speakers and enclosures. Consider, for example, the possibilities of three 5-watt transistor servo amplifiers driving three $4 production speakers, in a "de luxe" hi-fi console. I have no doubt that even today's elementary transistor amplifiers would deliver better performance from such a servo combination than one of the 20-watt vacuum-tube amplifiers driving present console combinations of this type. For that matter, consider the possibility of a transistor servo system with a small single-channel speaker in a table-model phonograph. I have no doubt that one can be built that would sound pretty good even to critical ears, particularly in the range below the cone-breakup frequency.

For this reason I believe the hi-fi

servo amplifier is most likely to find immediate application in mass-produced packaged units. Furthermore, I believe that the improvement brought about through such application will make packaged equipment a far more serious threat to the high-fidelity industry than it now is. On the other hand, the application of the servo principle to high fidelity can produce a corresponding improvement in this field. Speakers with sensing coils for feedback are long overdue. The application of the servo method would work with and improve the performance of presently available amplifiers, although the increased phase shift would be a problem. Once such speakers became available, amplifiers could be designed to accommodate the same variety of speakers as they now do and thus preserve the leeway for personal and individual preference which component hi fi today offers. The application of the servo system would be a big step toward eliminating the present inadequacies of speaker performance—even of our best speakers in our best enclosures.

Enclosure problems would be minimized; improved performance could be achieved from smaller and simpler enclosures. Furthermore, this could be one way in which the cone or motor speaker could fight back against the possible competition of wide-range electrostatics. On the other hand, electrostatics provide basically simpler possibilities for servo control. All that is necessary is for somebody to invent a practical way of translating the change in capacitance of



a moving electrostatic speaker into a change of voltage or current which can operate a feedback loop. No sensing coil would be necessary.

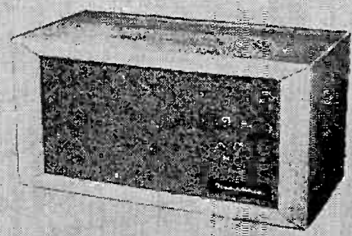
In short, I am willing to bet that the Integrand system is just the first step in a transition of the hi-fi technique into the servomechanism field. Though the advantages promise greater commercial success to the mass producers of hi fi, they will in the end also improve the highest-quality equipment. But it is certainly high time for engineers to put their minds and slipsticks to work on the further applications of the principle to both fields.

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**

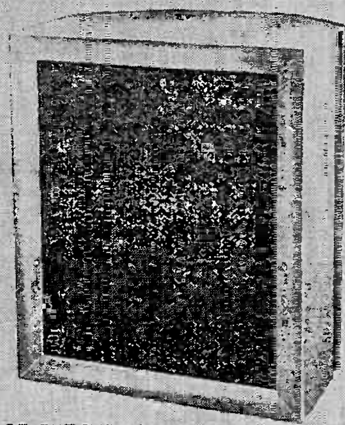


"BASIC" SPEAKER SYSTEM

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

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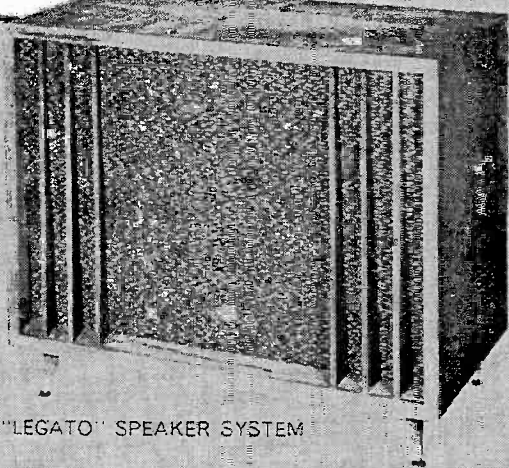
HEATHKIT "LEGATO" HIGH FIDELITY SPEAKER SYSTEM KIT

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

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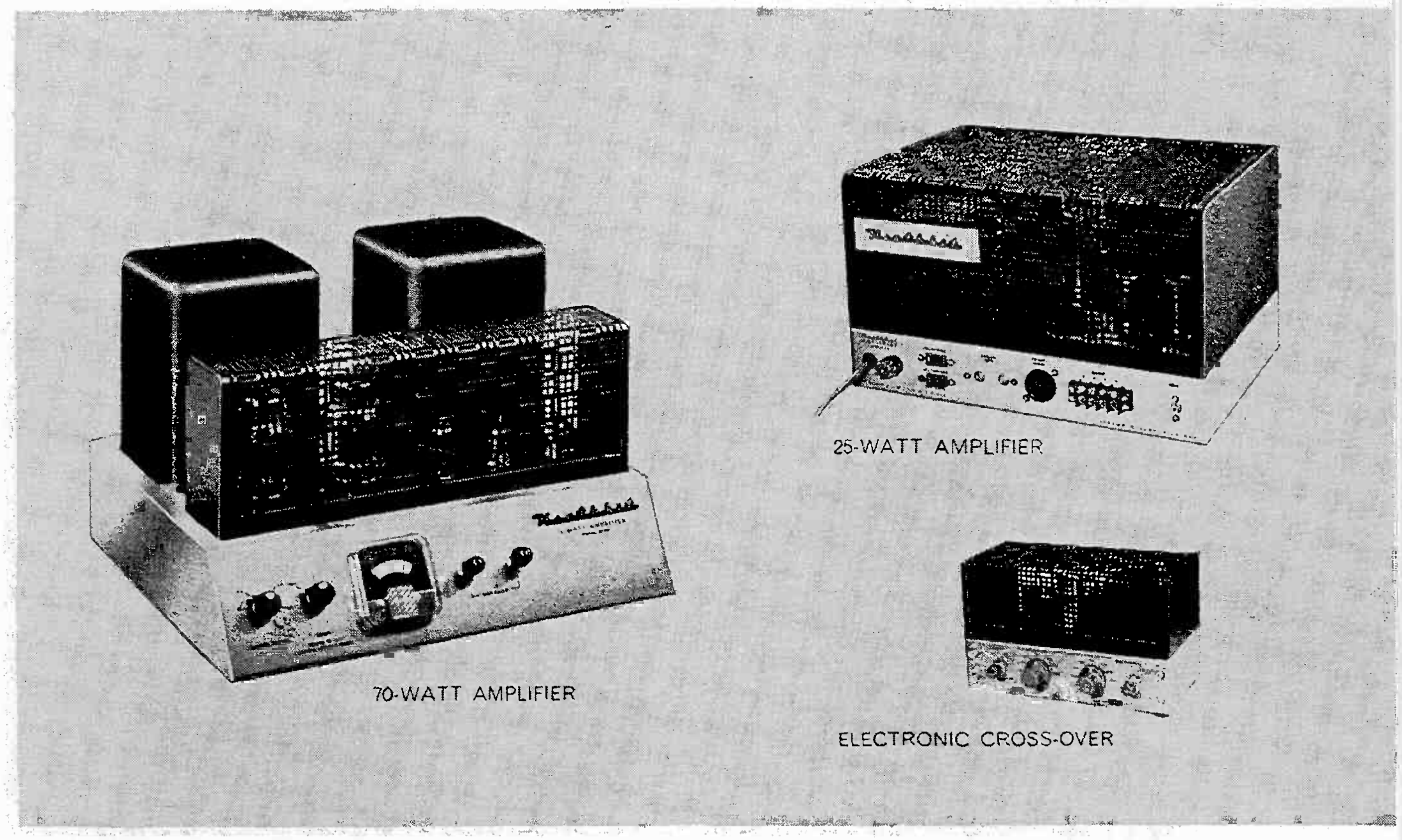


easy-to-build designs by HEATH *insure*

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

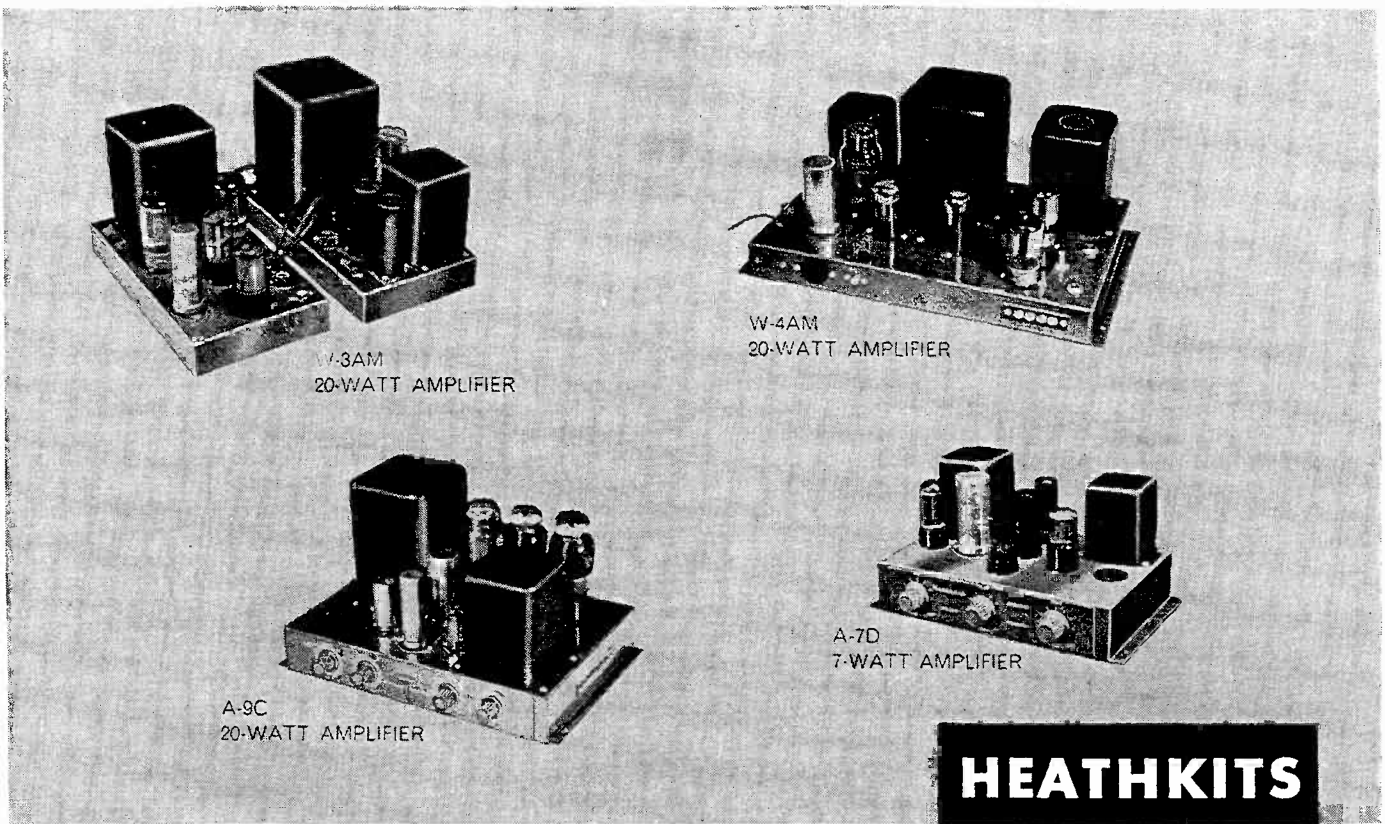
This device separates high and low frequencies electronically, so they may be fed through two separate amplifiers driving separate speakers. The XO-1 is used between the preamplifier and the main amplifiers. Separate amplification of high and low frequencies minimizes IM distortion. Crossover frequencies 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



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HEATHKIT A-9C
HIGH FIDELITY AMPLIFIER KIT

This amplifier incorporates its own preamplifier for self-contained operation. Provides 20 watt output using push-pull 6L6 tubes. True high fidelity for the home, or for PA applications. Four separate inputs—separate bass and treble controls—and volume control. Covers 20 to 20,000 CPS within ±1 db. Output transformer tapped at 4, 8, 16 and 500 ohms. Harmonic distortion less than 1% at 3 db below rated output. High quality sound at low cost!

Shpg. Wt. 23 lbs. MODEL A-9C $35.50

HEATHKIT A-7D
HIGH FIDELITY AMPLIFIER KIT

This is a true high fidelity amplifier even though its power is somewhat limited. Built-in preamplifier has separate bass and treble controls, and volume control. Frequency response is ±1½ db from 20 to 20,000 CPS, and distortion is held to surprisingly low level. Output transformer tapped at 4, 8 or 16 ohms. Easy to build, and a fine 7-watt performer for one just becoming interested in high fidelity. Shpg. Wt. 10 lbs. MODEL A-7D $17.95

Model A-7E: Same as the above except with extra tube stage for added preamplification. Two switch-selected inputs, RIAA compensation, and plenty of gain for low-level cartridges. Shpg. Wt. 10 lbs. $19.95

HOW TO ORDER . . .
Just identify the kit you desire by its model number and send check or money order to address below. Don't hesitate to ask about HEATH TIME PAYMENT PLAN.

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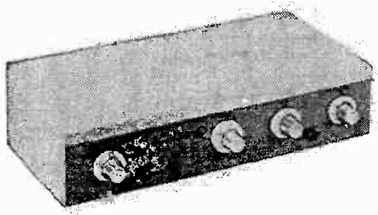
Audionews

DYNAKIT PREAMPLIFIER

The Dynakit preamplifier, recently introduced by the Dyna Company, includes a printed-circuit board on which all components are premounted and dip soldered at the factory, a built-in voltage-doubler rectifier to supply DC for the filament circuits, and a unitized switch



Dynakit unit is handsome and compact.

which contains 1% components for accurate compensation of recording characteristics.

The Dynakit utilizes a new type of all-feedback tone control with a flat center setting, and a control range of ±20 db at 30 cps and ±15 db at 15,000 cps. Frequency response is said to be ±0.5 db from 6 cps to 60,000 cps at any setting of the volume control. Distortion is stated to be less than 0.1% at full output.

Six inputs are furnished, with one being an option of extra phono, tape head, or microphone. A feature of value to tape recordists is the tape AB monitor switch which permits comparing the input with the recording. An additional front-panel control permits elimination of the loudness compensation of the volume control.

A complete brochure with performance and design information about the Dynakit preamplifier is available on request.

ESL DUST BUG

The ESL *Dust Bug* is an English invention which is supposed to solve the problems of dust, lint, and static build-

Dust Bug assembly fits any turntable.

up on phonograph records and pickup styli. The device is manufactured by Electro-Sonic Laboratories.

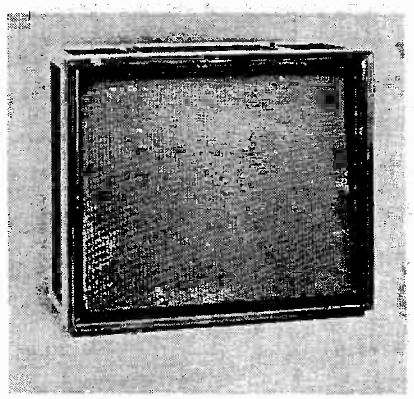
The Dust Bug consists of a special tuft of nylon fibers and a plush pad assembly mounted on a transparent plastic arm. The arm can be attached to a turntable by means of a suction-cup base.

Before a record is played, the plush pad of the Dust Bug is moistened with a special fluid from a replaceable applicator. This fluid helps to loosen groove dust and dirt, which is then collected by the pad. It also eliminates the static charge present on most records.

The ESL Dust Bug, complete with fluid in applicator, costs $5.75 and is available from high-fidelity equipment dealers.

WHARFEDALE SPEAKER SYSTEM

Wharfedale *Model SFB/3* is a 3-way speaker system developed by G. A. Briggs. The system includes a special group of 12-inch, 10-inch, and 3-inch speakers, tuned and integrated with a sand-filled baffle. The SFB/3 is distrib-



Cabinet illustrated is Windsor Deluxe.

uted in the United States by British Industries Corporation.

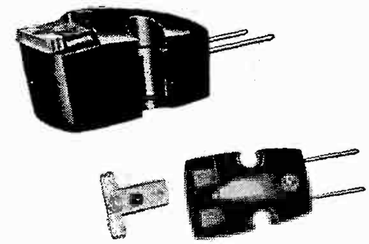
Two styles of the SFB/3 are available: the *Warwick* Custom, priced at $199; and the *Windsor* Deluxe, $249. In both cases, the speakers and engineering principles are identical, but the outward cabinet appearance varies. Each model is made in walnut, mahogany, and blond finishes.

Additional information on the SFB/3 is available on request.

PICKERING CARTRIDGE

A new, single, miniature magnetic cartridge for high-fidelity reproduction from phonograph records was announced by Pickering & Company recently. The new *Series 370* Single Fluxvalve measures only ⅝ in. by ⅝ in. by 1 in., and is said to mount in any type of high-fidelity pickup arm with ½-inch mounting center.

The Series 370 Single Fluxvalve is said to have a flat frequency response



Two views of the Series 370 Fluxvalve.

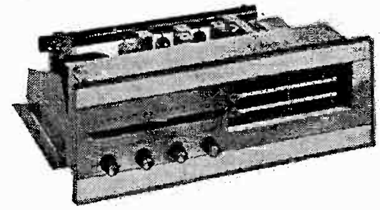
from 10 to 30,000 cps, and an output of 25 mv at 1,000 cps. It feeds into a recommended load of 27,000 ohms. It will track at from 2 to 6 grams, depending on the pickup arm used, according to the manufacturer.

Prices of the Series 370 Fluxvalve range from $17.85 for the Model 370-1S with a 1-mil sapphire stylus to $35.85 for the Model 370-.5D with ½-mil diamond.

Additional information about the Series 370 Single Fluxvalve cartridge will be furnished on request.

FLUSH MOUNT

The Sargent-Rayment Co. has announced that all models of its regular line of high-fidelity tuners and amplifiers are now available with a flush-mounting escutcheon for mounting in consoles or walls. Flush-mounted models will carry the same model numbers as the cabi-



Sargent-Rayment line is easily built-in.

neted models with an *M* added to signify mounting escutcheon.

There are two accessory kits available: one for conversion of a cabinet model to a flush-mounted model, and the other for conversion of a flush-mounted model to a cabinet model.

A brochure on Sargent-Rayment flush-models and kits is available on request.

MINIATURE RF TUBE

Amperex Electronic Corporation has announced the immediate availability of the new ECC85/6AQ8. A miniature,

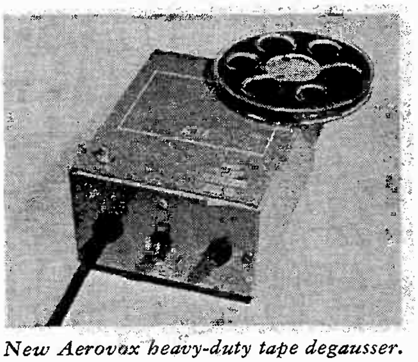
RF amplifier tube has internal shield.

high-mu, high-transconductance twin triode, the ECC85/6AQ8 has been specically designed for use in AM and FM receivers as a grounded-grid or grounded-cathode RF amplifier and as a self-oscillating frequency converter or cascode amplifier. Through the use of an internal shield, separating both triode sections, the ECC85/6AQ8 is said to reduce oscillator radiations from the antenna of the receiver to an extent not obtainable with previously available twin triodes. Higher transconductance permits increased front-end gain and lower noise, according to the manufacturer.

Detailed data and applications engineering information are available on request.

AEROVOX DEGAUSSER

The Aerovox *Type 710* heavy-duty degausser is constructed of heavy-gauge steel with a baked-enamel finish. It produces a strong external field when



New Aerovox heavy-duty tape degausser.

connected to 110-volt, 60-cps AC line, and it will bulk-erase 10-inch and smaller spools of magnetic recording tape, according to the manufacturer. The degausser is designed for alternating operation of 10 min. on and 10 min. off. Weight of the unit is 15 pounds. The list price is $49.95.

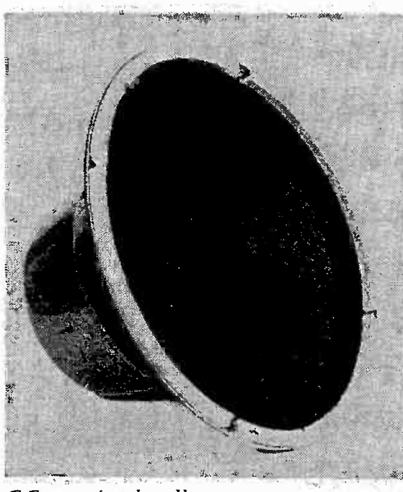
ALLIED BOOKLET ON HI-FI

Allied Radio Corporation of Chicago has announced the release of a revised edition of the booklet, *This Is High Fidelity*. Assuming no previous background knowledge on the part of the reader, this two-color booklet explains high-fidelity reproduction from the simplest of basic hi-fi components to stereophonic sound. Succeeding sections cover the basic hi-fi phono system, the function of different components in a hi-fi system, modernizing existing equipment, adding extension speakers, choosing components, and budget considerations.

This Is High Fidelity is available at 10¢ a copy from Allied Radio Corporation, 100 N. Western Ave., Chicago 80, Ill. It should be ordered under stock number 39 K 000.

NEW WOOFER

A new moderate-price 12-inch woofer, the General Electric *A1-403*, has several design features for improved low-fre-



G.E. woofer handles 40-1500 cps range.

quency reproduction to two- or three-way hi-fi systems. The new speaker is said to provide excellent low-frequency power output in the 40-to-1,500-cps range.

The A1-403 includes a built-in electromechanical crossover system for smooth rolloff at the 1,500-cps crossover point. Terminals are provided for direct connection of a tweeter, such as the General Electric A1-404.

Suggested retail price of the A1-403 woofer is $29.95.

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. Make use of this special service; save postage and the trouble of making individual inquiries to a number of different addresses.

STROMBERG-CARLSON TUNER

An FM-AM tuner, the *Model 403B*, has been added to Stromberg-Carlson's Custom Four Hundred line of high-fidelity components.

The Model 403B tuner is fully enclosed in a mahogany cabinet. The tuner is said to have a frequency response of

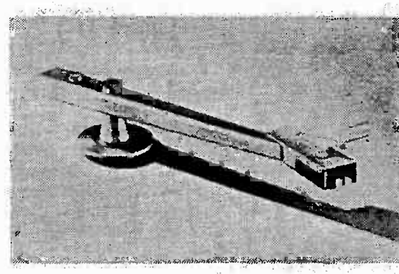
Tuner contains two built-in antennas.

from 30 to 15,000 cps with less than 1% total harmonic distortion. Sensitivity is stated to be 3μv for 20 db quieting on FM, and 5 μv for 0.1 v audio output on AM. Two antennas are built in. Front controls are an FM-AM selector and a tuning knob. A volume control is located on the back of the chassis. The cabinet is 7 in. high, 12 in. wide, and 7½ in. deep. The unit is priced at about $105.

GRAY VISCOUS-DAMPED ARM

A new high-fidelity tone arm, *Micro-Balanced* with two sealed viscous-damped pivots for both vertical and horizontal movement, was recently announced by the Gray Manufacturing Co.

The latest Gray tone arm is statically balanced around the vertical pivot to provide tracking stability. The stylus force is said to be adjustable from 0 to 15 grams, and the arm is designed for records up to 12 in. in diameter. The cartridge slide plugs in for easy removal



Gray tone arm employs viscous damping.

of cartridge and slide assembly. Single-hole mounting is provided on turntable mounting boards up to ¾ in. thick. Stylus height above the mounting surface can be adjusted over a 1-inch range.

by RICHARD D. KELLER

book reviews

THIS is an excellent time to pause and take stock of the many fine books in the audio field published and reviewed on these pages during the past year. A brief review of what's gone before can be especially helpful while drawing up lists of gifts which we'd like to give — and receive — this month. Such a resumé can also help point up worth-while contenders for our valuable time, and eliminate the weak and trite.

Since over 50 volumes are involved, they've been catalogued into logical divisions. In each category, the best ones in my opinion are grouped toward the top and the poorer or less worthy ones at the bottom, with a brief over-all impression or comment following each. Of course, the order shown cannot convey *absolute* ratings, since one particular book may be best for the practicing engineer, another for the part-time hobbyist, etc.

I've tried to feature a particularly complete listing in the transistor area because of the increasing interest in these devices today. Consequently, the listing at both the popular and engineering transistor levels has been augmented with a number of books and manuals not previously reviewed in this column in order to give you a more comprehensive guide.

Prices are those of the least expensive versions. For more detailed discussions of any individual book, refer to the month of the original review. All reviews appeared in 1957, except where marked 1956.

Electronics (Popular)

Author	*Title*	*Publisher*	*Price*	*Review Date*	*Comments*
D.C. Hoefler	Mechanix Illustrated Hi-Fi Guide	Fawcett	.75	Mar.	Interesting and pictorial
M. Upton	Electronics for Everyone	New Am. Lib.	.50	Nov.	Lucid, entertaining
L. Stern	Electronics Made Easy	Pop. Mech.	2.95	Jan.	Kits and projects
R.L. Oldfield	Radio-Television and Basic Electronics	Am. Tech. Soc.	4.95	May	Good for youngsters
A.W. Keen	Electronics	Phil. Library	4.75	Feb.	Wordy, small print

Electronics (Textbooks & References)

Author	*Title*	*Publisher*	*Price*	*Review Date*	*Comments*
H.F. Olson	Acoustical Engineering	Van Nostrand	13.50	Nov.	*The* standard reference
L.B. Arguimbau	Vacuum Tube Circuits and Transistors	Wiley	10.25	Aug.	Thorough, well written
Burris-Myer & Goodfriend	Acoustics for the Architect	Reinhold	10.00	Nov.	Right up to date
S. Seely	Electronic Engineering	McGraw-Hill	8.00	Jan.	Fairly complete
M. Mandl	Handbook of Basic Circuits — TV-FM-AM	Macmillan	7.50	Mar.	Nonmath approach
J.L. Stewart	Circuit Theory and Design	Wiley	9.50	Jul.	Extremely advanced
J.L. Hunter	Acoustics	Prentice Hall	8.50	Nov.	Theoretical

General Hi-Fi

Author	*Title*	*Publisher*	*Price*	*Review Date*	*Comments*
N.H. Crowhurst	Understanding Hi-Fi Circuits	Gernsback	2.90	Oct.	Good, solid material
J. Marshall	Maintaining Hi-Fi Equipment	Gernsback	2.90	Dec. '56	Excellent
E.M. Villchur	Handbook of Sound Reproduction	Radio Magazines	6.50	Aug.	Advanced audio and acoustics
C. Fowler	High Fidelity	McGraw-Hill	4.95	Feb.	Casual but good
A.B. Cohen	Hi-Fi Loudspeakers and Enclosures	Rider	4.60	Mar.	Authoritative and complete
G.A. Briggs	High Fidelity — The Why & How for Amateurs	Wharfedale	2.95	Apr.	British humor
W.F. Boyce	Hi-Fi Handbook	Sams	3.00	May	General planning book
I. Greene	The New High Fidelity Handbook	Crown	4.95	Jul.	For the layman
G. Slot	Hi-Fi from Microphone to Ear	Philips	2.75	Apr.	European ideas
S.M. Herman	Hi-Fi Equipment Yearbook — 1957	Herman	1.95	Jun.	Incomplete catalogue

Miscellaneous

Author	*Title*	*Publisher*	*Price*	*Review Date*	*Comments*
J.F. Rider	FM Transmission and Reception	Rider	$ 4.95	Sept.	Thorough and complete
ARRL	The Radio Amateurs Handbook	ARRL	3.50	Aug.	Good all round
J.F. Rider	Obtaining and Interpreting Test Scope Traces	Rider	2.40	Sept.	Excellent
R. Scharff	Easy Ways to Expert Woodworking	McGraw-Hill	3.95	Apr.	Features DeWalt tools
A. Schure	Frequency Modulation	Rider	.90	Sept.	Simple and good
A. Schure	Inverse Feedback	Rider	.90	Jun.	Easy to follow
R.L. Swiggett	Introduction to Printed Circuits	Rider	2.70	Jan.	Interesting coverage
J. Darr	How to Install and Service Intercommunications Systems	Rider	3.00	Jun.	Complete guide
A. Schure	Antennas	Rider	1.50	Nov.	Well presented
A. Schure	Resonant Circuits	Rider	1.25	Oct.	Simple, good
A. P. Hale	Electrical Interference	Phil. Library	4.50	Nov. '56	Interesting — long
A.D. Jones	Frequency Modulation Receivers	Phil. Library	6.00	Oct.	Overly verbose
A. Haas	The Oscilloscope at Work	Phil. Library	10.00	Jul.	Long but limited
A. Douglas	The Electrical Reproduction of Music	Phil. Library	12.00	Aug.	Electronic organ principles
A. Douglas	The Electronic Musical Instrument Manual	Pitman	7.50	Aug.	Typical commercial organs

Tape Recording

Author	*Title*	*Publisher*	*Price*	*Review Date*	*Comments*
H.D. Weiler	Tape Recorders and Tape Recording	Radio Magazines	$ 2.95	Dec. '56	Best on techniques
R. Hodgson	How to Use a Tape Recorder	Hastings	4.95	Jun.	Best for ideas
J. Bayha	All About Tape on Tape	Tape Rec.	5.95	May	Unique and good
K.A. Barbelen	Ribbons of Sound	U.S. Camera	2.50	Nov. '56	Well illustrated
C.J. Lebel	How to Make Good Tape Recordings	Audio	1.50	Mar.	Nontechnical
C.A. Tuthill	How to Service Tape Recorders	Rider	2.90	Sept.	Rather limited

Continued on page 50

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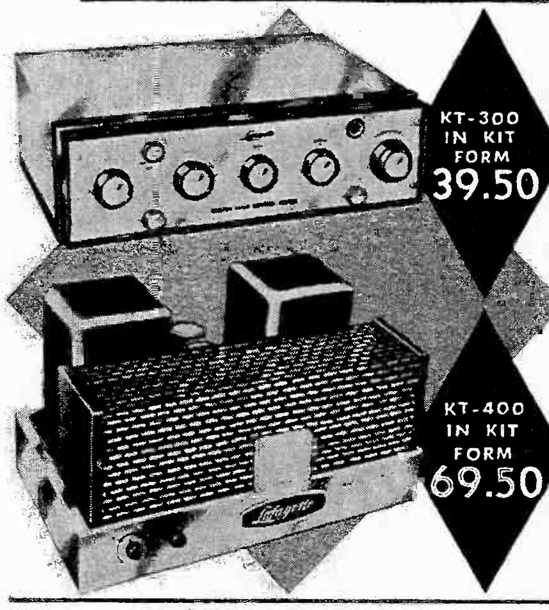

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The acoustical lens is only available on JBL Signature high frequency units. The 14 element lens on the 175DLH disperses sound within the listening area over a 90° solid angle, smoothly, with equal intensity regardless of frequency. The acoustical lens is the greatest contribution to life-like high frequency reproduction in 20 years, and it was developed for use with high fidelity equipment by James B. Lansing Sound, Inc. In addition to the lens the 175DLH consists of a high precision driver with complex phasing plug and a machined aluminum exponential horn. Designed for crossover at 1200 cycles with the JBL Signature N1200 Network.
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Readers' Forum

Gentlemen:

Two days ago the October issue of AUDIOCRAFT arrived and I was delighted to see the detailed report by Mr. Joseph Marshall about the Knight-Kit FM tuner. I had been seriously considering purchasing this kit from the Allied Radio Corp. as a second FM tuner for the stereo broadcasts which are available to us here in Milwaukee at certain times of the year. Mr. Marshall's report greatly encouraged me to purchase this FM tuner kit in the very near future.

On the same day there also arrived in our house the October issue of *Consumer Reports* published by Consumers Union of U.S., Inc., 256 Washington Street, Mount Vernon, N.Y. This issue contained a rather detailed report of tests of FM tuners, and the Knight-Kit FM tuner was also listed and evaluated.

Mr. Marshall's article, under the subhead "AUDIOCRAFT Test Results" on page 30, reads:

"The performance of the Knight tuner is excellent; especially gratifying is the low distortion. In this respect it is better than many higher-priced, ready-made units, and not greatly inferior to the expensive wide-band tuners. . . . The distortion remained low and the noise suppression was good."

Consumer Reports, on the other hand, gave the Knight-Kit FM tuner a low rating, stating that distortion was very high and AM rejection and selectivity poor.

The entire article on the FM tuner test results as reported in the October issue of *Consumer Reports* creates many doubts and confusion in one's mind, particularly when money to be spent for high-fidelity components has to be carefully budgeted.

Perhaps you would care to comment on these two reports.

Adolph Rebensburg
Milwaukee, Wis.

The only comment we care to make on Consumer Reports *is this: the test results and opinions expressed therein are very often not in agreement with the considered judgment of experienced men recognized as hi-fi authorities, and who spend full time working with high-fidelity equipment in various ways.*

It is no secret that by choosing test methods for the purpose, it is possible to produce nearly any results desired. By the same token, if test methods are used inadvertently that do not conform to

Continued on page 52

EDITORIAL

MANY sensible words have been written and spoken about accidental electric shock, and innumerable safety rules have been proposed. The old rule of "one hand in the pocket at all times" has been recited over and over.

But emphasis has been put on high voltages. Most electronic technicians and hobbyists have some measure of respect for kilovolts, but are contemptuous of anything less than about 200. This is dangerous, because caution should begin on the primary side of the power transformer. An alarming number of killings are caused by ordinary house current: the stuff we have come to call "110".

People killed or injured *directly* by 110 (not by some side effect) have had the current pass through their bodies. The 110 found a long path, such as from one hand or arm to the other, hand to foot, arm to leg, etc. A typical short path, the kind that seldom causes direct damage, is between two fingers of the same hand. When injury is sustained a large area of the body has usually suffered contact. This often is the palm of a hand, sole of a foot, thigh, forearm, chest, back, or buttocks. If the skin is moist, as it is when perspiring, the lowered contact resistance makes tragedy almost certain.

Everyone should make it his business to give house current the same respect he ordinarily accords high voltages, and to remove from his workshop, as well as from the rest of his home, all line-voltage booby traps.

Fasten a stout ground lead to any permanently installed machine tool and connect its other end to a *good* ground (a cold-water pipe, or a metal rod or pipe driven deep into moist earth). The frames of good portable electric tools, such as drills, saws, and sanders, are equipped by the manufacturer with a grounding lead which hangs from the plug-end of the power-cable. Don't snip this lead off. Use it the way it is intended to be used — connect it to ground before you insert the plug into the power outlet. A cautious worker will also ground the case of his soldering iron.

You will find that the power cables of many of your test instruments are furnished with similar grounds leads. Connect these leads to ground — don't just let them dangle. A hot case on a test instrument does more than introduce hum into a tested circuit: it is a potential killer. If there happens to be no safety ground on the instrument's power cable, fasten a dependable ground lead to the case yourself. Of course, you will have to remove it when the instrument is used in circuits for which the reference potential is not ground, but that will be seldom. A line-voltage potential difference between two chassis or chassis and case is dangerous! Use an isolating transformer when working with AC-DC devices or series-filament transformerless television receivers.

Most fatalities and injuries in the shop are caused by current finding its way back to ground through the worker's feet. Don't tolerate a hot floor in your workshop. The floor, your feet, and your shoes always are damper than you would think they are. Your shop should have a floor of dry wood or other insulating material; a cement floor very often is as bad as plain earth. If you cannot have an insulating floor or if the job demands that you stand on the bare ground, wear rubber-soled shoes or rubber overshoes. If you are stuck with your present shop floor, get a couple of good rubber mats to stand on, or build a platform of dry wood.

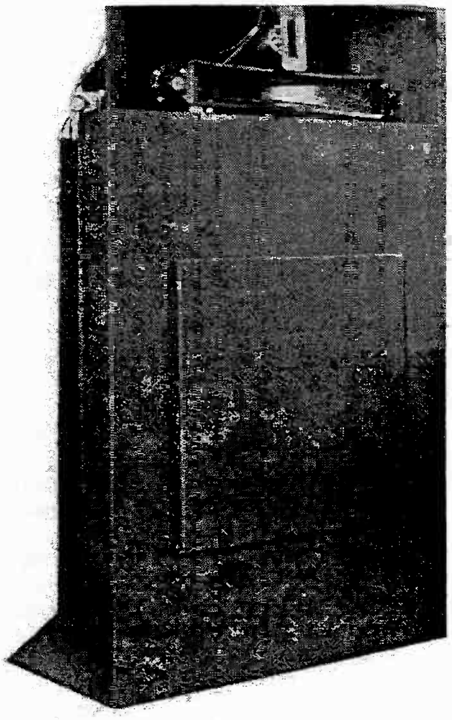
Never work on an energized power circuit unless you have no other choice. It is far better to pull the switch *and* remove the fuses, putting them in your pocket. While on this subject, we might point out that only a fool checks the line voltage with his fingers, although we have seen some electricians check a 220-volt line in this asinine manner. When emergency conditions absolutely demand that you work a power circuit hot, if you are not expert in such work protect your life by wearing rubber gloves and rubber-soled shoes and don't roll your sleeves up. Also, remove rings, metal watch bands, bracelets, etc.

Even when a piece of AC-DC equipment is enclosed in an insulating cabinet, there is still the possibility that a shock will be picked up from the setscrews in the tuning knobs. Use push-on knobs that require no screws, or cover the screw heads carefully with sealing wax. Never, under any circumstances, use any of the new fancy, all-metal knobs on hot AC-DC equipment.

Even in transformer-isolated electronic equipment, transformer primary windings have been known to short-circuit to the core or case and thereby make a chassis hot. This is another reason why grounding all chassis is always a good idea.

Check your equipment regularly for grounds and short circuits. Get your ohmmeter out and go over all the electric equipment in the house. When your soldering iron or electric drill shows leakage between the case and *either* prong of the power plug, *fix it*. Lose no time replacing any frayed power cords or broken plugs.

Remember to be careful; that way you live longer. — RUFUS P. TURNER.



Photos by Warren Syer

The Electro-Voice Patrician IV

THE Patrician is probably best known of all the very large, elaborate, and expensive loudspeaker systems. To many, it has become identified with an ideal in sound reproduction, in the same wishful-thinking category as a Rolls-Royce or Continental.

There has been some justification for this attitude, it must be admitted. Current net prices for different finished models of the Patrician vary from $819 to $1,086, a price range not likely to attract a mass market, even if it is quite reasonable for what the buyer receives. The Patrician is a four-way system completely horn-loaded over the entire range of each driver. For the range from 200 cps downward, an 18-inch woofer is used in a scaled-up Klipsch-type folded horn. From 200 to 600 cps a pair of special mid-bass drivers is used in conjunction with a smaller horn resting on top of the bass unit. Separate straight horn and driver assemblies cover the ranges from 600 to 3,500 cps and from 3,500 cps upward: these are mounted within the mid-bass horn mouth. All the drivers are the best that Electro-Voice makes. Either the T350 VHF horn and driver, or the T3500 Ionovac* assembly, is used for the top range. The outer cabinet is available in two styles and three finishes in each style. These options account for the differences in price.

There are, obviously, two ways in which the audiocrafter can save money in assembling a Patrician. One is by omitting the outer cabinet, which serves no acoustic function but which is large, beautifully finished by the manufacturer, and expensive in itself. The other is by building the complex bass horn and mid-bass horn and installing the drivers. Electro-Voice has encouraged do-it-yourself efforts on the Patrician (as well as other E-V systems) by publishing instruction books for each system, which provide parts lists, wood cutting plans, and step-by-step assembly instructions. Further, the driver components are available as individual units or as "system" kits. Finally, E-V sells kits of precut wood parts for the enclosures or bass horns. You can build the Patrician by starting with sheets of plywood and the plans; you can buy a kit for the horns, and a kit of driver components, and combine them; you can buy the unfinished horns and the driver kit; or you can buy the complete, finished system in a decorative enclosure. We'd say the most practical method of attack for the cost-conscious Patrician admirer is the one we chose: construction of the bass horns from the kit parts.

E-V's part number for the Patrician interior assembly kit is KD-1. This includes all wood parts for the bass and mid-bass horns, screws, glue, nails, and illustrated assembly instructions. It costs $118: little more than the raw plywood and parts you'd have to buy if you did

*"*The Blue-Glow Tweeter*": AUDIOCRAFT, II (May 1957), p. 28.

Fig. 1. Triangular braces (center) hold together sides of 200-cps horn assembly.

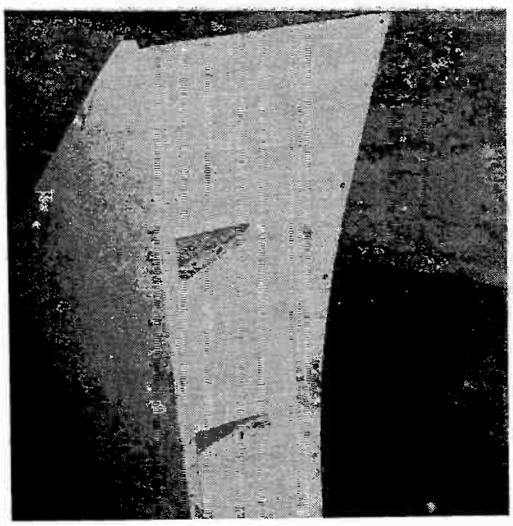


Fig. 2. Front view of 200-cps horn illustrates its sloping side construction.

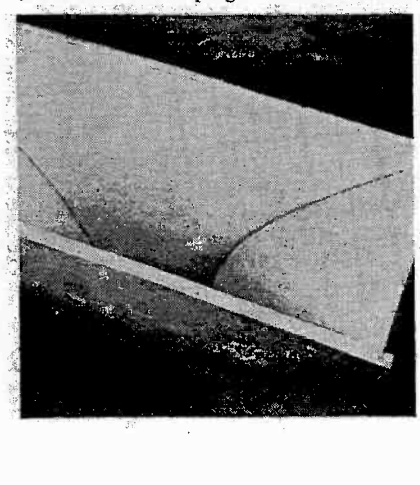
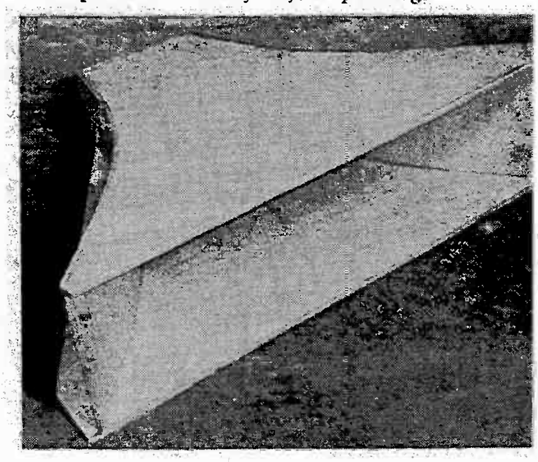


Fig. 3. Over-all view of the completed 200-cps horn assembly before painting.



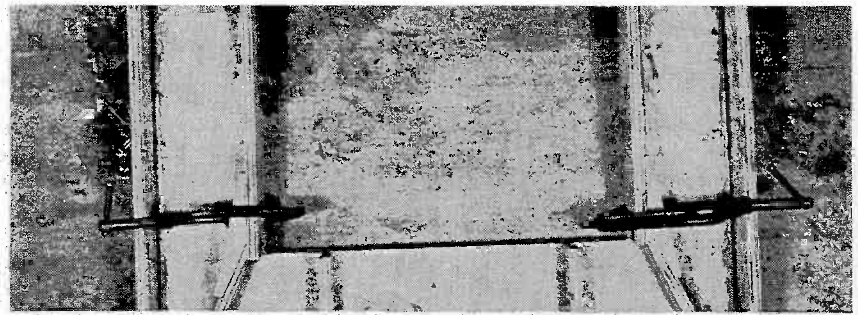


Fig. 4. The author recommends using clamps to hold the bearing wedges in position. All joints should first be calked, and the wedges smeared with glue before clamping.

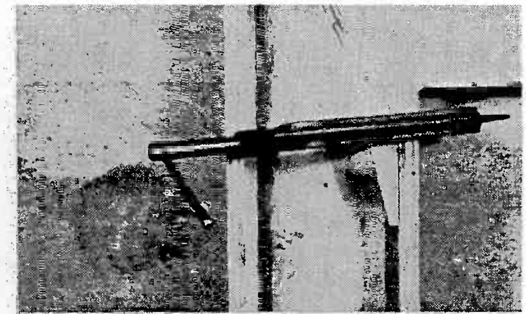


Fig. 5. Close-up of clamping technique shown in Fig. 4. See text for details.

all the layout and cutting yourself. The four-way driver package, Model 103E, contains an 18WK woofer, the 118B mid-bass dual-driver assembly, the T25A high-frequency driver with the 6HD horn, the T350 VHF driver and horn, the X2635 four-way crossover network, three level controls, wiring harnesses, and installation hardware; its net price is $431. Model 103D driver package is identical except that the T3500 Ionovac unit replaces the T350 for the top range. Total price of the 103D package is $520. Thus, you can get Patrician sound (if not Patrician appearance) for $638 or $549, depending on whether you choose the Ionovac tweeter or the standard excellent T350. Quite a substantial saving in either case. We chose the latter driver kit.

Our builder was the staff member who put together an E-V Centurion, which was the subject of a kit report in our July 1956 issue. His comments on the Patrician follow.

Construction Notes

Having previously tackled the Centurion speaker system kit, I looked forward both with optimism and some trepidation to building the monster Patrician. Optimism, because I now felt like a relatively experienced kit constructor, in view of my past experience; and trepidation, because I stood in awe of the Patrician's size and the possibility of construction difficulty in direct ratio to its bulk.

Happily, I found that, if anything, the Patrician is easier to build than the Centurion! In the larger unit space is much less crowded; where you might squeeze a finger into a place on the Centurion, your whole hand will fit on the Patrician. Also, I was not troubled by the necessity of being constantly on guard not to mar outside-finish surfaces on the Patrician. Reason: there aren't any. This is a kit containing only the inside working parts. Outside finishing or cabinetry is up to you.

Before we get into the actual construction details, a few advance warnings and suggestions: be sure to lay out and identify all the wood component parts before starting actual construction. A piece missing at a crucial point could mean more than just a simple irritation; it could undo a lot of good work which had gone before. — It's worth while to consider the purchase of a long-handled ratchet screw driver, also. Without it, your wrist may become very tired while driving dozens of screws without letup. — A portable electric drill will save several hours of slow manual labor; screw holes are not, in most cases, predrilled. — I am an unusually lavish glue user, but I predict that even the most conservative will quickly empty the two bottles of Elmer's Glue-All provided with the kit; I used four more. — After much experimentation, I returned to my original brand of calking material, Miracle Tub Calk. It never dries to a brittle state, but the surface hardens to a leathery toughness. Accordingly it doesn't stick to your hands and clothes as you brush by it later when working in an uncomfortably snug spot. — The ac-

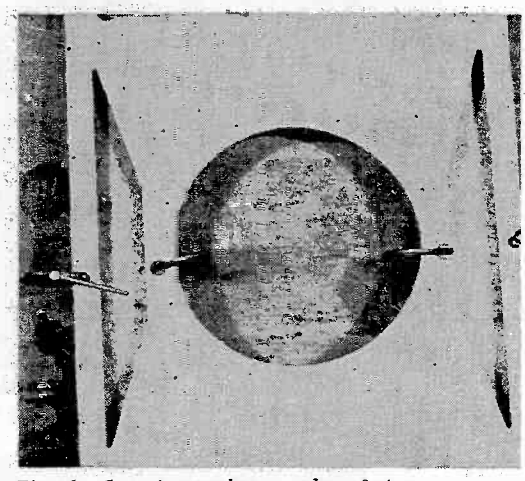


Fig. 6. Care is mandatory when fitting piece 21 (above) to assure correct fit.

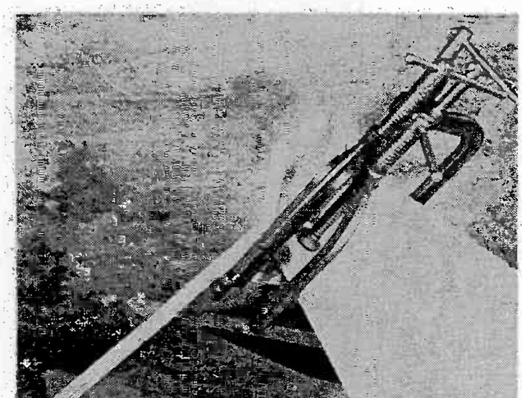


Fig. 7. Clamps are almost a necessity when fitting parts of woofer assembly.

Fig. 8. Clamped subassembly is nailed temporarily to guarantee proper angle.

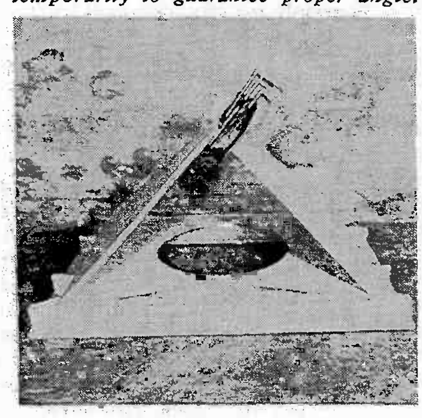


Fig. 9. Screws and calking compound are used to assure that cavity is airtight.

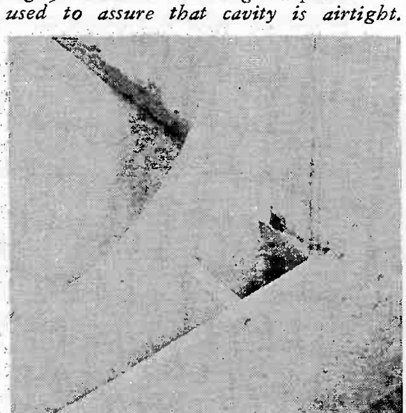
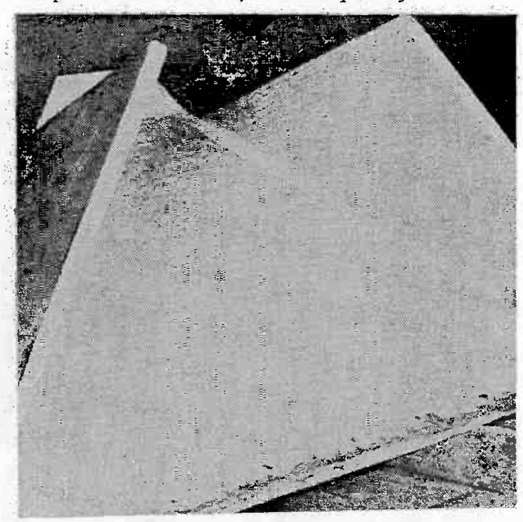


Fig. 10. Note generous use of calking compound to seal all joints adequately.



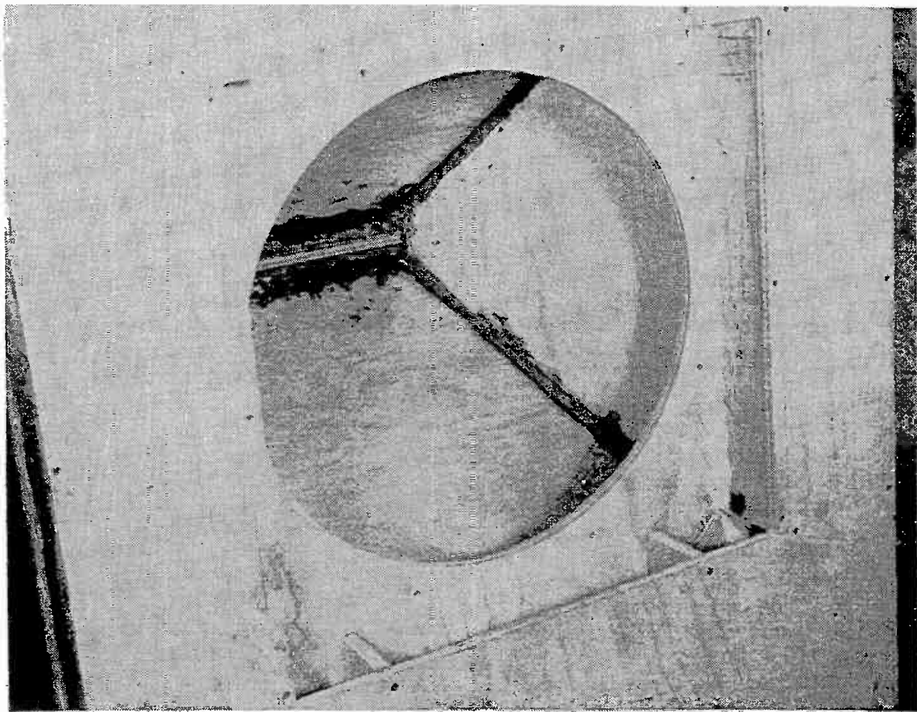


Fig. 11. Over-all view of the completed dashpot cavity illustrates the calking technique. Author recommends making certain screws are long enough to hold tightly.

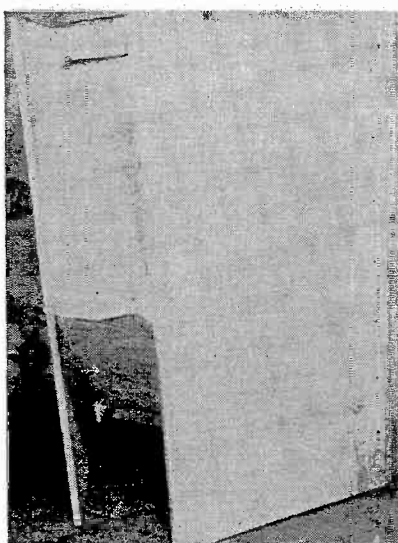
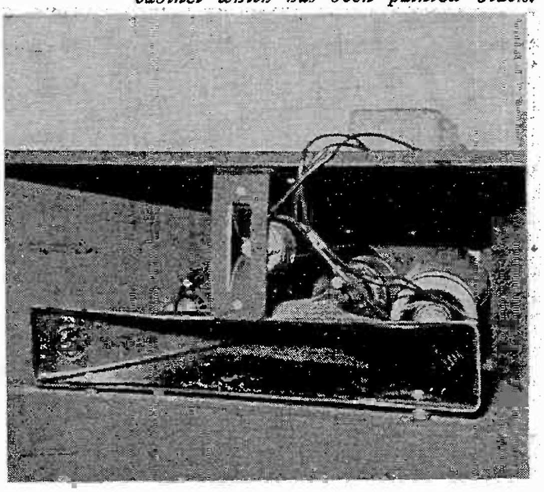


Fig. 12. Calking inside cabinet can be facilitated if it is turned on its side.

Fig. 13. Horns are shown installed on cabinet which has been painted black.



quisition of four 8-inch C clamps may well give you escape from frustration which can be had in no other way. There were a few times when it seemed impossible to pull parts into proper position without the clamps. If you have them, or decide to get them, consider using them in place of screws in every case possible. In the long run they are superior and guarantee a supertight joint. But tighten them only enough to make a good snug joint; they can exert an astonishing amount of pressure, which can bend or crack wood.

A *careful* reading of the instruction manual (particularly any supplementary instruction sheets) is a must. There are changes and improvements which have been made since the original book was printed, and you can waste a lot of time, even getting into some fairly serious trouble, if any up-to-date instructions are not meticulously heeded.

Now for actual construction notes. They will not be extensive, since the directions included with the kit are unusually complete and accurate.

If you start with the construction of the 200-cycle horn assembly (as the directions recommend) don't waste time looking for the stiffening battens described in the text and pictured in Fig. 10 of the instructions. They have been replaced by two small triangular brace pieces on each side which screw to pieces 1 and 3 (Fig. 1). *Do not* tighten the screws with undue force, for they may split the wood — just enough to squeeze glue out of the joint is sufficient (Fig. 2). While the instructions say to screw backboard 13 into place, this is not necessary if the fit is tight. Nailing is simpler and more logical under the circumstances. I would strongly advise that you select and install the appropriate metal hardware on piece 3 at this point. If you forget this installation, it becomes impossible after later construction steps. Also, any time you're waiting around for some recently glued joints to dry, you can paint this horn unit (Fig. 3) a flat black.

You will probably find it advantageous to dry-fit the various pieces that are to be screwed (or clamped) and glued to piece 22 as you start the assembly of the bass horn. If you do this, you can pencil guide lines either side of these pieces and then, with your power drill, bore guide holes for screws as you see fit between the scribed lines. After these guide holes have been drilled, turn piece 22 over and countersink them. Again, I would remind you to use clamps wherever possible. While this advice will be found more necessary and appropriate to later steps, clamps can be used to advantage even at this early stage.

The "boomerang" dead-air spaces can best be calked (as can all joints which must be so treated) by laying down a ribbon of calking material, directly from the tube, as close to the joint as possible, and then smoothing the material into the joint with a wet finger. No other way works as well.

Calk all joints before installing bearing wedges (pieces 13), which should be well smeared with glue. Here is an excellent and logical place to use clamps (see Figs. 4 and 5).

When you are about to install the large piece 21 (Fig. 6) over the smaller subparts already installed on piece 22, you will have reached the single biggest job of pulling down a panel which you will encounter. Reverse-side pencil scribing and guide-hole drilling as described above will be almost necessary to assure a perfect match between wood parts. For the guide lines opposing pieces 18, it will be necessary to extend with a straight edge the beginnings of these marks you will make with piece 21 in proper position. The calking in the boomerang cavities gets tough at this stage because of space limitations. It will certainly pay off in the final listening results, however, if you persevere.

I found it was best to glue and clamp together pieces 5, 6, and 7 (Fig. 7), then fasten this greenhouse-shaped subassembly into place on piece 21 (temporarily) with nails (Fig. 8). This secured the right angle of final setting for these pieces. Of course, the nails are removed later — after the glue has hardened. (When a fussy and/or big joint is involved it's a good idea to let the glue harden overnight.) After that the assembly can be permanently fastened to piece 21. Pull it down along both edges with screws until glue is squeezed out, and calk inside and outside edges.

Continued on page 46

Wall-Mounted Stereo System

ALL ears come to attention when the new speaker system shown on these pages goes into action. The system is installed in a large classroom at the State Teachers College in Mankato, Minnesota. The improvement in sound for the music classes obtained with this simply designed monaural/stereophonic installation has brought increased musical pleasure to both the students and instructional staff. It is easily duplicated; and it may provide an answer to installation problems in other classrooms, small auditoriums, and even in many home listening rooms.

by HOWARD M. VAN SICKLE

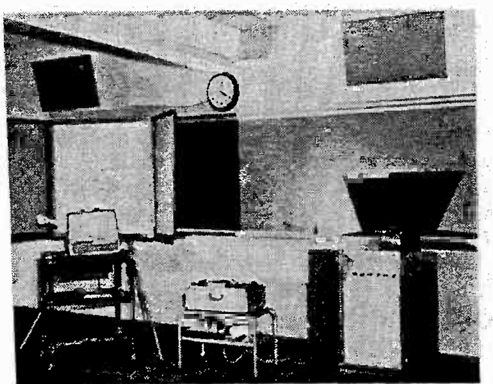


Fig. 1. Projector, tape recorder, and phono reproducer provide sound source.

Basically, this reproducing system consists of a pair of coaxial speakers mounted above the blackboard, set up so that they can be driven by the motion-picture-projector sound system, the record-playing equipment, a half-track tape recorder, or a 2-track stereophonic recorder (Fig. 1).

Designing the speaker system presented several challenges. The classroom enclosed more than 14,000 cubic feet of space; ½-inch punched-hole acoustical tile was on the ceiling. The other surfaces were of hard plaster, glass, glass brick, blackboard, and plastic floor tile. Classes ranged from 10 students to the maximum capacity of 80. Back of the blackboard was the record-storage room, the tape dubbing room, and the turntable headset listening room. The walls were of hollow tile and the ceiling was constructed of stressed concrete and tile. The challenge was to mount the speakers simply, inexpensively, and elegantly, meanwhile obtaining the maximum tonal advantage under the circumstances, and providing for an anticipated increase in the use of stereophonic sound for music-appreciation classes.

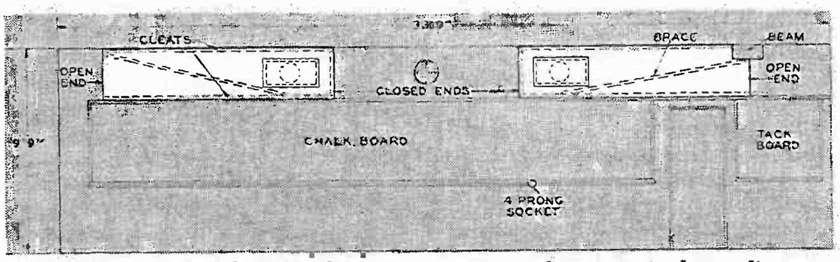


Fig. 2. The classroom housing this unique stereo speaker array is shown diagramatically in this outline drawing. The text explains how the construction was accomplished.

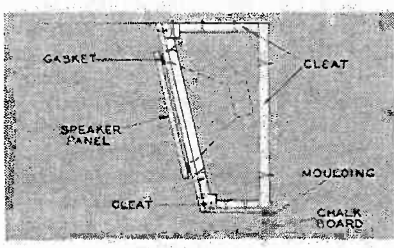


Fig. 3. End diagram showing position of speaker within each of the enclosures.

Wall space between the blackboard and the ceiling measured 29½ in. This was all above head height, with a good hard plaster finish over a hollow tile partition. The ceiling was acoustical tile fastened to hard concrete. Thus, two sides of the speaker enclosure were already in place. The upper molding of the blackboard provided a ready-made anchor for an extending cabinet.

The front wall was 33 ft. 9 in. long (Fig. 2). A clock above the blackboard was slightly off-center with the front wall but centered in relation to the classroom seating plan. Two enclosures were installed above the blackboard, starting 4 ft. from each side of the clock and extending some 14 ft. on each side. Thus, the enclosures were 10 ft. long and about 9 ft. apart.

A wooden cleat 10 ft. long was fastened by toggle bolts to the ceiling, about 18 in. from the angle formed by the front wall and the ceiling, for each of the two enclosures. This distance from the front wall was limited by the lighting fixtures. A plywood panel 10 ft. long and 9 in. wide was fastened to the top of the blackboard molding, and extended into the room parallel to the ceiling. A front panel cut from 1-inch fir plywood, 10 ft. long and 31 in. wide, was fastened to each ceiling cleat by screws, and also to the edges of the 9-inch panels. A 2-by-2-inch cleat was used at each joint, as shown in Figs. 2 and 3.

Rectangular holes were cut from each front panel near the clock end, in sizes larger than the frames of the speakers (15-inch and 12-inch) respectively. The angle of the front panel was such

Continued on page 47

Fig. 4. This is the left stereo speaker which fits in a corner above blackboard.

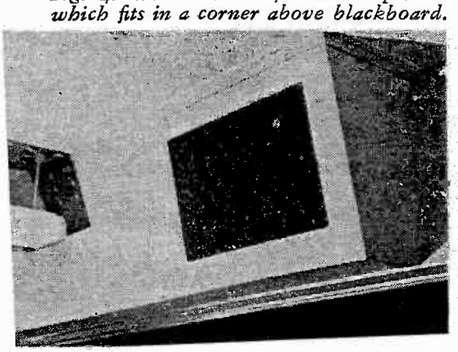
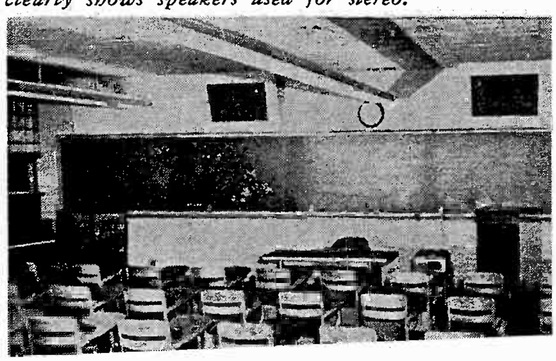


Fig. 5. View from the rear of the room clearly shows speakers used for stereo.



Audio Testing with Square Waves

by RUFUS P. TURNER

ALTHOUGH square-wave testing of audio amplifiers has been discussed in a number of articles for the practical man, few actually use this test. Some of the reasons given for avoiding it are insufficient instructions in interpreting the patterns, results not in accordance with author's claims, theory presented in a confusing manner, and uncertainty as to which frequencies to use. Occasionally, half truths in the articles have compounded the confusion.

This article will attempt to view the subject objectively and to dispel some of the fog which has settled (needlessly) around the square-wave test. If we can clarify the subject sufficiently, perhaps more use will be made of the valuable information that square-wave testing provides.

Utility of Square-Wave Test

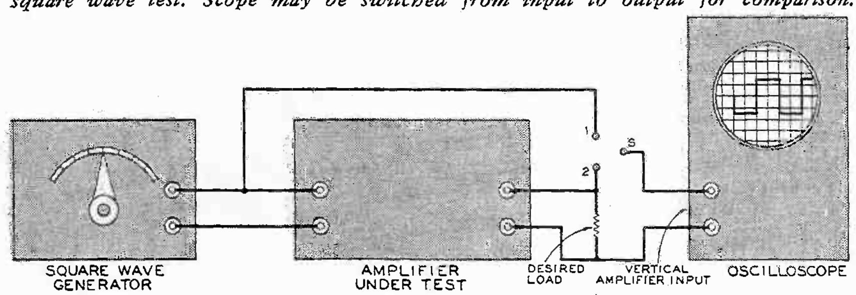
Since most sounds in speech and music are not simple sine waves (pure tones) but are complex combinations of fundamental and harmonic frequencies, transients (sharp impulses), and quasi-transients, their reproduction cannot be realistic unless the amplifier has excellent transient response. Thus, a measurement of frequency response using sine waves does not fully establish that an amplifier is high in fidelity, even though the amplitude-vs.-frequency curve comes out flat. The flat curve establishes merely that faithful reproduction would be obtained *with sine waves*. The flat-curve amplifier might not actually "sound good."

The square-wave test is important because it does check the transient response of the amplifier. If an amplifier will pass a square wave of suitable frequency without significantly altering the wave shape, the amplifier's performance will probably be in the high-fidelity category, since it also will handle faithfully the steep transients of musical tones.

A sine-wave test gives no indication of phase error. The latter is important in amplifier operation, since it determines the time relationship between the various harmonics and the fundamental of a transmitted signal. Phase error is different in amount and direction at different frequencies, and may contribute to unrealistic reproduction by distorting the amplified wave form. These considerations are especially important in amplifiers employing feedback. Faithful reproduction of a square wave can occur only when the phase error is small. Unlike the sine wave, the square wave appraises phase characteristics as well as frequency response. In pointing out the sensitivity of the square wave as a test signal, Terman* states that a 10% slope in the horizontal portion of the wave indicates a phase error of only 2°. This corresponds to a drop in amplification of only .06% at the fundamental frequency.

*F. E. Terman, *Radio Engineer's Handbook* (1st ed.; New York, 1943), p. 968.

Fig. 1. Block diagram showing method of connecting equipment when conducting a square wave test. Scope may be switched from input to output for comparison.

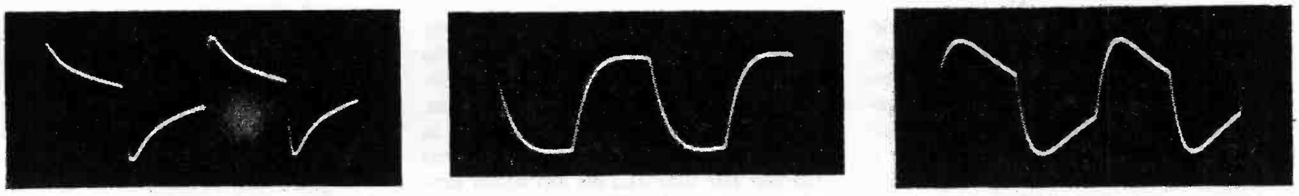


Square-wave testing is simple and rapid. Unlike slow, point-by-point frequency-response measurements using sine waves, two or three square-wave test frequencies will appraise frequency response over the entire spectrum of an audio amplifier and will expose phase error at the same time. The speed of the square-wave test is especially attractive in servicing and routine maintenance of audio equipment, and in developmental operations for which it is necessary to follow the effects of *many* circuit adjustments which would make repeated curve-plotting particularly tedious.

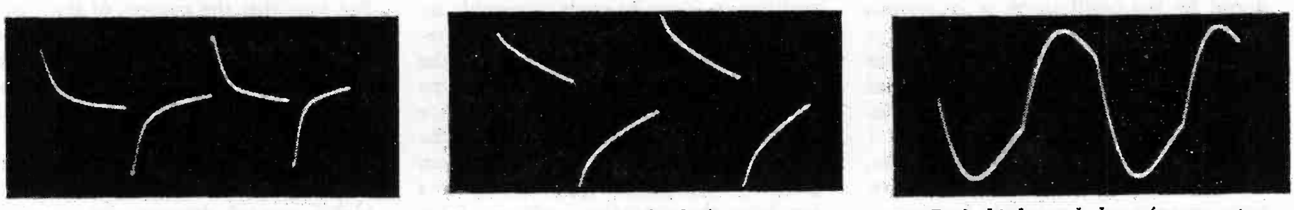
It should be clear from the foregoing discussion that the square-wave test offers advantages which strongly recommend its use. Some authorities insist that the transient response of an amplifier is much more indicative of its performance than a sine-wave response curve, since the latter neglects phase characteristics. No other single spot check can match its utility. However, the square-wave test must not be presumed to *supplant* all other tests. It is still necessary to check harmonic distortion and intermodulation, and the sine-wave-type of frequency-response measurement still is necessary when performance at specific frequencies must be known, when checking prototype amplifiers initially, and when checking response of circuits that are not supposed to give flat response — such as those of tone controls and equalizers. In the past, a disservice has been done square-wave testing by the erroneous assumption that it gives all the answers by itself.

Test Conditions and Requirements

Fig. 1 shows the test setup for square-wave testing an amplifier and Figs. 2 and 3 are photographs of commonly encountered square-wave distortions as they



A. *Poor low, fair high freq. response.* B. *Bad high, good low freq. response.* C. *Poor high and low freq. response.*



D. *Bad low, fair high freq. response.* E. *Fair low, good high freq. response.* F. *Bad high and low freq. response.*

Fig. 2. These are photographs of an oscilloscope showing wave shapes produced by the test setup of Fig. 1. These are the response patterns most often encountered when testing audio devices. An explanation is printed under each photograph.

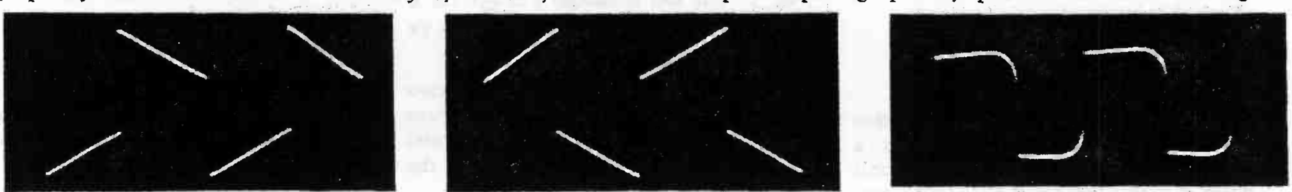
appear on the screen of an oscilloscope. In Fig. 1, the signal from a square-wave generator is presented to the input of the amplifier under test. The amplifier should be terminated in its normal output impedance, or in a reactive load of specific interest to the observer. When switch *S* (in Fig. 1) is at position 1, the vertical amplifier of the oscilloscope is connected to the input of the amplifier under test to view the applied square wave. When *S* is at position 2, the output signal of the amplifier is viewed. The internal sweep of the oscilloscope should be set to show one or two cycles of the square wave, made stationary on the screen by means of the internal sync. If the operator is absolutely sure of the squareness of the input signal at all test frequencies which will be used, the switching arrangement may be omitted and only the output signal viewed.

A voltage divider or potentiometer of the proper value to constitute a load can be connected to the output terminals of the amplifier, and adjusted to equalize the amplitudes of the input and output signals. This will obviate the necessity of readjusting the vertical gain of the oscilloscope as switch *S* is thrown from 1 to 2.

The square-wave generator and oscilloscope must be chosen with care. The generator must supply a wave of good, square shape at each desired test frequency. If a great deal of testing is to be done, it will be advantageous to have a variable-frequency generator. Otherwise, a generator supplying two or three frequencies (such as 50 and 2,000 cps, or 100, 1,000, and 20,000 cps) will suffice. Continuously variable control of the signal voltage also is desirable. Inexpensive, variable-frequency square-wave generators are available that supply signals throughout the range from 20 cps to 100 Kc. High-priced laboratory-type generators operate as high as 1 Mc, the higher frequency ranges being useful for testing video amplifiers. A few low-priced audio oscillators will deliver either sine waves or square waves, depending upon the position of a selector switch. However, the signal delivered by some of these instruments loses much of its squareness above about 2,000 cps and below 100 cps.

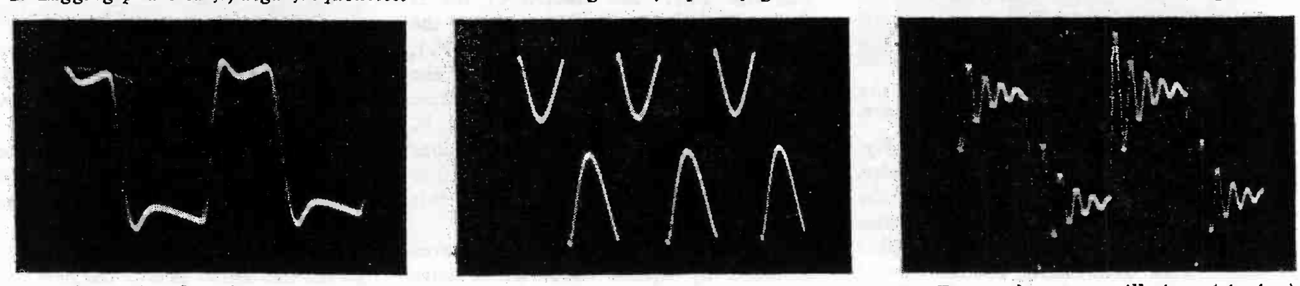
The oscilloscope must be capable of reproducing a square wave. This seems

Fig. 3. These photographs illustrate response to square-wave testing when the devices under observation exhibit specialized frequency distortion. Note the similarity of some of these wave shapes to photographs of patterns illustrated in Fig. 2.



A. *Leading phase shift, low frequencies.* B. *Lagging phase shift, low frequencies.* C. *Leading phase shift, high frequencies.*

D. *Lagging phase shift, high frequencies.* E. *Rising low frequency gain* F. *Accentuation of band of frequencies.*



G. *Drooping low frequency gain.* H. *Attenuation of band of frequencies.* I. *Damped-wave oscillation (ringing).*

an obvious requirement which should need no mention. Nevertheless, many experimenters have thoughtlessly attempted (and failed) to make square-wave tests while employing an oscilloscope totally incapable of reproducing a square wave at the test frequency. Since the square-wave signal must be reproduced by the oscilloscope, it is obvious that the vertical amplifier channel of this instrument must itself have excellent transient response and sufficient band width. In *modern* low-priced oscilloscopes, band widths extending up to 1 Mc now are easily obtained. However, many of these instruments still show poor square-wave response at frequencies lower than about 75 cps. The older-model low-priced oscilloscopes seldom go beyond 50 or 100 Kc before the frequency response drops off sharply. To use one of them in a 10- or 20-Kc square-wave test is a waste of time. For best results it is desirable that the vertical amplifier be direct-coupled and push-pull *throughout*, but this calls for a more expensive oscilloscope. The sweep-frequency range must extend high enough to permit a single square-wave cycle to be displayed on the screen at the highest test frequency.

If an amplifier passes a square wave of frequency f faithfully, the practical assumption is that the amplifier has good frequency response and low phase error over a band of frequencies extending approximately from $0.1f$ to $10f$. When the output wave deviates from squareness, however, significant conclusions can be drawn as to the response of the amplifier at high and low frequencies. The next section of the article explains this interpretation.

Interpretation of Square Waves

The response of an amplifier to a square wave approximates its response to a *unit pulse* (or *step function*). The unit pulse is useful because it has a frequency spectrum that ideally spreads over all frequencies. This characteristic suits it to the making of a 1-shot test which will

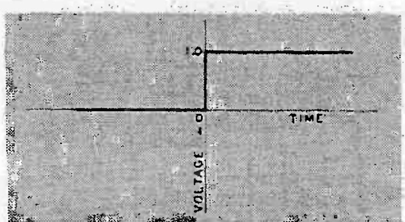


Fig. 4. This drawing illustrates the unit pulse, simulated by a square wave.

encompass a wide frequency range. Fig. 4 illustrates the theoretical unit pulse. The nature of this signal is seen to be such that the potential ideally rises abruptly from zero to 1 in negligible time. This is, of course, another way of saying that the pulse is a suddenly applied voltage. In practice, the narrower the pulse width, the more uniform is the amplitude of the energy that is distributed throughout the frequency spectrum.

How do you obtain a unit pulse in practice? A well-formed square wave has the fast rise time and flat top which simulate a unit pulse. Furthermore, it is repetitive, so it can be made observable on the oscilloscope screen. If the square-wave frequency is chosen properly, the amplifier response to this transient-type signal completely determines the behavior of the amplifier. We emphasize that the square-wave frequency must be chosen properly, since the square wave does not have the expansive spectrum of the theoretical unit pulse. (The range over which its "interference" extends is, as previously stated, roughly $0.1f$ to $10f$). If the fundamental frequency is too low, the last useful harmonic will not reach the upper frequency limit of the amplifier. If it is too high, the last harmonic will lie beyond the amplifier band limit in the region where response necessarily is poor. When a wide-band amplifier is tested, two or more square-wave frequencies must be employed. However, the number seldom exceeds three, except in the case of a video amplifier.

Fig. 5 shows an ideal square wave and its equation. The presence of the odd

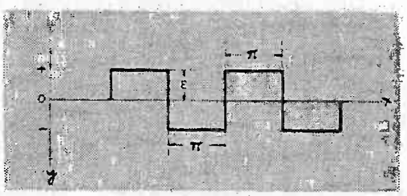


Fig. 5. Use this equation: $y = \frac{4E}{\pi}(\cos x - 1/3 \cos 3x + 1/5 \cos 5x - 1/7 \cos 7x + \ldots)$

numbers (1, 3, 5, 7) in the equation simply indicates that the square wave contains, in addition to the fundamental frequency, only the odd harmonics: the third, fifth, seventh, ninth, etc.

A square wave passed by a theoretically perfect amplifier will have its tops preserved flat and horizontal and its sides straight and vertical. In other words, it will emerge from the amplifier undistorted. Low-frequency deficiencies will cause the tops to tilt (Fig. 6), while poor high-frequency response will cause a rounding of the corners (Figs. 2B, 2C, 3C, and 3D). The amount of tilt is determined in *percent* by measuring the heights of the rise (V_1) and fall (V_2), as shown in Fig. 6, and performing the following simple calculation: % tilt $= (V_2/V_1) \times 100$. Heights V_1 and V_2 can be measured simply in scale divisions along the oscilloscope screen. A 10% tilt is not considered excessive, since this indicates only 2° phase shift.

Fig. 2 shows the generalized patterns assumed by square waves which have undergone some deformation in an amplifier. All distortions take one of these shapes to some degree. The user should become familiar with these general shapes; they can be used mentally as tools of reference when viewing square waves in practice.

Fig. 2A shows the tilting tops which indicate poor low-frequency response. But note that the corners of the pattern are sharp, indicating fair high-frequency response. In Fig. 2B, on the other hand, we have the rounded corners that show bad high-frequency response, but the flat tops here show good low-frequency response. Poor response at low frequencies tilts the tops in Fig. 2C, while deficient high-frequency response also rounds the corners. In Fig. 2D, the low-frequency response is so bad that the tops of the square waves have been squashed completely (severe tilt). However, the high-frequency response is fair, since the rise of the wave is rapid. The low-frequency response is slightly improved in Fig. 2E, where the angle of tilt of the tops is somewhat less steep than in Fig. 2D. Both high- and low-frequency response are so degraded in Fig. 2F that the pattern resembles a sine wave.

The direction of phase shift can be determined from the direction of the tilt or the position of the rounded corners. Thus, in Fig. 3A, the tops of the wave tilt from left to right, indicating leading phase shift at low frequencies; while in Fig. 3B, the tilt is in the opposite direction, indicating lagging phase shift at low frequencies. Curvature of the right corners, as in Fig. 3C, indicates leading phase shift at high frequencies, while curvature of the left corners (as in Fig. 3D) shows lagging phase shift at high frequencies.

Rising gain at low frequencies is disclosed by convex bulging of the tops (Fig. 3E), while drooping low-frequency gain is indicated by the concave sagging in Fig. 3G. An enclosed convexity (Fig. 3F) or concavity (Fig. 3H) shows boost or attenuation, respectively, of a band of frequencies.

The square wave can shock-excite into damped oscillation any resonant circuit in the amplifier. This can take place in

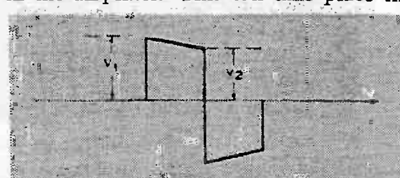


Fig. 6. Tilt indicates loss of lows. See text for method of measurement.

transformers, peaking coils, coupling chokes, tone-control inductors, tuned networks, or similar components or systems. When this happens, a damped wave is seen on the tops of the output square wave, as shown in Fig. 3I.

In practice, distorted square waves do not necessarily fit into the neat figures

Continued on page 48

by FRANK R. WRIGHT

Electronic Organ:

King of Kits

PART III: The finishing touches

ASSEMBLY of the electronic components of the Artisan Spinet was discussed in Part II of this article. Completion of that phase of the construction of the organ is a milestone, but there is still plenty of work to be done before the instrument is ready for use. This final installment will see the construction through to the end.

Wiring the Keyboard

The keyboard (Figs. 1A and 1B) must be wired. In order to understand just what is being done, let's have a look at Fig. 2, a drawing of the keyboard mechanism. The keys pivot so that the rear is lifted, raising the end of the contact bar, when the player depresses the front of the key. This, in turn, causes the center portion of the bar to swing sidewise. The coupler slides, on each of which are mounted 61 contact pins corresponding to the 61 contact bars, are engaged by magnets operated by the coupler tablets on the organ console. When the organist depresses a coupler tablet, a switch is closed and the magnet is activated, pulling the slide toward it. The contact pins are moved into position this way, so that the contact bars will touch them when the bars are in their sidewise position. When the coupler tablet is lifted, the switch opens and the magnet is deactivated. A spring returns the slide to its original position and the contact bars can no longer touch any of the contact pins on that slide.

Each of the pins in the slides extends downward and projects from the bottom of the keyboard assembly. The pins are very delicate and great care must be taken in handling the keyboard to see that they are not damaged. Wires must be attached to the bottoms of the contact pins and run to a terminal strip, through which they are attached to the tone generators. Complete instructions for wiring the keyboard are given with the kit, so it will not be necessary to go into the process any further at this point. Figs. 3 and 4 show the setup I used when wiring the Spinet keyboard. It is necessary to place the junction strip at approximately the same distance from the keyboard during the wiring as it is to be after it is mounted in the organ console. Hooks were used to hold the wires together until they could be tied into a cable. Wiring the keyboard took about 12½ hours.

Final Connections

Once the keyboard is wired and all the electronic components assembled, the next step is to put everything together into an organ. Now, at last, it really began to look as if I were making progress. The keyboard was put back in place and the power supplies and tone generators were mounted in the console. The tone changers were mounted inside the top of the Spinet, on the frame of the keyboard. The stop tablets and their switches were installed and wired, and the cables were run to connect power supplies, tone generators, et al. These are cables, mentioned earlier, that were furnished ready made. The individual conductors are tagged so there is no difficulty in finding where they go. Fig. 5 shows the interior of the Spinet console with power supplies, tone generators, etc., in place and hooked up. Fig. 6 is a photo of the top of the Spinet with the cover open. The manual and pedal tone changers can be seen mounted on the frame of the keyboard.

I ran into a snag wiring the coupler

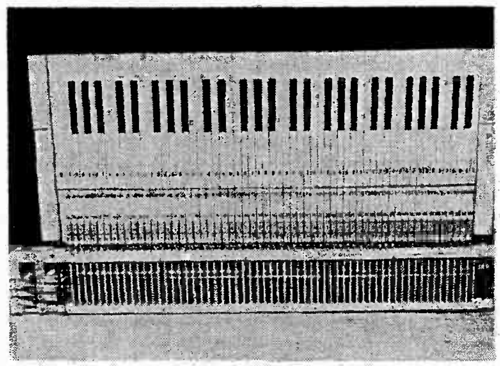
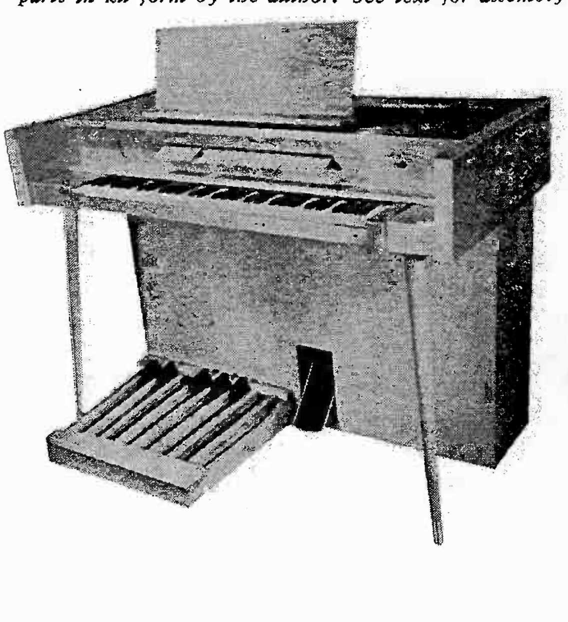


Fig. 1A. The keyboard looks like this from the top while still under assembly.



This is the Artisan Spinet Organ constructed from component parts in kit form by the author. See text for assembly notes.

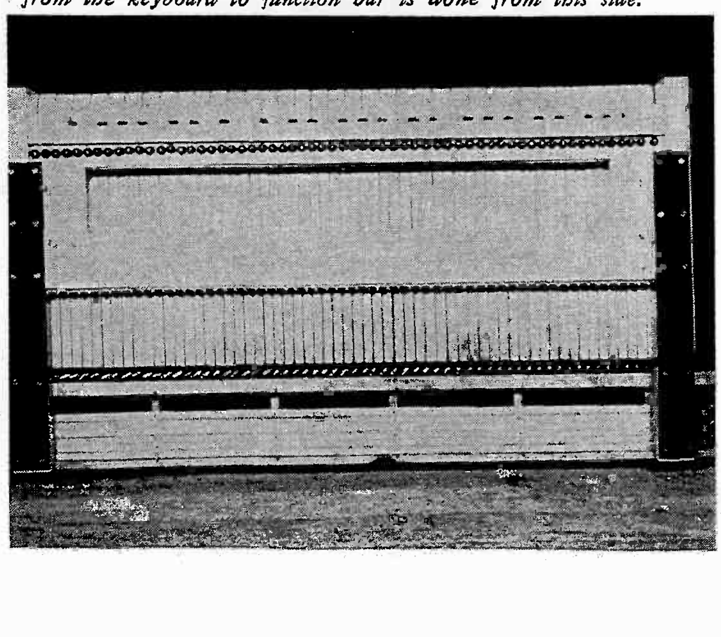


Fig. 1B. Bottom view of the Spinet's keyboard. All wiring from the keyboard to junction bar is done from this side.

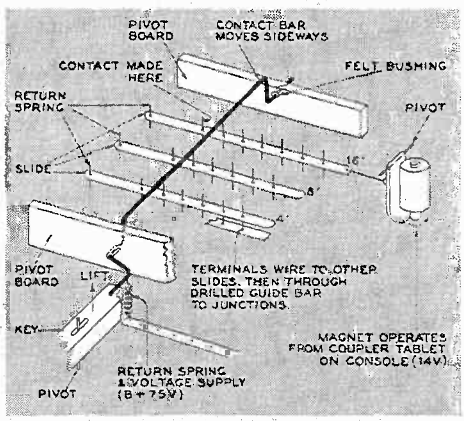


Fig. 2. Exploded diagram of keyboard shows how electrical contact is made.

switches, as I could find no mention in the instructions of how to connect the negative side of the 14-volt line to the magnets. I left this connection open until after power could be applied to the organ, and then followed a hunch and hooked the wire to a brass bar going across the top of the magnet assembly. This seemed to be the solution to the problem; the couplers all worked after the connection was made.

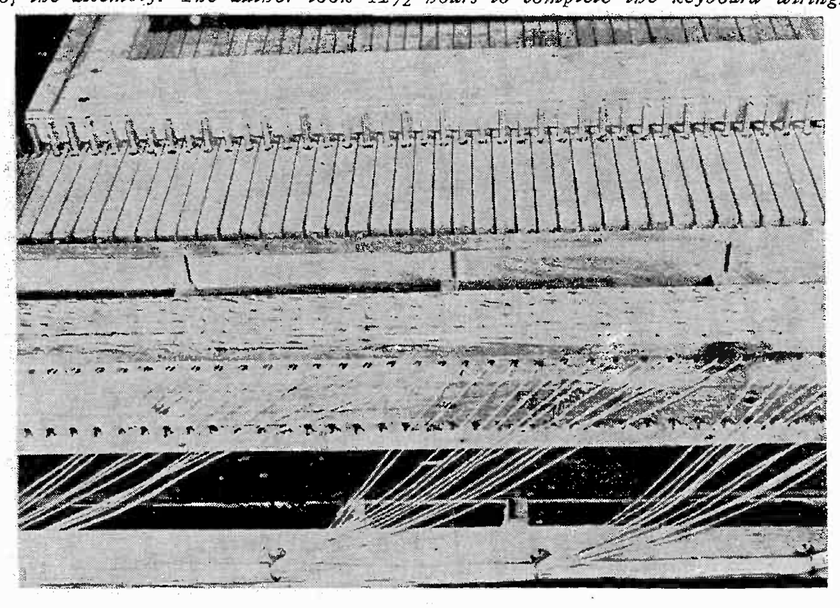
All this work took much longer to do than it takes to tell about it, but at last everything was done and the time came to turn the organ on to see if it worked. With considerable trepidation I flipped the power switch and was relieved to see the pilot light go on and the tube filaments glow. The greatest thrill came, though, when I pressed one of the keys and heard a tone come from the speaker enclosure. It seemed incredible that the organ should actually work, but it did. Other keys when pressed brought other tones, not necessarily in the right order, but tones that were music to my ears. I set to work at once to rough-tune the instrument, using the A tone broadcast by WWV, the National Bureau of Standards' radio station.

Troubles

After the Spinet had been rough-tuned and I had fiddled around with it for a while, trying different stops and couplers, I found that the *Harmonic Flute* and *Stopped Diapason* stops could not be silenced. I deduced that the trouble must be in the manual tone changer, and so I removed it and began tracing the circuits of the two recalcitrant stops. The mistake, a misplaced wire, was soon discovered and reconnected correctly.

Another aberration, this one not so easily put right, developed after the organ had been in operation for several hours. Four notes would play occasionally, but not always. I thought at first that the contact bars and pins on the manual were not making good contact, but this proved not to be the case. Voltage readings taken at different points in the circuits of the faulty notes when the notes were keyed were similar to readings taken at corresponding points in the circuits of notes that sounded properly. After mulling over the question for some time, I tried reducing the value of R2 (see schematic, Fig. 7), the resistor governing the time delay and volume of the note. I found that, by reducing the value of this resistor by ¼, three of the notes functioned properly. The holdout was brought in line by reducing its R2 resistance to ½ of the specified value. I did not notice that the volume of the notes treated in this manner was out of proportion to the volume of the rest of the notes. Upon further reflection, it occurred to me that the problem might also have been solved by reducing the value of C3, but, with everything working all right, I did not go back to find out.

Fig. 3. This close-up of the keyboard wiring shows in graphic detail the complexity of the assembly. The author took 12½ hours to complete the keyboard wiring.



All the notes of the organ except one came into tune easily within the ranges of their respective tuning coils. In order to tune the one note, it was necessary to replace its C1 capacitor with a capacitor of the next smaller value. This brought the circuit's frequency of oscillation up high enough that it came within the coil's tuning range.

After the Spinet had been in use for several weeks, I was dismayed one morning to discover that the tone of the notes in the top three octaves was unaccountably ragged. The total effect was so unpleasant that the instrument was unusable. Later in the day, the condition had cleared up of its own accord; but

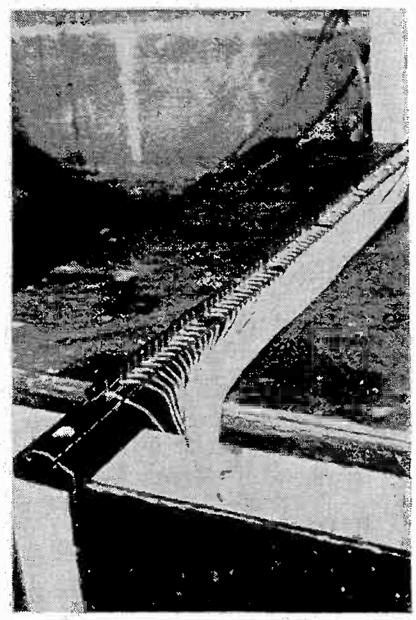


Fig. 4. Junction strip was laid on a table to facilitate the wiring process.

several days afterward the raspiness was back in the upper frequencies. The difficulty recurred intermittantly thereafter, without any apparent reason.

I puzzled over the problem for quite a while, and finally arrived at the conclusion that the trouble, whatever it might be, was centered in the power supply. A careful check of that unit disclosed absolutely nothing — voltage readings were normal, rectifier and voltage-regulator tubes checked out well, and the filter capacitors were good. A series of checks of the line voltage likewise provided no clue to the cause of the trouble; there were fluctuations of as much as 10 volts over a period of days, but these fluctuations did not invariably coincide with the distortion.

A spell of particularly warm, humid weather finally provided the key to the puzzle. The raspiness during this period extended well down into the lower octaves, and it occurred to me that the instrument might be sensitive to moisture. This proved to be the case. During the warm summer weather, the windows of the room in which the organ was

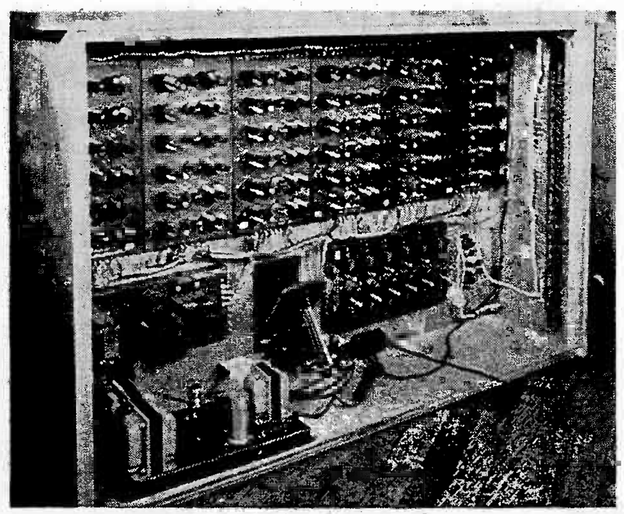


Fig. 5. Rear view of Spinet's interior shows rows of tone generators. The power supplies are mounted at bottom left.

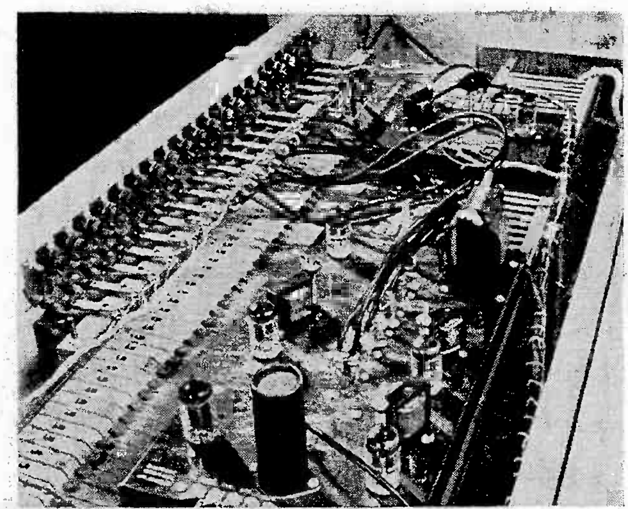


Fig. 6. With the lid up, the interior of the Spinet looks like this. Manual and pedal tone changers are in foreground.

kept were often left open at night. When the humidity was low, there was no trouble; but when the air was moist, the raspiness of tone recurred with severity in direct proportion to the degree of humidity. The cure, of course, was to let the organ warm up for a while before it was played. Usually a warm-up period of 15 minutes was sufficient to dry things out enough so that there was no trouble; in very damp weather a half hour warm-up period was necessary*. With the advent of cold weather in the fall, the trouble disappeared completely, since the windows were kept closed and the damp night air shut out.

After I had finished all the work on the Spinet, I received a memo from Electronic Organ Arts concerning the pedal tone changer. The pedal tone changer, as was pointed out in the preceding installment, contains the oscillator for the 13th pedal note. The flute output of this note did not pass through an RC filter as does the flute output of the rest of the notes in the pedal section. As a consequence, the 13th note was considerably louder than the rest of the pedal flutes. To correct this condition, it was suggested that an RC filter be added as shown in Fig. 8. The components of this filter are R4 and C4, and the values are given in the schematic.

The manufacturer's memo stated further that, since the 290-volt input to the pedal preamp is not filtered, there might be cross talk which would cause the manual strings to play faintly when the pedal stops were down. I had not noticed this condtion on the Spinet, but I added the filter suggested to prevent it. This change is shown at the 290-volt input in Fig. 8.

Tuning the Organ

Giving the organ its final tuning was a job that called for ears better trained than mine. Electronic Organ Arts has a kit of tuning forks which it will rent for $5 a month. Renting a set of these forks is probably the best thing for most organ builders to do, and I might have saved myself a lot of time if I had done so. When it came time to give the Spinet its final tuning, I called in a musician friend of mine, and with his help did the job in a little more than an hour. How much time I had wasted earlier trying to get the instrument in passable enough tune that I could pick out a simple melody on it, I don't know.

*I learned later that Electronic Organ Arts has an electric heating device that can be mounted inside the console. This heater radiates just enough heat to keep the inside of the instrument thoroughly dry.

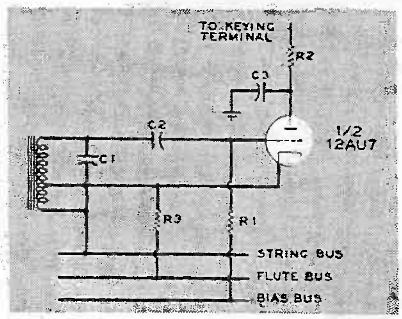


Fig. 7. Tone generator trouble on four notes was cured by reducing R2.

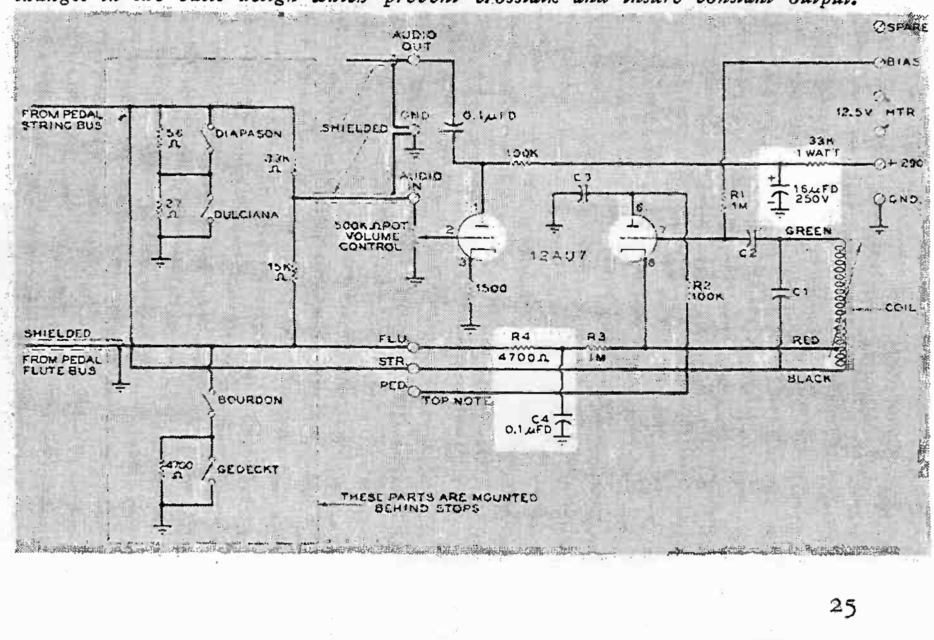
Once the Spinet was in tune, though, the fun began. People my wife and I hadn't seen for months dropped in to see the organ they'd been hearing so much about while it was being built. I was, understandably, favorably impressed with my own handiwork, and it was gratifying to find that people who came to hear it were impressed too. Some even made subsequent visits, bringing their own music since our supply was scant.

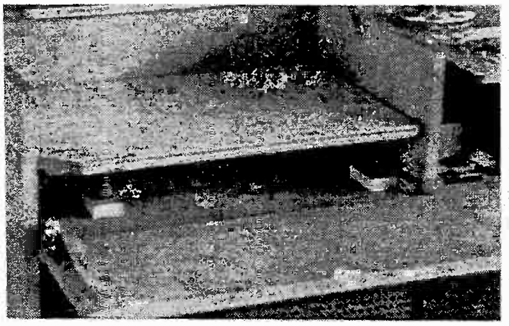
Bigger and Better

This experience in building the Spinet has been a fascinating one, and it has opened my eyes to some of the possibilities inherent in electronic musical instruments. Now that this organ is finished, I would like to build another—bigger and better. I've been looking

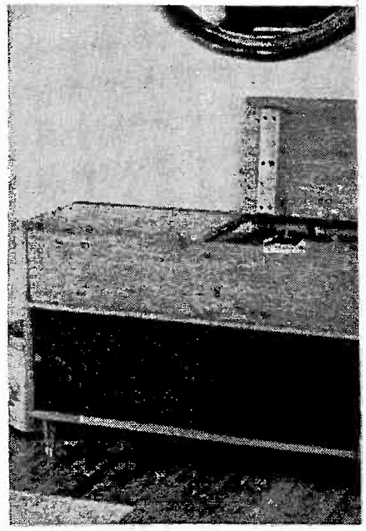
Continued on page 48

Fig. 8. Schematic diagram of the pedal tone changer. The white squares indicate changes in the basic design which prevent crosstalk and insure constant output.





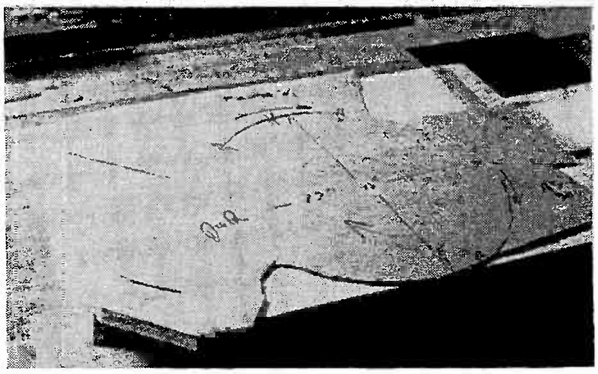
fit compartment with 7/8-inch clearance all around for spring suspension and ventilation.



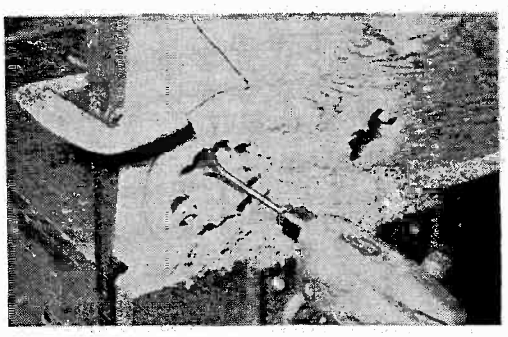
This is the cabinet in which the author installed the turntable and pickup arms in the process pictorially described on these pages. The hardwood cabinet was stained and varnished to match birch furniture and speaker enclosures. Tape recorder fits in right-hand compartment.

Spotlight on

a how - they - did - it feature by an AUDIOCRAFT expert on phono reproducers, Dr. John D. Seagrave



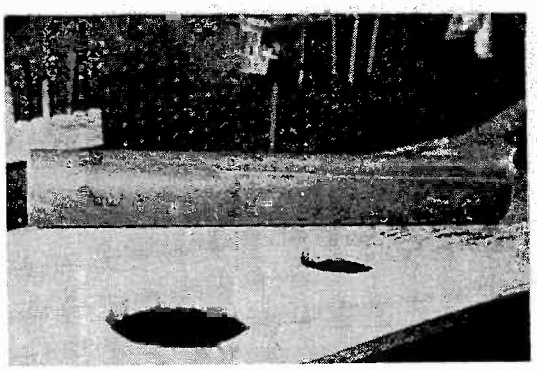
Cardboard outline templates were made of each component to help determine optimum location. Arm templates are cut concave with turntable radius to maintain correct spacing as templates are shifted. Center holes for turntable and cover plate were transferred to mounting board and the over-all outline marked.

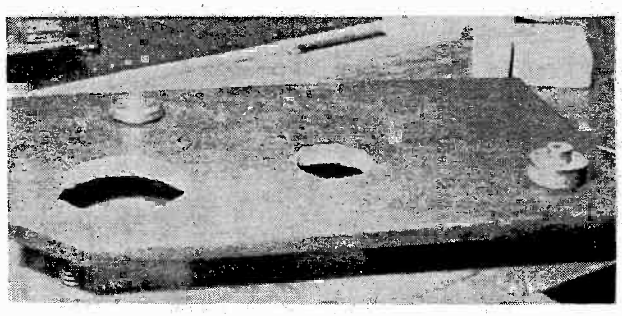


Motor and bearing clearance holes were roughed out by drilling a series of adjacent holes. The rough edges were smoothed with a file.

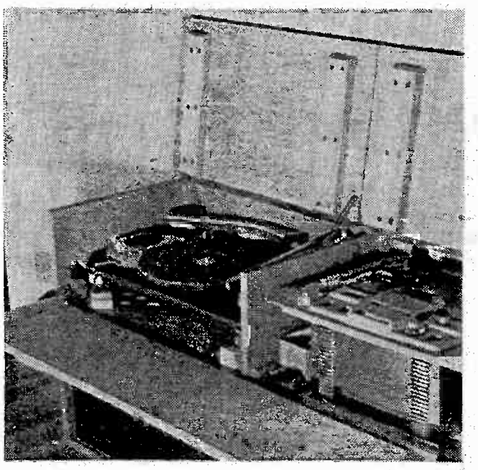
Motor clearance hole was offset with respect to cover-plate outline, and compass was used to find proper position. Compass center is in hole transferred from cardboard template.

After all mounting holes had been drilled and smoothed, board was ready for covering with plastic adhesive "veneer," shown rolled on mounting board.

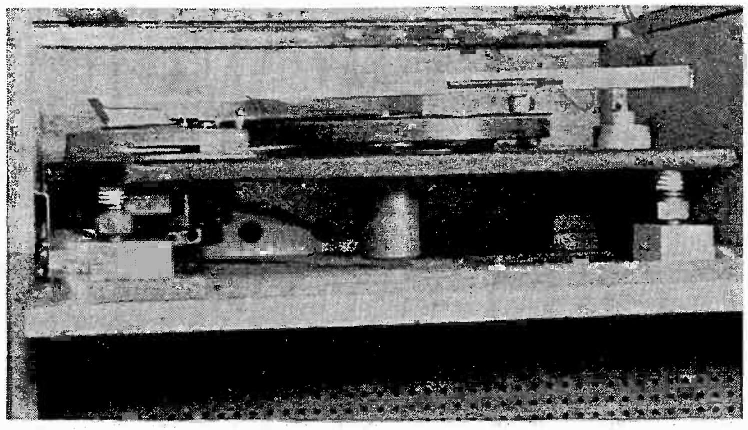




The mounting board has been covered with plastic, and all mounting holes cut away. The arm bases have been mounted and suspension springs placed in holes drilled part way through from underside of the mounting board.

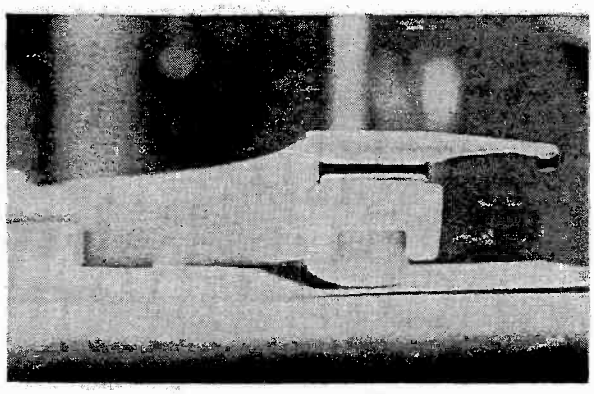


The completed installation, ready for operation. Note ventilating holes drilled in board under motor.



Edge view of the completed installation after levelling. Mounting springs rest on nuts which are threaded on bolts set in the wood blocks.

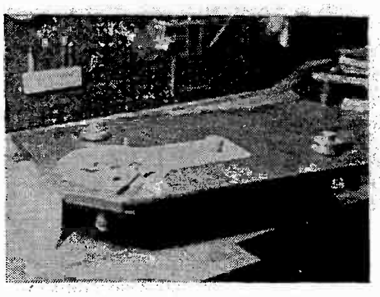
Phono Mounting



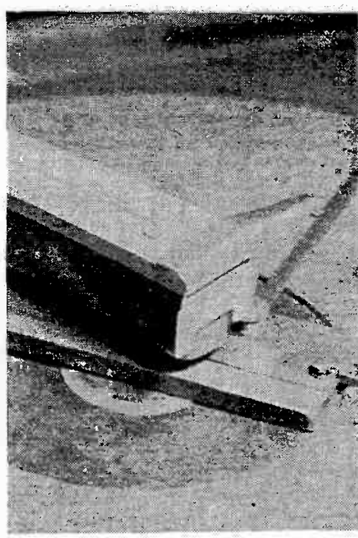
Horizontal alignment of Fairchild arm. The arm must be perfectly parallel with turntable over the entire playing surface of the record.

When you bought your latest turntable and base, were you forced to let the contraption rest atop a shelf or table, all the while resisting a yen to build it in because you didn't have the first idea where to start? If this has been your unhappy plight, cheer up! Study these pictures carefully for A-to-Z tips on turntable and arm mounting. The photos show an installation built by Dr. John D. Seagrave, an authority on pickups whose articles on minimizing tracking distortion appeared in these pages some months ago. He bought his cabinet ready-built from Country Workshop, Newark, N.J., and in it installed a D&R 12A turntable, and Fairchild 280A and Audio Specialties AS-30 pickup arms. Now look at the pictures to see how an expert went about the task, reading counter-clockwise from top of opposite page.

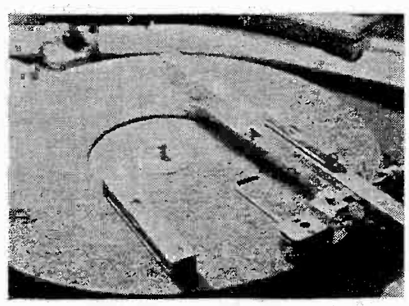
Underside of mounting board showing terminal strips used for motor and arm connections.



Motor and bearing have been screwed to the board, and unit is ready for final assembly.



Overhang of the Fairchild arm is adjusted using jig with scale which slips over turntable spindle.[1] Arm has also been levelled to track parallel with turntable.



AS-30 radial arm is positioned so that stylus is in line with turntable spindle at all points of travel. Adjustment is by means of an Allen wrench.

[1]"Minimizing Tracking Distortion", AUDIOCRAFT, Dec. 1956 and Jan. 1957, by the author.

TRANSISTORS *in Audio Circuits*

by PAUL PENFIELD, JR.

VIIIa: Intermediate Stages

In this part we shall take up a number of relatively unrelated topics, each of which is important. These include intermediate-stage amplifiers, interstage coupling, phase inverters, volume controls, loudness controls, mixers, equalizers, and tone controls.

Intermediate-Stage Amplifiers

Input stages require special techniques (covered in the preceding part) for reducing noise and properly terminating the source. Output stages require special effort to secure load-impedance matching without distortion. But with intermediate-stage amplifiers the only concern is usually maximum gain with the simplest circuit.

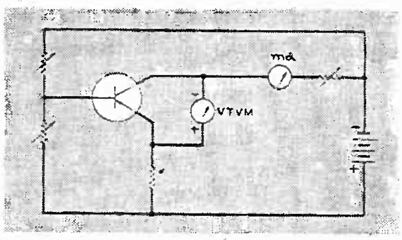


Fig. 1. Experimental circuit used to find values needed for best operation.

First, the bias network is designed by consulting the characteristic curves of the transistor, as discussed last February. It is also possible to design the bias network simply by trying various circuit values, working toward the desired quiescent point. A typical experimental circuit[1] is shown in Fig. 1. The voltmeter, incidentally, should be a VTVM type.

[1]Normally only grounded-emitter circuits are used for intermediate stages; Fig. 1 shows this type.

Remember that amplifiers meant to work reliably over any but a limited temperature range should have good bias stabilization. The simplest bias scheme for intermediate stages (Fig. 2A) has poor stability — that is, a high value of S, the stabilization factor. There are three ways to improve on this circuit.

A series emitter resistor as shown in Fig. 2B will help keep the emitter current steady. This will reduce the AC gain of the stage, but it can be bypassed, as shown, to prevent this. Capacitors larger than 50 μfd may be required to keep up the low-frequency gain.

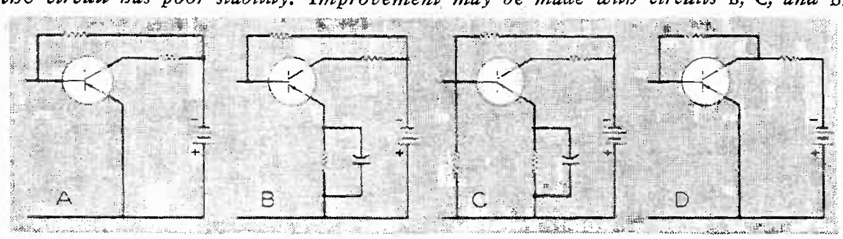
Second, the base can be fed from a voltage divider instead of a series resistor. This is especially helpful in conjunction with the first method, as Fig. 2C shows. The AC gain reduction is then small.

Third (Fig. 2D), the base can be fed from the collector, rather than from the power supply directly. The stabilizing effect here is that a slight increase in collector current will decrease the base current automatically.

It is customary in designing good equipment to use any combination of these three methods to advantage. Remember, when working with bias networks, to consider the capacitors as open circuits; but when making calculations of AC gain, input impedance, etc., consider them as short circuits.

Use the formulas given in the June installment to compute the AC quantities of interest. These formulas apply, of course, only to the transistor and not to the stage as a whole. So when computing the "load" or "source" resistances seen by any transistor, be sure to take account of the bias and coupling circuits.

Fig. 2. Four methods of intermediate-stage biasing. Example A is simplest, but the circuit has poor stability. Improvement may be made with circuits B, C, and D.



Of the several types of interstage coupling methods, the most common by far is capacitor coupling. Other methods include transformer coupling, direct coupling, and tandem coupling. Each of these has its own advantages and disadvantages.

Capacitor Coupling. As Fig. 3 shows, only one component (the capacitor) is needed besides the normal bias networks, and this is small, lightweight, and cheap. Capacitors last for a reasonable length of time and are fairly reliable. The distortion is negligible. High-frequency response is excellent, and the low-frequency response is limited only by the size of capacitor used. Between two Class-A stages one would normally not consider any other method.

The size of capacitor required depends on how low in frequency a full response is desired. Each coupling circuit introduces a loss in response starting at the "cutoff" frequency f; this should be chosen somewhat lower than the lowest frequency of interest, so that the effects of several capacitors do not add up too severely.

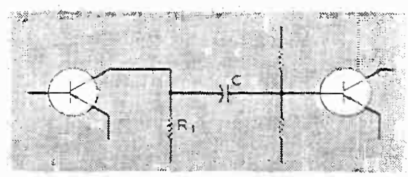


Fig. 3. Capacitor coupling. Text has formula for finding capacitor value.

Once this value of f is picked, the capacitance C is found from the formula,

$$C = \frac{1}{2\pi f R}$$

Where R is the AC resistance the capacitor "sees"; that is, the sum of the input resistance of the following stage and the output resistance of the preceding stage (including the bias resistors in each case). In many simple amplifiers this is almost equal to the collector bias resistor, R_1, in Fig. 3.

If f is in cycles per second and R is in ohms, C will come out in farads. Multiply by 10^6 (or one million) to get the value in μfd.

Transformer Coupling. Here there are many advantages with one big disadvantage: good clean transformers are hard to come by. At present it is impossible to make a good high-fidelity transistor transformer for interstage coupling that is small, cheap, and light in weight.

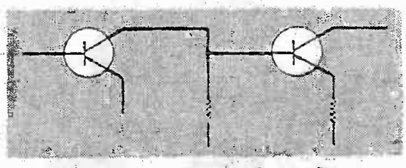


Fig. 4. Direct coupling has advantages of capacitor coupling with fewer parts.

All miniature transformers for transistor circuits sacrifice quality for small size. By high-fidelity standards the frequency response is poor and the distortion is too high. Even if the quality were not important, however, transformers are larger, more expensive, and heavier than capacitors. They are more efficient, to be sure, but it is still usually cheaper to use an extra stage of amplification instead of a transformer. For practical low-power coupling between Class-A stages one would have very little reason to use a transformer.

Direct Coupling. Fig. 4 shows the basic circuit, which uses very few parts and yet has all the advantages of capacitor coupling. In addition, the frequency response extends right down to DC. The only difficulty is that the two stages cannot be biased separately.

Biasing two stages at once is about four times as hard as doing one stage. The collector of the first stage and the base of the second stage must be at the same DC potential, which usually means either an extra battery for the second stage or else an emitter resistor.

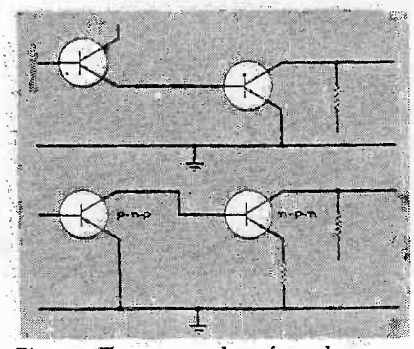


Fig. 5. Two examples of tandem coupling, another form of direct coupling.

We can no longer consider the temperature stability of each stage separately, but instead must work out a theory for both transistors together.

Aside from the biasing difficulties, however, direct coupling is an excellent method to employ. It is often practical for two stages, and sometimes even for three.

Tandem Coupling. One useful form of direct coupling is tandem coupling. Two simple circuits are shown in Fig. 5. In each, the entire collector (or emitter) current from the first stage flows through the base of the second stage.

The advantages show up when the first transistor is made for smaller bias currents, since the two bias currents must be quite a bit different for tandem coupling, as will be discussed later in this series.

Phase Inverters

Conventional push-pull amplifiers need some kind of phase inverter, and often ordinary low-power transistors will do the job. Many of the common vacuum-tube circuits can be used with a little modification.

Split-Load Phase Inverter. The transistor counterpart of this common circuit is shown in Fig. 6. Since the emitter and collector currents are nearly equal, the voltage drops across the two loads will be equal but opposite. Each output voltage will be less than the input voltage, so there is no voltage gain[2], although there is considerable current gain.

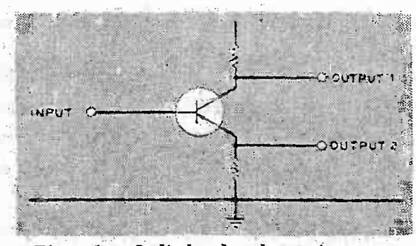


Fig. 6. Split-load phase inverter is extremely simple but effective.

Another disadvantage is that the collector and emitter currents are not exactly equal, and so the outputs are not quite balanced. They will be, however, if the two load impedances are in ratio $1{:}\alpha$.

So long as the loads seen by the transistor are in this ratio, then we have a good balance. Part of the "loads" may be bias network, and part may be the push-pull stage being driven. In order to get perfect balance, one of the biasing resistors may be made adjustable. At low frequencies this will correct for differences in input resistances of the following stage, as well as the inherent imbalance of the inverter.

In spite of these disadvantages, the split-load type of phase inverter is simple and effective, and will be very popular.

Transformers. By merely center-tapping the secondary or providing two separate secondaries, we have a phase inverter of good balance, but with the same disadvantages as outlined above. Often transformer phase inversion will prove to be the best answer in driving power transistors in spite of the obvious disadvantages.

[2]Think of the circuit without the collector load. Now we have a grounded-collector amplifier with a voltage gain less than one. Inserting the collector resistance doesn't raise the emitter voltage, so the voltage gain is still less than one.

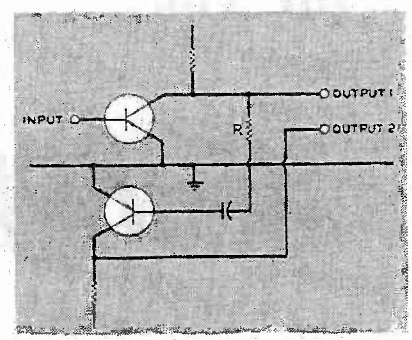


Fig. 7. Paraphase inverter circuit is not a practical one for transistor use.

Paraphase. The transistor counterpart of this popular vacuum-tube circuit (Fig. 7) is not very practical. The theory is that the bottom transistor has as its input a small fraction of the output of the top stage. Since the grounded-emitter stage by itself inverts the phase, the second output has been inverted twice, and hence the two outputs are out of phase. The base-current limiting resistor, R, is adjusted to keep the two output voltages the same.

The difficulty here is that as soon as the two outputs are loaded down, the resistor R must be changed. And whenever the transistor parameters change, R must be readjusted. If one of the push-pull transistors changes its input resistance, the resulting imbalance in paraphase output will tend further to upset the balance.

Emitter-Coupled. Also known as the *long-tail* inverter, Fig. 8 is analagous to the popular cathode-coupled circuit. In effect, the left-hand stage operates as a split-load inverter except that the emitter and collector loads are not equal. The second stage is a grounded-base amplifier, which does not introduce phase reversal. For balance the two collector loads should be nearly equal, but the

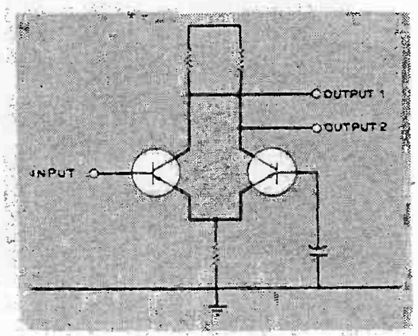
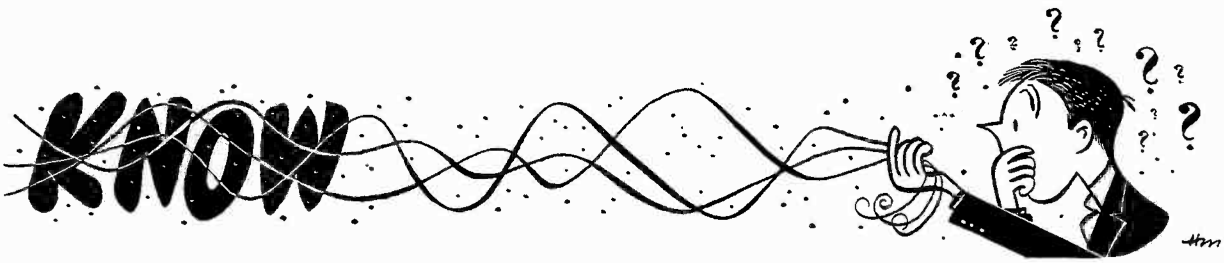


Fig. 8. The emitter-coupled transistor circuit has self-balancing advantages.

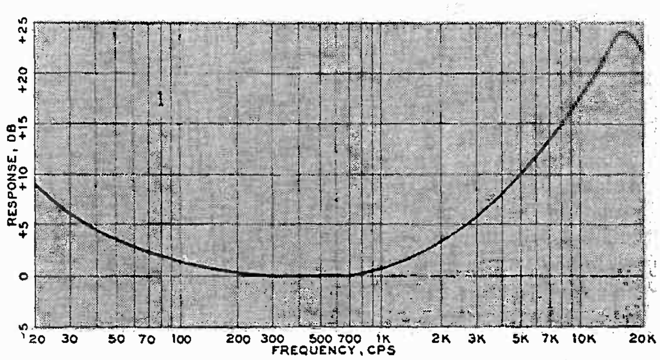
Continued on page 49

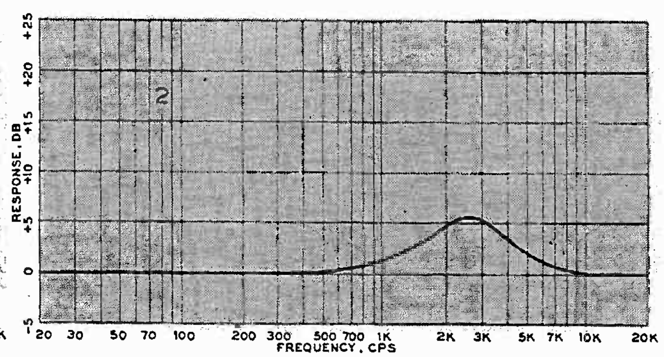
by HERMAN BURSTEIN

Do You Know Your Audio Curves



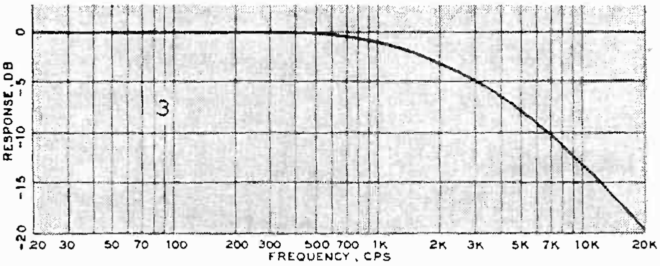
Most electronic components of a high-fidelity system — preamplifier, control unit, tuner, tape recorder, etc. — contain circuits for shaping frequency response. Best results can be obtained from a high-fidelity system only if the frequency-shaping circuits are properly operative and if the audiophile knows what to expect from them. How many of the following curves can you identify? If you name all 10 correctly, rate yourself excellent. A score of 9 is good, and 8, fair.

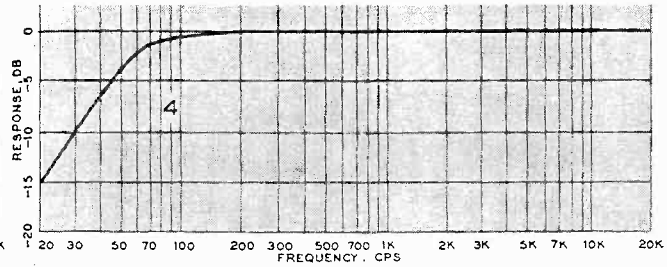


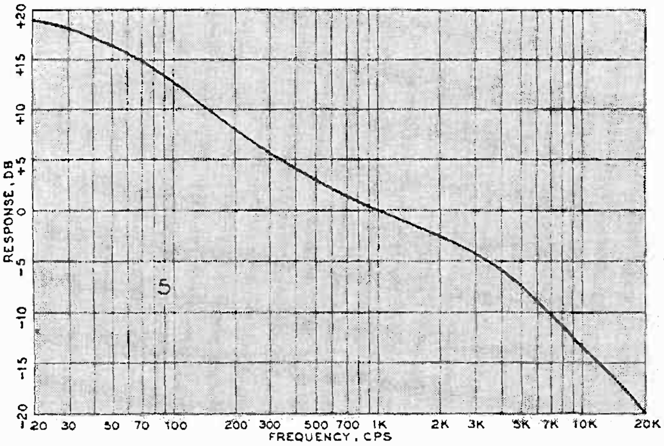


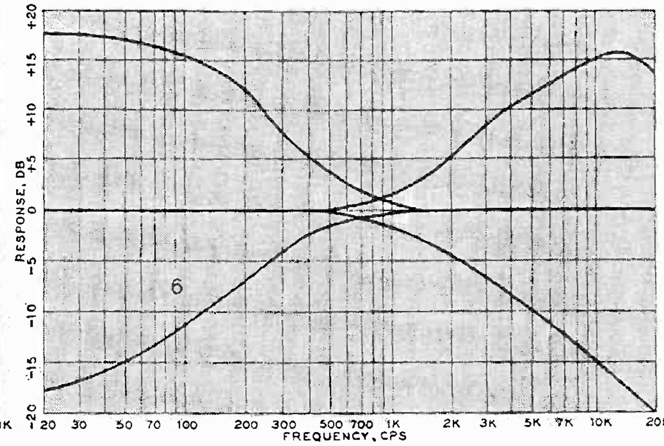
Answers:

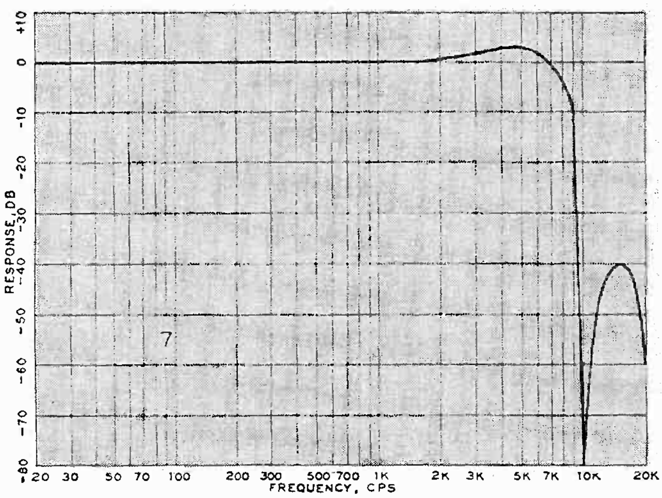
1. Record equalization of a tape recorder (typical).
2. Presence contour (typical).
3. FM de-emphasis curve.
4. Rumble filter (typical).
5. Playback characteristic for a magnetic cartridge — RIAA curve.
6. Typical bass- and treble-control range.
7. 10-Kc AM whistle filter (typical).
8. Playback characteristic for a tape recorder (typical).
9. Loudness compensation (typical): low-level and high-level settings.
10. Crossover network — 12 db per octave.

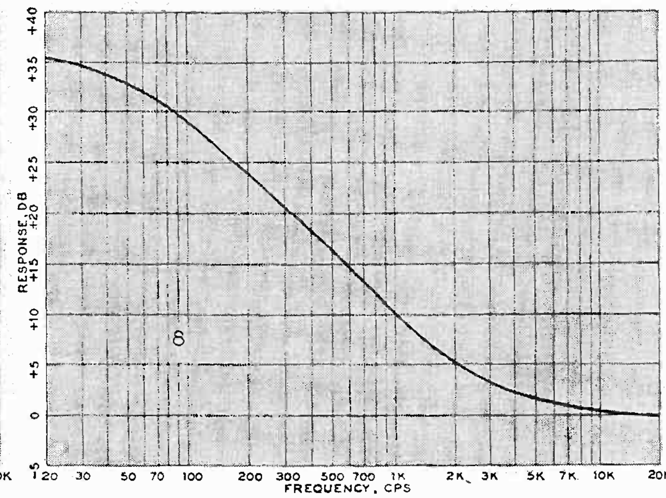

3
RESPONSE, DB
0 -5 -10 -15 -20
20 30 50 70 100 200 300 500 700 1K 2K 3K 5K 7K 10K 20K
FREQUENCY, CPS

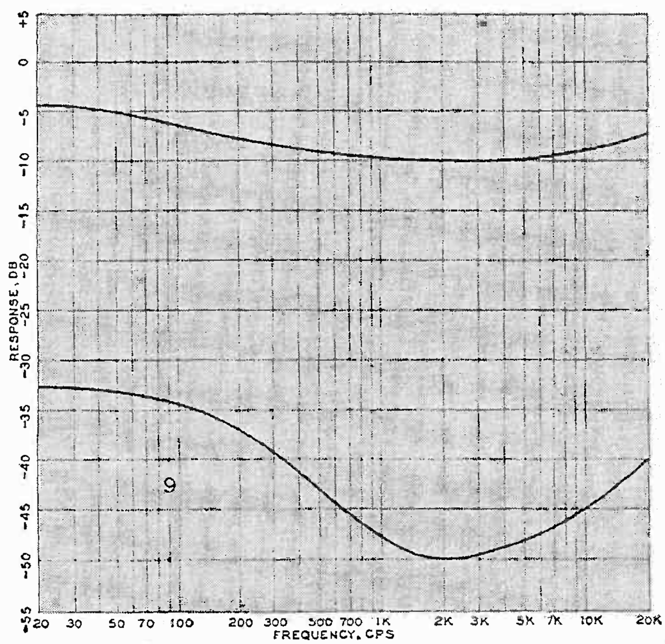

4
RESPONSE, DB
0 -5 -10 -15 -20
20 30 50 70 100 200 300 500 700 1K 2K 3K 5K 7K 10K 20K
FREQUENCY, CPS

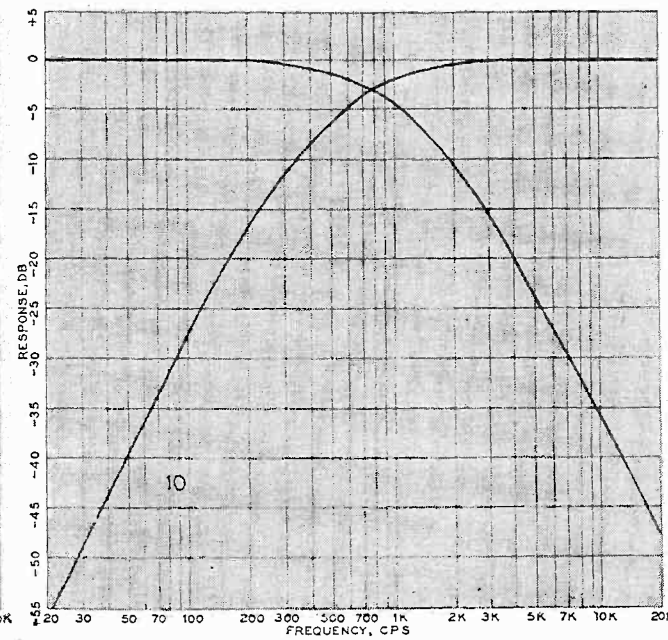

5
RESPONSE, DB
+20 +15 +10 +5 0 -5 -10 -15 -20
20 30 50 70 100 200 300 500 700 1K 2K 3K 5K 7K 10K 20K
FREQUENCY, CPS


6
RESPONSE, DB
+20 +15 +10 +5 0 -5 -10 -15 -20
20 30 50 70 100 200 300 500 700 1K 2K 3K 5K 7K 10K 20K
FREQUENCY, CPS


7
RESPONSE, DB
+10 0 -10 -20 -30 -40 -50 -60 -70 -80
20 30 50 70 100 200 300 500 700 1K 2K 3K 5K 7K 10K 20K
FREQUENCY, CPS


8
RESPONSE, DB
+40 +35 +30 +25 +20 +15 +10 +5 0 -5
20 30 50 70 100 200 300 500 700 1K 2K 3K 5K 7K 10K 20K
FREQUENCY, CPS


9
RESPONSE, DB
+5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55
20 30 50 70 100 200 300 500 700 1K 2K 3K 5K 7K 10K 20K
FREQUENCY, CPS


10
RESPONSE, DB
+5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55
20 30 50 70 100 200 300 500 700 1K 2K 3K 5K 7K 10K 20K
FREQUENCY, CPS

TAPE NEWS & VIEWS *by J. Gordon Holt*

Tape Hiss

AN acquaintance of mine, whose recording equipment seems to have an unusual predilection for obscure defects, told me several months ago about what he lightly described as an "interesting case of tape hiss." His recorder is rigged up with all sorts of gadgets like revolutions counters, head-azimuth adjusting knobs, and a cute little arrangement of a microswitch and roller, with the roller located where the tape coming from the supply reel passes over it, so that the microswitch flashes a warning light a minute or so before the tape runs out.

All had gone well for some time until suddenly he observed a marked increase in the hiss level of his tapes. He demagnetized the heads, he checked the record amplifier, the playback amplifier, and the bias oscillator, and he even tried a couple of other brands of tape. He still had too much hiss.

This was related to me as if it were just another everyday problem in the life of the happy home recordist, but I couldn't help thinking that if it had been my recorder I would have been less placid about it. Problems without solutions are fine as intellectual exercises, but I am not amused at finding them in my own equipment. As it turned out, though, there was a solution. This fellow had twice gone all the way down the list of possibles when he came to a third-time reconsideration of his tape guides. They were, he had been led to understand, made of chrome-plated brass or some similar nonmagnetic material. But just to be on the safe side he used the degausser on them, and in the process he came across one he wasn't so sure of — the microswitch roller on the warning-light flasher he had installed. He took a screw driver, rubbed it several times across the magnet pot on an old loudspeaker, and touched it to the dubious roller. It clung firmly to it. The roller was made of steel, and now that he came to think of it, by golly, he *had* used a similarly magnetized screw driver a couple of days ago to jiggle the roller back and forth, when checking the microswitch adjustment.

He used the bulk tape eraser on the roller (and the screw driver), and the hiss was gone. Then he cut the roller off and replaced it with a small piece of glass tubing so it wouldn't get magnetized again.

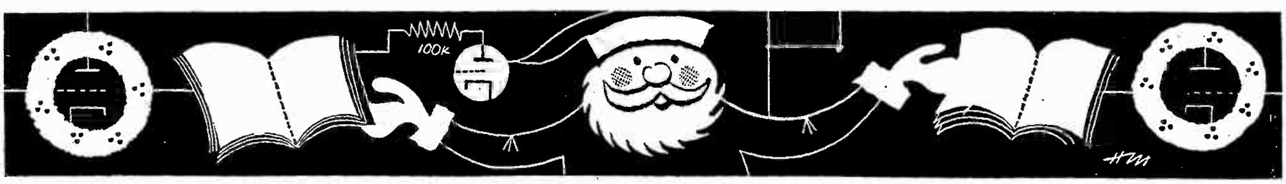
I am confident that science will eventually come up with some new ways of inducing high hiss into potentially quiet tapes, but at the present time there are only three things within the recorder itself that can cause it: the recording and/or playback amplifier, the bias oscillator, or the heads (and other tape contact surfaces). Last month we considered the conditions necessary for minimum hiss level from unrecorded tape, all of which amounted to a single requirement: total magnetic neutrality, or lack of magnetism. It was shown that neutrality could best be achieved by passing the tape through an alternating magnetic field of diminishing intensity, and it was further pointed out that this field should come from a pure sinusoidal signal. Anything that upsets the delicate balance of nonmagnetism on a tape will raise its hiss level. A DC magnetic component will certainly do it, as will any distortion in the bias signal. So let's take some rather more typical cases of hiss than the foregoing, and track down their sources. We'll worry about remedial measures when we come to them.

Assume that a recorder is noisy when first purchased. If head demagnetization, a new bias oscillator tube, and an argument with the dealer don't produce results, borrow another new machine of the same type and compare them. If they're both excessively hissy, then they are not meeting specifications (in which case neither should be purchased unless you can learn to be tolerant of hiss), or your loudspeaker system has a peaky or overly prominent tweeter, or you didn't choose a recorder with sufficiently high rated signal-to-noise ratio.

Now let's say that the recorder worked fine when purchased, but has suddenly (or gradually) developed excessive hiss. The first thing to do is demagnetize the heads and tape guides. Then recheck the hiss level by recording about 30 sec. of tape, with the record volume turned fully off. If there is no change in the hiss level, the next step will localize the source of the trouble.

Remove the tape from the recorder, prop open any safety switches that might normally stop the unit when its tape breaks or runs out, and start it running in the play mode, with all controls set to their normal listening positions. If the same offensive hiss level is noticed now, it is certain to be originating in the playback amplifier — probably in a noisy preamplifier resistor or tube, or a leaky capacitor. If the recorder uses separate heads and amplifiers for recording and playback, switch the output selector control to monitor the recording amplifier, and note whether this (with its input shorted and its volume control at a typical setting) is the source of the hiss. If not, there are only two remaining possibilities.

If the amplifiers are quiet, and the heads and tape guides have been demagnetized recently, the hiss must be the result of poor bias wave form or severe DC leakage into one of the heads. You can easily establish which it is by loading a reel of brand new, unrecorded



tape on the machine, adjusting all controls for typical playback settings, and letting about 30 seconds worth of tape play through the unit. Then with the record volume control turned all the way down, switch the unit to record for another 30 seconds, and finally turn the record level up full for a second or so to provide a signal that will indicate the end of the test when replaying the tape. Now rewind and play the whole thing through. If the hiss remains essentially unchanged throughout the whole test run, the playback or combination record/playback head has DC current running through it. This will usually be traceable to a gassy playback preamp tube. Try replacing this, or install an isolating capacitor between the head and the input tube grid. A .05-μfd, 600-volt unit should serve the purpose, and it may also be necessary to add a 1-megohm grid resistor between the preamp grid and ground.

If hiss is normal during the first part of the test run, but becomes excessive when the unit starts to record, there may be DC leakage between the record amplifier and the head. Alternatively, the bias oscillator tube or its associated circuitry may be at fault. Remove the oscillator tube from its socket, and then repeat the last test with another section of new, unrecorded tape. If the hiss level is now the same during both halves of the test, the oscillator tube may be defective, a component in the oscillator circuit may have drifted off value, or a capacitor between the oscillator coil and the head may be leaking. If, however, the results of this test are the same as the first, the hiss will almost certainly be due to leakage through the coupling capacitor between the record amplifier and the head.

That just about does it. Any recorder that continues to hiss badly without being defective in any of the ways described here should be sent back to the factory for reconditioning or should be replaced. I can't suggest anything else to do with it.

While we're on the subject of tape hiss, we might logically consider signal-to-noise ratio specifications as they would appear in spec sheets, and as they relate to audible hiss.

The signal-to-noise ratio of a tape recorder is defined as the intensity difference (in db) between the maximum recording level of a tape and the hum and hiss level of the tape in the absence of a recorded signal. The NARTB standard for signal-to-noise ratio calls for a rating of peak recording level versus total unweighted playback noise, when erasing a signal of peak recording level. Peak recording level is specified as that level which produces not more than 3% RMS harmonic distortion at 400 cps. Thus, to obtain a signal-to-noise specification conforming to the NARTB test standard, you would feed a 400-cps tone to the recorder, increase its level until the harmonic distortion in playback reached 3%, and then use this playback level as the zero-db reference. Then with the playback volume control at the same level as before, and the record volume control all the way off, the recorder would be used to erase the tape it had just made, and the output from the erased tape would be compared with the original output reading. The difference between these, expressed in decibels, would be the recorder's signal-to-noise ratio, à la NARTB.

There are, however, several other ways of measuring signal-to-noise ratio, and since each method will give a different (and usually more favorable-looking) specification than will the NARTB system, it is not practical to put too much faith in any signal-to-noise ratio specification for which the test conditions are not specified. Manufacturers of better-quality recorders will generally use (and specify) the NARTB method, but most others should be eyed with some skepticism unless their specs are specific. Remember that peak recording level as defined by the NARTB may be "normal" level to someone else who chooses tape saturation level as his peak reference.

As far as the audibility of tape noise is concerned, this is dependent to a great extent on the response smoothness of the loudspeaker system and the average playback volume in the room. It is always true that the louder a tape is played, the more audible its hiss will be during quiet passages. It is also true that, for a given playback volume, a peak of a certain amplitude in the loudspeaker system will increase tape hiss proportionally. So keep your speaker system properly balanced and, if necessary, plan to replace your tweeter sometime in the future. After all, when tape hiss is a real problem, an extremely smooth tweeter is likely to prove much less expensive than a tape recorder with a 60-db signal-to-noise ratio (by NARTB definition).

While we're still on the subject of tape noise, I should at least mention an obscure form of noise which often tends to degrade the performance of even the best recorders. It does not appear during unmodulated sections of tape, but shows up as hiss accompanying middle-range, steady-state tones, and increasing in severity with the frequency of the signal tone. On musical material, it is audible as a roughening of upper-middle and upper-frequency sounds, and may easily be mistaken for distortion or rubbing tweeter voice-coil noises. This FM noise is caused by excessive friction between the tape and the recorder's head assembly. Ideally the tape should slide smoothly over the heads in one continuous motion, but if the sliding friction is too high, the tape may tend to pass in rapid alternations, sticking to the head, slipping along a little bit, sticking again, slipping some more, and so on. The effect has been likened to that of a violin bow passing over a string; it does not slide smoothly, but tends rather to pluck rapidly at the string as it passes. Since recording tape is not free

Continued on page 50

It's recorded silence!

by NORMAN H. CROWHURST

Stereoddities

"This business of stereophonic sound has me confused," a friend from a far-away state complained to me recently. With all the conflicting notions about the subject, this did not surprise me too much. But his puzzlement sprang from a comparison between his own experiments with it and those of his friends. It seems his friends had been raving about certain stereo tapes being "way ahead of anything you've ever heard on 'monaural.'" So he invested in a stereo system, or rather converted his existing system into a stereo system, only to find a most disappointing result: the single-channel material all sounded better than the stereo tapes that his friends had been so pleased with.

Was something wrong with his ears or his listening room, or did he have poor copies of the tapes? Had he lived round the corner it would have been easy to listen and draw my own conclusions. As it was we had to sit down and theorize. He drew out the shape of his living room, which was reasonably typical, and sketched in different ways he had tried placing his loudspeakers. We discounted the possibility of bad tapes because *all* his stereo tapes seemed poor, and he had also tried borrowing copies from his friends. As a further check he had played monaural tapes, and also one track of his stereo tapes, over both speaker systems; in each case, he reported getting more pleasing sound than the true stereo.

Well, just what differences did he observe? It seems the single-channel presentation gave a better sense of "space" than the stereophonic tapes, and that the sound from the latter was "very confused." Musical instruments were not so readily identified from the stereo presentation. Were it not for the contrary experience of his friends, he would have concluded that stereo is all balderdash and poppycock, sold his extra equipment, and gone back to plain high fidelity. He had to admit that his friends — *with less expensive equipment* — were getting better results from their stereo tapes than he was, and he wanted an answer.

It was not his speaker placement that was wrong, but the actual choice of loudspeakers. His high-fidelity system had included one of the more expensive multiunit systems, with sound coming from several sources — the kind that comes with a certificate of its performance, complete with frequency response. There was nothing wrong with its frequency response, he had checked that. Nor had some mysterious distortion crept in.

His experience proved to be due to the fact that sound comes out all round the old loudspeaker system. On single-channel program, with one such loudspeaker, an orchestra sounds very good — much better than the smaller units without the distributed sources. Two loudspeakers of this type, which he had, sound even better than one *on single channel*, for orchestral program material anyway. That, apparently, is what he listens to most.

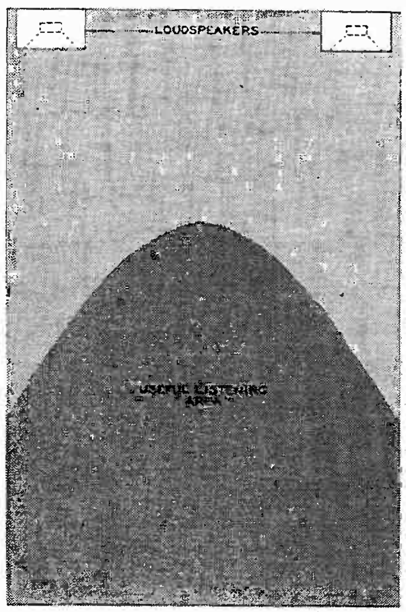


Fig. 1. Long, narrow living room will provide maximum stereo listening area.

So now, with what should be a superb system, all checked out with single-channel, familiar material, he sat back to listen to this wonderful new medium — stereophonic sound. What a disappointment he had! What had gone wrong? When I suggested it was the *kind* of loudspeaker he was using, he was incredulous; after all, wasn't this the best kind he could buy?

A little theory proved necessary to convince him. What does he listen for most in his favorite program material? Why, that clean, sharp "attack" on the sounds from individual instruments, particularly strings and percussion; freedom from harshness on the various wind instruments; and being able to identify all he hears. Right. All this requires accurate handling of transients in the program — those initial sound fronts, when each kind of sound begins. To take care of this on single-channel high-fidelity systems, careful attention to extension of the frequency range, especially at the high end, and to the smoothness of the response, is vital. That is partly why he went to the big, expensive loudspeaker unit. The other part was the greater "breadth of sound" it gave him.

How do we distinguish between the components of any given frequency that come from the different instruments? When an orchestra plays strings and wind instruments at the same time, they all use overlapping frequencies — in fact, sometimes they use the *same* frequencies — but somehow we hear the orchestra as a collection of instruments playing, rather than a collection of frequencies.

Two things help in enabling us to listen that way: both are based on transients. As each set of instruments has its own set of characteristic transients, accurate reproduction over a single-channel system is one way to help recognize the fidelity of the transients from individual instruments and groups of instruments. The other is our sense of directional separation, which is also particularly sensitive to transients, but which needs stereophonic presentation.

Obviously, with single-channel program material, the directional separation has no opportunity to work; all the sound comes from a single channel. The kind of loudspeaker we use can help, and even the use of two loudspeakers instead of one helps, making the total sound radiation more like the original (although it is quite impossible for it to be *identical*, because all the sound originates basically in one place).

So for single-channel high fidelity, the loudspeaker needs to have the widest possible frequency response, and the smoothest. Its directional radiation should suit the type of program material to which we want most to listen. Even when the frequency responses and distortion figures are quite similar, individual kinds of loudspeaker are noticeably superior in rendering *different* kinds of program sound.

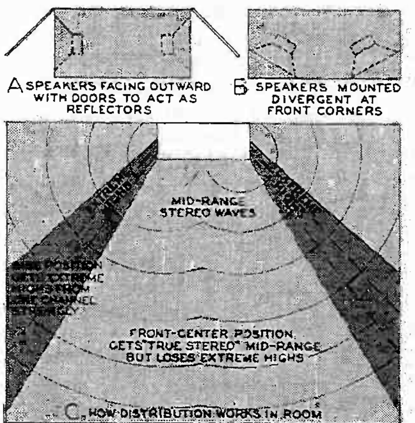


Fig. 2. Two speaker systems in single cabinet are specially made for stereo.

Few loudspeakers possess that subtle quality of being able to pinpoint a voice, particularly a deep male voice, and at the same time broaden out to reproduce a full orchestra. The ones that give this impression owe their apparent ability to *a*) better accuracy of frequency response, *b*) greater freedom from intermodulation distortion and, most of all, *c*) accuracy in handling transients.

The advent of stereo gives us another shot at the problem. The single loudspeaker never really has the ability to make the apparent distinction just described. It is a psychological distinction, made possible because of the greater accuracy in reproducing what *is* available. But stereo gives us the chance to separate transients from different original sources *spatially*. Successful use of this advantage depends on quite different characteristics of the loudspeaker's performance. The other things are still important, but now we impose a further requirement: that the two (or three, if we have three channels) loudspeakers can work together, with their slightly different program sources, to produce an integrated representation of the original sound field, with differential direction effects.

The disadvantage of the broad-source kind of loudspeaker that my friend used is that different frequencies come from different places. Consequently the transients from each group of instruments are not properly integrated, or associated together — not even as well as they were with a single-channel system. Then there was really only one source, and the big loudspeaker, or even two big loudspeakers, helped to give an impression of breadth, although it was not an accurate reproduction in this respect.

With stereo, we no longer need to cheat in this way to give the sound an *artificial* breadth. In fact, the effect of it is adverse, as my friend had found: stereo presented this way becomes confused.

At this stage in the discussion, he obviously had his faith in stereo renewed. Other related questions came to mind. He had noticed something he had vaguely dismissed as "psychological" without knowing why. In fact, many have noticed and queried this. Loudspeakers that are definitely deficient in extreme highs seem to have a better high-frequency response on stereo than on single-channel presentation.

This goes back to what gives us the impression of realism. With a standard high-fidelity system, accuracy of transient reproduction is of paramount importance. The extreme high frequencies do not make new sounds audible, as extended lows do. Rather, they make the rendition of sounds already heard *more accurate*. Triangles, cymbals, brushes, and similar sounds are audible on a system that goes to 8,000 or 10,000 cps; but extension, with smooth response, to a higher frequency improves the accuracy, making it possible to hear whether the brush is played on wood, skin, or the cymbal. It also clarifies the distinction between different sections of the orchestra, all of which were heard before, if not as separate entities.

With stereo we have a new aid to accuracy. Sounds from the different instruments can be given spatial separation. Actually, we never heard the extreme high frequencies as a separate entity (in program material), we only heard them as an improved accuracy in the reproduction of sounds whose basic, or fundamental, frequencies were much lower. Consequently, the interpretative faculty of the brain does not treat as an entity these extreme high frequencies in reproduced sound; it merely coordinates the impulses conveyed from them to increase accuracy in perception of other sounds.

This fact is confirmed by the impression given by some of the poor tweeters

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The RUMBLE *Seat*

Gentlemen:
I would like to comment, somewhat belatedly, on Mr. George L. Augspurger's article on loudspeaker testing in the March 1957 issue (p. 26) of AUDIOCRAFT.

Mr. Augspurger apparently believes that confusion reigns supreme in the field of loudspeaker performance measurement, that no one has reached any agreement on how loudspeakers should be tested, and that the measurements, in any case, tell us little that will enable us to predict the musical performance of the speaker. Specifically, with reference to evaluating distortion, he writes in total:

"The other types of specified measurements, such as harmonic distortion, are useful primarily to the manufacturer, who knows precisely the conditions under which the tests were made."

It is true that many aspects of loudspeaker performance measurement are controversial. Much more study, and further development of validated techniques, is required. I would like to point out, however, that other aspects of speaker measurement, and in particular those related to harmonic distortion, are as well understood and agreed upon among acoustics authorities as the corresponding measurements in the field of amplifiers.

There exist rigorous standards and procedures for measuring speaker harmonic distortion. These were published in 1942 by the American Standards Association (Standard C16.4 – 1942, "American Recommended Practice for Loudspeaker Testing"). At low frequencies, where loudspeaker distortion tends to become gross, RMS distortion measurements are hardly more difficult for qualified personnel than the corresponding measurements for amplifiers, and have comparable reliability.

Amplifier manufacturers vie with each other, justifiably, in boasting of values of harmonic distortion over the entire frequency spectrum which are a tiny fraction of 1%. Consumer organizations such as the Audio League have reported that values of speaker disortion in the low bass, more often than not, range from 30% to 100%. It is clear, then, that the high-fidelity enthusiast who has avidly read and checked amplifier distortion specifications, but who ignores the corresponding distortion characteristics of his speaker system, is being unrealistic. Our ears do not distinguish between the garbling of sound produced by a speaker and that produced by an amplifier.

I believe that the outstanding deficiency in manufacturers' published specifications for high-fidelity equipment is the absence of harmonic distortion vs. frequency data for loudspeaker systems, however unflattering these data may be. Audio consumers are used to amplifier distortion figures carried to the second decimal place, and a candid detailing of speaker bass distortion specs would probably create shock and consternation in some quarters, but this does not alter the need for such data.

Acoustic Research publishes distortion data on its AR-1 and AR-2 speaker systems, with test conditions specified according to the existing published standards referred to above, and the test results have proven to be entirely repeatable. Corroborating tests have been made by various organizations, both industrial and academic, using different measuring equipment (but always conforming to the established standard procedures); the results have been uniform without significant variation.

Properly measured speaker distortion data can be directly interpreted in terms of the cleanness of reproduced musical sound. If the latter were not so, all the time that has been spent in recent years talking about amplifier distortion, and reducing it to very low values, has been wasted.

Edgar Villchur
Acoustic Research, Inc.
Cambridge, Mass.

Reply:
The point I was trying to get across about loudspeaker testing was not that standards are nonexistent, but that considerable variation in measured data is possible within the framework of accepted procedure. Mr. Villchur is correct in stating that certain tests are understood and agreed upon by acoustics authorities. But the people who buy loudspeakers are not acoustics authorities. I am afraid that the nonengineer (or, quite often, the professional-engineer) purchaser is not aware of what constitutes "significant variation" and is quite often misled by specifications which turn out to be mere half-truths.

This is not a reflection upon Mr. Villchur's own organization. The extensive data published on the AR-1 and AR-2 speaker systems are probably unique for the thoroughness and honesty with which they are presented.

As to the question of measured harmonic distortion at bass frequencies, I certainly agree that accurate curves of distortion vs. frequency at various power levels are extremely valuable and should be supplied by more speaker manufacturers. But harmonic distortion is not the only standard of excellence — it measures only one factor involved in the reproduction of sound. A good speaker will have little measured harmonic distortion, but a speaker with low harmonic distortion is not necessarily good.

Mr. Villchur is to be commended for his efforts to open the "iron curtain" of loudspeaker specifications. I only want to emphasize that, as his letter states, measured performance is important only as it affects listening quality. Consequently, there is still no substitute for an extended listening test in the surroundings in which the speaker is to be used, regardless of how this may relate to measured data.

George L. Augspurger
Los Angeles, Calif.

Gentlemen:
I must object strongly to some of the statements made in the article ["The Electronic Organ: King of Kits", Part I, by Frank R. Wright, AUDIOCRAFT II, October, p. 16].

Mr. Wright states at the beginning of the article that he doesn't think an organ kit is suitable for the inexperienced amateur. Since he admittedly has no knowledge or experience of electronic organs in any form other than what he has learned from the particular Artisan kit he has, this categorical statement is ill advised, misleading, and reckless, as well as ill founded. The only such statement he is qualified to make is that the particular Artisan kit he has worked on is not suitable for the inexperienced. We state in all our advertising that no experience or skill is required to build the Schober Organ kits, and this is borne

Continued on page 38

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RUMBLE SEAT

Continued from page 36

out by the fact that many of our customers, all of whom successfully complete their kits, have never held a soldering iron before.

In the penultimate paragraph on page 35 he states that the organs which most successfully imitate pipe-organ tone are those with an independent oscillator for each note, such as Conn, Allen, and Artisan. Later in the next paragraph he says that frequency-divider organs are cheap and simple but cannot produce good ensemble tones. Again, in view of his own prefatory statements, he is not qualified to make this judgment, which is presumptuous and does not conform to the preponderance of opinion among those who are qualified to judge.

In addition to the fact that both statements with which I take issue are results of Mr. Wright's ignorance of the field and are not true, the fact that he, as managing editor, places these positive statements before your readers in the editorial columns of the magazine is a betrayal of the function of a magazine staff, which is to furnish readers with well based, unbiased information, plus comment and opinion by those qualified to give it and plainly labelled as such. In addition, the policy apparent from his statements is plainly foolish, since it labels itself to those who know enough more than he to realize that he is in error, and it alienates manufacturers (and potential advertisers) who are thus unnecessarily maligned.

Irwin Wayburn and I had discussed AUDIOCRAFT with the intention of testing its advertising strength later in the season. We plan to think very hard before going through with this now, since it would seem a bit stupid for us to advertise in a publication whose managing editor has editorially *a*) stated that our advertised claim that no experience is necessary is false and *b*) said that our organ is inferior because it employs frequency dividers. Let me suggest that you might try to repair the misleading effect your statements may have had on your readers either by publishing this letter or appropriate excerpts from it . . . , or by making an addendum to the last article of the series retracting the statements to which I have callen [*sic*] attention.

Richard H. Dorf
The Schober Organ Corp.
New York, N.Y.

Reply:

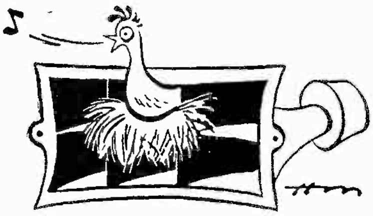
I am not so much amazed by what Mr. Dorf says as by the vehemence with which he says it, but let us examine the validity of his objections to my article.

Mr. Dorf objects first to my statement that "I do not think that an electronic organ kit makes a good starting point for the amateur kit builder just launching his career." I'm afraid that I must remain firm on this point. The simplest electronic organ is a complex instrument, and the cheapest is relatively expensive. I fail to see how anyone can conscientiously recommend that a completely inexperienced individual risk so much in a project which he may have much more difficulty in completing than he originally anticipates. Would it not make sense for him to test himself on something less ambitious, and then go on to the organ-building project with a degree of assurance that he is capable of seeing it through? I do not deny that it is possible for some inexperienced individuals to put an electronic-organ kit together and make it work, and I do not doubt that many have done it successfully. I simply say that I do not believe it *wise* for a completely inexperienced person to make an electronic organ his first kit-assembling project.

Mr. Dorf feels that I am not qualified to make any judgment in this matter since, in the opening paragraphs of this article, I stated that I had had no experience with electronic musical instruments prior to assembling the kit under discussion. His assumption that I would write an article on this, or any other, subject without adequate preparation is ungenerous, and, I might add, it is unjustified. Construction of the organ kit, research for the article, and writing were carried out over the period of a year. I do not set myself up as an expert on electronic musical instruments, but I do feel qualified to write an article of this type.

The next point seems to me to be better taken. The unqualified statement that electronic organs employing frequency dividers cannot produce good ensemble tones is ridiculous and I withdraw it. Apologies are due the manufacturers of Baldwin, Lowery, and Minshall organs — perhaps even more than they are due Mr. Dorf's company, which was not mentioned — and I hereby tender them most sincerely. I had thought merely to give a brief review of various types of electronic organs currently available, and there was no intention to cast aspersions on any particular type or make of instrument. As a matter of fact, the statement that frequency-divider organs are simple and "cheap" (your word, Mr. Dorf, not mine) was supposed to convey the idea that these qualities were to be desired. Simplicity and cheapness are, of course, relative to electronic organs: I have already observed that I consider these instruments to be neither simple nor inexpensive.

Frank R. Wright.
New Marlboro, Mass.



Sound-Fanciers'

IT'S impossible, nowadays, for a reviewer working long in advance to report on the releases of timeliest interest at the date his column is being read. But in the case of last-minute Christmas-music recordings — and considering specialized concerns of SFG readers — this is no real disadvantage. Such seasonal "specials" seldom are of notable technical interest (however appealing in other respects), and most sound-fanciers are properly hesitant about purchasing any just-off-the-griddle release until its technological qualities have been thoroughly tested.

For myself, although I may go overboard sometimes on a brand-new recording which bowls me over on first acquaintance, I prefer to wait until I have at least a few confirmatory reports, especially from listeners (professional or amateur) of quite different personal tastes and disparate sound-reproduction equipment. My own reactions may or may not jibe with those of others, but in either instance it's helpful to both reviewer and reader to know clearly whether any given reaction represents a generally accepted view, an intensely controversial one, or a frankly minority opinion.

Fortunately, one release of outstanding holiday-season importance appeared early enough to permit checking my almost incredulous delight against the reactions of several friends whose judgments I respect.

So it's with assured confidence that I hail the late Günther Ramin's version of the first half of Bach's *Christmas* Oratorio, with the chorus of St. Thomas's, Leipzig (where Bach himself was once Cantor), both as the finest performance of this stirring yet heart-warming music ever brought to records and one of the most completely satisfactory stereo recordings to date (Concert Hall RX 21-2). Every minute of the 90 or so taken up by these two reels is unalloyed sonic as well as musical joy, and irrefutable evidence that the single-channel medium, even at its best, is by no means adequate to cope with large-scale vocal-and-orchestral works — especially those demanding cathedral-acoustics spaciousness and clear differentiations among the contrapuntal lines and timbre contrasts of complex polyphonic music. In this area, at the very least, stereo is truly incomparable!

If so munificent a gift is beyond your hope of either giving or receiving, an apt consolation prize undoubtedly will be the forthcoming Shaw Chorale's *Christmas Hymns and Carols*, Vol. 1 (RCA Victor stereo CCS 86); for, although I haven't yet heard it for myself, I can safely recommend it on the basis of justly popular earlier LP editions (LM 1711, cited here just a year ago, which superseded LM 1112). If, however, your choice of a distinctive audio present must be confined to LP's my recommendations have to be drawn from quite different repertories, led by a couple of all-too-rare outstanding examples of sonic humor that every listener can enjoy to some extent, but which are sure to tickle most expertly the fanatically serious audiophiles.

Concert and Hi-Fi Burlesques

One is the anticipated release (Angel 35500) of an actual performance recording which has been delighting thousands of British gramophiles who missed the original *Hoffnung Music Festival Concert* of 13 November, 1956. Like all such documentaries, the uproarious bursts of audience laughter and applause sometimes seem inexplicable (visual-only shenanigans?) and eventually get a bit tiresome. Nevertheless, the comedy here is not only convulsively funny on first hearing, but demands interminable encores whenever you can inveigle fresh captive audiences into your living room. Its high points for me are the late Dennis Brain's heroic performance of a Leopold Mozart "Hosepipe-and-Strings" Concerto finale, Franz Reisenstein's "Piano Concerto to End All Piano Concertos", a four-tuba transcription of a Chopin Mazurka (with Hoffnung's dead-pan description of his subcontrabass instrument), and the Hoffnung-Arnaud recitation of Scott's "Lochinvar" to Humprey Searle's hi-fi-display percussion accompaniment. Not until you finally stop roaring over these, however,

Guide

by R. D. DARRELL

will you be able to appreciate the impressiveness with which the recording itself conveys the big but extremely brilliant acoustics of the Royal Festival Hall, and the novel tone colors of the preposterous wind-instrument ensemble demanded by Gordon Jacob for his sonically almost incredible variations on "Annie Laurie."

The other example is more sophomoric but even more directly deflationary of common audiophile foibles: *Hi-Fi Sounds for Hounds* (San Francisco M 33009), with takeoffs on frequency tests, sonic documentaries, etc., not excluding a gallery of candid self-portraits in sound of the San Francisco company's working personnel. Even if this disc is never played more than once, it's still well worth conspicuous display in every hi-fi fan's library simply for its jacket picture (a glumly headphoned hound) and annotations — including the recommendation to use, in reproduction, the new T.A.G.I.T.S.R. curve. New? Bosh! "Try And Get It To Sound Right" playback characteristics are as old as high fidelity itself!

Lagniappe for Jazzists

Definitely hot, nonsweetened jazz may seem an odd Christmas recommendation, but if you have the right ears for it there is little in modern recording (stereo tapes in particular) which can be more exciting. Even if you haven't such ears, those you do have may well demand resensitizing after too long exposure to the inanities and distortions of commercially PA-distributed exploitations of hackneyed carol materials. In any case, *The Jazztone Mystery Band* (Jazztone J 1270) is ideal for holiday-party testing of jazz-expert friends and guests. Be sure to play fair and try to identify the familiar-style soloists heard here before you read the jacket notes to discover who they really are.

It would give the game away to say where this recording was made, but while good enough by current standards, its comparative lack of acoustical warmth and transparency can be demonstrated by comparison with Buck Clayton's *Buckin' the Blues* (Vanguard VRS 8514). And then, again, what LP's even at their best still lack in dramatic atmosphere and impact can be realized only when you proceed to play the stereo versions (VRT 3006, with the same title,

Continued on next page

SOUND FANCIER

Continued from preceding page

and VRT 3008, *Jimmy Rushing Meets Buck Clayton*). Another illuminating comparison, for stylistic more than sonic differences, is with the *Buck Clayton Session* (Omegatape single-channel JT 1003), in which Buck is featured with expert French stars in five pieces and other Frenchmen appear alone in four more. However one may evaluate the extremely brilliant and clean Gallic recording here, he is sure to be impressed with the genuine idiomatic skill developed by overseas jazzists, and the consoling fact that they still have something to learn in the way of relaxation and true "coolness."

The jazz masterpiece of the year, however, is *Jazz at Stereoville* (Concert Hall stereo tape EX 40). I haven't heard the LP version (*The Big Challenge*, Jazztone J 1268), but while I'm sure the playing of Cootie Williams, Coleman Hawkins, and Lawrence Brown, as pitted against that of Rex Stewart, Bud Freeman, and J. C. Higginbotham, is mightily exciting there too, it's only in stereo that the whole idea of this "cutting" contest can be fully realized. For the first three soloists are clearly on the right side, the

other three no less clearly on the left, with the four-man rhythm section centered between them. And the pleasure of hearing just *where* the individual solos are coming from incalculably enhances one's relish of the infectiously swinging performances, as well as stamping this taping as one of the most imaginative of stereo triumphs — inconceivably as effective in any other medium.

South of the Border, It's *Alta Fidelidad*

A quasi-technical point I've harped on before, but which I feel never can be overemphasized, is that top-notch recording per se never is enough to make a sensational DDT (Display, Demonstration, and Test) record. The musical, or sheerly sonic, materials themselves must be capable of brilliantly exploiting both the recording and playback equipments' frequency spectra, dynamic ranges, transient-response and allied characteristics. Between the extremes of oddball effects and the big showpieces of familiar symphonic repertories, music of a somewhat exotic cast is particularly good for this purpose; and many of the best examples are provided by Latin-American musicians with their typical preoccupation with percussion, festive spirits, and piquant rhythmic animation.

Two unusually effective current LP's in this domain are similarly titled, but actually different: *¡Mexico, Alta Fidelidad!* (Vanguard VRS 9009) and *Viva Mexico!* (Capitol T 10083). The former is a folk-ensemble program of eight *sones jarochos* and five *huapangos huastecos* with lots of fervent singing, but most interesting to me for its sparkling recording of such transient-rich instruments as a folk harp and various guitar variants — *requinto, jarana*, and *huapanguera*. The latter disc demonstrates the high skills both of the Orquesta Sinfonica Nacional under Luis Herrera de la Fuente and of four national composers: Silvestre Revueltas, Blas Galindo, José Pablo Moncayo, and Daniel Ayala. The first-named's "*Homenaje a García Lorca*" is a really astonishing work; the dance pieces by the next two are more conventionally "Mexican," yet imaginatively scored and infectiously high-spirited; and if Ayala's "*Tribu*" scarcely succeeds as an evocation of ancient Mayan Music, some of its percussive and pentatonic passages do achieve notably eerie effects. But everything here comes off magnificently as beautifully recorded sound, with top honors probably going to the Mexican orchestra's genuinely big, solidly responsive bass drum.

Even more exciting and expansive, if less aesthetically substantial, is *¡Torero!*, Vol. 3 of Audio Fidelity's now famous *La Fiesta Brava* series (AFLP 1818), with Genaro Nunez again leading the Plaza Mexico Banda Taurina in festive bullring music and dramatic *toques* (signal fanfares). It will be treasured by many for its authenticity as a sonic documentary (and for its elaborately illustrated booklet on tauromachy), but I prize it most for its sheerly sonic and technical brilliancies — surpassing even those of its predecessors, to rank as one of the best-yet single-channel achievements of stereogenic spaciousness and open-air atmosphere.

After such big stuff, guitarist Laurinda Almeida's *Immpressoes do Brasil* (Capitol P 8381) seems musically more banal, for all the gracious charm of the little pieces by Sardinha and Almeida himself, and the novel timbre combinations of Gnattali's "Concertino for Guitar and Piano." Yet there is a fine vibrant richness to the recording of the guitar here, fairly closely miked, but without the usual loss of liveness; and many listeners will particularly cherish the haunting melodiousness of Villa-Lobos' quite unforgettable *"Gavota Chôro."*

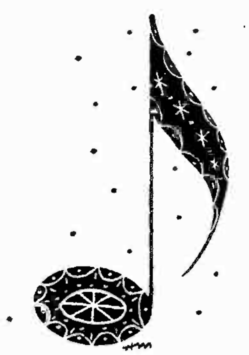
Transatlantic Exotica

From Spain we have another bullring

documentary, *The Day Manolete Was Killed* (Audio Fidelity AFLP 1831) and an aural evocation of the balletic art of *Antonio and his Spanish Dancers* (London LL 1481). The former has some background music and crowd noises, but is of primary interest to tauromachists for its vivid, detailed description of bullfight preparations and action, and its moving tribute to a great matador, well written but baldly narrated by Barnaby Conrad. The latter is notable both technically — for the crispness of its transient-rich castanets playing and *taconeo* work, or heel-and-toe clicks — and musically — especially for its suite of some six Scarlatti-like Soler sonatas, which in their restrained but piquant way are even more essentially Iberian in spirit than the more orthodoxly gaudy "Spanish" colorings of Granados (a seldom-heard piano-and-orchestra *"Allegro de Concierto"*), Turina, Falla, Larregla, and Sarasate.

Still more conventionally "local"-colored are the lighter symphonic pieces in Frederick Fennell's *Hi-Fi a la Española* with the Rochester Pops Orchestra (Mercury MG 50144) and the singular medley of offbeat music in *Africa Speaks, America Answers* by Guy Warren, African drummer and chanter, with the Red Saunders orchestra (Decca DL 8446). But the former well-diversified program is played with notable verve and precision, potent in immediate musical appeal, and of unusual technical interest for its astonishing dynamic range: from crystalline delicacy to the utmost power of well-nigh solid tonal impact. The latter makes mildly effective use of echo-chamber techniques to enhance the ritual atmosphere of some complex drumming and chanting, here all mixed up with jazz dilutions and adaptations featuring some swinging if rather oversentimental vibes playing.

For the last word in exotica, however, and more of the eeriest sounds that have ever been devised to perplex, titillate, and affright human ears, the prize LP is



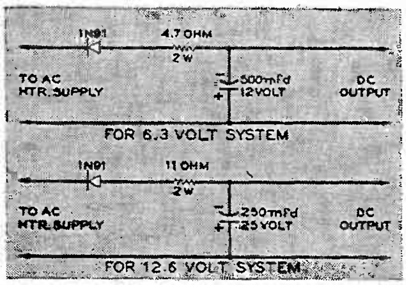
Vol. 2 of the *Panorama of "Musique Concrète,"* London Ducretet-Thomson DTL 93121). The most ambitious entry here, the Schaeffer-Henry *"Symphonie pour un homme seul"* is not as over-

Continued on page 50

DC on Filaments

Hum reduction in high-gain preamps is not always a simple and straightforward problem, and many times it becomes necessary to resort to DC for the tube heaters to achieve really good performance. Usually, the first stage is all that must be put on a DC source, and the power requirements are then within range of small and inexpensive components.

The 1N91 diode is not ordinarily rated by the manufacturers for operation at more than 100 ma load current. However, when the peak inverse voltage is very low, as it is here, the load current



Two versions of the rectifier circuit suggested for putting DC on filament of first stage of a high-gain preamplifier.

can be increased many times provided a current-limiting resistor is used to limit the maximum surge current. The resistor is usually required anyway to keep the DC output voltage low enough to prevent exceeding the heater voltage ratings of the tubes. The capacitor provides peak rectification so the required voltage can be obtained from the normally available AC heater-supply voltages.

Two versions of the circuit are shown: one for a 6.3-volt system, and the other for a 12.6-volt system. The exact value of the resistor in each case may have to be adjusted to provide the design center voltage to the tube heaters. The value of the capacitor may be varied ±50% without ill effect.

Thomas P. Prouty
Newport Beach, Calif.

Perfect Setting

Finding the "perfect" tone-control setting for a particular recording when played over a particular hi-fi rig is an art in itself; but trying to go back and locate it a second time is like looking for the lost chord.

The difficulty can be solved neatly by marking on the record jacket your opinion of the best tone-control setting. Note both tone-control and volume-control and any other variable settings your particular rig may have. By marking this information on the same place on each record jacket, you'll get into the habit of automatically setting the controls each time.

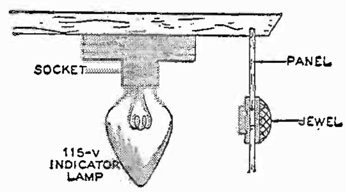
If the knobs on your control unit have no pointers and there is no scale for them to point to, these can be added fairly easily by means of decals which are widely available.

Paul Penfield, Jr.
Cambridge, Mass.

Pilot Lamps

Many manufacturers of modern hi-fi equipment and kits either don't believe in pilot lights or they don't want to fiddle around with AC leads to power them inside the chassis. But since I am somewhat forgetful, I want a healthy red light to remind me to shut off the gear when the music stops.

Rather than tap into the filament circuit, I used a small, 115-volt indicator lamp and plugged it into the



Simply arranged pilot-lamp installation.

"switched" outlet circuit on the side of the power-amplifier chassis. The jewel was merely screwed to the equipment-cabinet panel and the 115-volt socket mounted solidly behind it on a convenient surface.

L. E. Johnston
Madison, Wis.

Extending Crystal Life

The life of crystal microphones and pickup cartridges in humid climates may be extended indefinitely by storing them, while not in use, in screw-top jars with a silica-gel desiccant. This material is sold under various trade names (Dryrox, Nodamp, etc.) at department and drug stores. Occasionally, a weak crystal can be reactivated by this treatment.

R. L. Browning
Texas City, Tex.

14-Carat Solder

Along with most readers of AUDIOCRAFT, I have used solder for years, and have often bemoaned the fact that the smaller and handier one's soldering iron, the more certain it is to lack the heat needed for the job at hand.

My attention was recently directed to a discussion of solders in a machinist's handbook. This led to my building my latest kit with 60-40 solder (high tin content) with such pleasing results that I believe all audio enthusiasts should know about it.

Soft solder is an alloy of tin and lead; usually with more lead than tin, as in the standard 40-60 grade. The only reason for the higher lead content is that lead is cheaper than tin. Solders *are* made with higher tin content, and they have entirely different characteristics, as shown in the table.

% Tin	% Lead	Melting Temp. Deg. F.	Brinell Hardness
40	60	446.0	15.8
50	50	401.0	15.0
60	40	368.6	14.6
66	34	356.0	16.7
70	30	365.0	15.8

It is a point of academic interest that the alloy with 66% tin and 34% lead has the lowest melting temperature and the highest hardness. This is called the *eutectic* alloy of tin and lead. This is the term applied to alloys of such ratio that they pass directly from a liquid to a solid state (and vice versa) without passing through an intermediate plastic state.

A point of very practical interest is that the 60-40 alloy (just above the eutectic) is commercially obtainable, and has a melting point 77.4° below that of standard 40-60 solder. This means that your little pencil soldering iron that's so handy to use, but which so frequently lacks sufficient heat, will now have adequate heat for most kit work. Also, this solder sets far more quickly because it does not pass through so long a period of plasticity. Put simply, the 60-40 solder is a joy to use, and it costs but 40¢ more per pound.

Charles V. Thayer
Springfield, Vt.

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.*

PATRICIAN

Continued from page 18

Next comes what might well be the most ticklish part of the entire operation. With battens 19 and 20 installed, dry-fit panels 4 into place, particularly checking for a good fit where 4 meets 5. Don't be too concerned if the fit isn't exact, but do be prepared to use longer screws than the 1-inch screws furnished, to pull these pieces into snug fit (Fig. 9). They must be tight. Even if the longer screws (1¼ or 1½) pierce through the wood into the dashpot cavity, no harm is done. The important thing is to get this cavity sealed absolutely tight. Don't be satisfied to pull it nearly tight with wood screws, hoping to seal off any offending cracks later with calking; this won't do. After everything here is pulled into proper and tight position, calk inside and out (Figs. 10, 11, and 12). You can work easily inside the cabinet by laying it on its side on piece 4.

It might be possible to do some line scribing on the sides of piece 4 for the future installation of pieces 10 and 11, but you can decide for yourself whether or not this will be worth while. I chose first to fit pieces 10 and 11 (after panels 4 were in place) and then guess where the holes should go into 4 to accommodate the screws that were to hold 10 and 11 in place. I also found it best to make a unit of 10 and 11, let it dry, and then install it. Minor variations from perfection here may be corrected with calking. Incidentally, the advice given in the instruction book concerning the joy of two working on the project at this point might be well repeated a number of times over. My wife was more than once called away from the dinner dishes by a desperate call of "Help, this damn' thing's slipping!"

When you install the bottom piece 8 and the 200-cycle horn, try dry-fitting each of them at opposite ends to see which ends fit together best; there may be some preference. You may find both of the pieces somewhat warped, but don't worry about it. The bottom piece will pull down with no difficulty, and the 200-cycle horn can be sat on during the operation by various small children; they are a great help here. Be sure to put screws into the edges, bottom, and top, through piece 22, to seal things up still more securely. A ribbon of calking along those edges of pieces 10 and 11 which will oppose pieces 8 and 3 just before affixing the latter two will be a further sonic aid.

While the installation and wiring of the driver units and crossover network (Fig. 13) is not difficult, I suggest allowing a full evening for it. It took longer than I had anticipated, although I suppose my burning desire to hear how the brute sounded made time drag interminably at this point. After fastening the huge, 18-inch bass-driver unit (remove your wrist watch first) to its mounting board, place gasket material, carefully cut to exact size, around the cutout on piece 22. Be sure to knot and feed through the speaker lead, as explained. Next the outside sealing piece goes into place, after gasket material has been applied here also. The crossover network mounts on top of the 200-cycle horn where mounting holes are predrilled for it. No particular problem should arise in working with the other drivers and horns. The hardware here has been much simplified from the original plans and everything falls into place nicely. Just one thing: don't confuse the horn mounting flange (a part of the 6HD) and the flange collar (a separate piece which screws into the driver) as I did. Because of this mistake, a five-minute job took close to an hour.

The whole project took me about 40 hours, but I must point out that (except for these two kits) I am almost entirely unfamiliar with woodworking tools and practices. I'm sure that 20 would be about par for an experienced back-step repairman. I must say, however, that 80 hours would have been well worth while for the extraordinary pleasure this superb unit has afforded me since that memorable 2:00 AM when it first roared into full-throated operation.

AUDIOCRAFT Test Results

Speaker systems in the Patrician's size and price class are chosen more on the bases of sonic flavor and appearance than performance measurements, because virtually any measurable performance within the audible frequency range can be achieved when so little compromise is demanded by price. Anyone who plans to pay more than $500 for a speaker system is certainly going to do some comparative listening first. Therefore, it may be superfluous for us to say that our kit Patrician will shake the house at 30 cps (it will), or that the balance controls on all drivers covering the three upper ranges permit tailoring the acoustic perspective of the system to any conceivable combination of user's taste and listening-room acoustics (they do).

More important information, perhaps, is that our kit duplicates the performance of a factory-assembled Patrician perfectly, so far as our ears can tell. This is obviously the result of following scrupulously the assembly instructions for a kit that was prepared by a manufacturer with care and some insight into problems that kit builders face.

The Patrician is a complex instrument; it can't be thrown together in one evening. Considerable time and effort are needed to build this kit. If you're willing to invest it, however, you can save a lot of money, gain the immense satisfaction of a significant personal achievement, and wind up with one of the few speaker systems in the Rolls-Royce bracket.

WALL-MOUNTED STEREO

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that when a line was extended from the axis of the speakers and continued to the auditors it was ear height for those seated in chairs just half-way between the front and back rows.

The clock ends of the two structures were closed with plywood and sealed with ¼-by-1-inch sponge-rubber gaskets (Figs. 3 and 4). The extreme ends were left open but protected by screen wire mesh. Interiors of the enclosures were heavily padded with Kimsul blanket stapled into place. A 2-by-3-inch fir timber was fastened on the back of each front panel, diagonally from one upper end to the opposite lower end, to provide additional panel stiffening.

Coaxial speakers and tweeter controls were mounted on 20-by-32-inch plywood panels. These panels were covered by Saran plastic grille cloth which was gun-stapled to the backs. A sponge-rubber gasket was stapled around the rectangular cut in each front panel. The speaker panels were then screwed tightly into place with flat-head brass screws and brass washers. The exposed plywood panels were painted to match the wall color. Fig. 5 is a view of the completed installation.

Leads from the speakers were brought to a four-pin socket under the chalk tray. Locking jacks were attached to 4-wire shielded cables. For stereophonic reproduction the four wires connect the two speakers to the two independent sound tracks. When the phonograph or motion-picture projector is used, the two 16-ohm speakers are tied together in parallel to match the 8-ohm amplifier outputs. A cabinet from an obsolete, spring-wound, school-style Orthophonic Victrola, 1921 vintage, was discovered in the basement. The old acoustic horn had been wrecked. The wrecking process was continued until space for a good-quality 20-watt amplifier was made; and a new turntable and pickup arm were mounted in the top compartment. One faculty member who has a basement workshop did a skillful job of mounting a modern front panel on the old phono cabinet. A refinishing project to lighten the dark-stained cabinet is scheduled for later. This cabinet, with the other audio-visual equipment, appears in Fig. 1.

Besides the other obvious advantages, this installation made good use of the otherwise unexploited space above the blackboard. The materials cost was low, and the construction was simple. It provides for adequate separation between the front and back waves of the speakers. Bass energy is projected both from the front of the speaker and into the corners of the room. Treble is aimed at the auditors' ears, so the stereophonic effect is more easily perceived.

SQUARE WAVES

Continued from page 22

shown in Figs. 2 and 3. However, they bear sufficient resemblance to these shapes that the latter may be employed in the interpretation of a multitude of patterns. It is easy to see how practical examples might occupy an intermediate position between two of the shapes shown here. It is a rule of thumb that the top of a square wave is sensitive to low-frequency characteristics, while the corners and rise time are sensitive to high-frequency characteristics.

Practical Application

To put square waves into use, use the equipment setup shown in Fig. 1. The following table can be employed to determine which square-wave frequencies will be required for amplifiers with different band widths:

Table I

Supposed Frequency Range of Amplifier	*Required Square-Wave Frequencies*
20-20,000 cps	200, 2,000 cps
10-20,000 cps	100, 1,000, 2,000 cps
10 cps - 50 Kc	100, 1,000, 5,000 cps
20 cps - 50 Kc	200, 2,000, 5,000 cps
10 cps - 100 Kc	100, 1,000, 10,000 cps
20 cps - 100 Kc	200, 2,000, 10,000 cps

Then, throw switch *S* to position 1 and verify the squareness of the input signal. Set the oscilloscope sweep and sync for one or two *stationary* cycles. Throw switch *S* to position 2, and readjust vertical gain of the oscilloscope, if necessary, for a pattern of good, readable size. Note the shape of this output wave and use the patterns in Figs. 2 and 3 as guides to its interpretation.

ELECTRONIC ORGAN

Continued from page 25

over specifications and I think that a two-manual model with a 32-note pedal section will suit me very well.

Once an organ builder, always an organ builder! Better be careful or the bug will bite you too!

Bibliography

The following books were used, in varying degrees, in the preparation of this article. They will provide a good beginning for anyone interested in pursuing the subject of electronic musical instruments at greater length. Several of the books have excellent bibliographies of their own, and the interested reader will find that there is quite a bit of additional material available.

Where page numbers are given, the work cited is not devoted entirely to electronic musical instruments.

Dorf, Richard H. *Electronic Musical Instruments.* Mineola, N. Y.: Radio Magazines, Inc., 1954.

Douglas, Alan. *The Electrical Produc-*

tion of Music. New York: Philosophical Library, 1957.

Douglas, Alan. *The Electronic Musical Instrument Manual*. 3rd ed. New York: Pitman Publishing Corp., 1957.

Eby, Robert L. *Electronic Organs*. Los Angeles, Electronic Organ Arts, 1953.

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Geiringer, Karl. *Musical Instruments*. New York: Oxford University Press, 1945, pp. 35-36, 190, 255-258.

Sachs, Curt. *The History of Musical Instruments*. New York: W. W. Norton and Co., Inc., 1940, pp. 447-449.

TRANSISTORS

Continued from page 29

emitter resistance should be as high as is convenient for biasing. The circuit is largely self-balancing, and the bias stabilization is rather good.

A complementary emitter-coupled circuit is shown in Fig. 9. Here the term "long-tail" is a misnomer; the long-tail,

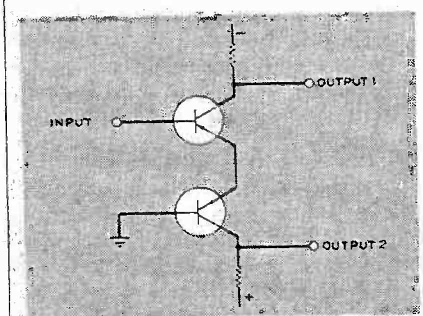

Fig. 9. This complimentary emitter-coupled circuit requires two batteries.

the common emitter resistor, is omitted entirely, since it is not needed for biasing purposes.

Unfortunately, two batteries are required, and the bias stability is not too good. But this can be improved by inserting a bypassed *resistor* between the two emitters. This simple, effective circuit is bound to be more popular when matched sets of *n-p-n* and *p-n-p* transistors are available.

Many other circuits can be dreamed up, especially using both *p-n-p* and *n-p-n* transistors. To be really good, they should 1) have good bias stability; 2) have good balance between outputs, independent of individual transistor parameters, which may vary in time; 3) maintain good balance even though the two loads are different, keeping the same current in each; and 4) use as few parts as possible. Of course, distortion should be low and frequency response good. It is probable that the best transistor phase inverter has not been invented.

Continued from page 12

Transistors (Engineering Works)

Author	*Title*	*Publisher*	*Price*	*Review Date*	*Comments*
L.P. Hunter	Handbook of Semiconductor Electronics	McGraw-Hill	$12.00	May	Best comprehensive
Lo, Endres, et al	Transistor Electronics	Prentice Hall	12.00	Dec. '56	Broad coverage
R.F. Shea	Transistor Circuit Engineering	Wiley	12.00	Oct.	Recent ideas
R.F. Shea	Transistor Audio Amplifiers	Wiley	6.90	—	Old but basic
RCA	Transistors I	RCA	2.00	—	Recent eng. papers
J.M. Carroll	Transistor Circuits and Applications	McGraw-Hill	7.50	Oct.	*Electronics* Mag. reprints
R.F. Shea	Principles of Transistor Circuits	Wiley	12.50	—	Basic principles still good
W. Schockley	Electrons and Holes in Semiconductors	Bell Labs	9.75	—	Extremely mathematical
H.E. Marrows	Transistor Engineering Ref. Handbook	Rider	9.95	Jul.	Mostly old spec sheets
W.D. Bevitt	Transistors Handbook	Prentice Hall	9.00	Jan.	Outdated
Coblenz & Owens	Transistors — Theory & Applications	McGraw-Hill	5.90	—	Outdated — few circuits
M.S. Kiver	Transistors in Radio & TV	McGraw-Hill	6.40	—	Outdated — for technicians

Transistors (Popular)

Author	*Title*	*Publisher*	*Price*	*Review Date*	*Comments*
L.E. Garner	Transistor Circuit Handbook	Coyne	$ 4.95	Feb.	Best for hobbyists
General Electric	Transistor Manual	General Electric	.50	—	Most valuable reference
L. Krugman	Fundamentals of Transistors	Rider	2.70	—	Good basic theory
R.P. Turner	Transistors — Theory & Practice	Gernsback	2.00	Nov. '56	Simplified theory
R.P. Turner	Transistor Circuits	Gernsback	2.75	—	Many basic circuits
Raytheon	Transistor Applications II	Raytheon	.50	—	Building hints
RCA	Transistors and Semiconductor Diodes	RCA	.25	—	Circuits & interchangeability
Raytheon	Transistor Applications	Raytheon	.50	—	Simple article reprints
Sylvania	28 Uses for Junction Transistors	Sylvania	.25	—	Basic circuit ideas
Gernsback	Transistor Techniques	Gernsback	1.50	Apr.	Nonaudio only
L.E. Garner	Transistors	Coyne	1.50	—	Extremely simple

SOUND FANCIER

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powering but just as indescribable as the extraordinary "Veil of Orpheus" in Vol. 1 (DTL 93090, reviewed here last April). Again, it and the shorter pieces included are certainly something that can be only approximated by the term "hysteria in sound" . . . or the blunter "odd-sounds-fanciers' nightmare." Can you imagine, for instance, what an aviary of wholly insane jungle and prehistoric birds might sound like? Listen to Henry's "*Vocalises*" and discover for yourself how far short of the mark even your wildest imaginings actually come.

The Strausses Go Hi-Fi

If such *musique concrète* is not too much for your own perhaps-by-now-cauliflowered ears, it certainly never will be tolerated by your sonically less sophisticated friends. Over the holidays, in particular, you'd better not test their "good will toward men" (and hi-fi?) so drastically. My guess is that your best bet is to demonstrate your latest rig in music everybody delights in, yet which is scored so that its ingratiating melodic and rhythmic charms can be ornamented with percussive accents, and substructured by powerful basses and drums, without such hi-fi display materials ever calling too blatant attention to themselves or seeming at all exaggerated. Such music is ideally that of the Viennese Strauss family, of course, and now on stereo as well as on LP it's better than ever.

Of the releases currently at hand, indeed, there's only one I can't recommend: Antal Dorati's *Music of Johann Strauss* (Mercury MG 50131), which is musically surprisingly cold and routine as well as technically uninteresting — both in marked contrast to the same conductor's superb stereo taping of Kodály's *Háry János* Suite (MDS 5-1). And only minor qualifications are necessary for my recommendations of Barbirolli's *Strauss Waltzes* (Mercury stereo MDS 5-4, LP MG 50124) and Josef Drexler's *Strauss in Stereo* (Livingston 721 BN), merely because the former's Hallé Orchestra and reverberant Manchester Free Trade Hall acoustics are almost *too* big for the familiar music (if certainly not for dramatic living-room expansion), and the latter's Vienna State Opera Orchestra is rather small and lacking in breadth of sonority, if certainly not in crisp brilliance and equable channel balancing.

Nevertheless, almost every listener should delight in these. The verdict should be completely unanimous for

Paulik's *Hi-Fi Carnival with Strauss* (Vanguard VRS 498) and Hagen's *Strauss Sparkles in Hi-Fi*, Vol. 1 (Urania stereo UST 1202, LP UR 8009), especially for their novel choice of less-familiar selections . . . and for Arthur Fiedler's full-length *Strauss Waltzes* and *Waltzes by the Strauss Family* (RCA Victor stereos CCS 45 & CCS 46; together on one LP, LM 2028), which boast really intoxicatingly symphonic sound as well as irresistible music.

TAPE NEWS

Continued from page 33

to vibrate as is a violin string, it will generate a rasp instead of a tone, and it is this irregularity that is heard as roughness superimposed on the signal.

FM noise may be caused by excessive tape tensions, binding in tape guide pulleys, guides that are too narrow for the tape, or heads and guides that have developed wear grooves at the edges of the tape path. In addition to these, the tape itself can cause FM noise, or even loud squealing, if it is not adequately lubricated. Most tapes are lubricated in production; some old ones that have dried out with age will require treatment with something like Robins Jockey Cloths for Tapes, which contain a silicone surface lubricant. Persistent cases of modulation noise in recorders that use head pressure pads can often be remedied by lightening the pad pressure, treating the pads sparingly with silicone lubricant, or removing them altogether (as long as the tape will make good contact without them).

Perhaps I should add at this point that most tape recorders are not as noisy as this (and last month's) column might suggest, and they do not normally develop clicks and pops, or wear out tapes with repeated plays. They do require more attention than does a phonograph, but then they're worth it.

Stereo Tapes

Things have been happening too fast in the stereo-tape field for me to be able to keep track of them. A couple of months ago I listed a few more of the major recording companies who had issued their first stereo tapes, and I seem to remember wondering who would be next: Columbia, or Angel, or someone else. Well, sir, Columbia was next, with 10 stereo releases.

Among the major companies, Angel, Decca, and London are still the only holdouts, (as of Oct. 1) and they are probably just holding out until they can outdo everyone else's sonics. The latest tapes from those in the field all show a significant upping of sound quality. RCA Victor's tapes in particular show a tremendous improvement; they are quieter, they have a wider dynamic range, and they have evidently licked the cause of the muddiness and distortion that characterized some of RCA's earlier efforts.

Prices are coming down, too. RCA Victor led this welcome development by removing the price tags from its latest reel boxes. Prices on these are now pretty much at the discretion of the dealers. Mercury's first batch is pegged at $12.95 per reel, Columbia's are still sky-high, ranging from $12.95 to $19.95, and Mercury is currently pricing about competitively with RCA Victor . . . from $9.95 to $16.95. No one has yet asked $25 for a tape, but some are still pretty close to it.

Finally, and this is the most significant thing to date, the fall issue of the *Harrison Recorded Tape Catalog* devotes about 2/3 of its 70 pages to listings of stereo tapes. There are fewer monaural listings than in the last catalogue. This, to me, makes good sense.

And they thought the tape-recording industry had grown up two years ago. It has only just begun to grow!

READERS' FORUM

Continued from page 15

typical conditions of use, the results will be misleading when they are not meant to be.

Concerning the Knight-Kit tuner, specifically, we are certain that our report was factual and fair. We have a high opinion of Joseph Marshall's ability to evaluate hi-fi equipment and to recognize distortion when he hears it. One member of our staff built a Knight-Kit FM tuner at the same time Mr. Marshall built his, and the results we obtained here coincided with Mr. Marshall's report precisely. — ED.

Gentlemen:

Re page 47, AUDIOCRAFT, October ("Readers' Forum"), may I enter a contrary opinion to Mr. Rosenstein's views? I agree with you that R. D. Darrell's "Sound-Fanciers' Guide" has been and continues to be one sound and tasteful source of the technical quality of disc releases (I am not as yet interested in tape).

Mr. Darrell represents a unique combination of technical knowledge and erudite musical taste. I have several discs in my collection which give me much pleasure and which I would have missed but for his column.

To say that the job is done ineffectually in other magazines would be an exaggeration, rather would I put it that nowhere else could I find the same degree of good writing and balanced knowledge.

Henry Bent
New York, N.Y.

PUZZLEMENTS

Continued from page 35

(or good ones poorly matched to the amplifier) producing a resonant response in this region. Then one gets the impression that the only audible addition from the tweeter is an increased background hiss. This is because noise components in a narrow band are overemphasized, and mask the improvement in accuracy (if any) in program transient response.

Stereophonic sound, with the right kind of loudspeaker, achieves the same objective, psychologically, by use of different physiological effects. The object is accurate separation and recognition of sounds from different sources in the composite. In single-channel sound this is dependent on accuracy of *form*, since spatial separation is impossible. In stereophonic sound we rely more on spatial separation, which is now possible.

Consequently we can have two different, but complementary, psychological impressions or illusions: one mentioned earlier, that a loudspeaker working on good single-channel material, and with

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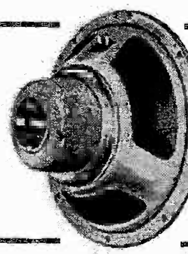

especially good capability for handling transients, in addition to being good in other respects, gives an illusion to the reproduction of almost stereophonic depth, breadth, and character. And the other, that good stereophonic reproduction gives an impression of better high-frequency response than it may really have, because it achieves the same end in a different way.

Theoretically, of course, one must sit in a position that is at equal distance from both loudspeakers to get a satisfactory stereophonic illusion. In practice, some deviation from this ideal position is not too serious; but if possible you should plan your system so the deviation in normal listening position is minimized. If you have a longish room, with two convenient corners on one of its shorter sides (Fig. 1), you will be able to get quite a large area toward the other end of the room in which the stereophonic effect is good.

Not too many American living rooms were made to this specification. Either they differ in shape, or the right combination of corners is not usable, because of doors, windows, or walk-through openings to other rooms. This is where the new trend in stereophonic loudspeaker systems is particularly helpful, consisting of two systems in one cabinet facing outward or divergent. Fig. 2 illustrates this arrangement.

The latter system has the advantage of making it possible to get an acceptable illusion over a greater proportion of the area in many living rooms. In a position center front, the stereo effect is at its theoretical best. Because the tweeters are directed away from this position, the listener here gets fewer of the extreme high frequencies, but he does not need them, because an adequate stereophonic effect serves the same purpose. For this reason, he is not even conscious of being off the beam.

For side positions, being more in line with *one* of the tweeters helps strengthen the stereophonic illusion in an area where the basic spatial effect is weakening. Having the loudspeakers in the same enclosure, so the time difference is

not excessively exaggerated by deviation from center front, is of course a help. But on the side, sound from the nearer speaker is characterized by better extreme highs, while that from the far side is relatively lacking. This provides an added "spatial" separation, due to the apparently different frequency content, which is quite similar to that imposed on live sounds with the same variation in listening position.

For a similar reason, if you are start-

Continued on next page

PUZZLEMENTS

Continued from preceding page

ing from the same kind of system my friend had, there is a convenient transitional way of getting a good stereophonic effect that will conserve your budget. One big multiway loudspeaker, on one channel of stereo, will give quite a passable stereophonic effect — much better than two of them — if the other one is a smaller, well-integrated unit, recommended for stereo use. Then, of course, the effect in all parts of the room

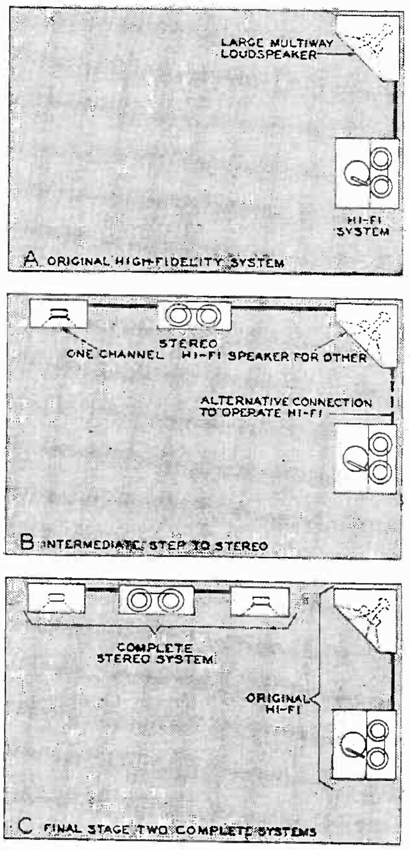

Fig. 3. These illustrations suggest a step-by-step progression to full stereophonic listening. The original single-channel speaker system (A) *is expanded* (B) *by the addition of another smaller speaker for stereo. Ultimately* (C) *two complete speaker systems are evolved.*

will be partly dependent on the difference in program *quality* on the two channels, and there will be no position where the illusion corresponds with the center-front of Fig. 2.

This intermediate system (Fig. 3) gives a better stereo illusion than single-channel, even over the same speaker combination, although it is not as good as full stereo. Then, later on as your budget allows, you can expand to the full system, keeping your large loudspeaker system then exclusively for playing your single-channel recordings. This will enable you to realize the approach to the best stereo in stages, and derive double enjoyment from the improvement.

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