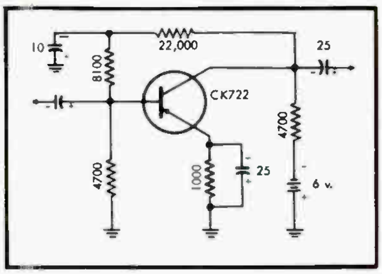
AUDIO

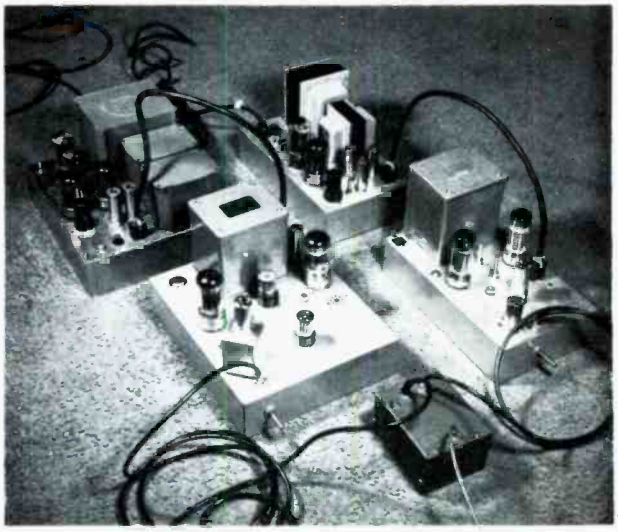
MAY, 1956

50¢

ENGINEERING MUSIC SOUND REPRODUCTION



For reliable operation, transistor circuits should be designed for stability of operation over a wide range of temperatures and with probable variations in supply voltages. The procedure is shown in the article on page 34.



These two amplifiers with their associated power supplies form the basis of an elaborate home system designed for use with a high-impedance crossover network. See At Home With Audio, *beginning on page 24.*

WHAT MAKES A WOOFER?

EXPERIMENT III—THE BETATRON

TRANSISTOR BIAS STABILIZATION

CARE OF AUDIO ATTENUATORS

Amperex® TUBES

are Making Music in the World's Finest Amplifiers

That's right! After decades of leadership in communications and industrial tubes, AMPEREX has "gone hi-fi" with a complete line of new tube types for high-quality audio applications. The new line offers the unbeatable combination of ultra-advanced design by Philips of the Netherlands *plus* AMPEREX engineering research for American applications. Leading manufacturers of high-fidelity equipment are now designing and building complete audio amplifier systems with *every* tube an AMPEREX 'preferred' type!

Detailed data, circuits, application information, as well as engineering assistance are available to manufacturers and professional designers of electronic equipment from the AMPEREX Semiconductor and Special-Purpose Tube Department.

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EF 86 — High-gain pentode with exceptionally low hum, noise and microphonics.* Particularly suitable for preamplifier and input stages.

ECC 81 — Medium-gain dual triode with low hum, noise and microphonics. Replaces the 12AT7 without circuit changes.

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EL 84 — Unique AF power pentode combining high gain and linearity with 9-pin miniature construction. Up to 20 watts in push-pull.

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GZ 34 — Indirectly heated, full-wave rectifier with 5 v., 1.9 amp. heater and 250 ma. output capacity. Octal base.

**Maximum levels specified and guaranteed.*

THE BRITISH INDUSTRIES

Sounding Board

WHICH SOLDER DO YOU USE?

Here is some information about the revolutionary new 5-core Multicore World's Finest Cored Solder

This solder is sold to consumers only through radio parts distributors, and therefore it is of special interest to the readers of Audio Magazine.

What follows may seem a bit technical to some, but it will give any reader an insight into a subject all-too-little understood by the consumer.

•

Ersin Multicore Solder contains 5 cores of a new non-corrosive flux, Ersin Type 366. All 5 cores are very close to the circumference of the wire.

Apart from the ever-important question of the flux, the following factors are of primary importance in manufacturing a cored solder of such high quality:

(1) Purity of Solder Alloy.
(2) Core Construction.
(3) Consistent Quality of Manufacture.

Since the bulk of cored solder is used for the assembly of electronic apparatus, millions of joints are made daily on components possessing a considerable variation of surface finish. Components are usually purchased from many different suppliers. Therefore, it is essential to use a cored solder which provides a large margin of efficiency.

Of course, it is necessary to insure that the flux will be entirely non-corrosive while the joint is being made, when the flux is being volatilized, and when the flux residue on the component is subjected to any operating conditions.

HIGH PURITY ALLOY: The first consideration is that the alloy used be of the highest purity, and of constant composition. As the manufacture of cored solder involves melting, extruding, and drawing operations, it is possible that segregation can occur during these manufacturing processes. In regard to purity of alloys, it must be appreciated that only a small percentage of the solder generally sold throughout the world is made from virgin metals. It is to the financial advantage of most solder manufacturers to use re-claimed metals in the manufacture of their products. While it is possible to use such alloys quite satisfactorily for many soldering operations, such as the filling of automobile bodies, it is vital that solder used in the jointing of electronic equipment be made from metals of the utmost purity. Only virgin metals are used in the manufacture of Multicore Solders.

IMPORTANCE OF ANTIMONY-FREE ALLOYS: A comprehensive investigation by the Tin Research Institute has shown that the antimony in a solder renders it extremely brittle. Impurities in the solder are dissolved during the soldering process and the incorporation of zinc, brass, or even iron from the soldering process leads to a joint which is easily snapped.

cut along dotted line and save

The Sounding Board

The Sounding Board

Furthermore, the solders do not flow so well and are not so easily fluxed as pure tin/lead/ metal alloys. With wire-to-tag joints, it is also essential that the solder should have a high degree of electrical conductivity. Solders containing antimony have the electrical conductivity lowered by some 10% as compared with comparable pure tin/lead alloys.

Even Distribution of Flux: The new 5-core solder has enabled the flux to be distributed more evenly throughout the cross-section of the solder wire and liberated with the utmost speed. The introduction of the additional cores of flux has not meant that the flux percentage has increased. The standard flux percentage provided by Ersin Multicore Solder is less than that contained in many single cored solders. The provision of flux in 5 cores insures flux continuity which, owing to the manufacturing process, cannot be guaranteed in a single cored solder. To make certain that every inch of cored solder of one specification is consistent in quality in regard to alloy, core construction, quality of flux and flux percentage involves a very close control in the solder manufacturing process.

Since the solder is extruded with the flux therein, in a comparatively wide diameter and is subsequently drawn down to the required gauge, the slightest inconsistency in one of the initial operations would produce a below-standard wire of considerable length. Unlike practically every other component used in the electronic industry, it is not practicable to test cored solder wire either visually or electrically. Consequently, "know how" in the manufacture of cored solder is possibly of more vital importance in its production than that of many other components used in the electronics industry.

Besides being the first company in the world to manufacture solder containing more than one core of flux, Multicore Solders Ltd. were also responsible for introducing Ersin, the first activated non-corrosive resin flux. Before Ersin flux was introduced to the United States in 1945, it had already been used by all the leading British Radio Manufacturers during the crucial war years. It was only accepted by the British Air Ministry in 1939 as being non-corrosive after very extensive tests had been undertaken by British Government Scientists. British Radio and Radar equipment, used in Malaya and the Far East during the war, was assembled with Ersin Multicore Solder. During a 17 year history, not a single complaint has been made that Ersin flux has promoted corrosion in radio or electronic equipment. Furthermore, Ersin Multicore Solder is approved and extensively used by Britain's General Post Office which is the Government Organization controlling the British Telephone Service. The anticipated life of telephone equipment is, of course, many times that of Army or Air Force equipment. It has become evident that it is only possible to safeguard against dry or high resistance joints by using activated non-corrosive flux as is incorporated in Ersin Multicore Solder.

•

Unless you are a manufacturer, you probably do not buy very much solder for your own use. Why not get the best when you do?

Leonard Carduner

Leonard Carduner is President of British Industries Corporation, Port Washington, New York. BIC is an American company which offers you the finest of audio equipment . . . fully guaranteed, with service and spare parts available throughout the country.

MAY, 1956 VOL. 40, No. 5
Successor to RADIO, Est. 1917.

AUDIO

ENGINEERING MUSIC SOUND REPRODUCTION

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Special Representative—
H. Thorpe Covington,
7530 Sheridan Road, Chicago 30, Ill.

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CONTENTS

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AUDIO PATENTS

RICHARD H. DORF*

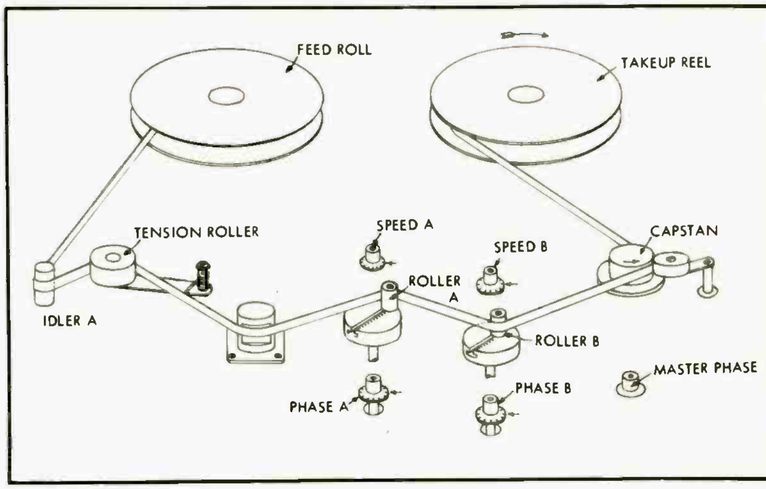


Fig. 1

I DOUBT that many AUDIO readers will have a good use for a device which scrambles (and unscrambles) tape recordings, but the idea is interestingly simple. The idea is to make tape recordings unintelligible to those without the proper combination, so that it may either be stored or transmitted in secret. I feel quite safe in explaining the scheme, even if you are an international spy, since you will not be able to use it without paying royalties to the assignee and thus revealing yourself.

The assignee is Conger-Groves Corporation and the inventor Chauncey C. Street. The patent number is 2,730,569, and *Fig.* 1 can be used to explain the general idea.

As in many tape machines there is a feed reel and a takeup reel. From the feed reel the tape passes over idler A, and thence over the tension roller which is mounted on a spring arm for obvious purposes. Then it passes over the record-playback head. So far, all is normal.

From the head it goes over roller A. This roller is mounted atop a disc which is driven by the motor, but mounted in such a way that the roller's position along a diameter of the disc can be adjusted by a screw going through it and a nut in an inverted T slot in the disc. As shown in the illustration, roller A is out toward the edge of the disc, so that it acts as an eccentric cam when the disc rotates. If we assume that the tape is being pulled to the takeup reel at constant speed by the standard capstan shown, then rotation of the disc on which roller A is mounted eccentrically will vary the speed of the tape passing the head from a maximum to a minimum every revolution.

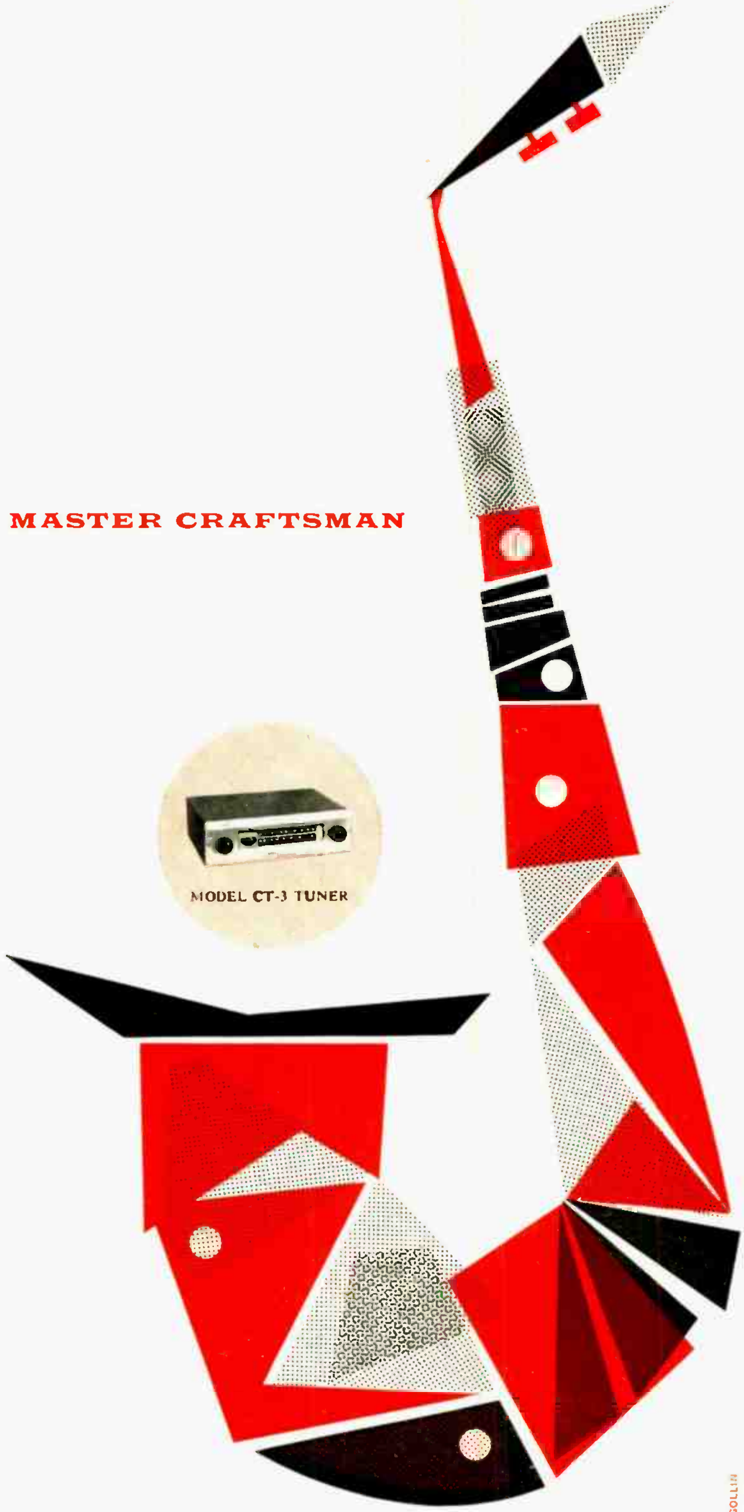
Just to complicate matters, roller B operates in the same way. As a result, the speed at any instant of the tape past the head depends on the resultant of the positions of both rollers.

In the actual invention there is more to it than that. The rotational speed of either roller can be varied by a calibrated control, and so can its phase—that is, the instant at which it reaches a particular position

(*Continued on page 79*)

* *Electronics Consultant, 255 W. 84th St., New York 24, N. Y.*

No. 2 in a series on the contributions of Master Craftsmen to the history of music.



ANTOINE JOSEPH SAX: MASTER CRAFTSMAN

This master craftsman achieved early fame in Belgium as a maker of superlative musical instruments, but his contribution to musical history did not stop there. In 1842, while working on an improved version of a bass clarinet, Sax made a startling discovery about wind instruments. He found that the timbre of the sound is not dependent on the material of the walls of the tube, as his contemporaries thought, but is a result of the proportions given to a column of air vibrating in a sonorous tube. In 1845, utilizing this discovery, he patented his saxhorn and in 1846 he registered the world's first saxophone.

You will find the same mixture of fine craftsmanship and scientific experimentation today in the sound laboratories of Radio Craftsmen. Since the first days of high fidelity, the name of Radio Craftsmen has been synonymous with "the sound of quality." At the same time Radio Craftsmen has introduced many firsts in high fidelity. The new Craftsmen Model CT-3 tuner with micro-accurate tuning meter, cascaded double limiters, wide band IF's and other features, is a typical example of Craftsmen leadership and scrupulous attention to quality details. The CT-3 has been hailed by critical audio-philes as a worthy addition to the famous Craftsmen line of high fidelity equipment. Ask for a demonstration of Craftsmen high fidelity components at your dealer now. Or write for free, illustrated catalog.

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World's Finest

MODEL 301

"the Professional"

transcription turntable

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MEASURING INSTRUMENTS & APPARATUS FOR AUDIO & VIDEO APPLICATIONS

133 WEST 14TH STREET
NEW YORK 11, N. Y. · OREGON 5-7820

Gentlemen: January 16, 1956

3 Stock machines selected at random!

We have tested the three Garrard Model 301 Turntables which the undersigned selected at random from sealed unopened cartons in your warehouse stock. These three bore the following serial numbers: 867, 937, 3019. We used a standard Model WB-301 mounting base without modification, a Leak tone arm fitted with their LP cartridge, and a complete Leak preamplifier and power amplifier, model TL/10.

Pickup and amplifier system conformed in response to the RIAA-new AES-new NARTB curve within ± 1 db.

Standards referred to below are sections of the latest edition, National Association of Radio & Television Broadcasters Recording and Reproducing Standards.

Our conclusions are as follows:

Turntable easily adjusted to exact speed!

Turntable Speed

Measurements were made in accordance with NARTB specification 1.05.01, using a stroboscope disc. In every case, speed could be adjusted to be in compliance with section 1.05, i.e. within 0.3%. In fact, it could easily be adjusted to be exactly correct.

WOW less than NARTB specifications!

Wow

Measurements were made at 33-1/3 rpm in accordance with NARTB specification 1.11, which calls for not over 0.20% deviation.

Garrard Serial No.	%
867	.17
937	.13
3019	.12

These values substantially agreed with those given on Garrard's individual test sheets which are included with each motor.

Rumble less than most professional recording turntables!

Rumble

Measurements were made in accordance with sections 1.12 and 1.12.01, using a 10 to 250 cps band pass filter, and a VU meter for indication. Attenuation was the specified 12 db per octave above 500 cps and 6 db per octave below 10 cps. Speed was 33-1/3 rpm.

* **Mr. C. J. LeBel**

President of the Audio Instrument Co., Inc.;
Chairman of one of the groups which prepared the NARTB Standards;
Founding member of the Audio Engineering Society, past president;
Member of the Acoustical Society of America.

Audio Instrument Co., Inc., makers of special high caliber test equipment for use in laboratory measurements.

Garrard 301 has been designed to provide the professional user and quality enthusiast with a unit supreme in its class—truly the world's finest transcription turntable for home use! At $89.00, this machine has proven its performance equal to units three to five times the price.

B.I.C. ENDORSED QUALITY

A quality-endorsed product of the B.I.C. Group.

to those seeking finest results in a transcription turntable!

***TESTED:** for performance by Audio Instrument Company, Inc., an independent laboratory.

RESULTS: **Garrard Model 301 tested even better than most professional disc recording turntables...sets a new standard for transcription machines!**

Read Mr. LeBel's report below

Signal to Rumble Ratio,
Using Reference Velocity of 7 cm/sec at 500 cps

This reference velocity corresponds to the NARTB value of 1.4 cm/sec at 100 cps.

Garrard Serial No.	DB
867	52
937	49
3019	49

Rumble: checked by official NARTB standard method (—35 db. min.) —52 db.!

The results shown are all better than the 35 db broadcast reproducing turntable minimum set by NARTB section 1.12. In fact they are better than most professional disc recording turntables.

Signal to Rumble Ratio,
Using Reference Velocity of 20 cm/sec at 500 cps

Garrard Serial No.	DB
867	61
937	58
3019	58

Rumble: checked by Manufacturer A's methods —61 db.!

We include this second table to facilitate comparison because some turntable manufacturers have used their own non-standard reference velocity of 20 cm/sec, at an unstated frequency. If this 20 cm/sec were taken at 100 cps instead, we would add an additional 23.1 db to the figures just above. This would then show serial number 867 to be 84.1 db.

Rumble: checked by Manufacturer B's methods —84.1 db.!

It will be seen from the above that no rumble figures are meaningful unless related to the reference velocity and the reference frequency. Furthermore, as stated in NARTB specification 1.12.01, results depend on the equalizer and pickup characteristics, as well as on the turntable itself. Thus, it is further necessary to indicate, as we have done, the components used in making the test. For example, a preamplifier with extremely poor low frequency response would appear to wipe out all rumble and lead to the erroneous conclusion that the turntable is better than it actually is. One other factor to consider is the method by which the turntable is mounted when the test is made. That is why our tests were made on an ordinary mounting base available to the consumer.

Of greatest importance! Always consider these vital factors to evaluate any manufacturer's claim.

Very truly yours,

AUDIO INSTRUMENT COMPANY, INC.

C. J. LeBel

CJL:ds

C. J. LeBel

Now there's a Garrard for every high fidelity system


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Plan Book

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LETTERS

Transformer Design

SIR:

In his article "Transformer Design for 'Zero' Impedance Amplifiers" (March, 1956), Mr. Grossner seems to take an over-simplified basis for distortion analysis and dress it up in such a way as to impress the uninitiated—a process that has been called "blinding with science"!

The first inconsistency appears in the use of X_L as a linear parameter from Eq. (*4*) on, while it is evidently a non-linear parameter, because the current through it, I_M is assumed to be *all* harmonics. Much later, at Eq. (*41*) an adjustment is introduced in the form of K_d, but this accounts for a different non-linearity in the property X_L. The variation in μ, shown in *Fig.* 2, bears no direct relation to the variation in harmonic component of magnetizing current, tabulated in Table II.

Rather than indulge in further "science" by criticizing the presentation in detail and adding to the confusion, I will summarize the matter by saying that much of the algebra he presented is rendered practically meaningless by the following considerations:

1) The total magnetizing current, represented by I_x in *Fig.* 1, *should* be accounted for by two parallel components of impedance or admittance:

(a) due to core loss eddy currents, which can be represented as a constant shunt impedance, or approximately as a shunt resistance;

(b) due to the hysteresis cycle, which can be represented as a non-linear impedance, containing both in-phase and quadrature components, as well as an equivalent harmonic generator.

The value of (a) is constant, referred to a given primary winding, but the complete specification of (b), in magnitude, phase and harmonic generation, varies with amplitude, frequency and waveform of applied signal. *Either* voltage and flux *or* current can be considered sinusoidal for theoretical purposes. In practice neither are, and the relation between them depends on the waveforms. Even a good *approximate* approach requires a more rigorous treatment than Mr. Grossner has given, because the assumption that distortion is associated with X_L and only loss with R_C is definitely not valid.

(2) Comparison is made between a "standard" amplifier, with finite generator impedance, and a hypothetical one with "zero" generator impedance. This is invalidated on two practical counts:

(a) The output stage, *by itself*, does not possess zero impedance. This property is dependent on an over-all feedback. Before feedback is applied, the effect of the transformer in conjunction with the non-linear tube characteristics will be the same as in a "standard" amplifier. Negative feedback will reduce this distortion, while positive feedback will increase it. Even this concept should be modified, because feedback alters the waveforms handled by the amplifier—the transfer characteristic cannot be adequately treated by simple algebra.

(b) The plate resistance of an output stage is never constant, but is non-linear, varying at different points on the signal waveform. Application of feedback can modify the effective plate resistance at the output, but the modifying effect will also vary, due to variations in gain at different points on the signal waveform. In general the variation in loop gain

Discs made from "SCOTCH" Magnetic Tape masters earn Capitol's Full Dimensional Sound Seal!

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Capitol Record's Full Dimensional Sound Review Committee. Left to right: Bob Myers; Roy Du Nann, Supervising Recording Engineer; Ed Uecke, Chief Electronics Engineer; Bill Miller and Francis Scott of the Capitol Artists and Repertoire Department.

You can thank the critical judgment of the five men pictured above for the wonderful tone and fidelity of the Capitol records you buy. They have the responsibility of listening to *every* Capitol Classical LP master recording before it is released to the public . . . appraising each disc's dynamic range, performance, background noise—in fact, judging it on *eight* critical points. Only the recordings which meet all of this Committee's rigid standards receive Capitol Record's famous gold stamp-of-quality . . . the Full Dimensional Sound Seal.

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SCOTCH BRAND Magnetic Tapes

(before clipping is reached) will be much less than the variation in output plate resistance without feedback. Consequently, the resultant effective plate resistance *must* vary throughout a signal waveform. When the source resistance *measures* zero, it indicates that its value must deviate positively and negatively throughout the cycle so the *average* value is zero. Thus a treatment of transformer design or performance based on an assumed constant zero-value source is modified by the practical circumstance that the *effective* plate resistance will behave as a non-linear resistance whose mean value is zero. This in itself will cause distortion.

(3) The distortion discussed assumes linearity of everything but the output transformer; this form occurs principally at low frequencies (not adequately shown in the treatment). Other forms of distortion appear at middle and upper frequencies in magnitude greater than this one.

That the value of X_L is not the determining factor for distortion current, as suggested by Eq. (*9*), with apologies to Mr. Wildfeuer here, can be demonstrated by considering a hypothetical transformer with a fairly large air gap. Here the primary inductance is due mainly to the magnetizing current required for the air gap, so both the inductance and the current due to it are much closer to linear than in a core where there is little or no gap. Similar variations occur with signal magnitude, frequency, and the type of core material.

The writer does not contest Mr. Grossner's observation in his concluding paragraph. But the basis for this conclusion could have been drawn much more easily and directly: it was long ago established that the low-frequency distortion introduced by an output transformer is dependent on the circuit impedance with which it works. Reducing one of these to zero would in theory make the distortion dependent only on the resistance of the winding connected to the zero impedance. *This is not a "magical" effect achieved only when zero is reached,* but is an effect generally approached with increasing damping factors.

So, although the attainment of precisely zero impedance *may* serve some useful purpose in the circuit external to the amplifier—a claim yet to be proved—it has no *singularly inherent* advantage in simplifying or economizing in output transformer design.

Norman H. Crowhurst
150-47 14th Road,
Whitestone 57, N. Y.

To Mr. Canby—Re: Audio Clubs

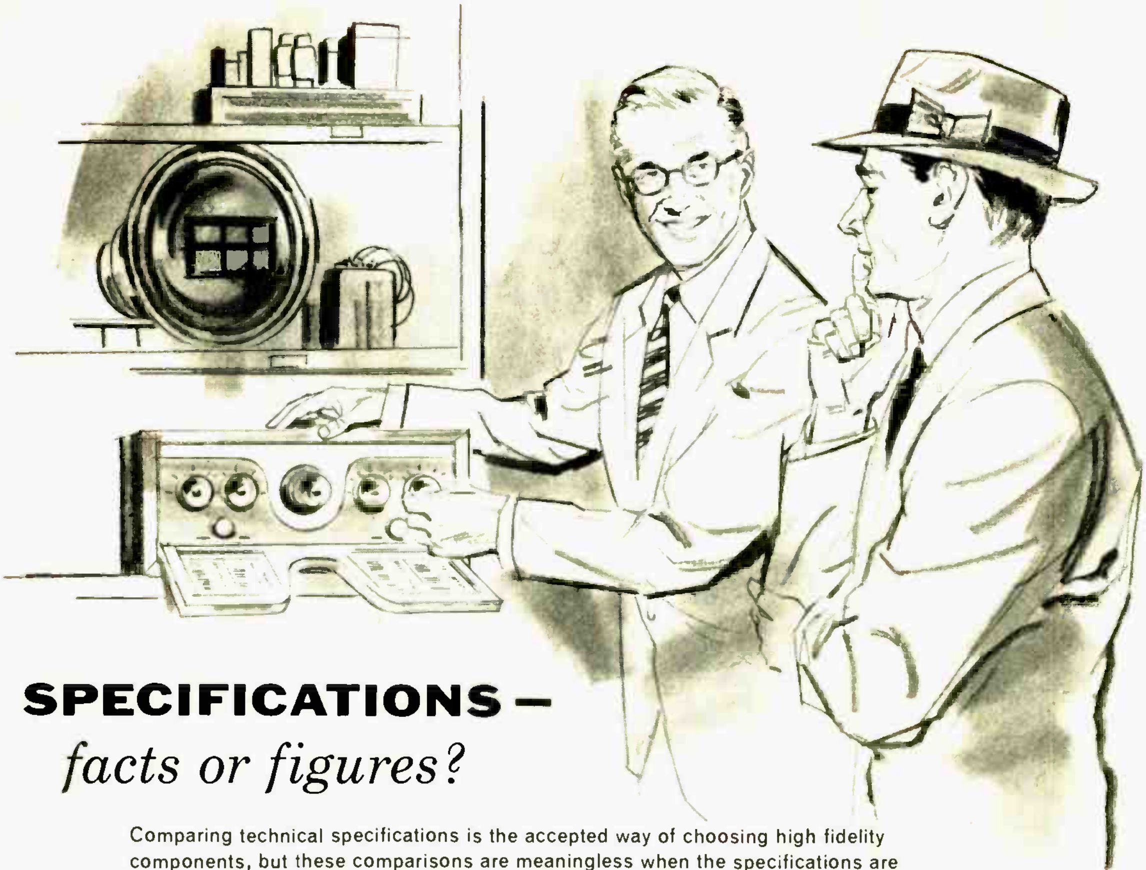
Sir:

Thanks for your note of February 25 warning me of the danger of a hi-fi club degenerating into an orgy of noise by sound "fiends." (*Quote ours.* Ed.)

Even so, it would seem that a club with good management could control this situation. A program committee could allocate time for those who prefer chamber music, time for opera fans, ballet fans, etc. There could even be time for those who drool over buzz saws, harbor whistles, and railroad cars going over switches! Perhaps this latter group might get exposed to a little good music, eventually become converted.

If you ever come across news regarding a well managed club, I am sure many readers of Audio would be interested. Why not ask your readers if articles on clubs would be welcome? The response would be a guide.

Henry F. Robbins,
2955 Grand Concourse, Apt A-25,
New York 68, N. Y.



SPECIFICATIONS — *facts or figures?*

Comparing technical specifications is the accepted way of choosing high fidelity components, but these comparisons are meaningless when the specifications are unsubstantiated by the manufacturer.

Ask your dealer why Altec Lansing's exclusive "Performance Guarantee" is more important to you than pages of impressive specifications that do not carry a warranty. As an expert on high fidelity, he can tell you the difference between performance you hear and specifications you can only see. After your Altec dealer has explained why engineering integrity, skilled craftsmanship and strict product testing allow Altec Lansing to guarantee the published specifications of each component they build, you will know why Altec is the finest name in sound.

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ABOUT MUSIC

HAROLD LAWRENCE*

Operation Cutout

Last March, the Schwann Long Playing Record Catalogue was studded with more black diamonds than in any previous issue, signifying the largest number of records discontinued since the advent of the microgroove disc. To be exact, 1,166 LP's were marked for extinction, and virtually all are on RCA Victor and Columbia. These companies operate on a quota basis. That is, unless a record meets certain sales standards, depending upon royalties, repertoire, and the cost of the actual session, it is stricken from the catalogue. Officials in these and other large firms cannot afford to be sentimental about an artist, performance, or composition. Ultimately they will have to translate their achievements in terms of numbers and figures. The disc that fails to attract enough sales is placed on the critical list.

At this point, one of four things may be done with it. It may be re-coupled, 'improved,' demoted, or permanently retired.

Re-coupling. In the early days of LP the 10-in. disc was an important factor in the record business. All the major companies promoted their own series of smaller records: Columbia its AAL's, RCA Victor its Concert Cameos, and London ffrr its Medium Plays. However, the public consistently preferred the 12-in. product. The price cuts of 1955 marked the beginning of the end for the 10-in. record. Since then there has been a gradual transfer of 10-in. material to 12-in. discs, usually giving the consumer the equivalent of two 10-in. records on a single 12-in. record.

With the development of margin control, or variable pitch, techniques,[1] more music can be engraved on a record than ever before. Thus, a version of Grieg's Piano Concerto that occupied two sides of a record over four years ago is given a new lease on life by being compressed on to one side and coupled with, say, the Schumann Concerto.

Finally, where an original coupling is commercially feeble, the offending side is dropped and replaced with a more appealing work. Take the case of a pair of Westminster releases. WL 5132 contained Prokofiev's *Winter Holiday* and Peiko's *Moldavian Suite*. Another disc contained Prokofiev's Sinfonietta and Divertimento (WL 5031). Westminster did the logical thing. Peiko was dumped, while the other three works were re-assembled on one disc, WN 18081.

Improvement. Most record companies have been quietly re-cutting many of their older recordings to make them more acceptable to users of up-to-date audio equipment. RCA Victor does so openly, describing its improved sound as "enhanced by the application of 'New Orthophonic' techniques and transfer methods which involve the extension of frequency and dynamic ranges." Sound cosmetics have done much to redeem many of their earlier issues. While this applies most dramatically to 78-rpm recordings, early LP's have also come in for some face-lifting.

Visual as well as sonic "improvements" are featured in this rejuvenating process. Stunning color photography on glossy covers can make an older recording seem like a newborn disc.

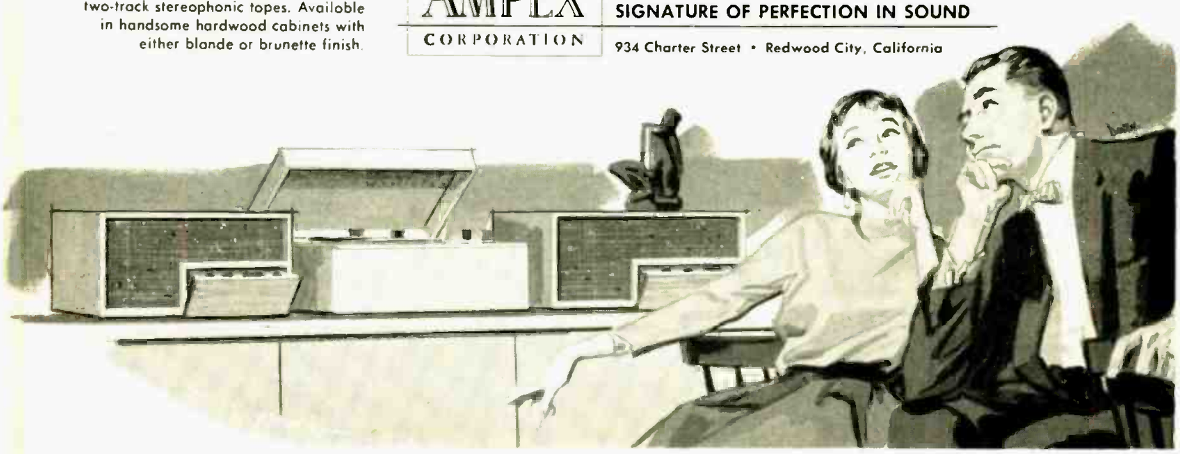
Demotion. An RCA Victor or Columbia LP that has lost some of its luster can be given a second chance on a cheaper label. Camden and Entré are the ideal outlets for performances which have outlived their welcome under the Red Seal or Masterworks aegis.

Permanent retirement. When an LP is beyond rehabilitation, it is dropped from the active list and filed away in the archives. This event is observed in Schwann's

* *26 W. Ninth Street, New York 11, N.Y.*

[1] These aren't *new*—they were used as early as 1930 in sound pictures. Only recently were they employed on LP's. Ed.

See page 79



monthly publication with the mark of a black diamond.

What of the doomed records? Which among them deserved their fate? Will any be missed? Were there any irreplaceable losses?

Certainly no one will shed tears over the early Fiedler and Ormandy repertoire which has since appeared in new versions. Unlamented are the sonically inferior Minneapolis-Mitropoulos recordings of "Scènes Alsaciennes" (ML 2074), "Le Boeuf sur le toit" (ML 2032), The Fantasia on a Theme by Tallis (ML 4196), and the overture to "Le Roi d'Ys," among others. As for Reiner's acoustically unheroic *Heldenleben* of Pittsburgh origin (ML 4138), Oscar Levant's Piano Recital (ML 2018), Nelson Eddy singing Gilbert and Sullivan Patter Songs (ML 4027), Hugo Rignold's performance of Haydn's "Military" Symphony, Gladys Swarthout's attempts at Canteloube's Songs of the Auvergne (LM 1156), etc. . . . the discophile can easily survive the departure of these and other like items.

The list of performances that *will* be missed, however, is a long one. Record collectors, please note:

Victoria de los Angeles. Spanish Songs (LM 131).

Sir Thomas Beecham. "Faust" (LCT 6100); Mozart: Divertimento (K. 131) and Handel: "The Great Elopement" Ballet Suite (LHMV 1030); Strauss: "Elektra," Final Scene (LCT 1135).

Leonard Bernstein. Stravinsky: Octet and "L'Histoire du soldat" (LM 1078).

Pablo Casals. Boccherini: Cello Concerto (LCT 1028).

Feodor Chaliapin. "Boris Godunov": Scenes (LCT 3).

Kirsten Flagstad. Duets with Melchior from "Lohengrin" and "Parsifal." (LCT 1105).

Beniamino Gigli. Featured in "Pagliacci" (LCT 6010); "Cavalleria Rusticana" (LCT 6000); "Un Ballo in Maschera" (LCT 6007) and Verdi's "Requiem" (LCT 6003).

Fritz Kreisler. Grieg and Schubert Sonatas with Rachmaninoff (LCT 1128); Mozart: Violin Concerto No. 4 and Mendelssohn Concerto (LCT 1117).

Wanda Landowska. Haydn: Concerto in D; and Mozart: Concerto No. 26 (LCT 1029).

Sergei Rachmaninoff. Schumann: Carnaval (LCT 12); recital including pieces by Chopin, Mendelssohn, Rachmaninoff and Schubert (LCT 1136).

Aksel Schiøtz. Schubert: "Die Schöne Müllerin" (LCT 1048); Schumann: "Dichterliebe" (LCT 1132).

Artur Schnabel. Schubert: Impromptus (LHMV 1027); Beethoven: Cello Sonatas Nos. 3, 4, 5 with Pierre Fournier (LCT 1124).

Igor Stravinsky. "Apollon Musagète" and Concerto Grosso (LM 1096); "Danses Concertantes" and Piano Concerto (LM 7010).

Arturo Toscanini. Pre-NBC recordings. Beethoven: Symphonies Nos. 1 (LCT 1023), 6 (LCT 1024) and 7 (LCT 1013); Brahms: Variations on a Theme by Haydn (LCT 1023).

Two of the greatest operatic recordings in the history of the phonograph are also included among the discontinued records: "Der Rosenkavalier" (LCT 6005) and Act I of "Die Walküre" (LCT 1033).

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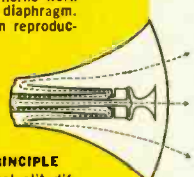

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Delius	Over the Hills and Far Away
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Haydn	Symphony No. 60
Hindemith	Symphony (1940)
D'Indy	Symphony No. 2
Milhaud	La Création du monde
Nielsen	Symphony No. 4
Poulenc	Concerto for Two Pianos; Mass in G
Vaughan Williams	Concerto for Two Pianos
Walton	Symphony (1934)

The term "collector's item," so long applied to rare 78-rpm recordings, now embraces the vinylite graveyard. Discophiles, it is later than you think!

COMING EVENTS

May 21–24—Electronic Parts Distributors Show. Conrad Hilton Hotel, Chicago, Ill.

June 15–17—Southwest Hi-Fi Show presented by the Southwest Hi Fi Distributors Association. Rice Hotel, Houston, Texas.

June 17–23—Second International Congress on Acoustics. Registration at Mass. Inst. of Technology, Cambridge, Mass.

Aug. 21–24—WESCON, I.R.E. Convention and West Coast Electronic Manufacturers Association show, Pan Pacific Auditorium, Los Angeles, Calif.

Aug. 22–Sept. 1—National Radio Show, Earls Court, London, England. For information, write Andrew Reid, 11, Garrick Street, London W.C. 2.

September 27–30—New York High Fidelity Show, New York Trade Show Building, New York. Presented by Institute of High Fidelity Manufacturers, Inc., with participation of Audio Engineering Society.

September 27–30—Eighth Annual Convention of the Audio Engineering Society, New York Trade Show Building, New York.

Oct. 1–3—National Electronic Conference, Chicago, Ill. For information, write J. S. Powers, Executive Secretary, 84 E. Randolph St., Chicago 1, Ill.

Oct. 4–7—New York Audio Fair, Hotel New Yorker, New York City.

Oct. 7–12—80th Convention, Society of Motion Picture and Television Engineers, Ambassador Hotel, Los Angeles, Calif.

Oct. 15–17—Radio Fall Meeting, I.R.E., Hotel Syracuse, Syracuse, N. Y.

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EDITOR'S REPORT

FM OBSERVATIONS

Contrary to the prognostications of several of the big names in radio, FM isn't nearly as dead as we have been led to believe. And while perhaps not as successful financially as their bigger brothers, many of the FM stations which devote a large portion of their programming time to "good music" are developing loyal audiences and they are apparently meeting the payroll every week.

One of the newest to come to our attention—and that primarily by its expedient of playing music that suits our particular taste—is WBAI-FM, atop the Hotel Pierre in New York City. This station, owned by Broadcast Associates, Inc., and under the direction of Theodore Deglin, president and general manager, is attaching unto itself the "hi-fi" audience—most of whom want good music and intelligent programming—by filling this demand and by offering in addition an innovation that anyone who is conscious of the quality of his reproduction finds interesting and useful. This innovation consists of transmitting a series of test tones, one at each hourly station break, ranging from 30 to 15,000 cps. These tones are introduced by "Our next test tone will be xxx cycles" and then follows the tone for a fifteen second period.

WBAI-FM transmits on a frequency of 99.5 megacycles, and is on the air from 8:00 a.m. to midnight every day. Of the five hours from seven to midnight—the hours of best listening—the first is devoted to show tunes, the next three to music that is principally classical, and the concluding hour to lighter music to taper off the day's activities. Transmission quality is excellent, and we are pleased to have such a station in our midst. Proof of the station's popularity with the hi-fi set is the nature of much of its evening advertising—the distributors and hi-fi products so familiar to all of us.

As to the test tones—these are likely to open the eyes of many of us who have been so proud of our systems to find that the 30-cps seems to have been absorbed by the atmosphere, or perhaps the station's carrier failed for the duration of the 15,000-cps tone. Can't use that as an excuse, however, so long as we can hear the accompanying hiss. Since practically any FM receiver will perform satisfactorily enough over the midfrequency range, the test tones are mostly confined to those frequencies from 300 cps down and from 8000 cps up. Over the period of a week or so, one could make a fair evaluation of his system's performance provided he managed to keep the average level set at the same point. Only one disadvantage of the absence of the midfrequencies—one can't check the hole in speaker response due to the crossover network. Not that the hole need be there, but it *is* there in some systems we've heard.

M. Robert Rogers and Pierson Underwood, president and chairman of the board, respectively, of WGMS, the Good Music Station, Incorporated, Washington, D. C., have announced their decision to sell the station to RKO-Teleradio Pictures, Inc. RKO is controlled by the Thomas O'Neil-General Tire interests which also control the Mutual Broadcasting System. Sale depends on FCC approval, as usual, and if the deal is completed, RKO will continue operation with only minor changes in the good music programming for which the station is well known. Mr. Rogers—who was responsible for the hi-fi concert in Constitution Hall in November, 1954, and in The Academy of Music in Philadelphia last February—will continue as general manager, while Mr. Underwood will continue as general music program director. RKO proposes to feed the good music program service to its other FM stations which will be severed from their AM affiliates for this purpose. Among these stations are WOR-FM in New York and WNAC-FM in Boston. Thus New York will get its fourth music station, Boston its sixth.

New York's other two good music stations are WQXR, owned and operated by the New York Times, and WNYC, which is owned and operated by the City of New York. Both of these stations operate AM and FM transmitters, WQXR being simultaneous during most of its programming but separated for stereo programs several times a week. Its new 50,000-watt AM transmitter provides excellent coverage and is particularly enjoyed by the music devotee while driving. WNYC operates simultaneously most of the time, but occasionally separates so that the AM transmitter can carry the doings of the UN and similar "public service" programs while the FM unit continues with the scheduled music programs. Both publish program booklets—WQXR monthly at a cost of one dollar per year, WNYC bi-monthly at a cost of only twenty cents in stamps per year to cover mailing—the booklet itself is free.

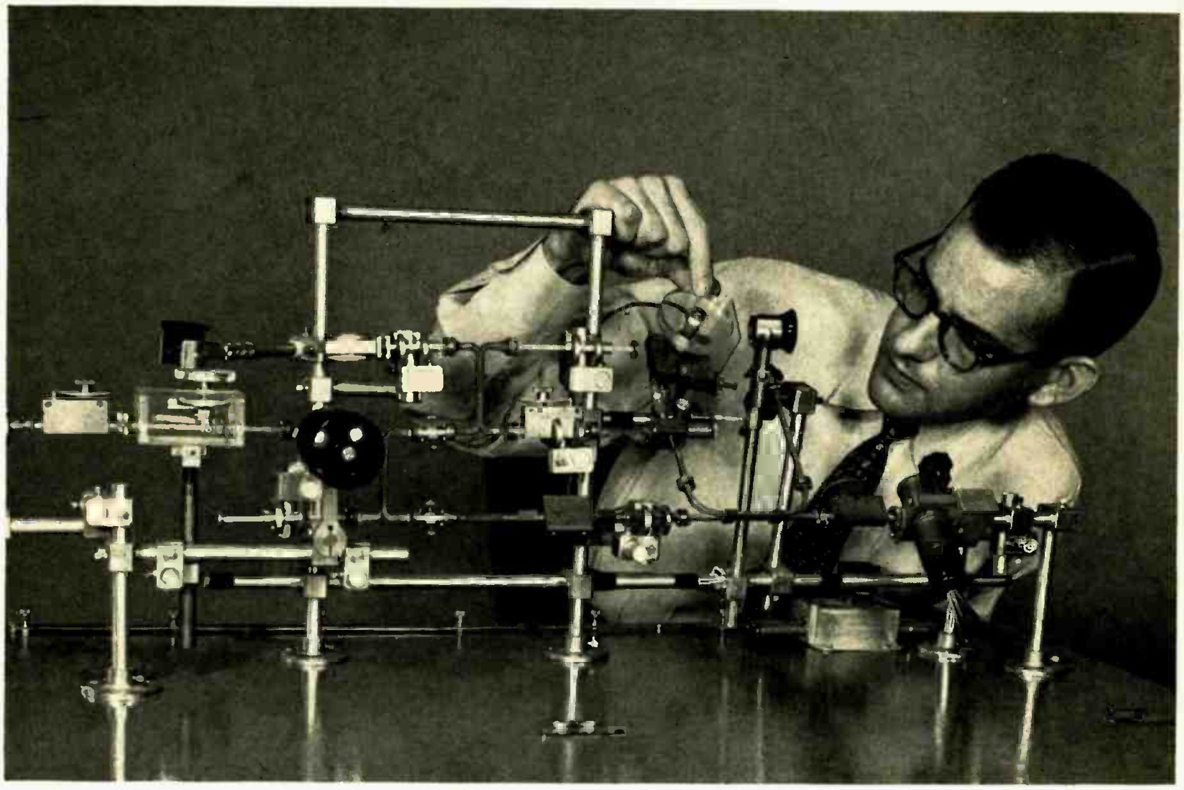
The FM stations are certainly the backbone of music programming, and as long as there is a demand for this type of station we may assume that they will be with us regardless of the opinions of the radio greats. We certainly hope so, for the quality and type of the programming is—in our opinion—of greater value than some of the more highly profitable mass-directed "entertainment" which is heard on so many AM stations.

A recent survey of the readers of the Philadelphia Daily News indicated that an overwhelming number of the residents of Greater Philadelphia own receivers that would play FM stations, and that almost 70 per cent of those who have access to FM stations listen to them both during the day and in the evening. Furthermore, the survey showed that 75 per cent of those who listen to FM are lovers of good music. To serve these listeners, the Philadelphia Daily News recently became the first paper in that city to list FM music programs on its radio pages.

So we look forward to a slow but steady growth for the operators of our FM stations who believe in good music and who are determined to continue to give it to those who are not esthetically satisfied by the rock-and-roll DJ programs. More power to them—literally.

NO FANFARE

Without any advance announcement, AUDIO published the second in its Audio Library Series—"Tape Recorders and Tape Recording," by Harold Weiler—during the past month, and deliveries are being made. For a review, see page 56; for the advertisement, try page 74. To order a copy, turn to the insert card following page 84.



Physicist G. K. Farney checks the frequency of Bell's new klystron, which is located at far right. Tube's output is about 20 milliwatts.

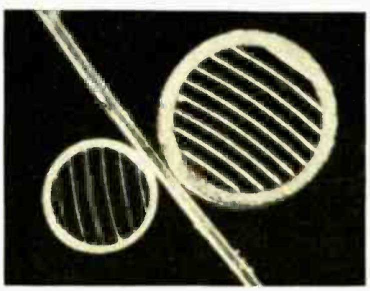
Sixty billion vibrations per second

A great new giant of communications—a waveguide system for carrying hundreds of thousands of voices at once, as well as television programs—is being investigated at Bell Telephone Laboratories.

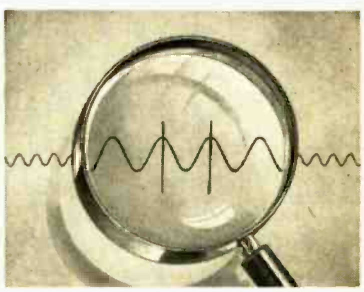
Such a revolutionary system calls for frequencies much higher than any now used in communications. These are provided by a reflex klystron tube that oscillates at 60,000 megacycles, and produces waves only 5 mm. long.

The resonant cavity that determines the frequency is smaller than a pinhead. The grid through which the energizing electron beam is projected is only seven times as wide as a human hair, and the grid "wires" are of tungsten ribbon 3/10,000 inch in width.

G. K. Farney, University of Kentucky Ph. D. in nuclear physics, is one of the men who successfully executed the development of the klystron. Dr. Farney is a member of a team of Bell scientists whose exciting goal is to harness the immense bandwidth that is available with millimeter waves . . . and to make certain that your telephone system remains the best in the world.



Grids in new tube, enlarged 30 times, with human hair for comparison. Electronic beam passes through smaller, then larger, grid.



Wavelengths produced by the klystron tube are only .2 inch long—1/15 that of the transcontinental radio relay system.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH

Audio Transformers CAN Be Good

NORMAN H. CROWHURST

A study of the influence the parameters of transformers can have in audio circuits—as well as the ones on which the transformer has little influence in spite of the common misunderstanding about them.

An old proverb says: "a person with a bad name is already half hanged." It seems that this principle applies to inanimate objects as well as to persons. In the realm of audio, transformers certainly have a bad name. To be sure, there is no other component in audio circuitry about which more misstatements have been made, and it does seem that the proverb has a parallel here, because some of the earlier forebears of the audio transformer certainly did *earn* themselves a bad name. But this is no reason why this bad name should stick to the present generation of audio transformers. The purpose of the present article is to clarify some of the misstatements that have been made about audio transformers so that some, who are prejudiced against them, will be prepared to accept an audio transformer—provided it behaves itself.

In the early days of radio, when audio was merely the a.f. section of a radio receiver, a great many people went into business—and out again—making various radio components, including audio transformers for duty as interstage coupling units. A number of these short-lived component manufacturers, working on the get-rich-quick principle, manufactured audio transformers from the cheapest possible materials, using sheet scrap iron for core material, and winding on any number of turns that came handy, so long as they gave the ratio advertised. Some were better than others, of course, even at that time, but many of them certainly did introduce quite serious distortion in the a.f. section of the receiver.

The bad name earned in those days has stuck, partly because many manufacturers in our present generation are prejudiced against the audio transformer, and hence do not bother to acquire the necessary know-how to make *good* audio transformers. This fact was pointed up recently when the writer wrote to a large number of transformer manufacturers for information about their audio components, with a view to cataloging the data and providing some performance criteria. The intention was to show that any well-made audio transformer could be utilized in an appropriate circuit to give good performance, in just the same way as a tube needs the correct circuit to give its optimum performance.

But the replies to the writer's inquiry showed unmistakably that a large proportion of transformer manufacturers had an appalling lack of knowledge on the functioning of an audio transformer. They evidently just wind them to some rule-of-thumb specification and sell them according to catalog information. Each manufacturer's catalog uses a slightly different form of listing, which adds to the confusion on the subject. If the transformer manufacturer doesn't know anything about audio transformers, what hope is there of the audio man obtaining the necessary information to *use* one properly?

On the other side of the picture, many may not realize that good audio transformers are in regular service in professional equipment, the quality of which we are listening to every day. These high-quality audio transformers, it is true, are somewhat of a specialist's job, and this fact has given the impression that a good audio transformer is a very expensive one. However, it *is* possible for transformers in the lower price range to be good also.

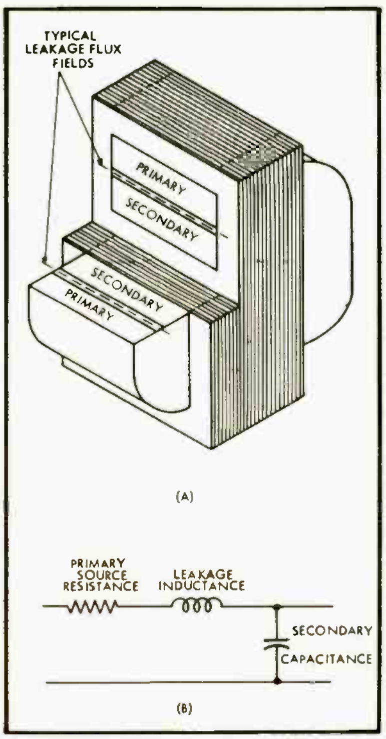


Fig. 1. Typical simple double-wound transformer, showing (A) arrangement of windings, and the path taken by leakage flux, responsible for leakage inductance; and (B) the equivalent circuit of the transformer, taking leakage inductance and secondary capacitance into account.

Distortion

Let's take the question of the distortion an audio transformer introduces, compared with the distortion tubes cause in a circuit. If you have ever made measurements on tubes operating at maximum signal level, you will know that it is difficult, with any type of tube, to achieve a consistent figure lower than 2 per cent harmonic distortion, and this figure of distortion occurs at all frequencies.

If a transformer is designed to maintain a frequency response down to the lowest frequency of interest within say 0.5 db, the distortion at this lowest frequency will almost certainly be as good as 2 per cent, and at higher frequencies —in the main part of the audio range— the distortion will not be even measurable. This may come as a surprise to many readers, but it happens to be true. Only if very cheap core material has been used, not intended for transformer core at all, or if the transformer has been very poorly designed so as to have a serious low-frequency loss, will there be appreciable distortion in comparison with the distortion a tube produces.

To check the statement just made, let's take some practical figures: even the lowest grade of transformer core material doesn't give more than 10 per cent harmonic component of its magnetizing current before saturation level is reached. This is 10 per cent of the component of magnetizing current due to hysteresis loss in the core. At the low-

* 150-47 14th Road, Whitestone 57, N. Y.

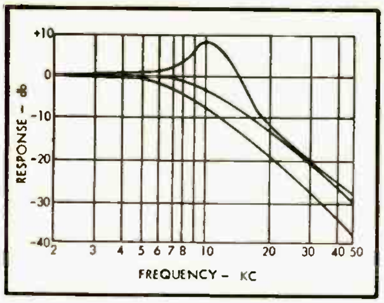


Fig. 2. Varieties of frequency response caused by the arrangement of Fig. 1. The frequency scale is typical—the frequency of peak or roll-off may also vary with different components.

frequency end of the spectrum other losses can be neglected, so we will be correct in saying that the harmonic generation is 10 per cent of the magnetizing current. To maintain a response to within 0.5 db the magnetizing current must not exceed one fourth of the load current, or one fifth of the total current. This means that the 10 per cent distortion component in the magnetizing current is 10 per cent of one fifth of the total load current from the tube, or 2 per cent of the total current. This assumes a high-impedance source, such as a pentode, in which we are neglecting the shunt effect of the pentode plate resistance. Under this circumstance, a 2 per cent harmonic current will produce a 2 per cent harmonic voltage. In the case of triode output tubes, where the source resistance is much lower than the load resistance, the harmonic generated will also be much lower, but we have taken the worst possible condition, at the low-frequency end of the response.

Assume this was 20 cps; now take a figure at 200 cps. The corresponding hysteresis component of magnetizing current will drop to approximately one tenth of its value at 20 cps, and now will be about one fortieth of the total load current. Due to the fact that the iron is not now operating at such a high flux density, the distortion component of this magnetizing current will be less than 10 per cent, but even assuming that operation at lower density does not appreciably reduce magnetizing current harmonic, this means that, at 200 cps, the distortion component of the total current will be approximately .25 per cent. At 1000 cps it will have dropped to less than .05 per cent.

This is surely much better than any tube can claim without the use of feedback to linearize it—and remember we can also use feedback to linearize the transformer's response too.

This discussion has taken an output transformer as an example, but with the same response limitations imposed, the figures would apply to an audio transformer in an input or interstage circuit equally well. In fact, the writer had an application in design recently, in which the lowest possible distortion proved to be with the use of an interstage transformer feeding a cathode follower. This was an application where a high voltage was required at low impedance in the output circuit. With the selection of tubes available, the previous plate would not deliver the swing required without running into greater distortion than the interstage step-up transformer caused. Incidentally the use of the audio transformer solved some other problems as well, and proved to be the best solution all around.

High Frequency Distortion

Another thing audio transformers get blamed for is distortion of the high-frequency end of the spectrum. When we examine the properties of an audio transformer, we find that they contain nothing that can directly cause waveform distortion at the high-frequency end. They *can* produce quite peculiar frequency responses, but not actual waveform distortion.

There seems to be quite a lot of unnecessary mystery surrounding the property known as leakage inductance or leakage reactance. Leakage inductance is due to leakage flux that manages to get either between the two windings, or through one winding without going through the other. None of the paths taken by this leakage field, either through the winding or the space between the windings, is occupied by any magnetic material—unless the winding happens to be wound with iron wire! This being the case, leakage inductance behaves in exactly the same manner as would an air cored inductance connected into the circuit somehow.

The exact behavior of leakage inductance may be a little more complicated to understand than an ordinary air-cored inductance, but its behavior from the viewpoint of distortion is precisely similar. To get an understanding of what leakage inductance can do, let's consider a few typical examples.

First take the simple winding arrangement of *Fig.* 1, which represents an input or interstage transformer. It has a single leakage inductance which may be regarded as an inductance in series with the transfer from primary to secondary. As the secondary has a much higher impedance than the primary winding, the principal capacitance effect in the transformer will be that across the secondary, due to the input grid capacitance and also the winding self-capacitance. This will combine with the leakage inductance, as shown in *Fig.* 1, to produce a series resonant circuit, the output being picked off across the capacitor element. The resistance in the circuit is provided by the source resistance connected to the primary winding, and multiplied by the step-up impedance ratio, which is the turns ratio squared. This configuration can give a response of the shapes shown in *Fig.* 2.

Next take the push-pull interstage arrangement shown in *Fig.* 3. Here two leakage inductances are operative, between the primary and each half of the secondary. Each half secondary will be loaded with its own winding self-capacitance and grid input capacitance, so there are two resonant circuits using the same source resistance. Only if the two resonant circuits contain identical values of both leakage inductance and winding shunt capacitance, will the response be equal in both halves. If, as shown here, the diameter of the windings is different, the leakage inductance at least is bound to be different, and probably the winding self-capacitance will also be different.

This means that the two tuned circuits will resonate at slightly different frequencies, resulting in a response on the separate half secondaries as shown at *Fig.* 4. The dip in each case, one below the peak and the other above it, is due

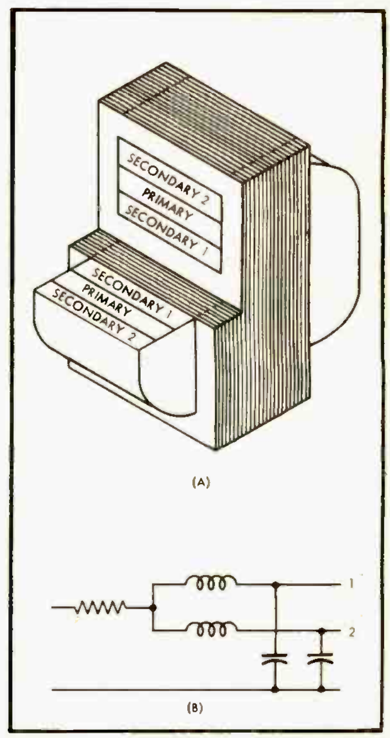


Fig. 3. A transformer intended for single-ended to pushpull operation: at (A) a section showing the winding arrangement; at (B) the equivalent circuit taking leakage inductances and winding capacitances into account. 1 and 2 represent the outputs from the separate secondaries.

to the other winding acting as an absorption circuit across the source resistance.

Such a transformer will not be a very good interstage transformer, because the signal fed to the two grids of the push-pull stage will vary in amplitude and phase in a quite erratic manner, so the over-all response at the output will look very poor. It may even show considerable distortion at some frequencies, but this will be not due to either the interstage transformer or the output transformer, directly, though in all probability the output transformer would get blamed for it.

In fact, if any transformer is to be blamed it would be the interstage transformer, in this case. At some frequency, due to the peculiar phase shift arrangement set up, associated with the responses of *Fig.* 4, the output drive at the plates of the push-pull stage will not be in true pushpull but approximately in phase, and one half will be driven much harder than the other half at this frequency. The output transformer will be transmitting a differential output instead of an additive output from the drive of the two halves. This fact alone would merely result in a very erratic looking frequency response. But the two output tubes themselves will not be operating with their correct optimum load at such a frequency, because they will be working effectively in parallel instead of push-pull.

This means that the tube giving the larger drive will be loaded down by the tube giving the smaller drive. As a result, according to whether the tubes are of the pentode or triode type, the one delivering the larger output will be looking into an open circuit or short circuit condition, instead of its correct optimum load. This means the tube will produce considerable distortion, long before maximum rated output for the single tube is reached, which will be much below the full rated output of the push-pull stage.

This fact alone can result in a considerably distorted waveform. If, on top of this, the output transformer has a notable resonance between the primary capacitance and its leakage inductance, which will overemphasize some of the harmonic frequencies generated in the distortion, the distorted waveform will get even more exaggerated, so as to produce a resultant wave somewhat as shown at *Fig.* 5.

This kind of waveform at the high-frequency end of the audio response usually gets blamed onto the output transformer, because measurements show the waveform at each grid of the push-pull stage to be quite sinusoidal. There may be difference in magnitude at this point, but the waveform is normal on both grids. Transferring the measurement to the plate circuit, the waveform appears as shown at *Fig.* 5 and so the

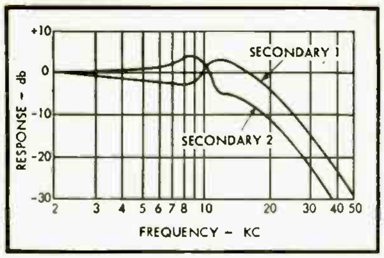


Fig. 4. Typical frequency responses produced by a transformer arranged as at Fig. 3. Notice the different response from each secondary.

output transformer gets blamed. In point of fact, what is happening is that the peculiar impedances presented by the transformers in the drive and plate circuit of this push-pull stage, are causing the non-linear characteristics of the tubes to act as a frequency-doubler circuit instead of a straight amplifier.

While it is quite true that use of a circuit not employing transformers would avoid this kind of distortion, yet the transformers themselves are not *producing* it. In fact, if the equivalent circuit of the transformers were synthesized entirely of air cored inductors, the same distortion would appear, because it is the tubes that are causing it and not the "inherent distortion" of the transformers.

Notice however, that the primary fault with these transformers is in their frequency-response characteristic. If they had a flat frequency response and were balanced on each half, this kind of trouble could not appear. This means that the interstage and output transformer should be arranged to give careful balance of both winding capacitance and leakage inductance, at least over the frequency range to be used.

What Makes Good Balance

Many of the more expensive transformers employ elaborate means to ensure this degree of balance. The windings are sectionalized in both directions, so the sections used in one half are absolutely symmetrical with the sections used in the other half. This involves winding the transformer in a considerable number of sections, and also a considerable amount of cross-coupling.

Often a cheaper and more effective method of construction could be employed, based on a little more knowledge of the characteristics of leakage inductance. First we'll state the characteristics of leakage inductance and then show a practical comparison of the methods of sectionalizing.

Increasing the mean turn length of the windings *increases* leakage inductance in direct proportion to the turn length.

Increasing the length of winding section, in the direction where they lie adjacent one to another, *reduces* leakage inductance in proportion to the length of winding.

Increasing the thickness through the windings, across the direction of interleaving of the windings, *increases* leakage inductance.

These dimensions are illustrated in *Fig.* 6. Now let's take a typical geometrically balanced well mixed transformer, of the arrangement shown at (A) in *Fig.* 7, as compared with the arrangement in (B). The arrangement of (A) employs a split bobbin or two separate bobbins to accommodate the windings; that of (B) accommodates the winding on a single bobbin, and necessitates a lower number of sections.

But from the viewpoint of leakage inductance, the winding of (A) consists of only three sections, one section of primary and two sections of secondary, or vice versa, although physically there is a total of six sections. From the viewpoint of magnetizing effect, the laterally adjacent sections of primary and secondary each count as a single section.

From the viewpoint of generating leakage field the arrangement of (B) consists of three whole sections and two half sections, which will be two sections of primary and the equivalent of secondary, except that the latter will be one whole section and two half sections.

Although the latter arrangement only requires five sections of winding in place of six, it will reduce the effective leakage inductance between primary and secondary using the same total number of turns by a factor of approximately four times. It will also achieve very close matching between the leakage inductance from the primary to each half of the secondary, or vice versa, because the length of mean turn of the center single section of the secondary is the same as the length of mean turn of the two outside half sections. Looking at the coupling from pri-

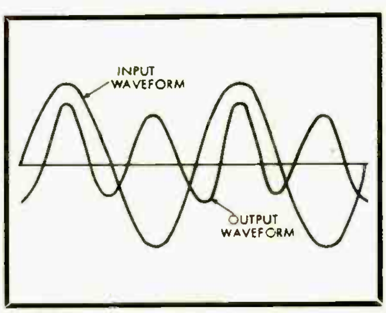


Fig. 5. Due to the phase shift effects in the grid transformer, and the impedance characteristic of the plate transformer, a pushpull output stage may operate as a frequency doubler at one particular frequency, giving waveforms like this. However the non-linearity that causes frequency doubling is in the output tube characteristics.

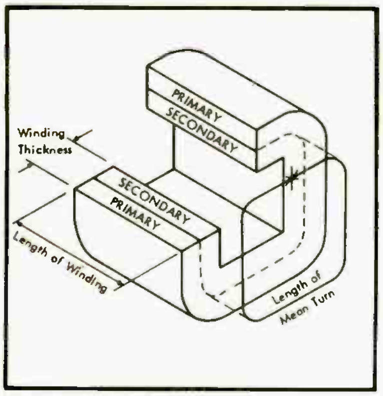


Fig. 6. Section of simple double winding, without core, to show dimensions relevant to leakage inductance value.

mary to one half secondary, the secondary whole section is sandwiched between two sections of the primary. Looking at the other half, the two primary sections are sandwiched between the two half sections of the secondary. This is illustrated by the partial diagrams of (C) and (D) in Fig. 7.

Winding capacitance can be equalized very approximately by the method of connection. In this case, it's true that the winding capacitance is assured of equality by the geometrical symmetry of the arrangement of (A) in *Fig.* 7 which it is not in the arrangement of (B). But the fact that the response is considerably extended by reduction of leakage inductance, together with the close matching in capacitance that can be achieved by careful arrangement and connection of the windings in the manner shown, does result in a transformer of considerably improved performance and at the same time of lower cost than the arrangement of (A).

This is just a simple example of how a correct understanding of the factors contributing to audio transformer design can simplify the arrangement while at the same time improving performance. It is not the purpose of this article to go into detail on transformer design—merely to point out that by correct design and use in circuits, audio transformers *can* be good, and can give results as good as a resistance-capacitance arrangement.

Effect of Feedback

There is one point connected with the use of feedback associated with audio transformers that is often misunderstood: the reason has been given for applying feedback from the secondary of an output transformer, in comparison with taking it from the primary, that connection from the secondary enables the feedback to "work on" any distortion caused by the transformer, whereas connection from the primary does not include the transformer in the feedback loop. This statement is not quite true.

The principal distortion in a transformer, as shown in the foregoing, is caused by the nonlinearity of the magnetizing current and manifests itself at low frequencies. Any other distortion is not directly due to the transformer, but to the effects of its impedances on the tube performance.

The magnetizing current taken by the transformer is drawn by the primary circuit through the a.c. resistance of the tubes, and hence will produce as much distortion voltage on the primary as on the secondary, except for any slight resistance drop in the primary winding. The distortion *voltage* generated is due to the flowing of the distortion current through the source resistance, and the total source resistance, from the viewpoint of the magnetizing effect in the iron, is the a.c. resistance of the tubes plus the resistance of the primary winding.

Usually the resistance of the primary winding will not be more than one tenth of the a.c. resistance of the tubes. This means that, from the viewpoint of working on distortion caused by the transformer, a connection from the primary circuit will be nine tenths as effective as a connection from the secondary circuit. This is hardly what the generalized statement just referred to implies.

In the case of the response caused by leakage inductance and winding capacitances, the situation becomes rather more complicated, because we are introducing additional reactance elements into the over-all feedback loop as soon as we apply the arrangement from the secondary. However, in the average output transformer the most effective winding capacitance is in the primary—the secondary winding capacitance has no effect until a long way above the audio band, because of the low impedance circuit it shunts. So the principal difference from the viewpoint of the feedback network is that a leakage inductance is included in the loop by connection from the secondary that is not included when connected from the primary.

Also, of course, connection from the secondary avoids the use of a blocking capacitor, because one end of the winding can conveniently be connected to ground instead of having to be at a B+ potential. This is in favor of secondary connection, but for a different reason.

Remember here that the primary purpose of an amplifier is usually to feed a loudspeaker, which is a load containing inductance as well as resistance. The inductance of the voice coil is usually many times the leakage inductance of the output transformer. This means that transferring the feedback take-off point from

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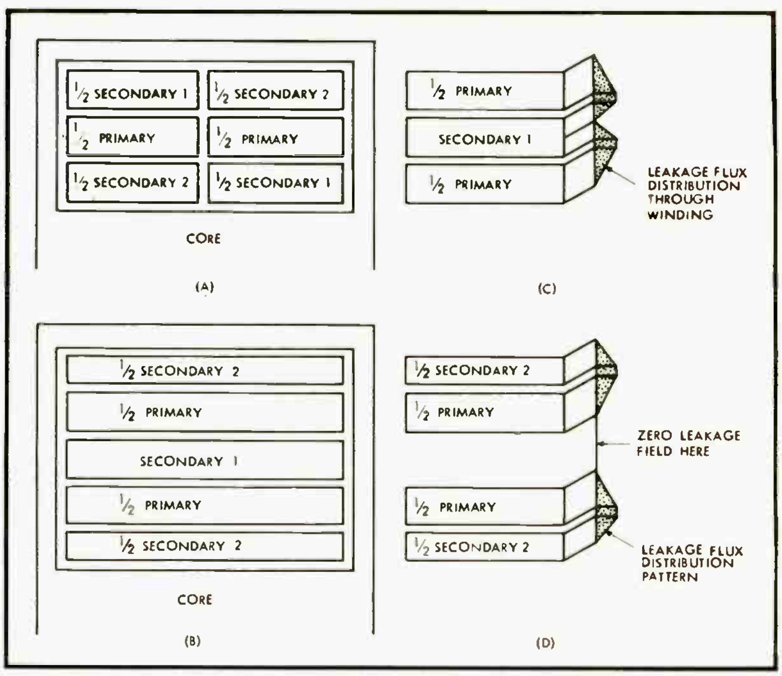

Fig. 7. The relative advantages of these winding cross sections for a pushpull transformer are discussed in the text. (A) a cross section ensuring absolute balance by geometrical symmetry; (B) a method using one less section, but improving coupling factor about four times; (C) coupling between primary and secondary 1; (D) coupling between primary and secondary 2; in (C) and (D), the black areas at the right show the distribution of leakage flux through the winding: note that both have equal area, and are also symmetrical about the mid-point of the winding.

AUDIOCLINIC ? ?

JOSEPH GIOVANELLI

Loudspeakers

Q. What is the principle of operation of a loudspeaker? L. Brookman, Utica, N. Y.

A. Let us take a permanent magnet and mount it so that it cannot move. If another magnet is brought into the vicinity of the first and if opposite poles face each other, it will be attracted by the first one. If the second magnet is rotated so that like poles face each other, it will be repelled.

If an electromagnet is substituted for the second permanent magnet, we no longer need rotate it to change the polarity. All we need do is reverse the leads which supply direct current to it; it can be done even more easily if we feed alternating current into the electro-magnet, since the poles are constantly reversing, bringing about varying degrees of repulsion and attraction and at a rate dependent upon the frequency of the a.c. supply. This is exactly what happens in a loudspeaker. The electromagnet is attached to a cone which, in turn, is suspended fairly loosely so as to be free to move. The electromagnet (or voice coil, as it is called) is very carefully interleaved with the permanent magnet so as to yield the highest possible efficiency. When we impress audio frequencies (which are a.c.) on the voice coil, we then cause the cone to move in accordance with the frequency or frequencies of the applied signal. Further, if the amplitude or size of the voltage and current making up the signal is increased, the cone will move further and if it is decreased, the cone will move less. The more the cone moves, the more strongly the air adjacent to it is moved, with our ears then telling us that the volume of sound has increased.

Some speakers do not use permanent magnets. Rather, they use a second electromagnet energized by filtered d.c. so as to have a constant polarity against which the voice coil can work.

Frequency Modulation

Q. What is meant by frequency modulation? V. Whitney, Jacksonville, Fla.

A. Transmitted waves, whether they are to be amplitude modulated or frequency modulated, would appear identically on a scope if no modulation were applied. When a program source is placed on this carrier or center frequency, as this unmodulated wave is called, the frequency varies to a value somewhat above the carrier frequency and to a value somewhat below it at a *rate* dependent upon the frequency or frequencies of the program source. This carrier, of constantly varying frequency, is passed through the various stages of amplification of the receiver until it reaches the detector which converts these radio frequency waves into audio frequencies. One of the most common of these detectors is known as a *discriminator*. It is a balanced circuit so adjusted that when the center frequency alone is being supplied to it, zero volts or nearly so appears at the output. When the frequency of the carrier shifts above the center frequency, a voltage is produced at the detector's output. When the frequency of the carrier returns to and proceeds below the center frequency, a voltage of opposite polarity is produced. This audio-frequency voltage is then fed to an audio-frequency amplifier stage and, finally, into a loudspeaker.

The more the frequency deviates from the center frequency, the more voltage is generated in the output of the detector with a consequent increase in sound level. This cannot be carried to extremes, however, since the various amplifier stages in the FM receiver are designed to accept a limited amount of this deviation. Also, if such deviation were unlimited, stations whose center frequencies are fairly close together would interfere with one another because of overlap at the extreme positive and negative points (above and below the center frequency). The maximum legal limit of deviation in each direction from center is 75 kc for commercial broadcast FM stations.

Selenium Rectifiers

Q. I've had a great deal of trouble with selenium rectifiers burning out. The circuit appears to be in good order so that there should be no need for such failures in my preamplifier. It is a home-built unit. J. McIntosh, St. Louis, Mo.

A. We have encountered many problems with selenium rectifiers and have found that the fault rarely lies with the rectifier. These units are, unfortunately, not conservatively rated. Thus, if the current you expect to pull through the unit is, let us say 30 ma, it is advisable to use a selenium rectifier with a maximum current rating of 45–50 ma. This should allow the unit to run cooler and will therefore give longer service. It would appear that excessive heat is the destroyer of selenium rectifier units. The unit should also have a voltage rating of perhaps 40 per cent higher than the voltage that will be applied to it. If a larger safety factor than this is provided, too much voltage will be lost in the unit itself.

Many builders mount these rectifiers with their plates in a horizontal plane, with the machine screw vertically oriented. When it is mounted in this manner, the heat generated by the lower plates is carried by conduction and convection to those above, which plates, however, have already produced heat of their own, and the heat thus added to them causes excessive heating with a consequent shortening of rectifier life. The units should be mounted with the plates vertical and the mounting screw oriented horizontally. This will keep any one plate from transferring too much heat energy to its neighbors.

Compliance

Q. In discussions of the performance of pickups, I've seen a great deal of reference to the term compliance. Will you please explain what it means? H. Weeks, Detroit, Michigan.

A. When we speak of compliance, we are referring to an aspect of the performance of a phonograph cartridge or pickup. It is the ability of the moving parts of the cartridge to move in accordance with the force supplied to them via the undulations of the groove walls. It is not a measure of the frequency response although it does have some influence upon it. The more compliant the system, the less is the energy that must be expended in moving the elements of the pickup. When the undulations of the groove try to move the assembly little motion takes place if a pickup suffers from poor compliance, and this puts a strain on the record surface. Finally, inertia will cause the arm to move instead. The motion of the arm is more violent, because of its mass, adding to the shortening of record life. It is not difficult for a manufacturer to make a pickup compliant but it is far more of a problem to so arrange the system that the moving parts stop their motion instantly when the modulation ceases. This ability of the moving elements in a pickup to cease their motion immediately after the groove stops imparting motion and to start moving again when the groove again attempts to impart motion is a measure of the damping of the pickup.

Enclosure

Q. Will you please outline the steps necessary for constructing a corner loudspeaker enclosure? Morris Sherman, Sunland, Calif.

A. For most satisfactory performance, it is desirable to have a volume of at least five cubic feet. Larger volumes, of the order of ten cubic feet, are to be preferred since they give better loading and a correspondingly greater low-frequency response. Smaller volumes require a port below the speaker; larger volumes do not. Some of the manufacturers of speakers and enclosures have prepared charts which show port sizes and locations suitable for their reproducers.

Corner enclosures should be neither too squat nor too tall and thin; either extreme will produce unwanted resonances. The speaker should be located well up from the floor. The minimum height of the cabinet should be two feet. The inside walls of the enclosure should be thoroughly padded with a sound-absorbing material such as Ozite or Kimsul.

The volume of a corner cabinet is given by the equation $V = \frac{1}{2}bcH$, where b and c are the legs of the right triangle which form the base and H is the height of the enclosure. Most enclosures are constructed with a right isosceles triangle as the base. In this case, $V = \frac{1}{2}b^2H$. If b and H are

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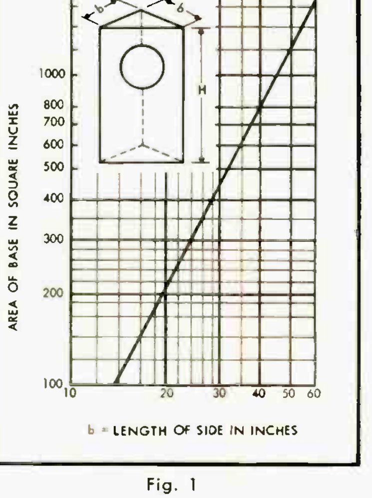


Fig. 1

Fig. 1 High impedance filter network for 3-way speaker system. Bud mini-box 6 × 4 × 4 inch chassis with open-end base removed to show components and connections. Values are given in schematic, Fig. 14.

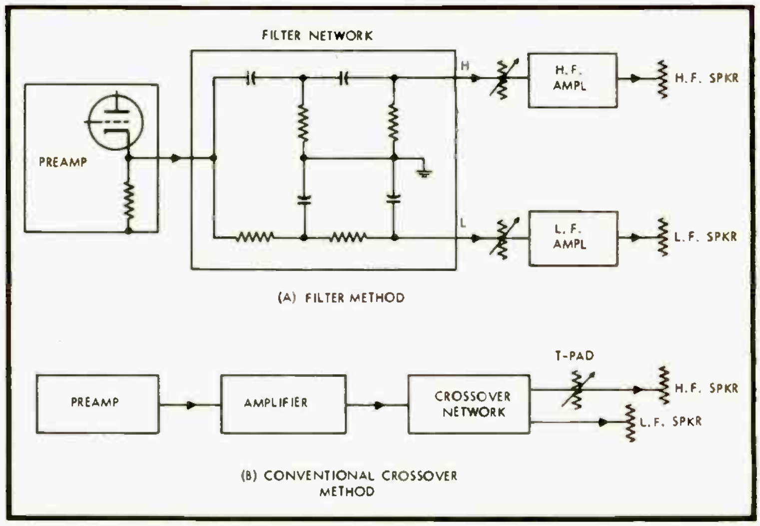


Fig. 2. (A) Filter network with dual-channel amplifiers compared with (B) conventional crossover network.

at home with AUDIO

LEWIS C. STONE

Hi-Fi Segregation

Second in the series "There Is No Hi-Finality." Filter network and separate power amplifiers for tweeter and woofer replace conventional crossover with gratifying hi-fi results.

IT MAY BE THAT the hi-fi turnabout we aim to describe this month may point to a trend. Or it may seem to some of you to be as necessary as a hole in the head. But the reader whose system we are about to embed in the striated amber of this department's rhetoric feels, on the contrary and perhaps justifiably, that if hole there be, it is of the hole-in-one variety. The point is that the subject reader, owner of as fine a hi-fi rig as you will find east or west of ol' man river (as described here in its darkling splendors June, 1955) decided recently to switch from his conventional dividing network to a filter-type system, with an additional power amplifier—all speakers aboard and intact.

The filter network (*Fig.* 1) to which reader Crofford has switched contains in its system one preamplifier with cathode-follower output stage for low output impedance; high-impedance filter network with low- and high-frequency outputs; and the original 60-watt amplifier plus a newly-built 40-watt unit. A block diagram of the filter network system, compared with a conventional crossover, is seen in *Fig.* 2.

No Fractured Frequencies

The new network feeds to these amplifiers, each fitted with a ½-megohm level control at its input. This means you can adjust the level of the tweeter without using expensive T- or L-pads inserted in the speaker line to hold correct impedance and create aural balance. Since tweeters are fitted with comparatively fragile elements, and must necessarily be kept within a maximum peak of one or two watts (higher power tweeters can be had, but at higher cost)—the crossover should be arranged so that the very high-frequency unit (in a 3- or 4-way system) reproduces only the harmonics of the upper tones: calling for crossover at 5,000 cps. By and large, the acoustic level of the harmonics is much smaller than of the fundamentals, which is why the power rating of the tweeter and mid-range amplifier is smaller than the low-frequency unit.

The high-frequency section can be handled with a low-power stage and by the same (inverse) token, a high-power output stage handles the mid- and low-frequency range. Then the two stages are put in balance, and held so permanently.

Our reader reports that he thus achieves a currently "hot" audio goal: not nearly stereophonic, obviously, but a something approaching a sonic stereo-sensory feeling is there. And because the values of the components seen in the schematics, it is to be expected that neither tweeter nor woofer nor mid-range will be likely to break up at their respective ranges of frequency. The filter network components have

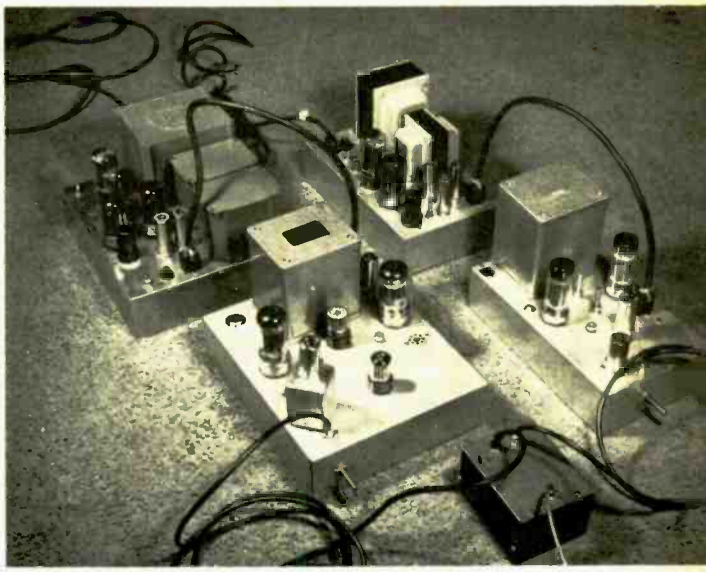


Fig. 3 (above). Dual amplifier system interconnected with filter network (small chassis in foreground). Left, array of 60-watt low-frequency power amplifier with power supply; right, 40-watt high-frequency array. Note two Mullord EL34's on this power amplifier.

Fig. 4 (left). Mockup of layout of components to guide cutting of chassis. Note three UTC units (LS Series power transformer, Special Series filament transformer and choke). Tube sockets and test pins along left rim. Tools shown: Greenlee punches, clippers, pliers, socket wrench, metal files. Carton upper left holds solder strips, used with Weller gun. Belden reels hold #18 solid insulated conductor.

been evaluated for adequate crossover operation in this speaker system—neither too sharp nor too gradual—and variable level controls are seen fitted to the early stages of the power amplifiers, where good practice requires that they should be. The interconnected array is shown in *Fig.* 3.

This could mean that you can play around with the speakers, holding them strictly to a fixed relationship or, if you will, ad-lib and improvise their response levels, depending on program or source, or the state of your hearing.

Transient's Fallout

It seems that reader Crofford locked onto the dual-amplifier, filter-network notion after a recent and lengthy bout with some stereophonic recording sessions (as a recording engineer with RCA Victor.) From then on, he claims that his pleasure-trove of ultra-satisfactory listening to his own hi-fi system somehow became false to his ears. The specific lack (to his newly stereo-sensitized perception) seemed to be mostly in the capacity of his home system to cope with transients: those leap-frog passages that are said to lend color and rhythm and texture to the music. Suddenly, what he heard held not the old illusion of realism for him. The quality of the output signals seemed somewhere along the route to have become vitiated. Questions of complete equipment replacement came to mind. But replace with what else better? The components in his hi-fi system certainly were as good as the industry had to offer.

We learned about the changeover to dual-channel amplification when we checked with owner Crofford about some inquiries sent in by readers, such as this one from L. B. Gettman (Washington, D. C.) from which we quote, blush or no:

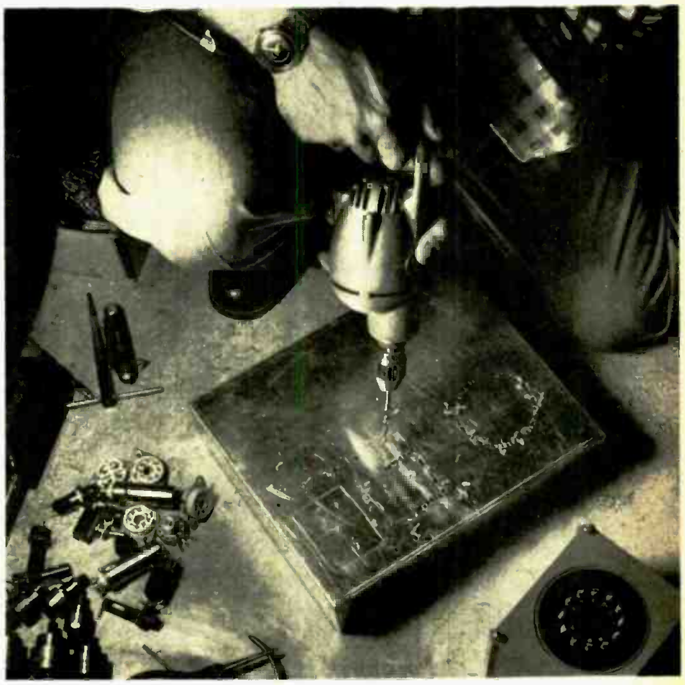


Fig. 5. Chassis cut-outs made by drilling holes in soft aluminum along perimeters of components, with ¼-inch hand power drill. Pocket-knife cut along perforations to complete openings.

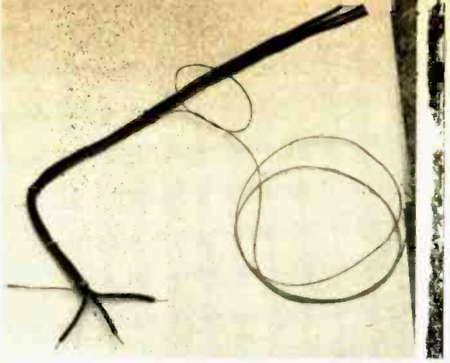


Fig. 6 (above). How wires are cable-tied. Use waxed facing cord for loops around bundles of related leads.

Fig. 7 (right). Bottom view of components assemblies, pre-wiring stage. Tube sockets, control, jacks, switches, fuses, transformers placed to require a minimum of wire. Allows neat and compact in-line wiring, as in accepted broadcast standards. Short lengths of contact-to-contact wiring give maximum freedom from hum due to ground loops.

"Your articles in AT HOME WITH AUDIO are most interesting and helpful to those of us who are planning initial high-fidelity rigs or the modification of existing installations. My only complaint is that you don't have an article in each issue of AUDIO.

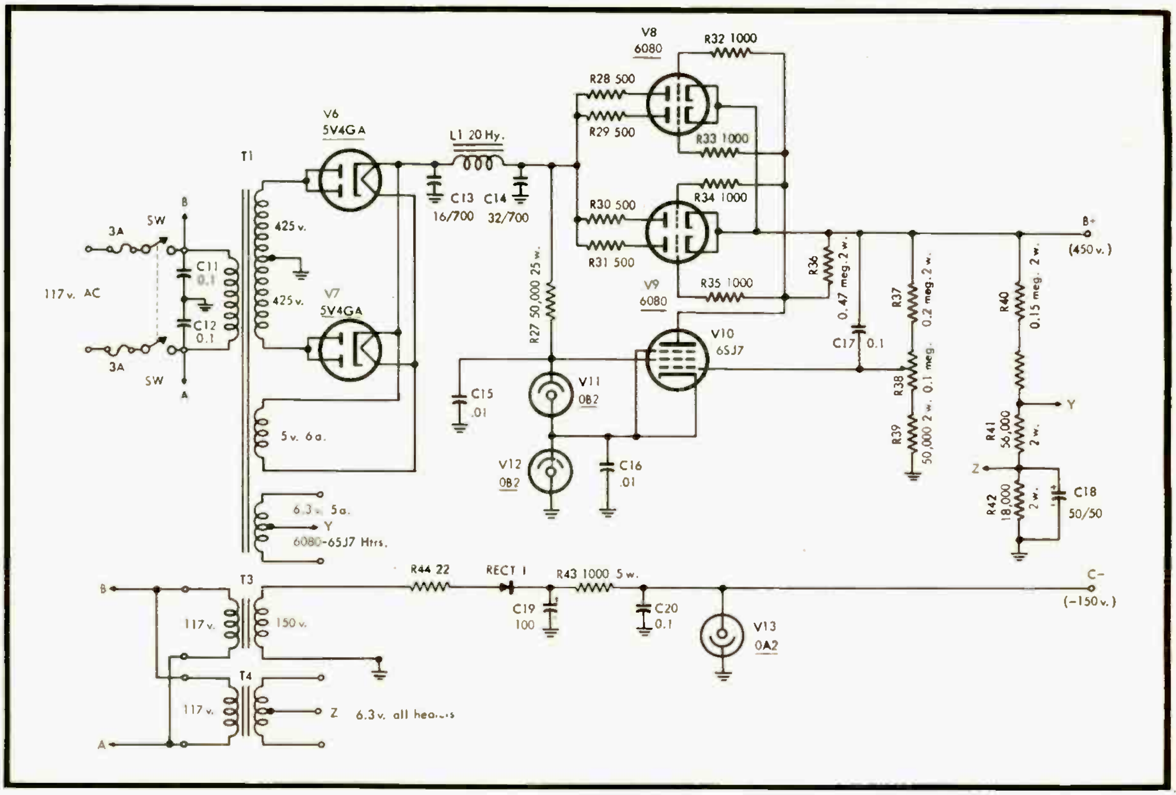
"Since I am in the process of planning major changes in my rig, your articles have been especially helpful. Of particular note to me was your article in the June 1955 issue. . . . Can you supply me with a parts list . . ."

This article got shaped up when reader Crofford told us how he went about making fi-perfection more hi-perfect. Or, at least, he anticipated such a result, by a "modification of existing installation," as letter writer Gettman so aptly puts it, above.

Kitchen (Floor) Mechanic

The Crofford kitchen is his hi-fi workshop and the floor his workbench. Working with the malleable-grade aluminum chassis, he avoided complicated tools. Cut-outs for the transformers were made with a ¼-inch hand power drill by perforating just inside perimeters and circumferences which he first outlined in crayon around each component, arranged loosely in mockup of the final layouts. (*Figs*. 4 and 5). He

Fig. 8. Schematic of separate power supply for 60-watt power amplifier. Values of all components are shown. V_{13} is actually located in amplifier chassis.



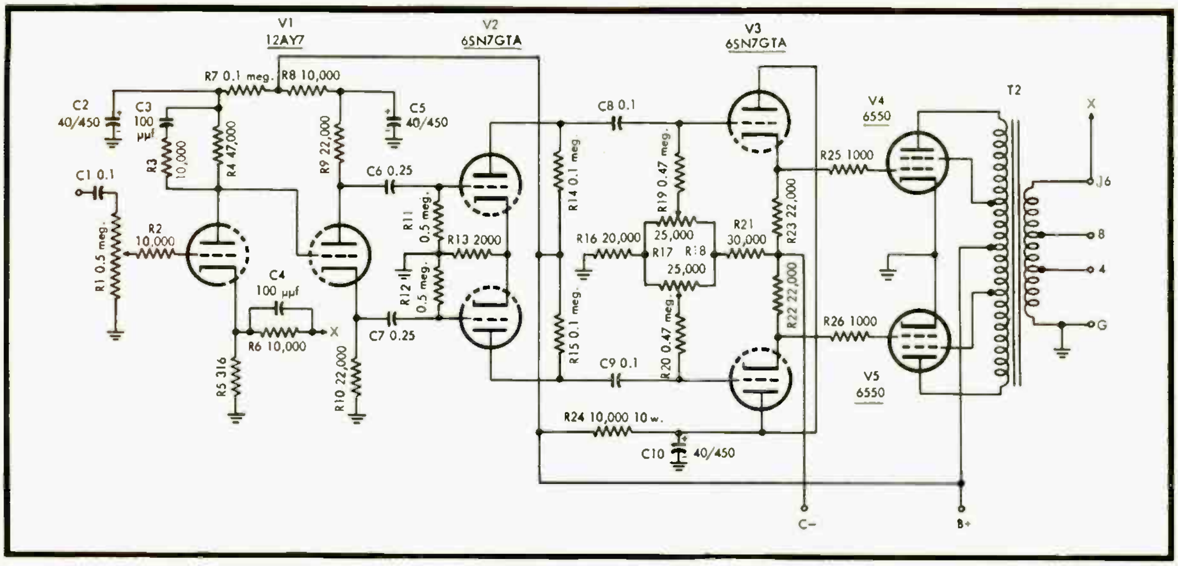


Fig. 9. Schematic of 60-watt power amplifier, component values given. 40-watt unit is similar, but with one less 5V4GA and one less 6080 in power supply.

used a heavy pocket knife to cut along the drilled perforations to complete the openings. Areas for tube sockets and Vector turrets were cut out with Greenlee and Pioneer chassis punches. The rough edges of each opening were then filed smooth to their net sizes and so readied for fitting and mounting the respective components.

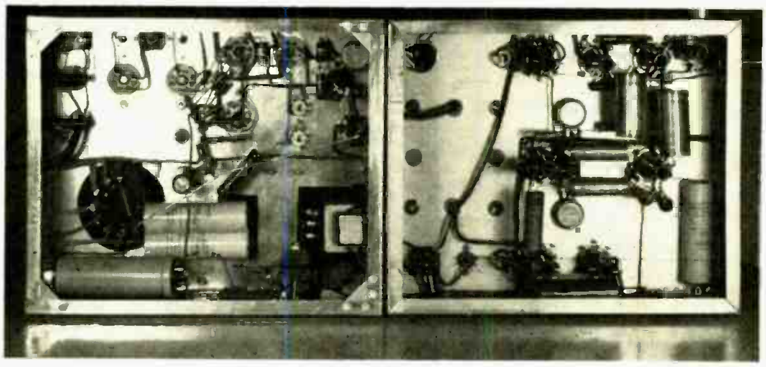
The steps followed in "filling" the chassis can be seen in the photographs, *Figs.* 4, 5, 7 and 10. Although the wiring is completely out of sight on the undersides of the four chassis, the job is a neat one, with cabled leads and busbars. The procedure for cabling leads is indicated in *Fig.* 6. All of it is therefore uncrowded and accessible, not to say easily identifiable for tracing and checking purposes.

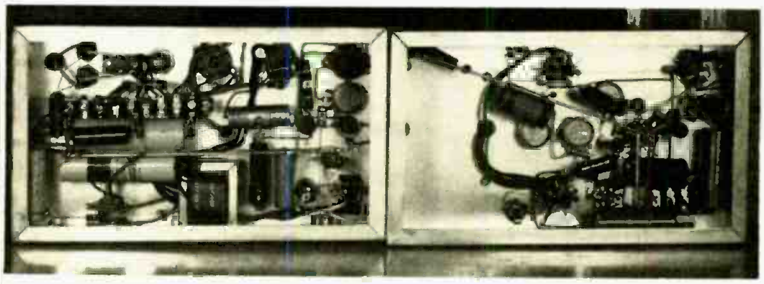
To fall into line with letter writer Gettman's and other similar requests, we now take space (elsewhere in the article) to list all the parts that went into the self-made 60-watt power amplifier and its separate power supply, as seen in two schematics, *Figs.* 8 and 9. As to the new 40-watt unit, that tweeter-nurser is twin to its elder brother except, we are told, for one less 6080 high-current dual triode and one less 5V4GA rectifier. Both arrays are shown, bottoms up, in *Figs.* 11 and 12.

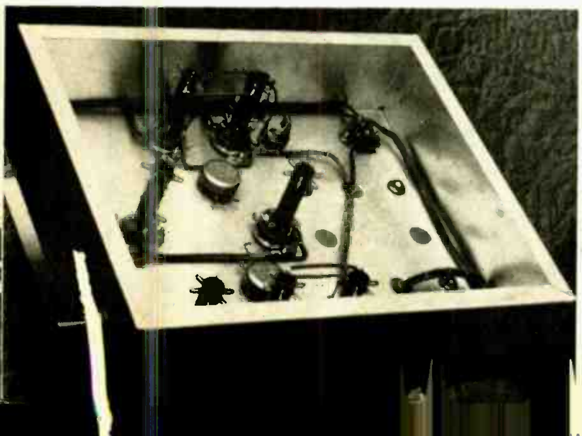
As to investment, the cost of the additional amplifier is offset somewhat by the savings in the cost of the conventional crossover, which has been replaced by the filter net-

(*Continued on page 74*)

Fig. 10 (below). Some resistors in place, solder-connected to Vector turrets. Filament wiring is kept snug to top and side of chassis frame to avoid induced hum in amplifier. Fig. 11 (upper right). Completed wiring of 60-watt low-frequency amplifier on 12 x 10 x 3 inch chassis. Note bus-bar in power supply (left), selenium rectifier on stand-off insulator, electrolytic capacitor, resistors mounted vertically on Vector turrets. Coupling capacitors bridged from voltage amplifier stage to output stage are clear of chassis "floor" to minimize stray capacitance affecting high-frequency response. Level control in upper right corner. Fig. 12 (lower right). Completed 40-watt high-frequency power amplifier on 12 × 7 × 3 inch chassis, with power supply. Wiring procedure identical with bigger unit.







Experiment III—The Beta-Tron

STAN WHITE*

An interesting, practical, and already-on-the-market application of feedback from the speaker to the input of its driving amplifier, which can also be used with any tweeter to provide electronic crossover network with separate drive for the two speakers.

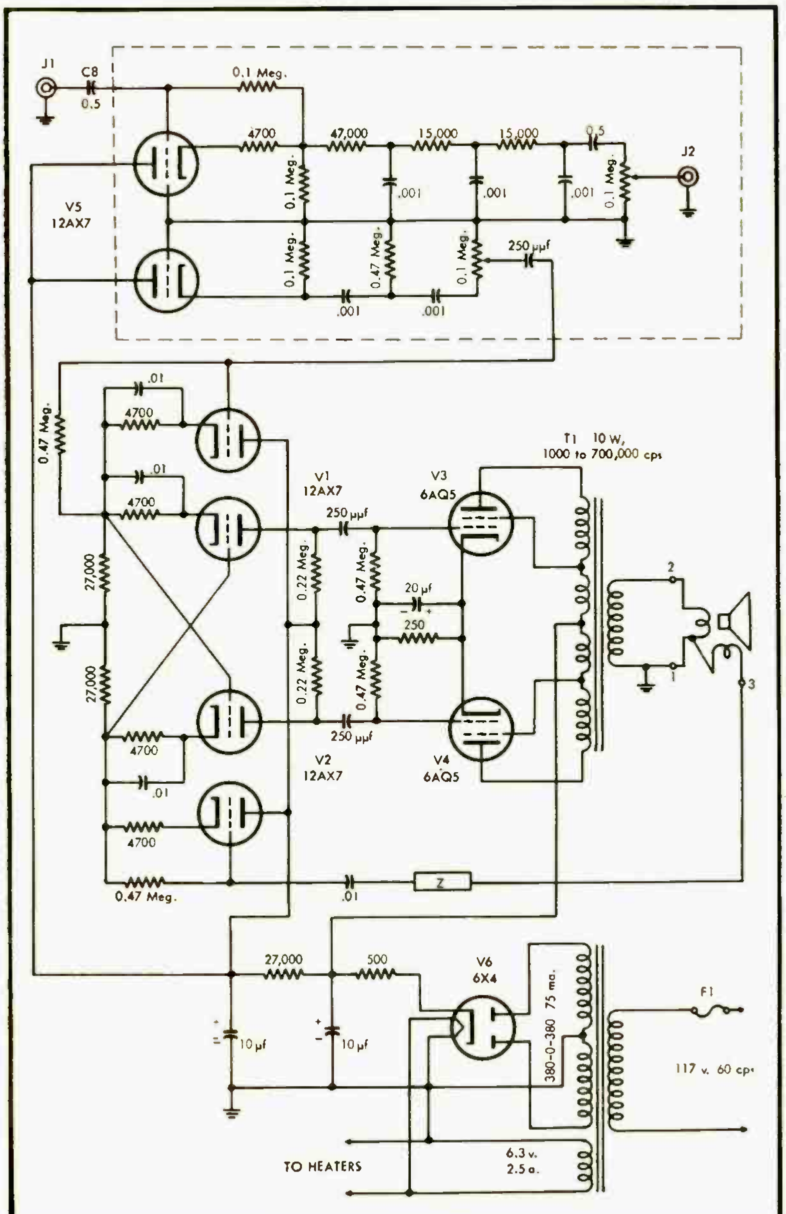


Fig. 1. Schematic of the White Beta-Tron amplifier as connected to its feedback tweeter. For use with other tweeters, the feedback circuit is simply shorted to ground.

The Powrtron amplifier was first described in Audio Engineering magazine and was recently discussed again in the 3rd Audio Anthology under the title, "The White Powrtron Amplifier." This article included the first discussion of the dual-channel amplifier (with electronic crossover networks preceding both amplifier channels) as a method of reducing intermodulation distortion in audio systems. These two ideas, introduced over three years ago by the writer, have proven themselves and have established a new trend in audio design.

The basic idea of the Powrtron was that an audio power amplifier should put out a constant-power signal regardless of changes in frequency and irrespective of shifts in loudspeaker impedances. The circuit employed discrete amounts of negative current feedback. Several people have attempted to show that the variations in the damping factor caused by the additions of negative current feedback has significance, but their efforts have not been too fruitful.

All this is by way of introduction to Experiment III, a further development of basic concept of Powrtron. Without going into the whole problem of audio reproduction, let us begin by agreeing that we cannot hear power amplifiers. It might be of interest to note that power amplifiers cannot hear the results of their labors either. That is, there is no mechanism within the power amplifier to correct for faulty *speaker* performance. Not only that, but the speaker does mischievous things to the amplifier to snarl up the amplifier's attempts at correcting itself. Let me explain this by pointing out that in order to convert a voltage signal (no power) to a power signal (voltage × current) requires amplification, which in turn has to result in distortion. Feedback is a method of reducing the distortion caused by amplification (in this case *power* amplification).[1] Until Powrtron, the various kinds of feedback assumed passive conditions beyond the amplifier, and with the Powrtron experiment we were able to

* *Stan White, Inc., 725 So. La Salle St., Chicago 5, Ill.*

[1] See Olson's "Elements of Acoustical Engineering" p. 158–159.

see that the crossover networks and speaker loads effected the feedback loops around the amplifier creating a new kind of distortion not theretofore analyzed.

In Experiment III we propose to show that the distortion created in the electrical power phase of audio reproduction is in itself without significance. To repeat, we cannot hear an amplifier. The important consideration we recall from Experiment I is that the acoustical waveform radiated from the speaker system be a transformed replica of the voltage waveform presented to the input of the power amplifier. We therefore propose to throw away all feedback loops around the power amplifier and go one step further and employ a feedback loop which controls the speaker. Ordinary amplifiers drive the speaker, but cannot correct speaker defects. With Experiment III we propose to control the motion of a speaker through a motion-sensing coil, and thereby create a new world of sound.

This experiment is designed to show that motional feedback is superior to ordinary feedback methods, and that by incorporating the tweeter into the amplifier a better unified whole is obtained.

The system will comprise a bass amplifier, a high-frequency amplifier, bass speaker(s), a tweeter with isolated motion-sensing coil, an electronic crossover network, and a sound source. The conclusion of the experiment will be determined by comparing this system with ordinary systems and assaying the results.

Figure 1 shows a schematic of the Beta-Tron amplifier-speaker system, including power supply and electronic filter network. The amplifier contains a cross-coupled phase splitter coupled to beam power output tubes, and has several phase correcting networks scattered throughout the system. However, if the values as shown are employed, the circuit is extremely stable and requires no special parts (close tolerance) other than the output transformer, and the Beta-Tron tweeter.

The amplifier itself has a good frequency response, being flat from 1,000 to 200,000 cps, but when used in conjunction with the Beta-Tron tweeter the response on the top end increases to 500,000 cps, or 50,000-cps square waves. The Beta-Tron tweeter responds acoustically to 30,000 cps,[2] but will not radiate beyond that because of limitations of cone materials. The Beta-Tron system employs a motional feedback loop, with a motion-sensing coil located in the Beta-Tron tweeter. A phase correcting network, *Z*, is located in the tweeter. Care must be taken to ensure that the proper phase relations are maintained when connecting the tweeter to the amplifier, the sensing coil must present negative feedback to the system, or oscillation will occur.

To connect the Beta-Tron to an existing system, plug the output of the preamplifier into J_1, the input to the Beta-Tron. Connect the Beta-Tron tweeter to the Beta-Tron amplifier, connect the input of the ordinary amplifier to the output J_2 of the Beta-Tron amplifier and its output to the bass speaker. The length of cord between the tweeter and amplifier is not critical (keep below 500 ft.) and the separate controls R_{14} and R_{17} permit independent adjustment of the levels of bass speaker and tweeter.

The advantages of the Beta-Tron system over conventional systems are legion. We saw in Experiment II that dual-channel amplifiers are superior to ordinary amplifiers, the reasons being about the same as the reasons for using woofer and tweeter combinations as against single general purpose speakers. Intermodulation is reduced to zero, according to standard methods of testing. Harmonic distortion is greatly reduced, and in any comparison between electronic crossover *vs.* standard crossover systems, the electronic crossover is, in the writer's opinion, definitely superior.

Of course, the Beta-Tron may be used with any system and for those who do not wish to take advantage of the Beta-Tron tweeter and merely wish to use the electronic crossover feature, the circuit may be easily modified to ordinary types of feedback systems by shorting terminals 2 and 3 on the output plug. The crossover point in the Beta-Tron is 2,000

(*Continued on page 74*)

[2] See G. A. Briggs in Loudspeakers—the Why & How of Good Reproduction (4th Edition).

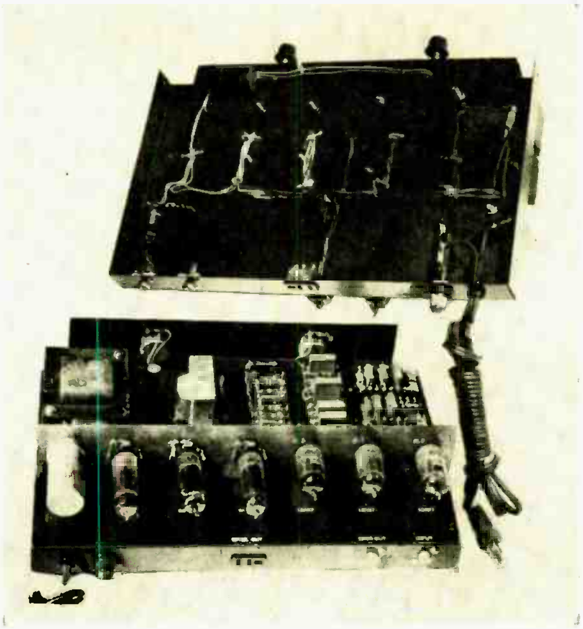


Fig. 4. (Right, above) Underside of the amplifier is extremely simple and compact.

Fig. 5. (Right, below) Top view of the amplifier with the cover removed.

Fig. 2. External appearance of the Beta-Tron amplifier shows the separate controls for bass and treble speakers.

Fig. 3. The feedback tweeter resembles any 5-inch cone unit except for the relatively large housing.

What Makes a Woofer?

SAUL J. WHITE*

Describing a new speaker having high compliance, low mass, and inherent damping

WHAT IS A WOOFER? The term originated as a slang or colloquialism describing the tone character of the bass end of a reproducing system. When two-way speaker systems were first introduced to motion picture theatres nearly three decades ago, the contribution of the low-frequency loudspeaker was referred to as "woof." A system with good bass response had lots of "woof." The speaker handling this low registry was naturally referred to as a *woofer*.

Improvements of our arts and sciences create a continual demand for new terms. At first the term *woofer* was a special technical expression without any dignified professional standing. But through the spread of the audio art, the name has been adopted by the engineer and layman and it is today well defined and well accepted. The term has force and color. Similar words such as tweeter, wow, squacker, cornerless-corner, birdies, and so on, will conduce to expand our technology and love of high fidelity to the multitudes with understanding and precision.

What makes a good woofer? How is it distinguished from a general-purpose or wide-range speaker? Actually any single wide-range speaker should provide for the same bass characteristics as would be expected from a woofer. The main difference being in the output at the top end of the woofer response, where it may or may not cutoff slowly somewhere between 1000 and 3000 cps depending upon the weight or mass reactance of the moving system. Thus most conventional woofers employ heavy cones and large voice coils so as to inherently attenuate their high-frequency output. It would appear that the only justification for the promotion of a woofer is that the high end has been sloughed off.

The writer takes a diametrically opposite point of view, and will show that a high-mass moving system has many attending evils, such as low conversion efficiency which may be restored in some cases by extraordinarily large magnets which, in effect, penalizes the purchaser in cost; poor transient response; failure to achieve inherent damping showing up as unnecessarily high mechanical "Q"; and finally failure of the speaker to benefit from the high damping factor in the better quality amplifiers.

* *Chief Engineer, Racon Electric Co., Inc., 1261 Broadway, New York 1, N. Y.*

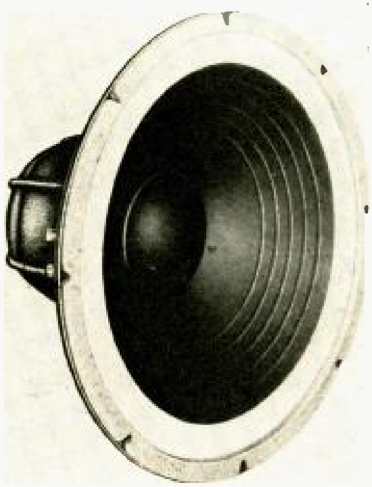


Fig. 1. 15-in. woofer having high compliance cone, with plastic foam surround. Resonant frequency is 24 cps.

The writer will describe a woofer conceived on the principles of low mass, high compliance and self damping.

Equivalent Mechanical Circuit

The mechanical impedance which involves mass and compliance is of great importance in a direct radiator at very low frequencies, particularly as it effects hangover and non-linear distortion.

Figure 2 shows the equivalent circuit as a simple series resonant circuit in which M_s is the mass of the moving system; M_a is the mass of the air set in motion; C_s is the compliance of the moving system; R_s is the resistive component of the compliance; R_a is the resistive factor of the air set in motion. Both M_a and R_a are dependent upon frequency and are fixed in range of values by the diameter of the cone. For large amplitudes of vibration as at low frequencies, the compliance C_s must be large. The reactance of the mass M_s should be small for efficient transfer into acoustic energy, and the smaller this mass, the smaller may be the damping component R_s for any given value of efficiency. M_s, C_s and R_s are at the control of the designer. A gain in performance at low frequencies can be realized if M_s is small, (i.e., a lightweight moving system), because then R_s may also be small, for a given decay modulus, both factors working in the direction of higher conversion efficiency. It may also be looked at in another light where for the same efficiency, we can design for higher damping R_s by reducing the mass M_c. Any increase in damping reduces the self-oscillatory tendency of the system, thus minimizing hangover and creates a smoother response.

Lowest Frequencies

To reproduce frequencies within the first two octaves of human hearing (20–80 cps), the loudspeaker, as a direct radiator, must have a combination of three characteristics: first, a large diameter; second, a large cone movement; third, a low fundamental resonance. Smooth low-frequency output is achieved when the air volume displacement becomes proportionally large (at square law rate) as frequency is lowered. This will result if the cone area and cone excursion are large. Because of the inverse square law relationship between axial motion and frequency, it is today not mechanically possible to provide for the necessary large excursions at frequencies below about 50 cps, for direct radiators. For instance, to produce 50 cps, at one watt acoustic output from a 15-inch speaker in an infinite baffle, the

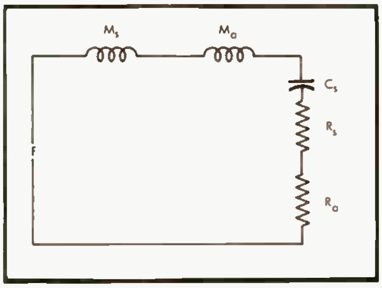


Fig. 2. Equivalent circuit at very low frequencies.

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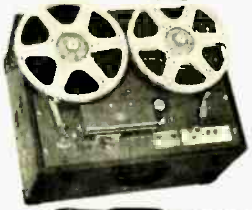

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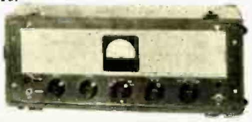

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cone would be required to travel 0.4 inches peak to peak, which is within the range of some existing designs. But at 25 cps a cone travel of 1.6 inches peak to peak is required for the same acoustic output.[1] Such large excursions are not available in any speaker manufactured today.

Because the cone cannot travel through these large axial distances, the radiation resistance falls off with a loss in acoustic output. This may be offset to some extent by keeping the resonant frequency as low in value as possible where speaker sensitivity is at a maximum. In other words, the loss due to insufficient atmospheric loading is offset by large cone excursion in the neighborhood of resonance where the maximum air volume displacement occurs. It follows that reasonably linear output at 20 cps is not available (for a direct radiator in an infinite baffle) unless the resonant frequency is no higher than 25 cps.

To achieve a proper low resonant frequency, it is essential that the stiffness of the flexible supports of the cone—that is, the corrugations of the cone rim and the centering spider—be reduced to a minimum to lower the mechanical restraints against large axial vibration. This resonance is a function of the mass reactance of the moving cone and voice coil and its stiffness impedance. Increasing the mass in order to lower the resonant frequency is objectionable because it reduces conversion efficiency and interferes with good transient response as will be shown later. Efficient conversion of electrical energy into acoustic energy dictates the use of a lightweight moving system in order that only the smallest portion of the electrical energy will be expended in overcoming the inherent inertia of the vibrating system.

[1] Interpolated from Olson: *Elements of Acoustic Engineering*, 1st Ed. pg. 115.

Resonant Frequency

Below the fundamental resonance, the speaker is stiffness controlled, that is, the flexing of the cone takes place against high mechanical impedance. Further, since the radiation resistance of the atmosphere is proportional to the square of the frequency, the sensitivity will disappear very rapidly below this resonant point. High harmonic production and non-linearity develop in this region. For a given cone diameter, the only remaining attack for lowering resonance and distortion, is to increase the compliance or freedom of the cone. However, ultimately even the best types of suspension become non-linear with the development of high orders of distortion. (See *Fig.* 3) natural resonance sufficiently low, would

It would appear then, that making the natural resonance sufficiently low, would automatically involve the maximum compliance and presumably permit linear operation to some frequency just below resonance if enclosed in a suitable baffle or cabinet.

Just how mass and stiffness (the reciprocal of compliance) affects the resonant frequency is shown by the relationship:

$$f_1 = \frac{1}{2\pi}\sqrt{\frac{S}{M}}$$

where

f_1 = fundamental resonant frequency
S = stiffness (centimeters per dyne)
M = Mass (grams)

Since in the interest of efficiency and good transient response, the mass should be held at a given minimum value, the stiffness S must be reduced (i.e. increase compliance) in order to obtain a low resonant frequency. But the square law relationship indicates that this compliance must be increased by large amounts. In order to reduce the resonance by one octave, keeping the mass constant, the compliance must be increased by a factor of four. This taxes the skill of the loudspeaker designer and calls for unusual ingenuity since mechanical stability and cost must be considered, factors which are all too important.

In the woofer illustrated in *Fig.* 1, a remarkable increase in compliance has been obtained by discarding the usual corrugations at the rim of the cone. Instead the piston portion of the cone is suspended from a ring of special plastic foam which has great flexibility and allows large axial motion before mechanical restriction is encountered. Fundamental resonance has been set at 24 cps which represents the lowest useful frequency without sacrificing stability. Further reduction of fundamental resonance would probably increase cost. Laboratory models have been constructed with a resonant frequency as low as 4 cps, but this is more interesting experimentally than for general use.

Somewhere between 600 and 1000 cps the conventional speaker is characterized by severe peaks and dips due to sound waves travelling through the body of the cone to the rim or supporting basket and then being reflected back into the

(*Continued on page 79*)

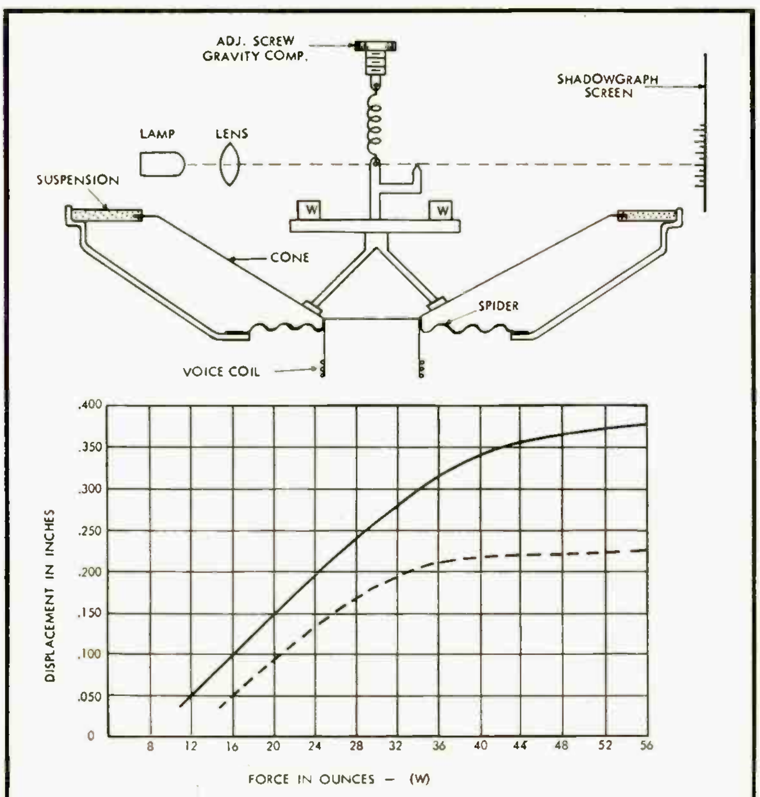

Fig. 3. Force vs. Displacement curve for the Racon high-compliance 15-in. woofer, shown in solid line. The dotted curve was taken on a conventional woofer having edge compliance in the form of rolls or corrugations integral with the cone. The mechanical illustration represents the general method for obtaining the Force/Displacement relationship for the mechanical portion of the moving system. The adjusting screw is used to cancel the effect of gravity on the cone and the test apparatus before applying the weights (W).

Transistor Bias Stabilization

PAUL PENFIELD, JR.*

In two parts—Part I

Intelligent design of transistor amplifiers demands that the designer provide adequate bias stabilization to minimize temperature effects.

A SUBJECT OF PARAMOUNT INTEREST to transistor amplifier designers is adequate biasing. In order for a transistor to operate properly as an amplifier, it must be presented with the proper d.c. bias conditions. In this respect it is similar to a vacuum tube, which also requires correct d.c. bias to function properly.

Also like normal vacuum tubes, the transistor has parameters which vary when the d.c. bias conditions change. In a normal triode, for example, a decrease in grid-to-plate transconductance is caused by a decrease in plate voltage. In a similar way, transistor parameters vary with operating point—sometimes drastically. Normally transistor parameter changes are determined as functions of the d.c. emitter current, and the d.c. collector-to-base voltage. Shea[1] shows curves of the *h*-parameter variations with both emitter current and collector voltage for typical fused-junction transistors—in most cases the parameters change by factors of two or more in the range of emitter current between 0.1 ma and 5 ma, and by similar factors with changes in collector voltage from 100 mv to 10 v.

A transistor amplifier designer wants to place his transistor at a certain operating point, and wants it to stay there. If the d.c. biases change, the small-signal a.c. parameters change, and his amplifier changes accordingly. Unlike vacuum tubes, transistors tend to wander from their original bias points when put in amplifier stages, as the temperature changes. The reasons for this are quite easy to see.

A transistor is normally placed so that the collector-to-base junction is biased backwards—that is, little current flows. To a first approximation, the current that does flow is made up of two parts: one part proportional to the emitter current, due to normal transistor action, with a constant of proportionality called α. The other part is a temperature-dependent reverse leakage current. This current, known as the collector cutoff

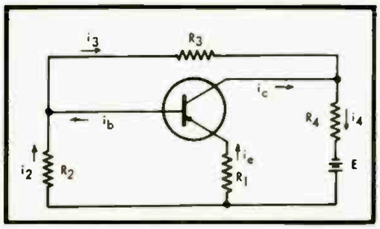

Fig. 1. Circuit used in example. See text.

current, is roughly independent of collector-to-base voltage, but increases exponentially with temperature—doubling every 10 or 11 degrees centigrade. Depending on the particular circuit in which the transistor is used, however, an increase in collector cutoff current can produce a net change in collector current many times the increase in cutoff current.

It is true that transistor parameters do change somewhat with temperature. However, when instability or unwanted changes in operating gain, impedances, etc., are noticed with changes in temperature, it is more likely that the trouble is caused by the attendant change in d.c. bias point, rather than the change in temperature directly. It is most important to stabilize the d.c. operating point adequately—after that is done, transistor amplifiers will work without undue difficulty over wide temperature ranges.

If an amplifier stage that is not stabilized properly is operated at an increasing temperature, the increasing cutoff current may increase the collector current so that the transistor parameters are changed significantly, or may, if the trouble is serious, push the transistor into saturation, where no amplification at all is possible. The trouble is especially severe in low-level amplifiers, where the normal collector current may be set not far from 100 microamperes. Some present-day low-power transistors have cutoff currents of 9 microamperes or so, although most are better than this. If this transistor were operated in a circuit which changed the collector current 10 times the change in cutoff current, then a five degree change in temperature would cause an increase of collector current of 37 μa—over one-third the low-level quiescent point. Another ten degree rise in temperature, and the normal current would be literally lost under the action of the cutoff current.

Importance of Bias Stabilization

This example should suffice to prove to the reader the worth of adequate bias stabilization for transistor amplifiers. Fortunately the stabilization of a stage can be put in mathematical form, whereupon it is not difficult to determine what circuit values should be used for adequate stabilization. An increase in stabilization, incidently, is usually accompanied by an increase of power dissipated in the bias resistors, so that in each case a compromise must be worked out between adequate stabilization, power requirements, and loss of signal due to shunting by bias resistors. In order to make this compromise intelligently, the designer must know how the stabilization criteria are derived.

A Typical Example

Consider the amplifier stage shown in *Fig.* 1. Only the d.c. components are shown—for instance, capacitors are omitted, since they will pass no d.c. The resistors R_1, R_2, R_3, and R_4 may be in any form—they may represent the resistance of transformer windings, for instance.

We will derive mathematically the effect which a small change in cutoff current will have upon the collector current. We will define a stability criterion S which merely stands for the ratio of the change in collector current to the change in cutoff current which causes it—or just $\left(\frac{di_c}{di_{co}}\right)$. The lower the value of this factor, the more stable is the stage—that is, the less effect will a temperature-caused change in i_{co} have upon i_c. With the assumptions we make in this article, the value for S will always be greater than one. Upon closer examination (in Part II) we will see that this is not always true.

In order to define S we must derive a

* *752 Lakeside, Birmingham, Mich.*

[1] T. E. Shea, *Transistor Audio Amplifiers*. Wiley, New York, 1955, p. 18.

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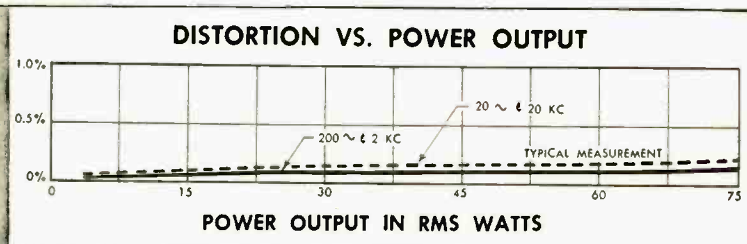

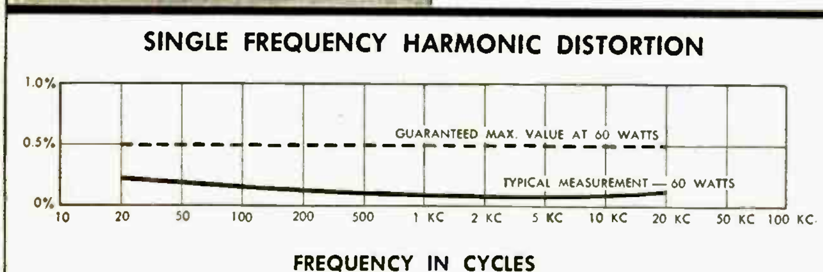

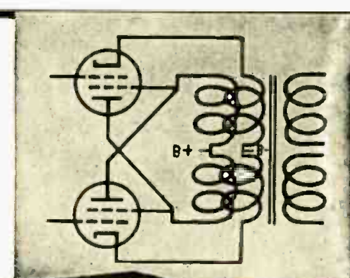

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mathematical expression for i_c in terms of the constants of the circuit plus i_{co}. In order to simplyfy the analysis, we will make the following two assumptions:

(1) The transistor is being operated in a region in which the collector voltage has no influence on the collector current. This implies not only that we are operating in the normal operating range and that we never go out of that range, but also that the output impedance of the stage is infinite. Although this is not true, it is quite a good approximation for simple circuits using good quality modern transistors.

(2) The value of base-to-emitter voltage is zero. Again this is not true, but in most cases dealing with low-level amplifiers using modern transistors, this approximation is quite true.

A more complete analysis will be made next month which takes into account deviations from these two conditions. However the formulas obtained this month are sufficiently accurate for most purposes.

Again referring to *Fig.* 1, we have the following conditions imposed by the circuit:

$$i_2R_2 = i_eR_1 \qquad (1)$$

(Assuming that base-emitter voltage is equal to 0)

$$i_2R_2 + i_3R_3 + i_4R_4 = E \qquad (2)$$

$$i_e = i_b + i_c \qquad (3)$$

$$i_3 = i_b + i_2 \qquad (4)$$

$$i_4 = i_3 + i_c \qquad (5)$$

In addition we have the transistor equation mentioned above:

$$i_c = \alpha i_e + i_{co} \qquad (6)$$

which assumes that the collector current is independent of the collector voltage. In Eqs. (1) to (6), the currents are as labeled in *Fig.* 1. These six equations are sufficient to eliminate the five unwanted variables i_b, i_e i_2, i_3, and i_4, leaving one equation relating i_c, i_{co}, α, and the various circuit constants R_1, R_2, R_3, R_4, and E. This relation, setting i_c all by itself on one side, is:

$$i_c = \frac{R_3 + R_1 + R_4 + \left(\frac{R_1}{R_2}\right)(R_3 + R_4)}{(1-\alpha)R_3 + R_1 + R_4 + \frac{R_1}{R_2}(R_3 + R_4)}\, i_{co} + \frac{\alpha E}{(1-\alpha)R_3 + R_1 + R_4 + \left(\frac{R_1}{R_2}\right)(R_3 + R_4)} \qquad (7)$$

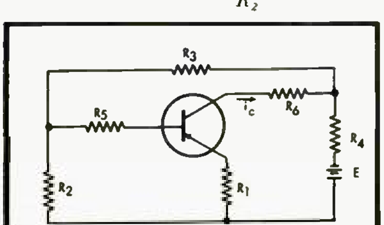

Fig. 2. A general bias diagram, which can be specialized into a number of practical circuits by appropriately selecting the resistance values and placing the voltage sources.

Thus, considering E to be a constant and varying i_{co} by a small amount di_{co}, we get a corresponding change in collector current di_{co}. The stability factor S, which is equal to (di_c/di_{co}), is

$$S = 1 + \frac{\alpha R_3}{(1-\alpha)R_3 + R_1 + R_4 + \left(\frac{R_1}{R_2}\right)(R_3 + R_4)} \qquad (8)$$

Remembering that α is a number a little less than one for most modern junction transistors, we can replace α by 1 in the expression for S and arrive at a little simpler expression:

$$S \cong 1 + \frac{R_3}{R_1 + R_4 + \left(\frac{R_1}{R_2}\right)(R_3 + R_4)} \qquad (9)$$

This approximate value for S will be greater than the actual value by a small amount—and may be used conveniently in design work as an approximation, with the assurance that the actual stability will be slightly better—not worse.

By varying the values for R_2, R_3, R_1, and R_4, the values of S may be changed at will. In order to prevent excessive shunting of the a.c. signal the values of R_3 and R_2 want to be large—but as can be seen from Eq. (8), this produces a large value for S. Similarly, raising R_1 to lower S will provide a.c. degeneration unless the resistor is adequately bypassed. And in any event the values of the resistors must be such as to bias the transistor at the correct point. The designer is likely to run into the need for a compromise in the selection of suitable resistors—and must select the proper circuit values considering all relevant factors—one of which is the need for adequate stabilization.

A More Universal Formula

The reader should now appreciate that designing a stable amplifier which will not drift upon temperature changes, and which will have the proper gain at the proper battery power, is not an easy matter. It is necessary to have at one's disposal formulas for stability for various bias network configurations, so as to select in each case the particular network most appropriate. The chart on page 41 gives formulas for S and approximate formulas (neglecting the difference between α and 1) for each bias configuration shown. The method used in deriving the chart will be explained, since an understanding of it is necessary for intelligent use of the formulas presented.

Note, first of all, that in the example

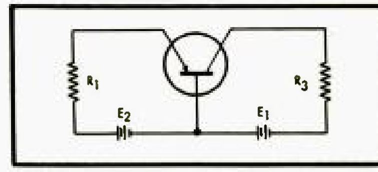

Fig. 3. Popular 2-battery bias circuit can be had by specializing various resistances in Fig. 2.

we went through before, the value of E did not enter into the final value for S. This is because we imagined E held constant as we varied i_{co}. Thus any value of E consistent with our desire to have the transistor biased at the proper point could be used, and our stability formula would remain unchanged. Similarly, additional constant-voltage batteries could have been inserted in any of the other branches of *Fig.* 1 and the resulting formula for S would not have been affected. This suggests that in deriving formulas for S, we can ignore constant terms like the battery voltage E in *Fig.* 1. Such is indeed the case, and from now on we will ignore these batteries while deriving equations—and then will put the batteries back in, to describe certain specific cases. In this way, we can derive formulas for S on the basis of the surrounding circuit configuration alone—and these will be valid for perhaps two or three different positions of bias batteries, so long as the external resistors remain unmoved.

Of course the transistor *must* be biased in the normal operating region—that is where the collector voltage has little effect on the collector current—for the formulas to be valid at all. But two or three different battery locations, using perhaps two batteries or more, may provide this correct bias, and the value of S will *not* depend on the actual battery voltage.

A large number of circuit configurations can be expressed as special cases of the circuit shown in *Fig.* 2. The circuit of *Fig.* 1, for example, is a special case of *Fig.* 2—with R_5 and R_6 equal to 0. Similarly, a very popular two-battery bias circuit (*Fig.* 3) is a special case of *Fig.* 2, with R_5, R_2 and R_6 equal to 0, and R_4 equal to ∞, and with the bias batteries moved about somewhat. *Figure* 4 shows a practical amplifier circuit, whose d.c. bias circuit is a special case of *Fig.* 2, with $R_1 = 1000$, $R_2 = 4700$, $R_3 = 30{,}100$, $R_4 = 4700$, $R_5 = 0$, and $R_6 = 0$. For the reason that most popular configurations can be expressed as special cases of *Fig.* 2, we will derive the formula for S for this case, and then make appropriate changes to obtain formulas for S for special cases. Analyzing the circuit of *Fig.* 2, we obtain, after a somewhat lengthy argument, a value for S, as in Eq. (10):

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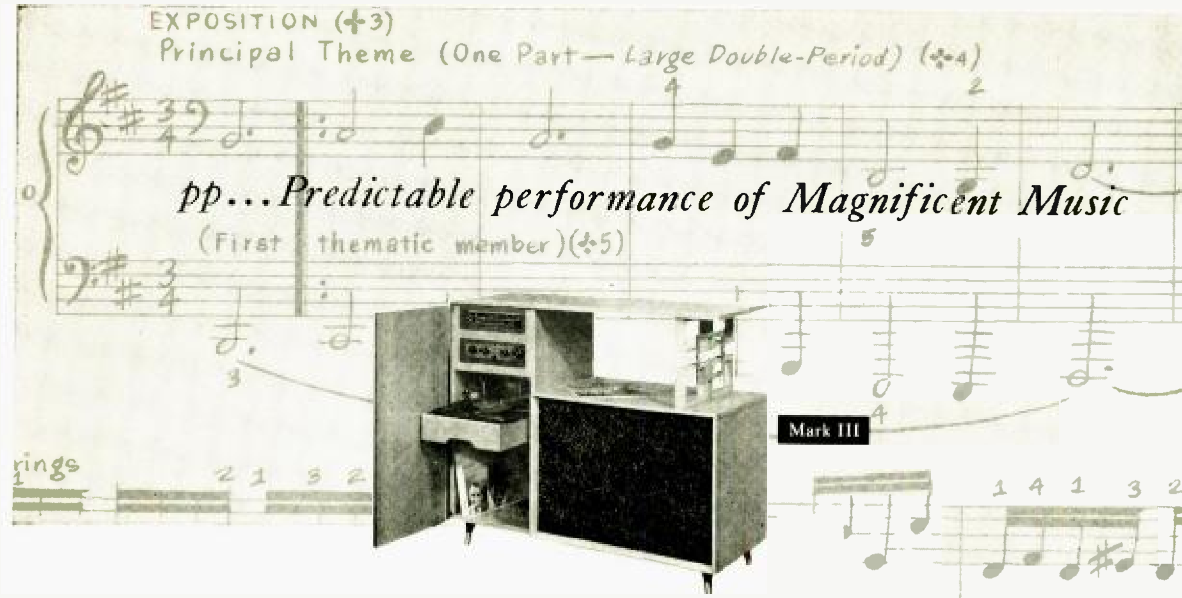

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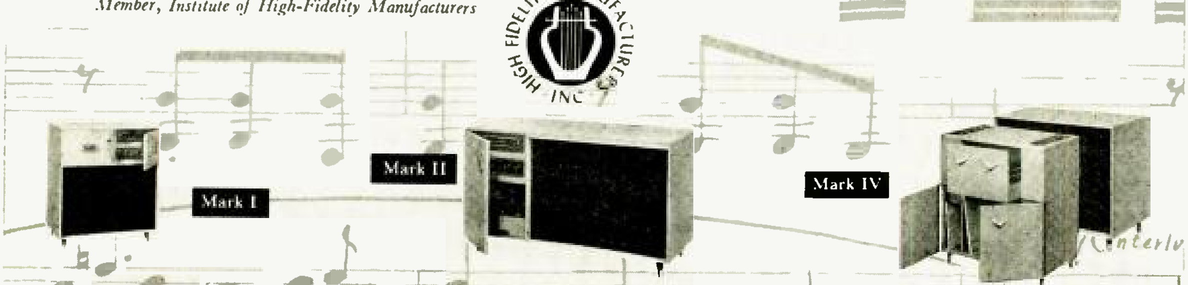

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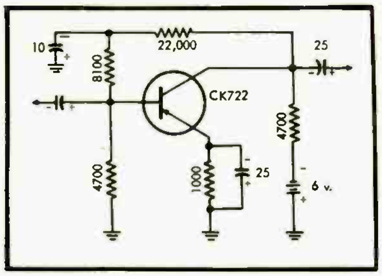


Fig. 4. A practical stage which can be put into the form of Fig. 2 for calculating the bias stability, which happens to be equal to 2.96.

very good in this case. The stability is equal to $\left(\frac{1}{1-\alpha}\right)$ for all values of external resistance. This circuit, in addition to being the worst with respect to stability, is the simplest. It is usually the one used in books to illustrate "typical" bias circuits. Upon scanning the popular literature in electronics the reader will notice a large number of bias circuits of this type, used when the designer should have known better.

Also notice that in all cases an increase in the value of R_1, the external emitter resistor, will improve the stability. This can be appreciated more

$$S = 1 + \frac{\alpha\left[\frac{R_5}{R_2}(R_3+R_4) + R_5 + R_3\right]}{(1-\alpha)\left[\frac{R_5}{R_2}(R_3+R_4) + R_5 + R_3\right] + R_1 + R_4 + \frac{R_1}{R_2}(R_3+R_4)} \qquad (10)$$

assuming as before that the collector voltage has no effect on the collector current, and that the emitter current has no effect on the emitter voltage.[2] Note that the value of R_6 does not appear in the formula. This is consistent with our assumption that the collector voltage does not affect the collector current. Of course in practice if a high value of R_6 were used, we would be likely to run the transistor out of the region in which this assumption is valid—and Eq. (10) would no longer hold.

By neglecting the difference between α and 1 we obtain an approximate formula for S:

$$S \cong 1 + \frac{\frac{R_5}{R_2}(R_3+R_4) + R_5 + R_3}{R_4 + R_1 + \frac{R_1}{R_2}(R_3+R_4)} \qquad (11)$$

As expected, this formula is quite a bit simpler than Eq. (10), and is slightly higher in value—so the error is on the safe side. It can be used in practical cases more easily than the full equation.

Referring to Table I on page 40, notice that the top figure and formulas correspond to the general case we just described. Below this are eight popular single-battery bias configurations, each made by specializing certain values of circuit parameters in *Fig.* 2 to either *0* or ∞, as noted in each case. Since the value of R_6 never enters into the formula, it is left in in all cases—although its value could perfectly well be *0*.

A number of interesting things can be seen from a study of the chart. First of all, Case 9 shows the worst stability. Indeed the "approximate" case, neglecting $(1-\alpha)$ yields a value of S equal to infinity—clearly this approximation is not

[2] The condition that the emitter-base voltage be constant, rather than zero, is a little less strict. A zero value is not necessary, since a constant value will not change (di_c/di_{co}).

fully when one realizes that this acts much like the cathode resistor in normal vacuum tube amplifier circuits—that is, it introduces degeneration, or negative feedback, into the circuit. And every audio fan knows that negative feedback, properly introduced, improves stability. Introducing a resistor R_1 thus improves the d.c. stability. Similarly, decreasing R_3 improves the stability—as is expected, since this act increases the amount of collector-to-base negative feedback. This viewpoint is consistent with the formulas presented in Table I.

Another point: increasing the value of R_5 always increases the value of S, so this resistor may appear rather useless. Normally it is—that is, better results all-around can be had by letting it be *0*. However, there are cases in which it is desirable to have it in, from the standpoint of signal-shunting, especially with grounded-collector circuits, with their high input impedance. The signal may then be brought in at the base. Normally, however, it should be omitted.

Charts 10–13 represent popular two-battery configurations. A single tapped battery may be used, of course, in each case. Usually in this configuration R_4 is made infinite, but the first case is shown for the sake of completeness. The formulas for Case 10 are the same as for Case 1—after all, they should be, for only the batteries have been changed, and we have seen that placement of the batteries does not change the formula for S. The popularity of the two-battery bias networks lies in the fact that it is possible to eliminate R_4 completely and achieve normal bias. This, it turns out, results in quite low values for S with a small power dissipation occurring in the biasing network.

Indeed, for Case 13, we see that the stability is *1*—independent of particular values of biasing resistors. Actually this value is not quite *1* with practical transistors—here we are violating the simplifying assumption made earlier that the emitter-to-base voltage is constant. A more complete analysis next month will modify this result slightly.

The stability factors given apply equally well to n-p-n transistors—in each bias network only the polarity of the batteries and other polarized components (like electrolytic capacitors) will be reversed. The formulas, which happened to be associated with circuits involving p-n-p transistors, apply equally well to n-p-n units.

The reader may be interested in working out formulas not offered in the chart—for example, the formula for the stabilization factor S for *Fig.* 5. This particular circuit does not offer any immediate advantages over the circuits listed in Table I, and for that reason it was not listed. The formula, incidentally, is the same as listed in Table I for Case 8. Besides *Fig.* 5 there are quite a number of single-stage circuits that offer no immediate advantages, and so are not presented. All can be analyzed, however, either by specializing values from Case 1, or by re-computing (di_c/di_{co}) for the particular circuit.

The derivation presented here proceeded from certain assumptions we made at the beginning to simplify our work. These assumptions, valid in most cases when small-signal transistors are under consideration, were the following:

(1) The collector voltage has no effect upon the collector current, and
(2) The emitter current has no effect upon the emitter-base voltage.

For cases in which these assumptions do not hold, a more complete linear derivation may be made which takes into account departures from the ideal case discussed here. Part II continues with transistor bias stabilization, in which more complete formulas are derived—for cases in which the restrictions stated in this paragraph do not bold. In any event calculation of the more complete formulas will, if nothing more, indicate the extent of the errors introduced by these assumptions.

However, the formulas presented here will normally prove sufficient for all but the most exacting requirements.

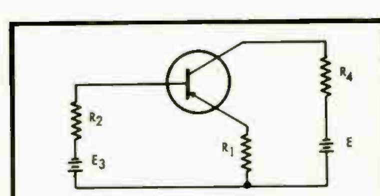
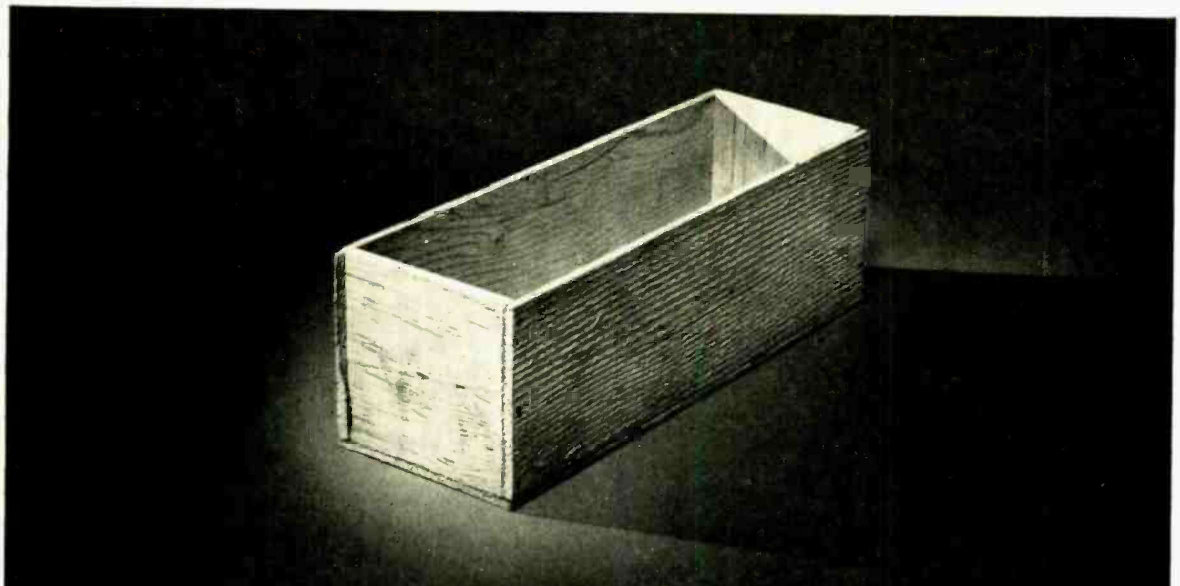


Fig. 5. One possible bias circuit not presented in the chart, but which can be easily solved by specializing resistance values from Case 1.



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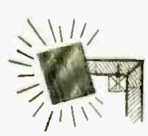

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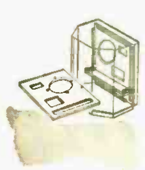

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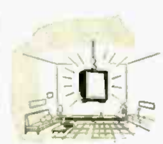

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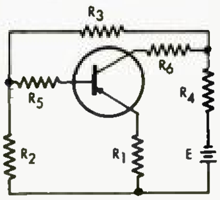
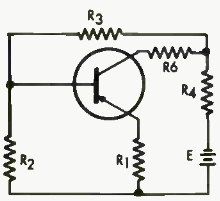
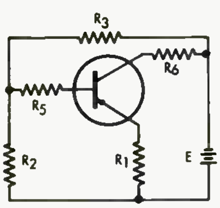
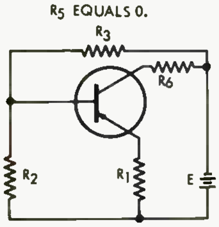
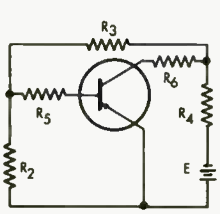
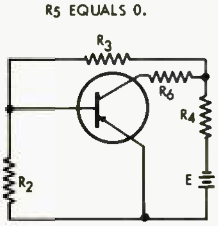
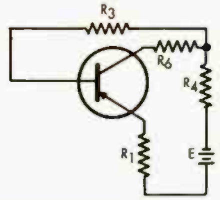
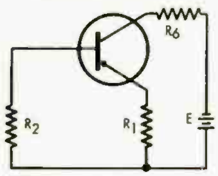
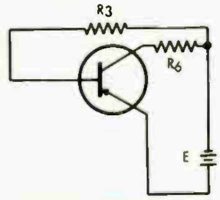
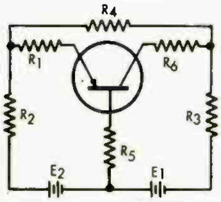
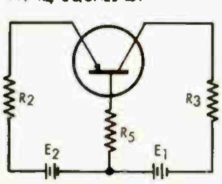
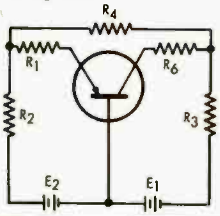
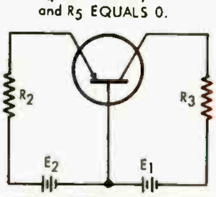
TABLE I
TRANSISTOR CIRCUIT STABILITY FACTORS

Circuit	Formula for stability factor, S	Approximate formula for S, neglecting (1 −)
1. GENERAL ONE-BATTERY CONFIGURATION 	$S = 1 + \frac{\alpha\left[\frac{R_5}{R_2}(R_3 + R_4) + R_5 + R_3\right]}{(1-\alpha)\left[\frac{R_5}{R_2}(R_3+R_4)+R_5+R_3\right] + R_4 + R_1 + \frac{R_1}{R_2}(R_3+R_4)}$	$S \cong 1 + \frac{\frac{R_5}{R_2}(R_3 + R_4) + R_5 + R_3}{R_4 + R_1 + \frac{R_1}{R_2}(R_3 + R_4)}$
2. R_5 EQUALS 0. 	$S = 1 + \frac{\alpha R_3}{(1-\alpha)R_3 + R_4 + R_1 + \frac{R_1}{R_2}(R_4 + R_3)}$	$S \cong 1 + \frac{R_3}{R_1 + R_4 + \frac{R_1}{R_2}(R_4 + R_3)}$
3. R_4 EQUALS 0. 	$S = 1 + \frac{\alpha\left[R_5\left(1 + \frac{R_3}{R_2}\right) + R_3\right]}{(1-\alpha)\left[R_5\left(1 + \frac{R_3}{R_2}\right) + R_3\right] + R_1\left(1 + \frac{R_3}{R_2}\right)}$	$S \cong 1 + \frac{R_5 + \left(\frac{R_3 R_2}{R_3 + R_2}\right)}{R_1}$
4. R_4 EQUALS 0 and R_5 EQUALS 0. 	$S = 1 + \frac{\alpha R_3}{(1-\alpha)R_3 + R_1\left(1 + \frac{R_3}{R_2}\right)}$	$S \cong 1 + \frac{\left(\frac{R_2 R_3}{R_2 + R_3}\right)}{R_1}$
5. R_1 EQUALS 0. 	$S = 1 + \frac{\alpha\left[\frac{R_5}{R_2}(R_3 + R_4) + R_5 + R_3\right]}{(1-\alpha)\left[\frac{R_5}{R_2}(R_3 + R_4) + R_5 + R_3\right] + R_4}$	$S \cong 1 + \frac{\frac{R_5}{R_2}(R_3 + R_4) + R_5 + R_3}{R_4}$
6. R_1 EQUALS 0 and R_5 EQUALS 0. 	$S = 1 + \frac{\alpha R_3}{(1-\alpha)R_3 + R_4}$	$S \cong 1 + \frac{R_3}{R_4}$

7. R_2 EQUALS ∞.[1]  	$S = 1 + \frac{\alpha R_3}{(1-\alpha)R_3 + R_4 + R_1}$ 1. When R2 is set equal to infinity, the effect of R5 can be included in the effect of R3, since the two are in series.	$S \cong 1 + \frac{R_3}{R_4 + R_1}$
8. R_3 EQUALS ∞.[2]  	$S = 1 + \frac{\alpha R_2}{(1-\alpha)R_2 + R_1}$ 2. When R3 is set equal to infinity, the effect of R5 can be included in the effect of R3, since the two are in series. Similarly, the effect of R4 can be expressed by R6.	$S \cong 1 + \frac{R_2}{R_1}$
9. R_2 EQUALS ∞,[1] R_1 and R_4 EQUAL 0.  	$S = 1 + \frac{\alpha}{1-\alpha}$ 3. Obviously in this case the approximation $\alpha = 1$ is not valid. Generally, in the stability formulas presented here, the approximation is better for lower values of S.	$S \cong \infty$[3]
10. GENERAL TWO-BATTERY CONFIGURATION.  	$S = 1 + \frac{\alpha\left[\frac{R_5}{R_2}(R_3+R_4) + R_5 + R_3\right]}{(1-\alpha)\left[\frac{R_5}{R_2}(R_3+R_4) + R_5 + R_3\right] + R_4 + R_1 + \frac{R_1}{R_2}(R_3+R_4)}$	$S \cong 1 + \frac{\frac{R_5}{R_2}(R_3+R_4) + R_5 + R_3}{R_4 + R_1 + \frac{R_1}{R_2}(R_3+R_4)}$
11. R_4 EQUALS ∞.[4]  	$S = 1 + \frac{\alpha R_3}{(1-\alpha)R_5 + R_2}$ 4,5. As in Footnote 1, the effects of R6 and R1 can be expressed by R3 and R2.	$S \cong 1 + \frac{R_5}{R_2}$
12. R_5 EQUALS 0.  	$S = 1 + \frac{\alpha R_3}{(1-\alpha)R_3 + R_4 + R_1 + \frac{R_1}{R_2}(R_3+R_4)}$	$S \cong 1 + \frac{R_3}{R_4 + R_1 + \frac{R_1}{R_2}(R_3+R_4)}$
13. R_4 EQUALS ∞,[5] and R_5 EQUALS 0.  	$S = 1 + 0$[6] 6. This expression is not quite right. In Part II a more exact formula will show this.	$S \cong 1$

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Care of Audio Attenuators

Maintenance of "pots" used in professional equipment requires only a small portion of the total maintenance time, but for top-quality performance it is important that they receive attention at regular intervals on a routine basis.

EUGENE F. CORIELL, Major, USAF*

The variable attenuator is a device that the broadcast and recording fields could not get along without, but frequently the attenuator itself is required to get along without the simple maintenance needed for long, trouble-free service. Probably few other precision devices require so little attention, but there is a minimum of care essential to prevent the two principal difficulties of audio noise and mechanical roughness of operation. Incidentally, not all the instances of noise blamed on attenuators are properly chargeable to this element, as will be brought out in this article.

Most audio attenuators consist of groups of resistors which are cut in and out by blades wiping across contacts which terminate these resistors. The blades are rotated by the shaft on which they are mounted, the shaft being carried in bushings which do not ordinarily require lubrication. Connections are made to the blades through collector rings.

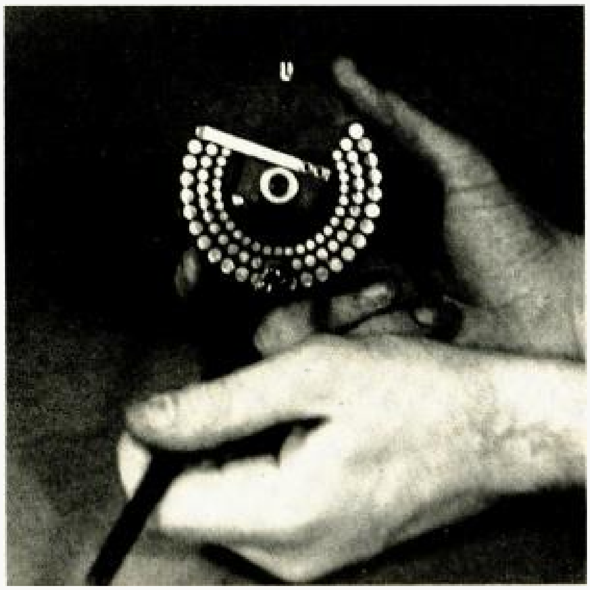
Before cleaning and lubricating—which should be done at frequent intervals, depending on use—it is a good idea to check for loose or broken parts. It is particularly important that there be no excessive play in the shaft, and that the blades bear firmly on the contacts and on the collector rings. Earlier types of attenuators required the blades to be bent slightly upon occasion to provide sufficient tension to maintain proper contact. However, newer models often feature self-adjusting blades such as those used in the Daven "knee-action" design. The blade should continue to touch one contact until it is firmly seated upon the next, in order to prevent the noise that would otherwise result from breaking the circuit continuity. Also check to see that all contact surfaces lie in the same plane and that all contacts are firmly imbedded in the insulating base. Otherwise, rough and noisy operation will result. If the contacts are loose, pitted, or of uneven height, the unit should be returned for repair to the manufacturer. Contact surfaces are lapped at the factory—a highly critical precision operation necessary to provide smooth rotation and minimum noise. These surfaces therefore should never be sanded or otherwise refinished in the field.

The suggested checks usually can be made without removing the control (attenuator) from the panel. However, if removal should be necessary, this is a good opportunity to check the condition of any integral cueing or relay-energizing switches in the front or panel end of the unit. Also examine the detent or indexing mechanism sometimes incorporated on master gain controls, and lubricate it sparingly with unmedicated white vaseline. Incidentally, if there are more than three wires going to the control, make a sketch of their connections before unsoldering them to remove the attenuator. It is most embarrassing after everything is reassembled to find you have wired the cueing circuit to the output terminal.

Cleaning and lubricating the contacts and collector rings are probably the principal requirements of attenuator maintenance. While the purpose of both cleaning and lubricating is, of course, to prevent undue wear, cleaning is also necessary to remove dirt which might vary the contact resistance and thereby cause noise. Wipe the contacts and collector rings dry with a soft clean cloth, and use a toothpick or a small stiff brush to clean out the small spaces between the contacts, in order to avoid high-resistance leakage paths. This is also a good time to check the insulating base that carries the contacts and clean out any cracks found, again to prevent leakage which is a potential cause of noise.

If the contacts are tarnished, polish them with a soft pencil-type eraser. Then apply a light coat of unmedicated white vaseline, or silicone grease such as Dow Corning #44, or the lubricant recommended or supplied by the attenuator manufacturer. Rotate the shaft rapidly back and forth before wiping again with a cloth. On units without detents, a convenient way to rotate the shaft is to loop the middle of a string around the knob and alternately pull the string left and right. Repeat this process until the cloth remains clean. Then apply a final light coat of lubricant. Never use carbon tetrachloride or silver polish to clean attenuator contacts as these tend to damage the surfaces and may even necessitate refinishing at the factory.

(*Continued on page 78*)



Tarnished contacts can be polished with a soft pencil eraser before applying vaseline or other lubricant. The attenuator can usually be cleaned in place in the console.

* *Armed Forces Radio Service, 250 W. 57th St., New York 19, N. Y.*

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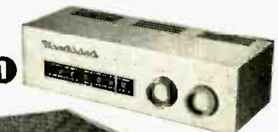

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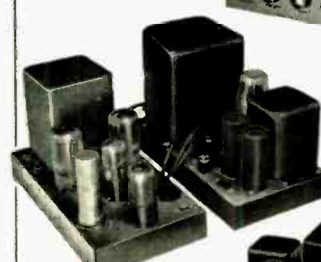

❺ Heathkit Williamson Type HIGH FIDELITY AMPLIFIER KIT

This is the lowest price Williamson type amplifier ever offered in kit form, and yet it retains all the usual Williamson features. Employs Chicago output transformer. Frequency response, within ±1 db from 10 cps to 100 Kc at 1 watt. Harmonic distortion only 1.5% at 20 watts. IM distortion at rated output 2.7%. Power output 20 watts. 4, 8, or 16 ohms output. Hum and noise, 95 db below 20 watts, uses 2-6SN7's, 2-5881's, and 5V4G. An exceptional dollar value by any standard. Kit combinations:

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❻ Heathkit 20-Watt HIGH FIDELITY AMPLIFIER KIT

This model represents the least expensive route to high fidelity performance. Frequency response is ±1 db from 20-20,000 cps. Features full 20 watt output using push-pull 6L6's and has separate bass and treble tone controls. Preamplifier and main amplifier on same chassis. Four switch-selected inputs, and separate bass and treble tone controls provided. Employs miniature tube types for low hum and noise. Excellent for home or PA applications. Shpg. Wt. 23 Lbs.

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Loudspeakers

A discussion of the mechanical and electrical characteristics of the next-to-last link from original sound to the ear of the listener.

EDGAR M. VILLCHUR*

Sound—Chapter 9

THE SUBJECT OF LOUDSPEAKERS is so closely associated with that of enclosures that the two must be studied as interdependent parts of the same system. The division used here, which assigns separate chapters to each, is arbitrary and purely for the sake of convenience.

However, whatever type of enclosure is being used, the speaker must move its diaphragm according to the characteristics of the sound being reproduced. We will consider this problem first, ignoring the enclosure for the moment: later we will see that the demands made on the speaker mechanism itself vary according to the type of enclosure.

Until very recently there was only one type of loudspeaker in general use, the dynamic or moving-coil speaker. (The term *dynamic speaker* is sometimes mistakenly used to describe a speaker whose magnetic field is supplied by an electromagnet instead of a permanent magnet). The distinguishing feature of the moving-coil speaker is that the input electrical signal is applied to a coil which is "immersed" in a magnetic field, and which is free to move back-and-forth along its axis. This *voice coil,* and its associated cone or diaphragm, then vibrates at the dictates of the signal, creating sound. To use the precise, almost archaic language of patent attorneys, the voice coil "executes excursions in the presence of a magnetic field."

The dynamic loudspeaker has reigned supreme for over twenty-five years; the first serious challenge has appeared only in the last year or two, in the modern, push-pull version of the electrostatic speaker.

* *25 Thorndike St., Cambridge 41, Mass.*

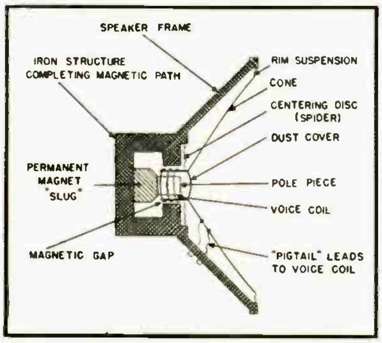

Fig. 9—1. Basic construction of the moving coil loudspeaker.

Basic Construction of the Dynamic Speaker

Figure 9—1 shows the working parts of a dynamic speaker.

The input signal, of relatively low voltage, high current and high power, is applied to the stationary terminals. The current is then carried to the voice coil through flexible *pig-tail* leads, which made a solid electrical connection but a very loose mechanical one.

When current flows through a coil a magnetic field forms around the coil: that is, the coil becomes a magnet with north and south poles. If alternating current flows in the coil the instantaneous strength and polarity of the magnetic field must also alternate, according to the characteristics of the electrical current. In this case, of course, the current is alternating in the same manner as the mechanical vibrations of the original source of sound being reproduced.

The voice coil will therefore have a varying magnetic field about it. Now it is positioned in such a way that it is constantly immersed in the fixed magnetic field of the speaker magnet, whose polarity always remains the same. For one direction of voice-coil current the two fields interact in such a way that the voice-coil is thrust forward: for the opposite direction of current, during the second half of the signal cycle, the coil is thrust backward. Alternating electrical energy is thus converted to vibratory mechanical energy.

The fixed magnetic field of most modern speakers is produced by a permanent magnet (PM) in the form of a ring, bar, or other shape. The magnet pictured in *Fig.* 9—1 is of the bar or "slug" type.

Such a bar of magnetic material will form a field about itself like that shown in *Fig.* 9—2, where the arrows indicate the direction that a test north pole (so-called because it points towards the earth's north pole when free to do so) would tend to move. This field configuration could be plotted experimentally with a small magnetic compass.

It may be seen that the field is disposed evenly, and that it is diffuse rather than concentrated. We are interested in using *all* of this field, and over a rather limited space. Fortunately there is a simple method of concentrating the magnetic lines of force as we please.

We have seen that different materials have different reluctances in relation to magnetic fields, just as they have different electrical resistances. When an electrical circuit presents more than one path to a generator, most of the current will flow through the path of lower resistance: when materials of different reluctances present parallel paths to a magnet, most of the lines of force will be concentrated in the material of lower reluctance. In the case of the magnet in B of *Fig.* 9—2 the choice of path is between the U-shaped piece of iron, and the air surrounding the magnet. The magnetic lines of force, it can readily be seen, are concentrated in the iron.

But there is one point in the magnetic "circuit" at which there is no choice—

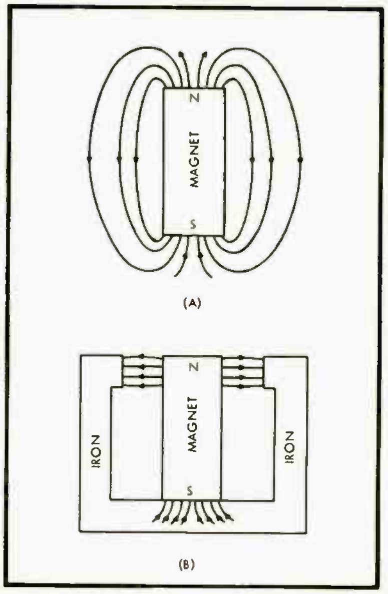

Fig. 9—2. (A) Magnetic field around a bar magnet, in air. (B) Magnetic field directed by a low reluctance path of iron.

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3. Laterally balanced—No delicate levelling required – no skidding across records.
4. Quick Cartridge Change (Audio League says "Less than 5 second dead interval").
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and many other exclusive high-performance features. Net Prices: 280A (12") **$33.95**; 281A (16") **$35.95**.

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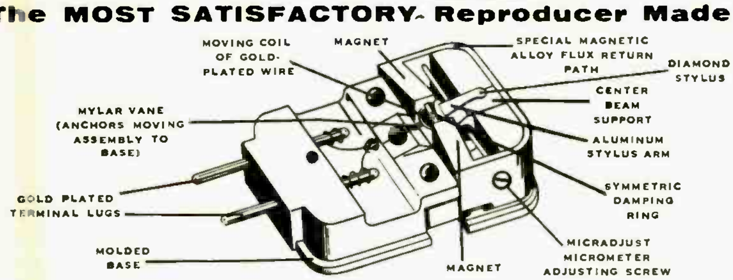

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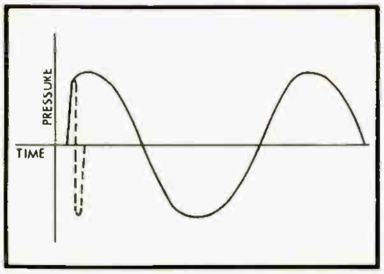

Fig. 9—3. Simplified wave-form of a sound with percussive attack and abrupt decay. Transient response to the attack is a function of mid- or high-frequency speaker response: proper reproduction of the decay, without hangover, is associated with uniform low-frequency response.

there is nothing but air at the gap. And the gap is the business end of our magnetic structure. Virtually all of the magnetic lines of force must cross where we have arranged for them to do so, and where we have placed our voice coil. The voice coil thus receives the benefit of virtually all of the lines of force of the magnetic field.

The Mechanical System of the Speaker

The mechanical system of the loudspeaker is easily recognizable as a mass-elasticity system. This must be so unless we find a massless cone, or a suspension with infinite compliance or "give" in the axial direction and yet high stiffness in the radial direction. (The voice coil must be kept centered in the gap, even during violent motion, without rubbing.)

Since the speaker's mechanical system comes under the mass-elasticity category it must have a resonant frequency. A discussion of the effect of the speaker's resonant frequency on performance is not possible without taking into consideration the speaker enclosure—for one thing the enclosure may change this resonant frequency by as much as an octave. If we assume that we are speaking of the resonant frequency of the speaker as mounted, however, we may come to certain conclusions:

1. Bass response falls off rapidly (at least 12 db per octave) below the resonant frequency. In a bass-reflex enclosure there are two resonant points: response falls off below the second.
2. If the speaker system is underdamped it will show a response peak at or somewhat above the resonant frequency or frequencies, and the speaker will have poor bass transient response. The sound will be "boomy."

Speaker Damping

If the speaker is properly damped, its output, other things being equal, will be flat over the resonance range, until it begins to drop off, and transient response will be good. If the speaker is overdamped the transient response will be good but the bass will be attenuated, and may be significantly down from reference level at resonance. The term *damping* has a very specific meaning, as pointed out in our first chapter: it is the introduction of a resistive element (friction, or its equivalent) into the speaker's mechanical system in three distinct ways, all of which, however, have the same effect:

1. Mechanical resistance in the suspensions themselves—literally friction—which is normally minor.
2. Acoustical resistance contributed by the enclosure, and that associated with the work actually performed in radiating sound.
3. An equivalent mechanical resistance created by the speaker's electro-mechanical system. This system acts like a generator, and is loaded down by the source resistance of the amplifier. (An intuitive understanding of this effect can be achieved by taking a loudspeaker with a heavy magnet, and gently working the cone back and forth while the speaker is not connected to anything. Then short out the speaker terminals one to the other, or connect the speaker to an operating amplifier with a high damping factor, and again try to work the cone back and forth. It will feel as though the voice coil is being retarded by some heavy, viscous substance.)

Horn-loaded enclosures and resonant types, such as the bass reflex, rely primarily on acoustical damping: direct-radiator systems on the electrical damping just described.

Multi-Speaker Systems

The constructional requirements of loudspeakers are not the same for the different frequency ranges. Therefore the frequency spectrum is often divided up, by a *dividing network* between amplifier and speaker, into two, three, or even four parts, and each part is fed to a separate speaker system designed for that particular application. When the units are mounted together on the same physical axis the speaker is called *coaxial*.

A less expensive way of achieving a division of frequencies and specialization of speakers is to cause the division to take place due to the mechanical characteristics of a particular speaker (such as allowing one section of the cone to vibrate at high frequencies), and to assign the different parts of the frequency spectrum to different parts of the same speaker rather than to different speakers.

Low-frequency speakers are referred to as *woofers,* high-frequency speakers as *tweeters;* these terms are by now generally accepted as part of audio technical language rather than audio slang.

Speaker Performance Characteristics

The most important performance characteristics of loudspeakers relate to harmonic distortion, uniformity of frequency response (and the transient response associated therewith), frequency range, power handling capability, efficiency, and the directional pattern at the higher frequencies.

High-quality loudspeakers are expected to keep harmonic distortion below two or three per cent. at an acoustic power output producing concert level in a relatively large room, over the frequency mid-range and upper bass. In the octave below 60 cps. however, things change radically. Reports issued by a consumer testing organization,[1] for example, have revealed that from an entire group of speakers tested only one had harmonic distortion as low as 5 per cent at 30 cycles (at an acoustical output roughly corresponding to that referred to above); others had distortion percentages ranging from 30 to 100 per cent.

This should explain the fact that a perusal of speaker advertisements will find data on harmonic distortion conspicuous by its absence.

We have seen that intermodulation distortion can only be introduced when signals of different frequency are passed through the same distorting device. No matter what the harmonic distortion of a woofer, then, no intermodulation will be created with a treble signal which is reproduced by a separate tweeter. Furthermore, intermodulation test frequencies may be chosen so that the lower of the two frequencies is above the region where bass distortion becomes gross. In such a case the test results will not accurately reflect speaker distortion, even when both signals are reproduced by the same speaker. Until such matters have been standardized, then, a more, reliable guide to speaker distortion is a graph which plots distortion percentage, at given acoustical output, over the frequency scale.

The subjective effects of speaker bass

[1] The Audio League, Pleasantville, N. Y.

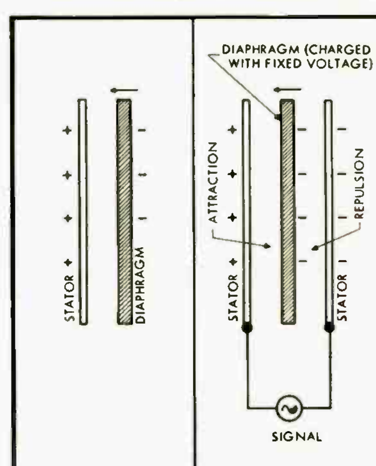

Fig. 9—4 (left). Basic elements of a "single-ended" electrostatic speaker. Fig. 9—5 (right). Basic elements of a push-pull electrostatic speaker.

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The original Stan White Electronic Crossover (24 db/octave)
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distortion can be detected readily with a little experience: the music takes on a muddy or wooden quality, especially when sustained, very low tones such as those from organ pedal pipes or bowed bass viols, appear. High-frequency distortion is associated with a strident, nasal effect.

Loudspeakers show the same weaknesses in frequency-response characteristics as in distortion, if we compare their performance with amplifiers or pickups. Variation in power output is usually at least 5 db each side of reference level over the range reproduced, and sharp peaks and dips in the response curve are common.

There are two aspects of transient response: reproduction of the attack of a sound, and reproduction of the decay. A steady-state frequency response which is smooth and full-range predicts good performance on both counts: peaky response predicts "ringing" or hangover on decay, and poor mid- or high-frequency response detracts from the crisp quality of the attack sound.

Consider the wave form of *Fig.* 9—3, for example. This is a simplification of the wave form of a sound that begins with a percussive attack, and later ends abruptly; let us assume that this sound is to be reproduced through a woofer-tweeter system.

The attack is part of the cycle shown in dotted line, whose frequency is many times higher than the fundamental of the actual steady tone. This attack frequency may not even be reproduced by the woofer, but in any case has no relation to its low frequency performance.

On the other hand, when the tone stops the ball is being carried exclusively by the woofer. It, too, must stop abruptly, and not add any vibrations of its own for good measure.

Poor transient response in the decay of sound results in a "boomy" or "ringing" quality, making it difficult to distinguish the exact pitch of low-frequency tones. Poor transient response in attack, of either bass or treble sound, results in sound which is unnaturally dull.

The writer was once present at a demonstration of a loudspeaker whose bass response was supposed to extend to 20 cps. The demonstrator turned his audio signal generator on at 20 cps, and the loudspeaker "responded," vigorously, with a noise resembling machine-gun fire. Perhaps a tiny fraction of the sound was 20 cps energy: in any meaningful language this speaker could not have been described as having response to 20 cps. Its frequency range rating should have been restricted to that portion of the spectrum in which harmonic distortion was kept reasonably low.

Modern developments in loudspeakers have made it possible to achieve reproduction of a range of sound from 30 to 20,000 cps with reasonable uniformity and low distortion. However, if the writer were assigned the task of drawing up a list of advertising standards for the speaker industry the first suggestion would be to ban the unqualified expression "frequency response from x to y cps." This description, while in itself meaningless, is misleading for the unwary in that it tends to imply meaningful things.

Speakers are usually rated according to the maximum number of electrical watts that are recommended for their use. This rating must be related to their electro-acoustic efficiency, since the same electrical power into one speaker may produce as much as 30 times the actual sound power as into another. Speaker efficiencies range from one per cent or lower to perhaps 30 per cent (for horn-type systems), with five per cent a typical figure. Efficiency has no relationship to speaker quality, but inefficiency is a hidden cost, as it makes necessary an amplifier with higher power.

As the frequency of sound is raised there is a tendency for the sound to be confined to a continually narrowing beam on the axis of the speaker. The sense of "space" is destroyed by such beaming. Paradoxically, the larger the individual treble radiator, the more pronounced is this beaming effect. Countermeasures include the use of several speakers in an array, and the use of acoustic dispersion "lenses."

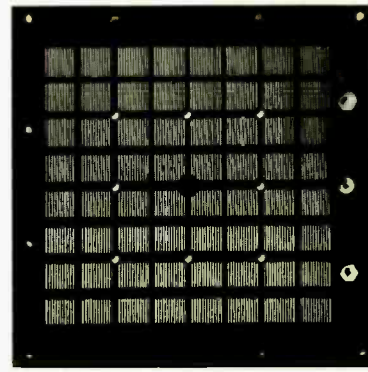

Fig. 7. One section of the Janszen electrostatic speaker. Complete unit usually consists of four of these units.

Electrostatic Speakers

The electrostatic speaker uses the attraction and repulsion forces of electrostatic charges between plates, rather than electromagnetic forces. If two plates, closely spaced, are held parallel to each other as in *Fig.* 9—4, and one is allowed to move, they can be stimulated mechanically by varying the electrostatic charge between them. A fixed charge is placed on the stationary plate, and the signal is applied to the movable plate.

There is a difficulty, however. The force between the plates is a function of the charge, and of the square of the separating distance: thus as the plates move further apart the force is weakened, and as they move closer together the force is increased, independently of the signal. The pattern of vibration will therefore not be an accurate replica of the pattern of the electrical input signal.

The solution to this distortion problem is to use a push-pull arrangement. In *Fig.* 9—5 we have two stationary plates instead of one, with the movable plate between: when the repelling force between the moving diaphragm and one "stator" is decreased by distance, a compensating increase in attracting force to the second stator is created by greater proximity. *Figures* 6 and 7 show two commercial condenser speakers.

The great advantage of the push-pull electrostatic speaker is that the diaphragm is driven uniformly over its surface, and must therefore move without flexing or "breaking up," making possible a uniformity of frequency response and a low distortion percentage probably unique as of this writing.

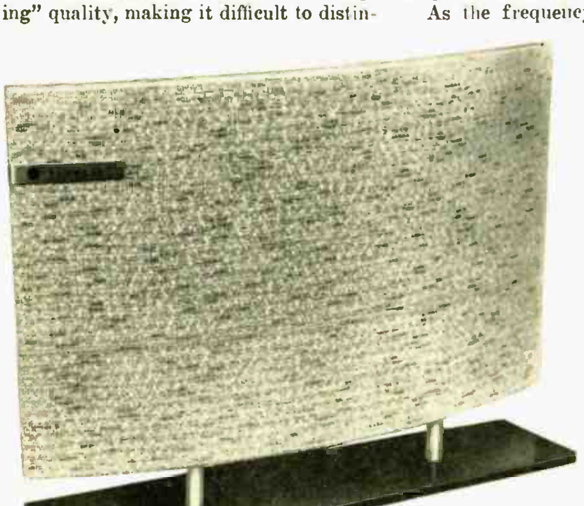

Fig. 6. The Pickering "Isophase" speaker is designed to operate with a conventional woofer.

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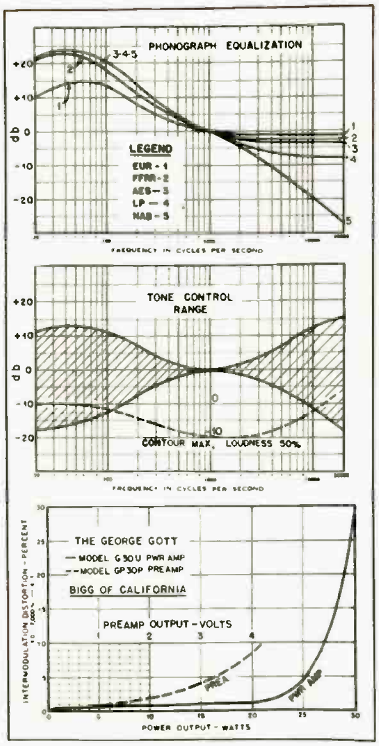


Fig. 1. Performance curves for the George Gott amplifier by Bigg of California.

Equipment Report

The George Gott amplifier and preamp by Bigg of California—Heathkit AG-9 Audio Generator

Conventional in almost every particular except price, the George Gott amplifier and preamplifier are of considerable interest because they show that it is possible to construct an amplifier of good performance at a price that is particularly attractive. These two units are a power amplifier rated by the manufacturer at 30 watts and following the usual Williamson-type circuit arrangement, and a self-powered preamplifier with several inputs, five phonograph equalizations, bass and treble tone controls. Performance curves for both are shown in *Fig.* 1.

The power amplifier, model G-30-U, utilizes two 5881's and two 6SN7's, with a 5U4GB rectifier. It is fairly compact, measuring 12 by 8½ inches and 7 inches high, and is equipped with a hum balancing potentiometer and two a.c. outlets for attachment of other equipment. There is no power switch, since it is expected that the unit would be plugged into a control amplifier on which there would be additional a.c. outlets controlled by the power switch on the latter unit. By standard measurement techniques, the hum level from the amplifier is 83 db below 1 watt, which agrees within 1 db with the manufacturer's specification of 98 db below maximum output. Input sensitivity is such that a signal of 0.22 volts at the input gives the standard 1-watt output. Observations show good response to square waves up to better than 20,000 cps, and the output of the power amplifier is down 6 db at 300 kc, indicating an excellent output transformer. A slight oscillation was noted when a 0.1-µf capacitor was placed across the 16-ohm resistive load of the test circuit. The external appearance is shown in *Fig.* 4.

Figure 2 shows the preamplifier—Model GP-30-P—mounted in its wooden cabinet, which is available as an accessory. There are five controls on the panel—from left to right they are: treble, bass, selector, loudness, and mixer. The tone controls are of the Baxendall type, and give the limiting curves shown in the center section of *Fig.* 1. The selector switch provides for the five phono equalization positions, and for six high-level inputs, although there are no input jacks for the three marked AUX. Presumably these could be added if the user required the additional inputs. As can be seen from the schematic, *Fig.* 3, the TAPE OUT jack provides a feed for a tape recorder ahead of the tone and loudness controls, and a MIKE jack connects directly to the grid of the first section of the second 12AX7. Additional preamplification would be required for the microphone, but the input jack would be a convenience to some users. The output is from a cathode follower. There are two jacks labeled BINAURAL IN and BINAURAL OUT. These feed to and from the 1-meg. control labeled MIXER on the front panel, and could serve as the volume control for a second channel if such were to be controlled at this point.

The loudness control is rather unusual in that it works on the tone-control feedback network. On the rear apron is a control marked CONTOUR (R_{30} on the schematic). This changes the feedback circuit so that at settings of the loudness control of less than maximum there is compensation. The amount and character of the compensation is shown in the center section of *Fig.* 1 for the maximum setting of the contour control and with the loudness control at its midpoint. One useful feature is the adjustment of pickup loading resistance from 1800 to 101,800 ohms, and the hum control potentiometer provides a noticeable effect on over-all hum output, which was measured at 60 db below 1 volt on the phono positions, and 70 db below 1 volt for the high-level inputs. An input of 26 mv at the phono jacks gives a 1-volt output; the same output is obtained from an input of 1.25 volts at the high-level jacks. IM distortion for the preamplifier section is shown by the dotted line in the lower section of *Fig.* 1 in reference to the scale indicated in the graph. N-24

Fig. 2. The preamplifier section of the Gott amplifier system shown in its accessory cabinet.

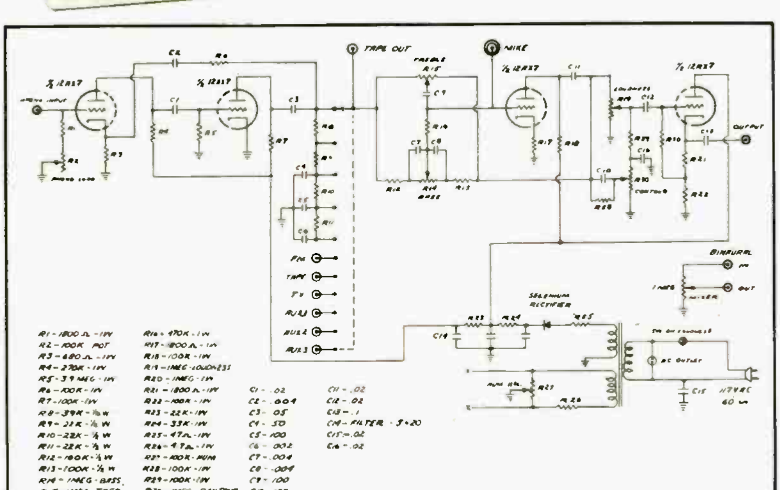


Fig. 3. Schematic of the preamplifier section of the unit.

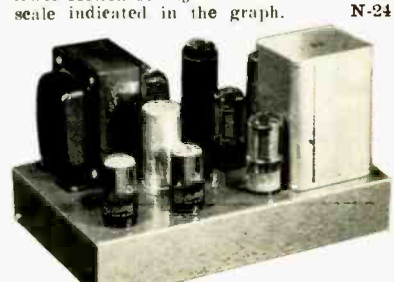
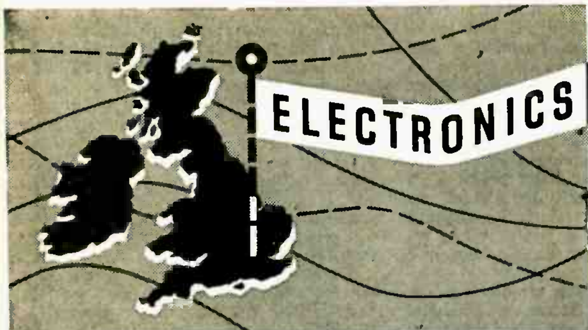


Fig. 4. External appearance of the power amplifier section.



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Another significant feature of this tube is its high transconductance value of 11,000 μmhos, resulting in high power sensitivity and low drive requirements.

Supplies of the EL34 are now available for replacement purposes from the companies mentioned below.

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MEV35

HEATHKIT AG-9 AUDIO GENERATOR

Building and servicing audio equipment without adequate test equipment is somewhat like trying to build a house without a carpenter's rule—it can be done, but you are not sure about the results. And one of the most important units of test equipment is the audio generator—a device which provides a test signal of known level at any frequency in the audio spectrum. It used to be sufficient to cover the range from 20 to 20,000 cps, but with the almost universal use of feedback in amplifiers, it is now almost that the upper end of the range be extended to at least 100,000 cps.

Until fairly recently, the most common type of audio generator to be employed for routine and development measurements was the beat-frequency oscillator, which provided the entire range of frequencies with one sweep of the dial. When properly built, this unit was quite useful, for the user could sweep the entire band at once, and the accuracy of setting was roughly logarithmic, which gave the same percentage throughout. However, a good beat-frequency oscillator was—and is still—expensive, and anything but a good one was subject to considerable drift, had to be checked for calibration frequently, and was difficult to use below about 30 cps because the oscillators would lock together.

These oscillators were largely superseded by the resistance-capacitance type which gave a continuous sweep over a band of frequencies having a ratio of 10 to 1 between upper and lower limits. This type of generator is still in general use because its output is relatively constant over the entire range, it is stable and requires no recalibration during use, and it has a high output.

Some two years ago a circuit was described by Peter G. Sulzer of National Bureau of Standards which offers some advantages over both of those previously described, particularly with respect to purity of waveform, resulting in an instrument which could be used for distortion measurements without the need for filtering of the source signal. In fact, the distortion may be held to less than 0.1 per cent over the audio spectrum with little difficulty.

One such instrument has recently been announced by the Heath Company, and in addition to using this simple and reliable circuit, it incorporates three switches to select the frequency—one numbered 0 to 10 in units, one numbered 0 to 100 in tens, and one marked X1, X10, X100, and X1000. Thus by simple settings of the three switches, the user may obtain any desired frequency from 10 to 100 in steps of one cycle per second, from 100 to 1000 in ten-cps steps, 1000 to 10,000 in 100-cps steps, and from 10,000 to 100,000 in 1000-cps steps—all very stable and repeatable at will with considerable accuracy, and at a very low distortion.

Added to this generator is an output control, which permits the user to obtain any desired output from approximately 10 volts down to less than one-tenth of a millivolt, and a meter which indicates the signal intensity. The unit is self powered, and the hum level is well below the minimum output signal.

The signal is fed from an effective source impedance varying from 300 to 1100 ohms (the lower figure at the high and low settings of the output control) on the 10-volt setting, from about 600 to 1100 ohms on the 3-volt setting, and of approximately 600 ohms on all other output settings. An internal resistor may be switched into the circuit to terminate the instrument properly so as to maintain accuracy of output voltage as indicated by the meter when feeding high-impedance inputs. On the whole, this instrument is easy to use, compact, and extremely reliable.

Since the generator is a kit, some might approach the construction with trepidation, feeling that the problems of instrument building are too complicated for the inexperienced builder. But the clear and concise instructions which accompany any of the Heathkits make them easy enough for anyone who can follow instructions to complete the unit with the assurance that it will work when it is finished. We have built a number of Heathkits—both test equipment and amplifiers—and have always been impressed by the methods outlined for calibrating the instruments. With only one of these units has it been necessary to employ any other instrument in the calibration of the Heathkit upon completion. We have never yet found one instrument which did not do what was claimed for it, and we have yet to receive a kit in which even a single lockwasher was missing from the required parts.

This generator required about five and a half hours in construction, worked properly and correctly when first turned on, and the calibration checked throughout the entire audio band within one per cent.

Fig. 5. Heathkit AG-9 Audio Generator, with step-type switching for selection of output frequency.

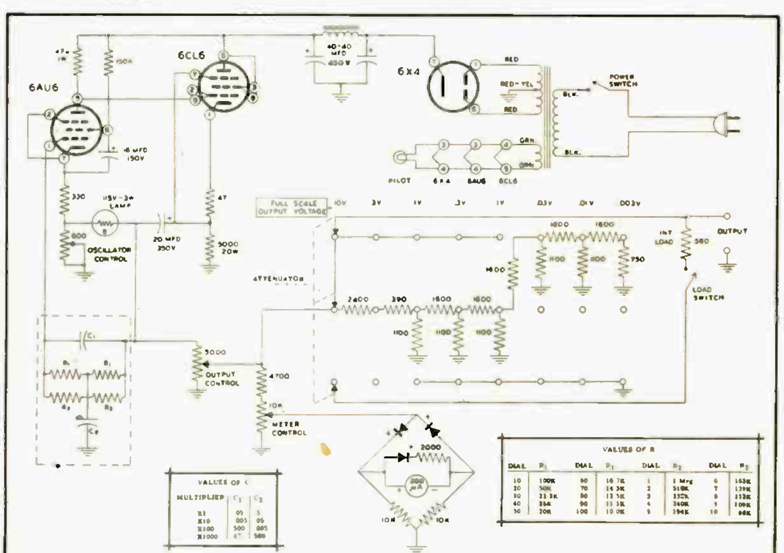

Fig. 6. Complete schematic of the AG-9 Audio Generator.

The Circuit

The AG-9 Audio Generator is shown in schematic form in *Fig. 6*. The frequency-controlling elements are shown in the dotted box at the lower left side of the circuit, and are essentially a bridged-T null network. The oscillator functions as a result of the positive feedback from the cathode of the 6CL6 to the cathode of the 6AU6 through a low-wattage lamp which maintains a constant output. The null network furnishes a negative feedback for all frequencies except the one to which it is tuned, and consequently the circuit is prevented from oscillating except at the one frequency. The resistive elements of the switching circuit consist of four sets of four resistors each which give the values shown in the table at the right, while the capacitance is provided by five capacitors which are selected by the multiplier switch. The design is unique and economical, and the output is constant within less than 0.5 db throughout the entire range.

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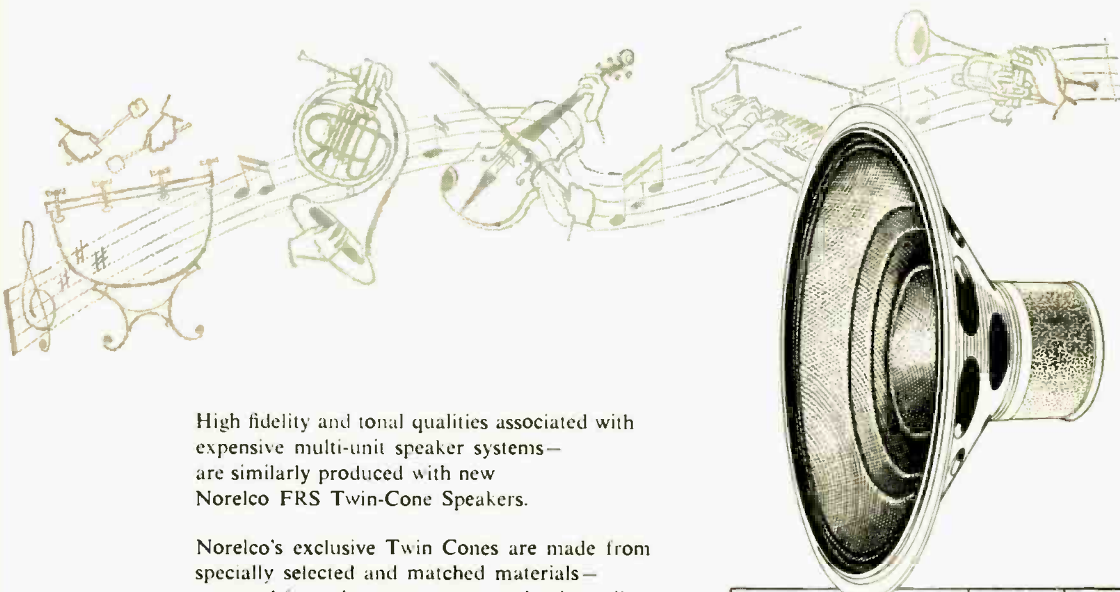

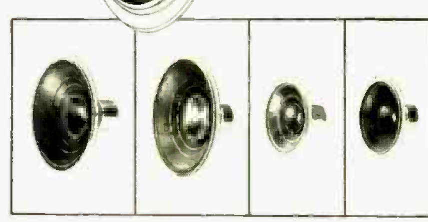

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Be Your Own Record Critic

And many Audio readers did just that—in fact, rather more than were expected.

But that is just what *could* be expected—that our expectations would be exceeded.

The prizes—all so generously furnished by Angel, Westminster, Columbia, and Cook—have been dispatched to the lucky (and energetic) winners. Will you be on the list in June?

FIRST PLACE

Newton Avrutis, 160 W. 225th St., New York 63, N. Y., whose winning review appears here, followed by Mr. Canby's own comments. For his prize, Mr. Avrutis selected these records:

A Portrait of the Waltz .... Angel 35154
Tchaikowsky—6th Symphony
Westminster WN 18048
Janacek—Concertino
Columbia ML 4995

SECOND PLACE

Don Sasman, 821 E. Mulberry St., Lancaster, Ohio. His choices were:

Janacek—Concertino
Columbia ML 4995
Steel Band Clash .... Cook 1040

THIRD PLACE

Fred H. Schwartz, Jr., 909 McClain Road, Columbus 12, Ohio. Mr. Schwartz wants to be a record reviewer as a profession—we trust this will give him a "leg up." His choice of prize record was:

Monteverdi and Marenzio—Madrigals on texts from "Il Pastor Fido"
Westminster WLE 105

Stravinsky: The Fire Bird (complete ballet). L'Orchestre de la Suisse Romande, Ansermet. **London LL 1272**

Here is Mr. Avrutis' winning review:

Ernst's Firebird is a beast of gorgeous plumage, found Hi in the Fi, but he didn't get there under his own steam—he was hoisted by superb recording techniques. True, the tympani bang you in the belly; the highs stretch the ears upward like a rabbit's.

The true Stravinsky Firebird is full of nervous excitement expressed in timing; of suspense; of slight hesitations (not easily indicated on a score) before hell broke loose. The fuse gets shorter and the Firebird takes off and takes you up there with him.

Ansermet, however, leaves you safely on the ground. He plays all the right notes and they sound beautiful individually. The timing is based on mathematics, not on adrenalin or the nervous system. Fairytale princesses? These are sturdy peasant girls with big, muddy feet. Cradle song? You see instead a flatfooted Firebird leading Roman legions between the pine trees of the Appian Way. The Finale is loud and sonorous in the right places, but the right places get there just a fraction late. Jet planes and Firebirds require fast reflexes.

And here is Mr. Canby's review of the same record.

This is no ordinary Fire Bird! Here we have the complete original ballet score, in a super-modern, super-hi-fi interpretation.

The complete score is much longer than the ultra-familiar Fire Bird Suite of separate dance movements that most of us know. The music here plays continuously and a large part of it is "new," though the familiar themes appear everywhere in new guises; the familiar dance numbers are imbedded in this continuous-flow music, here and there, without the formal beginnings and endings of the Suite, and their order is quite different as well, which makes the cumulative impact altogether different.

The "new" music—most of the record—is remarkably unlike the familiar sections. It is largely active, "acting" music, to accompany specific happenings on the stage that advance the plot; whereas the set dance movements of the suite are like arias in an opera, formal dance numbers that take place while forward plot action waits. The two types of music are clearly different here, even though the score plays continuously, and the contrast is most interesting.

The total impression is of a much more modern work than the Fire Bird Suite. First, the extensive "new" connecting pasages between the familiar items are, somehow, more dissonant, less tune-ish, more radical; the traces of old-fashioned romanticism à la Rimsky-K. that abound in the familiar parts are largely absent. The combined effect is of a modernism much closer to "Petrouchka" and even the "Rites of Spring" than most of us would have imagined possible.

Moreover, Ansermet and London between them have put down a remarkably modern-slanted performance here. The big, romantic-style string tunes, so familiar in the usual concert performance of the Suite, are played 'way down. They come out in an offhand, square-cut modern way with no slush and nonsense. The surrounding wind and brass material is played up, in all its incredible complexity and color, as it surely has not been heard before. Voices and figures of astonishing variety come through, that are usually lost in the golden haze of distance. (But not in a ballet theatre, which tends to be dead acoustically, not live like a concert hall.) An ultra-modern brass-woodwind-percussion sound predominates everywhere, even in the passages that used to sound forth so juicily from the strings. Even the tempi are streamlined, speeded up, squared-off.

Finally, this is a dream hi-fi record, not only in these musical respects but in London's superb and appropriate close-up ffrr recording, beautifully clean and transparent. Best of all, there's the biggest, lowest bass drum ever recorded, and it booms not just once but many times. One-note-bass fans, please note.

A Note on the Contest . . . E.T.C.

This promises to be an interesting project! The first review record, Stravinsky's complete "Fire Bird," was chosen deliberately because it offered a number of interesting and debatable points for discussion, thereby allowing for a wide freedom of choice in your postcard reviews. The answers we received were as interestingly divergent as we had hoped and the choice of a winner and runners-up was anything but easy—which is exactly what we had expected.

The three winners were chosen to some extent because of their merit in approaching the subject from three different viewpoints. Mr. Avrutis uses picturesque language to object to the musical performance itself, while approving of the "fi." I think his point is strongly expressed and reasonably argued. Other reviewers agreed with him and, to tell the truth, I do myself, with qualifications.

Mr. Sasman concentrates on the musical significance of the complete score as compared to the various Suites and does a good job at it, though he disagrees with Mr. Avrutis as to the interpretation itself. And Mr. Schwartz writes an interesting review from the audio standpoint which, again, I think is well expressed.

I was mildly shocked to note that whereas a number of our do-it-yourself reviewers felt it necessary to write in what has been called "reviewerese" English, one or two seem to have aimed more or less at my own style of writing! Probably a good idea, since I'm a judge . . . But the interest of the review itself, the clarity of expression and the defensibility of the viewpoint will continue to rate first in all judgments, whatever the style.

P.S. If you don't like our prize choices—write your own. See latest review record, page 58.

Edward Tatnall Canby

BOOK REVIEW

Tape Recorders and Tape Recording, by Harold D. Weiler. Published by Radio Magazines, Inc. 190 pages, illustrated, index. $2.95.

Here is a book that should be warmly welcomed by every amateur of tape recording who wants to get a firm hold on the operation of his machine. Mr. Weiler, author of the classic "*High Fidelity Simplified*," has turned his talent for clarification to the problems the amateur faces in making tape recordings, at home and abroad, that really sound good.

Without the slightest statistical evidence, we can guess that many tape machines yield, say, 10 per cent or less of their potential for gratification to their owners. Simple errors of technique in using the machine can make the difference between tapes that please and keep on pleasing, and tapes that discourage. The latter kind is responsible for the fact that some tape machine owners do not use their machines the maximum of their applicability.

Mr. Weiler has the answers for these puzzled or semi-discouraged tape recordists, and for all of us he has information that will inevitably raise the attractiveness and finish of our tape recordings by a good number of notches. After initial chapters given to the basic nature of sound and the human ear's response to it, he has written four chapters on microphones and microphone techniques, which is surely the crucial knowledge-area for the amateur operator.

These chapters are pitched straight at the every-day tape machine owner, who has no technical background. He will be able to read and understand the material rapidly, thanks to Mr. Weiler's gift for straightforward, accurate translation from the technical to the lay language. And he will be able to handle correctly the microphone part of almost any recording situation he is likely to be involved in, as an amateur, after he has absorbed Mr. Weiler's excellent information.

The advanced amateur or semi-professional will find very much less to interest him, which is a natural and expected result of Mr. Weiler's choice of level.

A chapter on recording from records, radio, and television has nearly the same virtues as the microphone chapters. Mr. Weiler describes the causes of poor results in transferring material from discs or radio to tape. Here, this reviewer felt that Mr. Weiler had perhaps made it sound a little bit *too* easy, by omitting the difficulties and distortions arising from poor matching, hum pickup, signal level adjustment, and so on, when one electronic unit is connected to another. However, the information given is all relevant and important.

In subsequent chapters on tape editing, on sound effects, and on adding sound to movies and slides, Mr. Weiler describes practical operating procedures that should be of the greatest value to every tape recordist. It is just this kind of tried and proven, down-to-earth information that is hard for the amateur to come by, and that makes all the difference between successful, pleasureable tape activity and tapes that just miss out in one way or another.

Also included is a chapter on the basics of magnetic recording, somewhat oddly but not objectionably positioned in the middle of the book, after the chapters on microphone techniques. There is in addition a useful chapter which covers in simple style maintenance activities, which though few, are essential to successful operation.

—*R. S. Lanier*

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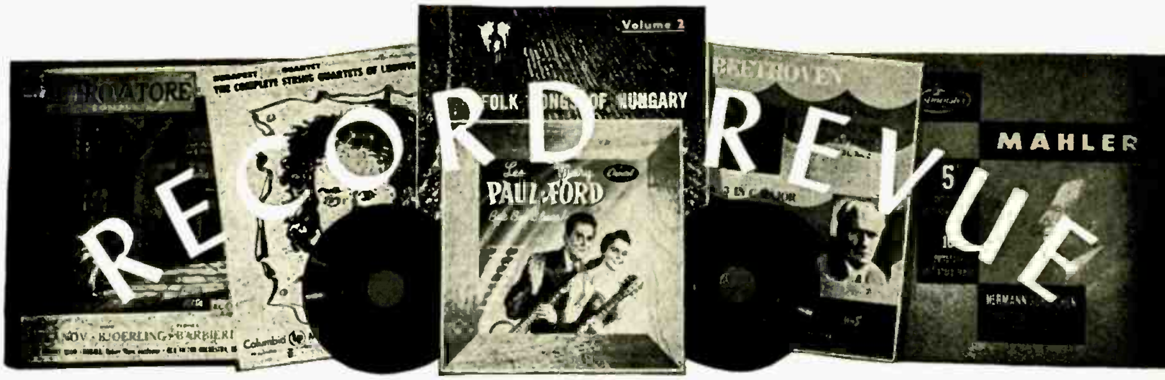

EDWARD TATNALL CANBY*

1. SOME TAPES

I decided to turn off my phonograph for a spell (with apologies to the disc companies) and listen to some tapes, non-competitively, just to see how it would feel. Below are some specific reactions.

There's more to be said on tape than I managed to squeeze into the February issue—but suffice it to note, for the moment, that tapes and discs are now being handled utterly separately, as though neither knew of the other's existence. Tapes, evidently, sell principally through hi-fi dealers, tape recorder dealers and by mail. Record shops aren't handling very many.

The mere fact that tape and disc do happen to be alternative sound media—for any kind of sound—seems to be quite irrelevant. Equally irrelevant, it would seem, is the already mentioned fact that many a tape is, in content, a duplicate of a disc. Not even the labels are the same, except for RCA Victor.

So, you record collectors who are curious about tape, don't expect to find it right on the shelves along with your favorite disc records. You probably won't. But this department will persist in calling spades spades and will continue as well as possible, to treat discs and tapes for what they really, honestly are, alternative media for recorded sound, of every sort. And we'll look forward to the time when the two branches of recording begin to get acquainted with each other, and maybe with each other's markets, too.

Dvorak: Symphony #4. Sibelius: Origin of Fire; Song of My Heart; Finlandia; Pohjola's Daughter. Cincinnati Symphony, Helsinki Univ. Chorus, Thor Johnson.
A-V 1030

This and several other A-V tapes I've had around quite awhile; my apologies here, too. Labelling and description on tapes are still somewhat confused and you may find a different line-up on some more recent tapes, but these items should all be available—on one tape or several. (Most items come in 3¾ ips too, in different combinations, which adds to the confusion.)

The Dvorak is an excellent performance, that will stand up to anybody's, and the music is most endearing, as easy as the "New World" but lighter, more active and tuneful. The Sibelius works are excellent, too. The "Origin" is for men's chorus and orchestra, the next two for male chorus unaccompanied, and very well sung with great precision and an odd Finnish phrasing, with hesitations, that is most attractive; the final Sibelius is for orchestra alone, in spite of the label. I don't know how these Finns got together with the Cincinnati, but I'll take A-V's word for it that it happened.

Some "motor rumble" sound on my tape, and the bass is a bit thinnish; may have been corrected on later editions.

Mozart: "Jupiter" Symphony, #41. Austrian State Symphony, Wass.
(A-V 1006)

I can't find this one in current catalogues—but that doesn't mean it's vanished. (One catalogue lists classical recordings "alphabetically by *manufacturer*" so you can understand my troubles . . .). It should be coupled with a Mozart Symphony Concertante (Sinfonia Concertante, K. Anh. 9, I suspect) but mine was single track.

Anyhow . . . the sound is very good, the playing lyric and gentle, though not with the full strength and subtlety that is in the music. Not bad; I'd prefer it to some of the more eccentric versions by famous conductors. There are numerous other Austrian Symphony-Woss A-V items. If I am right, you'll also find them on Remington records (disc), though it doesn't say so on the tape box.

Haydn: Piano Concerto in C; Emperor's Hymn. Corelli: Suite for Strings (arr.). Bach: Suite #3 for Orch. Philharmonia of Hamburg, Hans-Jurgen Walther.
A-V 1029

This orchestra, now playing for various M-G-M recordings, does a fairly good but not very exciting job with the Haydn concerto; the pianist in the same, Sondra Bianca, seems to me to lack wholly the feeling for Haydn, especially in her unmusical and forced ornaments. The Corelli, an arranged suite, and the Bach Suite are both routine and nothing at all special. The "Emperor's Hymn" is for string quarter, the variation movement from one of the Haydn Quartets, the "Emperor," the tune being the familiar Austrian national hymn, also borrowed as "Deutschland uber Alles."

Haydn: Symphonies #6 ("Le Matin"), #7 ("Le Midi"), #8 ("Le Soir"). Vienna Chamber Orch., Litschauer.
Berkshire BH-1004

Bach: Concerto for Three Harpsichords. Vivaldi-Bach: Concerto for Four Harpsichords. Haydn: Trumpet Concerto in E Flat; Horn Concerto in D. Vienna Chamber, State Opera, Symphony Orchs., Heiller. **Berkshire BH-1003**

Berkshire has come nearer to making intelligent order out of general chaos than any other tape producer except RCA-Victor. These tapes actually state, on the box, that they come from Haydn Society master tapes—as though this were something to be proud of, which it

---

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Each month, Mr. Canby will name one record as the "Problem of the Month." Listen to it, study it both as to music and as to recording quality. Then write a brief review on a postcard—no other entries will be considered—and send it to AUDIO, Dept. RR, P. O. Box 629, Mineola, N. Y. so that it arrives on or before June 5, 1956. Winners will be announced in the July issue, and the review chosen as first will be published, along with Mr. Canby's own review, in the same issue.

For this month's problem, Mr. Canby has selected:

The Three Ravens (Songs of Folk and Minstrelsy out of Elizabethan England). Alfred Deller, countertenor, Desmond Dupre, guitar and lute. **Vanguard VRS 479**

Buy it, borrow it, or just listen to it somewhere—then tell us what you think about it.

RULES

1. Decisions of the judges are final and no correspondence will he entered into regarding entries or choices of the judges.
2. Reviews of the selected record must be submitted on a government postcard. No others will be considered.
3. Only one entry will be considered from each contestant.
4. All entries are to become the property of Radio Magazines, Inc., and the one chosen as first will be published.
5. From the list of records reviewed by Mr. Canby in the issue in which the "problem record" is announced, the writer of the review chosen as first will be given three records of his choice; the writer of the review chosen as second will be given two records of his choice; the writer of the review chosen as third will be given one record of his choice.
6. Entries will be judged on the basis of both musical ond technical accuracy. Neatness and form will not count, but the reviews must, in the opinion of the judges, be sufficiently legible to be read easily.

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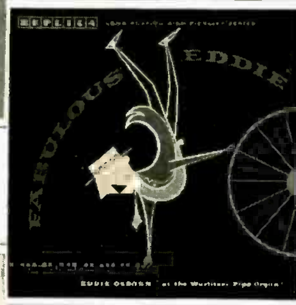

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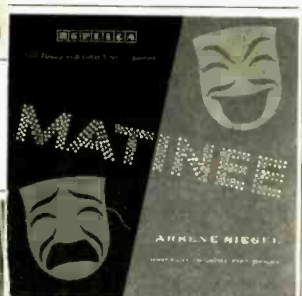

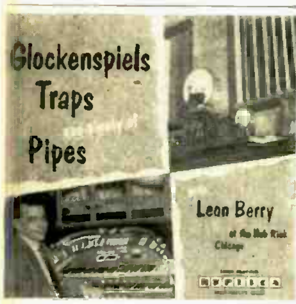

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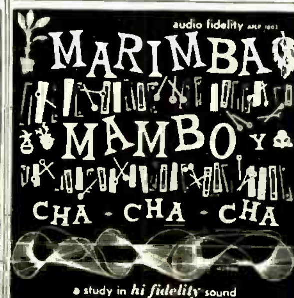

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is. (But see below). The packaging is nice, there are—or will be—annotations. Altogether a good looking, confidence-inspiring presentation. (And note well that the Haydn Society, as of this writing, is out of business and may not get back. These tapes, then, are unique and the only versions of the music available.)

Of these two, I'd pick the "Morning, Noon and Night" trio of little symphonies at the drop of a hat. This is their only threesome recording, and all are nicely played, beautifully recorded. The other tape, with the four concertos, is a bit on the ponderously documentary side, *very* authentic but mostly somewhat inflexible in the playing. The catchy trumpet concerto is the best.

The Berkshire taping is excellent in the main (and well above the quality of the originally issued discs as I remember them). Recorded level, however, is deliberately quite high, to the point of some slight distortion in the loudest parts. I trust that eventually tape companies will decide to give up this sort of doctoring to fit cheap players. We long since gave it up in the disc field.

Brahms: Symphony #4. Cremona Symphony Orch., Florentino Curci. (See below!) **Berkshire B-2102**

I did pretty well on this. Here are notes I wrote on the box, before I was wised up. "*Rather nice concept of the music, fairly heavy and solid—surprising in an Italian orch.! Bit slow . . . but a real understanding of Brahms.*"

Pretty good, because, you see, this is actually, so a small bird later told me, a Urania recording and *German all the way through.* If there is a Cremona Symphony, it didn't play this, and evidently Signor Florentino Curci is 101 per cent imaginary. So also is Herr Kurt Schwertfeger, in the succeeding review. Pseudonyms.

To tell the truth, I don't think it's at all funny, this making up of fake names to palm off on an (unsuspecting) public. In the present case, the impetus seems to have come, oddly enough, from the original record company. If I gather things rightly, Urania was quite willing to lend out its material for taping, but wouldn't allow the correct names to be used—presumably so it could put out the same stuff itself on tape, if and when. All quite legal, but not very ethical. The public be damned, in all its gullibility.

I don't like it, and I suggest that Berkshire stand up and announce publicly a policy that no fake names will be used on the label unless so designated (as with RCA's Camden records). It should pay off in prestige.

Anyhow—a good Brahms performance but—come to remember—a typical early type Urania tape, with much distortion in the loud passages, probably from German Magnetophon originals made awhile back. Definitely not a hi-fi job.

Tchaikowsky: Symphony #6 ("Pathétique"). Oberammergau Festival Orch., Kurt Schwertfeger. (See below). **Berkshire B-2107**

I hereby suggest that some of our German-based readers do a bit of investigating at Oberammergau, that small village where the Passion Play (but not the Pathétique) is performed once every so many years. In a word, there ain't no sech orchestra. And Herr Schwertfeger doesn't have his name in the phone book, either. He doesn't exist, I think.

I.e., this is probably another Urania-Anonymous, dressed up with somebody's idea of a good pseudo-title. So it would seem, though this item is not listed in current LP catalogues as far as I can see.

Anonymous or no, it is a good performance, full of a lot of life, without that hectic overnervousness that spoils (for some of us) many another "Pathétique." And better, this one is a clean tape with low distortion—though Berkshire's high level taping creates a bit of breaking-up in some of the loudest passages. Recommended, anonymous or no.

Haydn: Quartet, Op. 3, #5. Schubert: Quartet in E Flat, Op. 125, #1. Mendelssohn: Octet, Op. 20; Andante Scherzando from Viola Quintet, Op. 87. Fine Arts Quartet and guest artists. **Webcor 2923-5**

Debussy: Quartet. Haydn: Andante, Quartet Op. 76, #2. Granados: Lady and the Nightingale. Ravel: Alb. del Gracioso. Liszt: Son. del Petrarca; Mephisto Waltz. Fine Arts Quartet. Robert McDowell, pianist. **Webcor 2923-1**

Webcor's classical (also used as mood) music centers around the excellent Fine Arts Quartet. The first of these two brings in extra strings for one of the liveliest and most enjoyable playings of the Mendelssohn Octet I've heard, bar none, plus a "dividend" of a short and unusual Mendelssohn movement with a lovely theme, as well as the quite good Schubert and the fairly good Haydn quartets. A very nice string tape.

The second tape features the Fine Arts group on one "side" (can't help using that familiar term) in a really excellent Debussy, high up on anybody's list of such recordings. On the other "side" is a piano recital which I fully expected to be just another mood-music thing—but which turned out to be nothing less than extraordinary.

Robert McDowell is a really first rate pianist, the sort who can get *music* over to any listener with a maximum of dramatic sense and a minimum of just notes-and-technique. His playing—for a change—is unusually smooth and legato, where most pianists now play hard and brittle with little pedal. And he sings, everywhere, phrases beautifully, whizzes through the pyrotechnics of Liszt with effortless joy, never missing the melodic sense for an instant. Best of all, his piano is wonderfully, resonantly recorded.

A top-rank tape that should be a pleasure for anybody, from mood-listener to classical highbrow!

Kodaly: Summer Evening. Prokofieff: Summer Day Suite. Concert Artist Symphony of London, Vicars.
Omegatape 7005 (5")

A tape with beautiful orchestral sound quality, miked to perfection, but the playing of these two nicely paired easy works is routine, though accurate. The Kodaly is too long for what it says, but it's full of interesting orchestral color. The simple little Prokofieff children's pieces seem to me over-orchestrated in this, the composer's own version of the piano originals. Still—not a bad tape for general interest, both musical and hi-fi.

Beethoven: Piano Concerto #5 ("Emperor"). Horowitz; RCA Victor Symphony Orch., Reiner.
RCA Victor TC-4

One of the first batch of RCA tapes that I didn't get around to, this one makes an interesting comparison with the small-company tapes above. Quality of sound is, of course, very high, but not too noticeably superior to the general run. Tape recording is good anywhere and everywhere these days, or should be. What's more immediately noticeable is the performance—not so much its superiority as its much higher tension. That's what you pay for in these big-name artists.

To tell the truth, my main impression, in spite of the skill and dramatic craftsmanship displayed, was adverse. Too tense, too hard, too high-strung.

Horowitz's piano is so hard that at times you'll wonder whether it's bad microphoning. I doubt it. Reiner himself, the great conductor, can be a driving, steely orchestral taskmaster in music of this sort and, it seems to me, the two men egg each other on here. Yes—it's of our times in the spirit of the atomic age, and a *tour de force* of showmanship as well. But I'd rather prefer a less nuclear reading, big-names or no. Try it yourself and you'll see what I mean.

(This recording is also available on disc, as with other RCA tapes, one of *eighteen* versions now extant on LP!)

Vivaldi: Concerto Grosso in D Mi., Op. 3, #11. Mozart: "Eine Kleine Nachtmusik." Bach-Stoessel: Prelude in E Major. Tchaikovsky: Serenade for Strings. Bolzoni: Minuet. Sorkin Symphonette. **Webcor 2923-3**

This is the Fine Arts Quartet, as above reviewed, augmented with more strings to make a string orchestra of excellent recording proportions, for a very nice taped sound.

The orchestra's sense of style is not profound, nor perhaps should be if this is background music. For my ear it is anything but background stuff and so I can only suggest that whereas the Vivaldi is routine string playing (minus the harpsichord *continuo* that should be included), the Mozart is excellent and the Tchaikowsky the same. These three are the main items and should please any listener who wants a good and musical string sound, beautifully recorded.

The remaining two short bits, Bach-Stoessel and Bolzoni, are musically unnecessary. They are put on the tape to round out timing, in a process that I'm now beginning to understand as a very serious thing in tape circles—indexing.

Indexing means simply that the two halves of a two-track tape must be made to end within a few seconds of the same length. Why? Well, of course, so you won't have to reel off the extra blank tape on the shorter half. But the important reason is background music.

Many tape buyers, it seems, string their tapes together in one long stretch, for hours and hours of discreet background. Therefore every individual two-track tape must be filled up with music to each end, uniformly, or there will be long silences where the longer half runs beyond the end of the shorter track.

That, my friends, will give you a nice idea of the tape promoters' present heavy preoccupation with background needs. Fine and dandy. Except that a few of us insist on thinking that tape music is so good that it's just as worthy of *foreground* listening as disc music—perhaps even more so.

You see, a mood-music review of this recording might read very differently—"A nice, clean string tape, pleasantly relaxing, well indexed."

Maybe that's all I should have said.

2. POSTSCRIPT ON TAPE

The above hunk of commentary on tape was originally slated for the March issue. But by that time I had written so assiduously that vast piles of Canby copy were lying around looking for a berth. We rearranged our space, in order to get the April comment on discs into place *in toto*, and the tape stuff was transferred to May.

Well natch, in this fast-moving world, anything can happen in a couple of months. Since then the tape situation has taken a sudden new turn in the direction of maturity. There has been a series of reorganizations going on behind the scenes these last months—tape companies sold, bought, regrouped, re-staffed—and the first results are now out.

Within a week, two of the tape concerns instituted regular periodic releases, tied in with reviewers' service for magazines and newspapers, disc-company style. One company is fairly new, the other has been around for some five or six years without ever having a set policy as to releases and review material.

Both companies are set to flood the market. One is distributing through a disc company set-up, already long established, and so will at last penetrate into regular record stores and reach some of the *musical* record buyers, as well as the background-music and hi-fi shoppers. A big change! Indications already are that this trend—at last—will become strong, and maybe after all we'll find tape and disc actually competing on equally informed terms for the same buyers. Didn't look that way back around New Year.

It looks as though a large proportion of coming recorded tapes would be of material also available in disc form. This is inevitable—for why should there be two separate repertories when all recorded material comes from tape in the beginning? Technically, many new tapes will be reissues, from the original tape masters for discs already available. But eventually the simultaneous release, in both forms, is bound to be more in evidence, as tape repertory expands.

Next: stereo. That development is booming now, but almost wholly undercover. Everybody's making stereo recordings, but nobody's letting on about it. We'll see about this in future issues.

3. SCOUT SURVEY

Note—My scouts have been indefatigably at work plowing through vast piles of wonderful (often) records and here are some of the results of their collaboration with my own pair of ears. Many of these records make my mouth water and my eyes weep for the time and leisure to listen to them as they should be heard and clearly merit—at length. Indeed, that is the way I still do most listening—at leisure and without time restrictions, regardless of pressure; for I believe that even in this day of mass production the musical art requires and deserves the same steady, wholehearted, full-timed attention that it has always demanded for understanding and for enjoyment.

I would feel obliged to stop rendering any sort of judgment of records if I could not, most of the time, listen at true length and at full leisure to *all* that each recording has to offer, living with it as a good listener should and for as long as the enjoyment takes to develop to full maturity. That doesn't always happen in one or even two playings!

But the records do pile up and we aim to serve, hereabouts. Between me and my scouts I think we can cover the greatest amount of territory in the most informative way through the present share-the-experience system, whereby six ears and three minds are pooled to cope with the flood, though the product comes out on one typewriter, my own, and the responsibility is wholly mine.

MORE GRAND OPRY

Mozart: Die Zauberflöte (The Magic Flute). Hilde Guedon, L. Simoneau, W. Berry, Paul Schoeffler, and others; Vienna Philharmonic, State Opera Chorus, Karl Böhm.

London XLLA 33 (3)
(With vocal score)

Mozart: Le Nozze di Figaro (Marriage of Figaro). Siepi, Gueden, Della Casa, Poell, Danco and others; Vienna Philharmonic, State Opera Chorus, Kleiber.

London XLLA 35 (4)
(With vocal score)

These monumental editions of the two famous operas include a complete score—full octavo size—with a special pocket in the outer album; the records are in an inner box-within-a-box. At this point I don't know what you do if you *don't* want the score, but if you're inclined to give it a fling, I think you'll find it a valuable aid to listening, even if you do get lost every so often. Scores are certainly not necessary to good listening, for musicians or non-musicians; but they can be interesting and useful to anybody.

Scout #2, a Mozart enthusiast (as am I), makes a distinction between these performances, the first of a German-language opera, the second in Italian. He finds the "Nozze"—The Marriage of Figaro—excellent; say it is full of sunlight, gay, charming and intelligent, as well as beautifully recorded. He likes the solos, especially Suzanne Danco as Cherubino, the love-struck youth; only the Count, Alfred Poell, seems to him miscast, with a poor accent and an awkward approach. Highly recommended.

The "Magic Flute," in German and full of a mixture of complicated Masonic symbolism and low-brow slapstick of the most delightful kind, is less successful in this performance according to Scout #2. The details are lovely and so is the fidelity. But somehow, that marvellous all-over magic in this opera, that slightly crazy but superbly inspired "sunniness, burlesquiness and just plain livingness," as the Scout puts it, is missing. In all its parts, it's "quite nice," but in the all-over it's never radiant—and radiant, joyful, mystic it must be, to be right. Not so highly recommended.

Mozart: Don Giovanni. Taddei, Valletti, Tajo, et al.; Orch., Chorus Radiotelevisione Italiana, Turin, Max Rudolf.

Cetra (Capitol) C 1253 (3)

This is interesting! An all-Italian performance (if you discount the conductor) of the most famous of all Mozart operas. The text, of course, is in Italian and after the Italian manner of the late 18th century; but it was composed and produced in Austria by an Austrian for non-Italian audiences and it remains basically a German opera. How does it fare with an Italian cast?

Scout #2 finds it quite fascinating—though he adds a qualification, that "Don Giovanni" can stand up under any kind of attack, even an Italian one! To his surprise, he says, they don't do it as much harm as he had expected—though the "harm" that is done is of the sort

(*Continued on page 72*)

AUDIO ETC.

Edward Tatnall Canby

Bits and Pieces

1. Music Synthesizer

One of the most stimulating and "controversial" topics in audio in recent months has been the synthesis of musical tones by electronic means, as brought to a head, as far as the arguments are concerned, by the now famous RCA Electronic Music Synthesizer, an "all-out" device which carries the logical idea of tone-creation to a presently 100 per cent basis. Reactions on all sides have been healthily extreme and if it does nothing else (which Heaven forbid), the new device will have promoted some very fundamental thinking among many of us as to the relations between music and science and the very meaning and purpose of musical expression.

The inventors' attitude towards the Synthesizer is characteristically and honestly the approach of science. Analyze musical sound into the component factors, synthesize these one by one, piece by piece, combine according to formula—and you'll have your synthetic product. We've heard much of this kind of scientific progress, notably in the drug field. It is the accepted engineering approach to any problem and—in the scientific fields—it is indeed the only approach, granting a bit of sheer intuition, a trace of hunch and a lot of horse sense on the side.

But when applied to a product of human *expression* such as music (I am avoiding the word "art") there are complications. We know of doctors who ignore psychology in their diagnoses, to the patient's cost. Illness is people, so to speak, and so is music.

You cannot ignore the human behavior aspect in medicine, even though the disease may have perfectly clear organic evidence. Colds may be caused by viruses, but cold susceptibility may very well be affected by emotional factors, as most of us know only too well. So with much else.

Music itself can be analysed as sheer sound and, to a point, it can be re-synthesized, from synthetically produced tones. The "natural" product may be imitated and, more interesting, synthetic new products may be arrived at. But no scientist can get away from two or three basic points.

1. Music is an expression of human emotion. It makes sense largely in its own absolute terms, varied as they are. Without people, music would be no more than noise. That's what it is to my dog, who ignores it except when she things she hears a dog barking or a cat meowing.

2. Music throughout our history has been, like stage drama, a human expression *in action*. There has been a performer always, even when on occasion he is also the composer. We have always been acutely conscious of the *performer-in-action*, the human being in the act of producing musical sound, even to the point of ignoring the music itself. Right now, indeed, we are in the most exaggeratedly performer-conscious time in the history of music.

The Electronic Synthesizer would remove the performer-in-action as we know him, substituting the composer, who would work out his music as one creates a film or painting. We would no longer see him in the act of creation, nor (what is equally pleasant), hear him in action.

Note that tape editing of musical performance has removed much of the literal time sequence of performing as we hear it today—but we still like to believe in the old in-action continuity, from beginning to end. We resent rather violently (as I said in "The Home-Grown Tape Program II") any disturbance of time and performance, as we imagine it to be happening. What sort of time sequence would the Synthesizer's music provide for us? Will we be able to dispense with the imagined performer?

3. Music depends on limitations for its sense. In solid scientific style, the Synthesizer's engineers seek to *remove* the limitations of present musical production, providing an almost unlimited expanse of sound-material for music-making. But every musician knows that the "limitations" in music are in plain fact the shapes and boundaries that allow music to make sense. Music has expanded against all sorts of physical limitations, of course; but only at a constant and dreadful peril, for until new "rules," new "limits" of meaning are staked out, the "limitless" music does not convey any sense. You can't make up a new language without defining it—limiting it—and it won't be of any use until not only the promoter of the language but also the listeners understand it.

And so, perhaps, it will take centuries to work out a new musical language that fully expresses all the new things inherent in the Music Synthesizer. That is both a stimulating thought and a depressing one.

And meanwhile we've battered down so many of the old "limits" in our 20th century music that entirely too many people don't make head or tail of what we have already—from Stan Kenton to Stravinsky.

* * * * *

These are profound questions. Instead of quoting to you from the dozens of letters, pro and con (*"Did I like your 'Synthesized music?' Certainly not!"*) that have given rise to these and other thoughts, I'll merely end by reminding you that the present Synthesizer's rather unmusical sounds are no indication of its potential importance. Most of them are now imitations of "real" music, a necessary contradiction but an unpleasant one that has thrown many a music lover 'way off the track.

The imitations, at this point, are admittedly crude, and their "faking" of a real, live performing effect is pretty dreadful. (*"The piano selection sounded as if the instrument—'piano'—had been soaked in a pond for some weeks. The 'voice' sounded rather the same."*) But this, I remind you, is not a criticism of the idea of the machine itself.

For in the end, the Synthesizer will not imitate at all. The Hammond "organ" and the vibraphone, the electric guitar, et al, have already gone a long way on this path, towards their own, unique sounds, not to be considered as imitations of any other. The Synthesizer, similarly, will create its own inimitable sounds, to be judged—and composed into music—on their own merits.

The trouble is, they're so unlimited. Where is a composer to begin? The first thing he'll do, natch, is to select some, a few, a *limited* number of them. And right there, he'd better begin to look out. It looks as though the Synthesizer is going to be all things to all composers, every man on his own, with his own set of arbitrary limitations. That'll be a pretty mess.

Except that composers, being birds of a similar feather, are bound to get together. Got to have some sort of working agreement, a recognizable coinage, a common language. Compatibility, interchangeability, the engineers might call it. And so you see, we'd be right back where we started—limitations and all. That's why the Music Synthesizer is so interesting.

(Note: See "The Music of the RCA Victor Electronic Music Synthesizer," an RCA Victor LP record.)

2. "Sealed Records and Factory Inspection

Mr. W. P. Ramsey of Claremont, California, writes me succinctly about his idea for a *real* record seal, as follows:

"Simple but effective, this seal consists of a thin piece of tissue paper covering the center hole and placed between the label and the record as they are assembled. It could be a part of the label itself. It would be impossible for the record to be placed over a turntable spindle without puncturing the tissue paper. . . ."

"Your idea . . . is much too good," I answered. "It will never be used until the manufacturers decide they really want to seal records."

I might add that though I suspect Mr. Ramsey's seal is impracticable because of the pressing process itself, I am quite sure that something of the sort could be worked out easily, and dramatically. Might even be a neat circle or square of rice paper or equivalent, *pasted* (no rubber cement) over each side of the hole. Good advertising could make an asset of it and surely nobody would mind the torn remainder, any more than people object to a torn seal on a bottle of bonded Bourbon.

But never forget that, at this point, better pre-sealing *factory inspection* is even more important than sealing itself, though the two are not actually for the same purpose. Sealing is to prevent pre-purchase playing of the disc. Inspection is to prevent factory imperfections. Right now, a lot of imperfections are being sealed up and neatly packaged. I could quote letter after letter on *this* subject, and many of them rather bitter, too.

A number of defective lots of records

have been let out on the market recently, full of inexcusable imperfections—if my correspondents are right. ("I feel that record surfaces are a scandal!"). Some were recalled and good records soon came along, but the damage was done and the prestige of that little claim "factory inspected" has been given a staggering blow. For how could such a thing happen, if the records were actually inspected and passed?

The answer, as you may guess, is factually simple. Most factory inspection is done on a spot-check basis. One record in every hundred, or thousand. Until now, at least, nothing more drastic has been practicable under the conditions of mass production. It takes perhaps three quarters of an hour to play an LP for an audible check. Visual checks aren't too reliable, or would be too time-consuming if they were.

Well, so what! say the buyers. If you claim factory inspection than you'd better jolly well enforce it if you want any peace of mind with your public—or else take off those "factory inspected" labels, but quick.

I honestly think that the "factory inspected" gambit has boomeranged this time. I am sure that record manufacturers are doing their darndest to see that quality is high and uniform, but I think the front-office publicizers have put them 'way out on a limb here, and it's really too late to crawl back. Not far, anyhow.

Let me state, for the gripers, that to the best of my knowledge record material has been getting steadily better and better ever since the LP was introduced and the average quality of the plastic now used is really extraordinarily high—in view of the extreme sensitivity of the LP-45 needle to the tiniest imperfections. I, personally, have no general complaint to make on this score, speaking averagely. I can only praise.

But unfortunately, that average includes a wide range of irregularities and some pretty awful boners—all of which have slipped past the factory inspection stage. Since "factory inspected" is now printed so prominently on so many records, there's nothing for it but to hike up standards and make them stick, even tho' it hurts.

Maybe Publicity has done us buyers a good turn, unwittingly. Nothing like setting your sights high!

3. Dynamic Leveling

One correspondant suggests his own brand of "dynamic leveling," for your supposedly level table, to ensure (as the British say) that there is actually no side-pull on the stylus as it plays. Mr. L. Wesley Chatman of Kalamazoo says, "You need just one piece of equipment . . . a record with a perfectly level, blank, flat surface, no grooves, no music. An inexpensive 12-inch recording blank is just right. Put the pickup gently down near the outside edge of the turning record. If the turntable is level the pickup will stay put, without lateral movement, one way or the other. . . ."

An excellent idea, and I have been guilty myself, as I told him, of a sort of make-shift version of the same. Put the stylus in the lead-away grooves at the end of a record, or in the lead-in grooves at the beginning. As the record turns, push it lightly with a careful finger, to see how easily it is dislodged, either inwards or outwards. (No good on the outside edge of the new raised edge discs, which slope downhill towards the center.) Counterbalance the pickup with a coin, if you can, for extra-light pressure.

This way works quickly and, though some will cringe, really does no harm to a light-weight modern pickup. Maybe I shouldn't say so, but on occasion I've even tried it on the playing grooves of a record. Just give the stylus a *very* gentle shove so it skips a groove or so, first one way and then the other. You can quickly tell how well the table is levelled, for side pull. But better not try it on your more precious discs!

Far better a single tick or so on one disc than a continuous and damaging side-pull on all the records you play.

4. Mike Subtleties

The play between improved records, improved loudspeaker systems, and improved pickup cartridges is quite fascinating now, as audio continues to climb towards the improbable peak of absolute perfection. It's astonishing how the ertswhile "best" really does turn out to be not *quite* as good as the newest "best," even to an untrained ear, given a bit of time and leisure for careful listening.

But it isn't easy at all, on the other hand, to make clear listening distinctions between these three as to the increasingly delicate and precise increments of superiority in performance. It's more than ever easy to praise—or blame—the wrong component. Test instruments and procedures still can show up the characteristics of each element, in spec form, given the proper laboratory conditions. Graphs, oscillograms, charts, plus-or-minus this and so-many-db that, performance is still described and describable in engineering terms.

But for most of us, tests are all very well—we want to know about the sound itself. How does the gadget *sound*? And so we plant our trusting ears next to the one end of the long audio chain that can enlighten us, the loudspeaker. It takes a very, very careful listening analysis these days to figure out what is happening from this point backwards—all the way to the dim-distant microphone that picked up the sound in the first place. It has its own characteristic too, even in the very fanciest professional models.

Slim-Trim Dynamic

Which brings me to an Electro-Voice microphone of high professional quality which I've had on hand for months, the Model 655 Dynamic. I have hesitated again and again to render a judgment upon its audible performance for these very reasons—until I should have listened "through" it, and all manner of other attached equipment, long enough to say something useful. And now that I get to it, I'm not sure just how to begin.

Remember, all really good microphones are more or less "flat," and so all should sound alike. Within reason they do. They're all wide range, they all avoid ugly peaks and valleys and what-not. They all—these top professional mikes—live up to very high standards of recognized performance. They would hardly be in production at the price, otherwise.

And yet, oddly enough, as you listen and get to know them, differences creep in. And those differences are very hard to pin down, even for a toughened mike artist who listens to more sound with his mikes than with his unaided ears. Some differences, of course, are those of pickup sensitivity and directionality. Big differences. But there is more to it, decidedly.

The E-V 655 is a slim-style, thick-pencil dynamic, of the toughest construction, practically undamageable; it has a "chicken-wire" blast-proof head and that dull, respectable unglittering appearance that now betokens high quality—before the TV camera. TV mikes are about as glamorous as army tanks and trucks. This sort of dynamic mike features ruggedness first of all, plus a general-purpose omni-directionality. The essence of high quality simplicity, slimmed down for inconspicuousness.

Well, first, I made one fine mistake that anybody might. The other day, after long since having decided that—compared to the whopping output of my present mike—this E-V was sort of feeble, I found by sheer accident in my files a white card with a small wrench attached. THIS MICROPHONE IS CONNECTED TO 250 OHMS OUTPUT, it said. Didn't say what mike, but it gave instructions for de-wiring, with the aid of the special wrench and a soldering iron, to arrive at a 50-ohm figure. I did a double-take, and discovered, then and there, that I'd been feeding the E-V, at 250 ohms, into my low-impedance (50-ohm) input all this time. That's where the card and wrench had come from.

Not a difficult job to change, even though it meant disassembling the plug end of the mike and relocating two of the wires, but now my mike jumps to the pin beautifully, at the proper 50-ohm setting. This shouldn't be registered as a complaint since the mike wasn't intended for amateur use. But it is still a wonderful mike for rugged non-professional purposes, where its fool-proof and simplified hi-fi are especially useful and so—my moral is, when you use professional equipment, look out for the taken-for-granted.

I used to talk that way, I remind you, about plain, ordinary, separate-unit record playing equipment as sold in radio parts stores, back in the days when "hi-fi" stuff was still made similarly for professional use, rather than the home. I remember distinctly (I won't look back) writing in this very magazine a long piece about the desirability of plugs, of simple, built-in standardized connector arrangements on amplifiers and the like, so that home buyers could *plug* their equipment together, without having to play around with bare wires and solder! Remember those days, old readers? *Circa* 1947.

How does the E-V 655 work out in actual sound? Mind, you, this is a high-quality mike and its performance is surely within the very high tolerances that are rightly taken for granted in superior equipment. But as I say, even the very expensive mikes have the oddest way of sounding unlike each other.

Immediately we're in a fascinating jungle of preference here, and the question at once arises—*what do you want* from your mike? For I find that some professional mikes produce a musical sound that, over considerable experience on my part, is more alive, more immediate, more lovely, more soulful, more piquant, than do others. I suspect the E-V is even "flatter" than my own present mike, which has a slightly rising characteristic over part of its higher range. In fact, E-V notes that the Model 655 (40 to 20,000 cps.) is used in many laboratories as a standard, and I do not doubt this.

Perhaps you get my line of thought. In this curious art of recording, it may be that some users prefer, and perhaps will always prefer, a somewhat "unrealistic" mike performance, that gives a certain highlighting and presence, a polish and roundness to sound that, strictly speaking, isn't *quite* literal.

But I recommend the E-V 655 highly, if you will allow in your calculations for a slight *relative* lack of color and brilliance which may in fact be more accuracy on this mike's part. If you want a top quality mike that will go anywhere inconspicuously, can be dropped on a concrete pavement from any old height and probably will record under water too, then you will like the 655.

NEW PRODUCTS

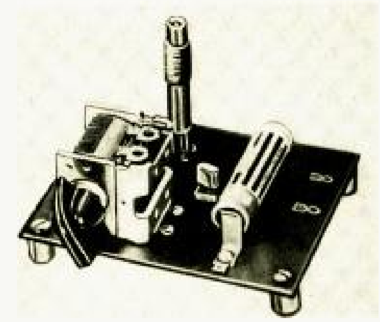
• Fisher All-Transistor Preamp-Equalizer. Believed to be the first all-transistor device of any kind in the high-fidelity field, the new Fisher Model TR-1 preamplifier-equalizer is characterized by a hum level of absolute zero and complete freedom from microphonics. Equally suitable for use as a phonograph or microphone preamplifier, the TR-1 weighs but twelve ounces and draws only .033 watts from a self-contained battery. It can be used with any existing amplifier, audio control, or sound system. Three controls afford complete flexibility of function. A cartridge impedance selector permits use of the TR-1 with all popular magnetic cartridges, including the very-low-level types. The

phono-microphone selector allows operation as either a phonograph or microphone preamplifier. The volume control permits the TR-1 to be connected directly to a basic amplifier which has no level control. Fisher Radio Corporation, 21-21 44th Drive, Long Island City 1, N. Y. **N-1**

• Expanded-Scale Frequency Meter. Many industrial and laboratory requirements will be satisfied by the new Model 500B high-accuracy frequency meter recently developed by the Hewlett-Packard Company, 275 Page Mill Road, Palo Alto, Calif. Although extremely compact, the 500B covers frequencies from 1 cps to 100 kc and provides direct readings accurate with ±2 per cent full scale. A feature of the instrument is an expanded scale which permits any 10- or 30-per cent segment to be viewed full meter range for high accuracy. Input requirements are 0.2 volt on sine waves and 1 volt minimum to 250 volt peak maximum on pulsed signals. Included in the unit is a self-check based on line-voltage frequency. Readings are not affected by signal- or line-voltage variations. The 500B will speed and simplify measurements such as counting sine waves, square waves and pulses, determining oscillator

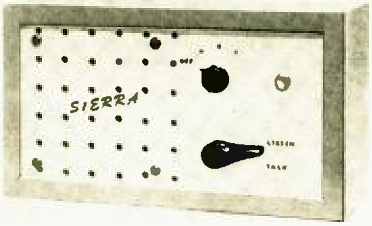
stability, measuring beat frequency between r.f. signals, and measuring temperature, pressure, and other physical quantities which can be converted to frequency. Further information is available on request. **N-2**

• Knight Transistor Radio Kit. Featuring a printed-circuit component mounting board that eliminates all wiring and reduces soldering to only a few connections,



this kit can be assembled by even the most inexperienced of amateurs in a matter of minutes. Operating power is supplied by a single pen-light cell which will last for months under normal use. An important feature is a specially-designed coil which provides positive separation of all stations even in locations were several powerful transmitters are on the air. The entire unit is small enough to fit in the palm of the hand. Frequency range covers the standard broadcast band. Allied Radio Corporation, 100 N. Western Ave., Chicago 80, Ill. **N-3**

• Intercom Kit. Intended primarily for home use, this handy do-it-yourself intercommunication set comes complete with master and sub-station, and is supplied with detailed simplified instructions. Constructional details include printed cir-

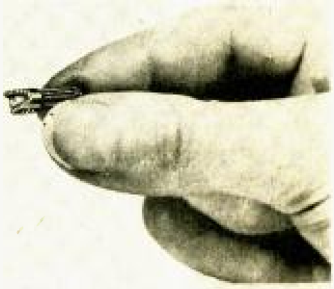


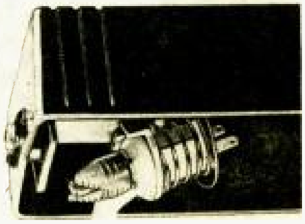
cuitry, 4-in. PM speakers, and listen-talk switch. For further information and literature write: Sierra Scientific Company, 5415 York Blvd., Hollywood, Calif. **N-4**

• Improved "Trend" Amplifier. Three tape equalization positions for tape speeds of 15, 7.5 and 3.75 ips are included in the newest version of the "Trend" amplifier

manufactured by Harman-Kardon, Inc., Westbury, N. Y. A separate rumble filter has also been added which progressively attenuates all frequencies below 50 cps. Rated at 30 watts at 0.5 per cent distortion, the new Trend features variable damping from 0.1 to 20 in six steps, as well as a 6-position dynamic loudness contour control. **N-5**

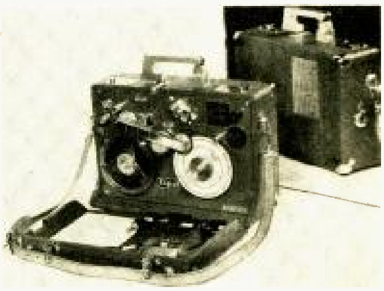
• Electro-Voice Phono Cartridge. A thoroughly new approach to pickup design is evidenced in the new E-V "Power Point" cartridge, which integrates both cartridge and styli into one easily replaceable unit. Tiny in size, the "Power Point" approximates the dimensions of a transistor, yet provides performance superior to that of many regular-style cartridges. When the two sapphire styli are worn, the entire "Power Point" is simply slipped out and a new one installed, an operation which can be performed in a matter of seconds. The user is assured of a fresh ceramic cartridge every time he changes needles, at a cost which is substantially less than that for needles alone with most conventional cartridges. High output with low distortion, and excellent compliance are





benefits of the miniaturized construction. Only four different models and three mounts are needed to allow use of the "Power Point" as a replacement cartridge in virtually every modern record player. Electro-Voice, Inc., Buchanan, Mich. **N-6**

• Improved Tapaks. Three new 1956 models, incorporating a number of distinct improvements, have been introduced as successors to earlier versions of the spring-powered walkie tape recorders known in the broadcast industry as Tapak (tape-pack) Newscasters. The Duplex model provides not only broadcast-quality recording but, in addition to the usual



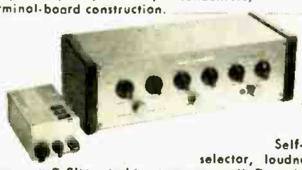
headphone playback, it also includes a built-in speaker for reproduction to room-size audiences. A subminiature basic amplifier and transistorized bias oscillator permit this advance without sacrificing battery life. Another model, the Triplex, incorporates a VU meter and a 600-ohm zero-level output for feeding a line. The Simplex, an economy model, consists of the basic recorder-reproducer without loudspeaker. Broadcast Equipment Specialties Corp., P.O. Box 119, Beacon, N. Y. **N-7**

HARVEY
The House of Audio

MARANTZ Audio Equipment

40 WATT POWER AMPLIFIER

Built-in metered operational adjustment. Output transformer with low leakage reactance and high flux-handling capability. New type-6CA7 output tubes are more efficient and distortion-free. Variable damping from separate 4, 8 and 16 ohm outputs. Oil input-filter capacitor, long-life telephone-quality electrolytic condensers, terminal-board construction. .... 189^{00}



AUDIO CONSOLETTE

Self-powered. 7 inputs. Input selector, loudness compensation, volume, bass, cutoff filter, treble, turnover, rolloff, and power on-off controls. Low and high-impedance outputs. 3 switched AC power outlets. Response ±1 db, 20-40,000 cps. 1% maximum intermodulation distortion at 15 volts output. 4 microvolts equivalent maximum open-circuit noise at first phono grid. .... 162^{00}

New FAIRCHILD 225 *'Micradjust'* DIAMOND CARTRIDGE

Latest version of the famous FAIRCHILD moving coil cartridge, incorporating many new and important improvements. New 'Micradjust' construction permits individual micrometer adjustment for optimum performance in each installation. Improved magnetic circuit eliminates all turntable attraction. New symmetric damping ring provides further reduction of distortion. Reduced moving mass extends frequency range and increases smoothness of response. Many other improvements.

Model 225A, B or C (1.0, 2.5 or 3.0 mil diamond styli, respectively) 37^{50}

FAIRCHILD Transcription Arm — Series 280

Accepts all variable reluctance and dynamic cartridges, and permits interchange without screwdriver or other tools. Built-in muting switch eliminates hum when interchanging cartridges. Provides perfect midgroove tracking with no side thrust or groove jumping. Has adjustments for height and level. Requires no arm rest. Two models available:

Series 281A for 16" transcriptions .... 35^{95}

Series 280A for more compact installations 33.95

GARRARD TRANSCRIPTION TURNTABLE
Professional Model 301

A unit designed specifically for discriminating listeners and owners of home sound systems. The turntable itself is a 7½ lb. disc, precisely machined, accurately centered and balanced. A 4-pole induction motor was specially developed by Garrard for use in this unit. Armature is dynamically balanced and the rotor set in self-centering phosphor bronze bushings. A newly designed motor mounting technique, employing counter-balanced springs, absorbs virtually all vibration.

Intended for all 3 speeds: 33⅓, 45 and 78 rpm, the 301 features an eddy current speed control for making fine adjustments. Speeds cannot be changed unless the unit is shut off, thus preventing any possible jamming of the idlers.

Model 301 .... 89^{00}

Model 4C
BROCINER CORNER HORN

One of the most natural-sounding speaker systems ever designed, giving effortlessly realistic sound with complete absence of listening fatigue. Exclusive PM-2 twin-cone driver, expressly designed for horn loading, has field magnet with a flux of 20,000 gauss in the gap, providing exceptional damping, efficiency and transient response. Front of driver exhausts through unique reflector horn, giving optimum mid-range and high-range dispersion; back of driver is loaded by folded exponential horn supplemented by the entire space below the cabinet plus the corner of the room, for superbly defined reproduction of the range below 150 cps. Dimensions: 42" high x 32¼" wide x 24" from front into corner.

Model 4C, golden mahogany or dark mahogany .... 396^{00}

Special woods and finishes at slight extra cost.

HARVEY carries a complete line of pre-recorded tapes — Westminster Sonotape, Concertape, Livingston, etc. — blank recording tape, tape accessories, blank recording discs, and recording styli.

AMPEX 600
PORTABLE TAPE RECORDER

A high quality tape recorder designed for professionals: broadcasters, recording studios, and other critical users. Housed in a truly portable case, the entire unit weighs less than 28 lbs. The quality of performance of the 600 is identical to the console model 350.

Has separate erase, record and playback heads . . . and separate record and playback amplifiers. A direct-reading meter permits continuous checking of recording level. Tape speed is 7½ inches/sec. with a frequency response from 40 to 10,000 cycles ± 2db, and to 15,000 cycles ± 4db.

Other features include:

•Signal-to-noise ratio: more than 55 db • Flutter and wow: less than .25% • Fast forward and rewind: 90 seconds for 1200 feet • Microphone input: high impedance • Line input: for high level source (.5 volt level) • Separate level and mixing controls for microphone and line inputs • Monitoring: through phone jack or playback output • Playback output: 1.25 volts into 10,000 ohm load (matches input of most amplifier systems) Recording distortion is negligible.

Complete with tubes, less microphone **$545.00**

PRINTED-CIRCUIT — MINIATURIZED

'Preamp with Presence'

— as described by C. G. McProud in May Audio Engineering. 3 equalization choices, presence control, volume and loudness controls, and Baxendall-type bass and treble controls.

Basic kit containing the 1.0 henry encapsulated choke, the printed circuit panel completely drilled, and the 4 metal chassis parts .... 7^{50}

The complete kit of parts, including the basic kit and all other parts and tubes as specified by author. With complete, simplified instructions. .... 35^{50}

Model SR-402
STROMBERG CARLSON
FM-AM Radio Tuner

Only tuner with dynamic cascade noise limiter. Frequency response on FM 20 to 20,000 cps. at less than 1% total harmonic distortion. Temperature compensated oscillator prevents drift on both FM and AM. Geared tuning condenser and expanded tuning scale assure ease of control. Sensitivity 1.5 microvolts for 20 db quieting. 2-position selectivity control on AM. AFC provided .... 150^{00}

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HARVEY RADIO COMPANY, INC.
1123 AVENUE OF THE AMERICAS
(6th Ave. at 43rd St.) New York 36, N. Y.
JU 2-1500

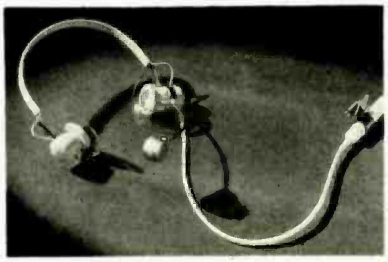
• **Bell 50-Watt Amplifier.** Exceptionally well suited for installations which require good music reproduction, as well as voice, and where a large area is to be covered, the new Bell Model 5650 is a high-power commercial amplifier with a high degree

of fidelity. Equipped with four microphone inputs and a special input for tape, the unit delivers 50 watts with less than 3 per cent total distortion. Separate volume controls are provided, plus boost and cut for both treble and bass. Among features of the 5650 is the use of low-microphonic 5879 input tubes and the new 6550 power tubes. Locking microphone connectors are used, while speaker taps are by means of two 5-prong sockets and a terminal strip. Output impedances are 4, 8, 16 and 500 ohms, and 70-volt constant-voltage tap. The control panel is illuminated. Dimensions are 13"d × 17"w × 9"h. Weight is 40 lbs. Complete technical information may be had by writing Bell Sound Systems, Inc., 555 Marion Road, Columbus 7, Ohio. **N-8**

• **Spherical Speaker System.** The Bonn "Sonosphere" is a new high-fidelity speaker system using a sphere of molded plastic as its enclosure. Made of light-weight foam plastic only 18 inches in diameter, the spherical shape eliminates baffle reflections and contributes to even, wide-angle sound dispersion. Sound quality can be tailored to individual taste simply by turning the Sonosphere so that the speaker opening faces the ceiling, the floor, or any intermediate position which

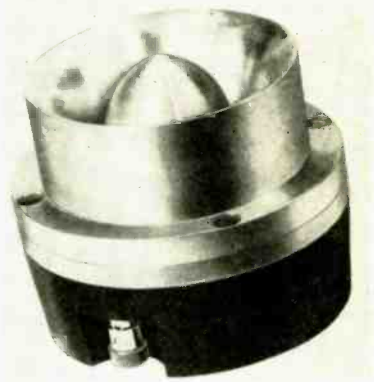
may be preferred. The speaker normally supplied with the Sonosphere is the 8-inch Phillips-Duotone Model 9770M. The unit stands only 21 inches off the floor when placed on its removable stand. Since it weighs only six pounds, including speaker, it can easily be hung from the ceiling by wires or threads. Complete specifications of the Bonn Sonosphere may be obtained by writing Plastilex Products, Inc., 6515 N. 10th St., Philadelphia 26, Pa. **N-9**

• **Headphone-Microphone Sets.** Amplivox Series 2566 headphone-microphone sets represent a new approach to the design of headsets for radio and line operators who



are required to perform continuous communication duties for extended periods of time. They were chosen by the Ministry of Transport and Civil Aviation for use in the new London Airport control tower and have now been accepted as standard for all British airports under MTCA administration. The headsets weigh only seven ounces complete with microphone. The headphones are constructed of molded plastic parts fitted on a flat stainless steel headband. "Perspex" eardiscs are attached to the earphone units by flexible rubber diaphragms which distribute the pressure of the discs lightly and evenly over the outer ear, avoiding contact with any part of the bone structure. The basic headset can be fitted with any of three alternative microphones. For further details write to Amplivox, Ltd., Industrial Products Division, 2 Bentinck St., London, W. 1. **N-10**

• **Jim Lansing High-Frequency Radiator.** This new addition to the Signature line of high-fidelity speaker systems is designed to reinforce extended-range speakers in the high-frequency band. It radiates efficiently and without perceptible resonances from 2500 cps to beyond the limit of audibility. Entirely unique in design and construction, the Model 075 is, in effect, a "ring radiator" coupled to a large aluminum ribbon-wound voice coil which contributes a minimum of inertia to the



dynamic system. In complementing the performance of extended-range speaker systems the unit should be used in conjunction with the Signature N2500 dividing network which attenuates the signal to the 075 at the rate of 12 db/octave below 2500 cps. Power rating is 20 watts above 2500 cps and input impedance is 16 ohms. Dispersion is 90 degrees. James B. Lansing Sound, Inc., 2439 Fletcher Drive, Los Angeles 39, Calif. Descriptive sheet will be mailed on request. **N-11**

• **Tape Timing Chart.** As an answer to the confusion which has developed due to the introduction of long-play and extra-long-play tape, Reeves Soundcraft Corporation, 10 E. 52nd St., New York 22, N. Y., has developed a Timing Chart which enables the tape recordist to determine, before he starts recording, how much tape he will need to record for a given period of time or how long a given tape will record at any recording speed. Accurate, easy to use

and handy to carry, the Soundcraft timing chart will save the user time, tape and trouble by enabling him to plan his tape requirements before he starts to record. Because the chart is semi-logarithmic, it is exceedingly accurate in determining the length and time factors for short commercial announcements. Professional recordists will find this advantage of the chart helpful in planning recorded broadcasts. **N-12**

NEW LITERATURE

• **University Loudspeakers, Inc.,** 80 S. Kensico Ave., White Plains, N. Y., will mail free of charge a new brochure on the entire line of Decor-Coustic 3-way speaker systems. Introducing University's complete line, which includes the new Master, Senior, and Tiny-Mite cornerless-corner systems, the publication also contains an interesting feature story on the company's exclusive "Acoustic Baton." Request for copy should specify Brochure 78A1 and should be directed to Desk LA-1 at the address shown above. **N-13**

• **Hycor Division of International Resistance Company,** 12970 Bradley Ave., Sylmar, Calif., has published a 4-page bulletin covering the company's complete, expanded line of precision electrical components for audio equipment, industrial control and telemetering. Included in the illustrated brochure are basic specifications for program equalizers, decade inductor units, variable filters, and variable attenuators. Requests for copy should specify Bulletin G-3. **N-14**

• **Carter Motor Company,** 2644 N. Maplewood Ave., Chicago 47, Ill., has revised and brought up-to-date a series of maintenance and parts catalogs, individually covering each of six classes of Carter rotary power supplies. A complete set of these bulletins should be in the hands of every person who buys, sells, uses or services Carter power supplies. They are intended to replace all previous maintenance catalogs, and contain all that is new and up-to-date in service and repair procedure. Requests for copies should be directed to the attention of the Service Department. **N-15**

• **Lafayette Radio,** 100 Sixth Ave., New York 13, N. Y., covers the entire field of transistors and components for use in transistor circuitry in a new 32-page brochure which has just been issued. Featured is a complete listing of miniaturized parts, including technical specifications of virtually every transistor on the market. The brochure may be obtained free of cost by writing to the address shown above and requesting Brochure No. T4-56. **N-16**

• **CBS-Hytron,** Danvers, Mass., is now offering the eighth edition of its Reference Guide for Miniature Electron Tubes. Revised and brought up-to-date, the new edition lists all miniature tubes, irrespective of make. It supplies pertinent data for 416 miniature types of which 88 are new, and 168 basing diagrams of which 33 are new. Requests for free copy should specify Bulletin PA-1. **N-17**

• **Electronics Division of Elgin National Watch Company,** 370 S. Fair Oaks Ave., Pasadena 1, Calif., has released a new 20-page catalog of the company's wide line of American microphones and phonograph cartridges. Styled in yellow and black to match new packaging of the American Microphone product line, the catalog lists prices, specifications, and characteristics of each item. Highlighting the catalog is a section devoted to the new ceramic turnover and single-needle cartridges recently added to American products. **N-18**

• **Johns-Manville Dutch Brand Division,** 7800 S. Woodlawn Ave., Chicago 19, Ill., has issued a new 12-page booklet which will help you to choose the type of electrical tape best for every insulating and protecting application in electrical construction, maintenance and manufacturing. Titled "Tool Up With Tape," the booklet is complete with illustrations, technical data, characteristics, and performance specifications for plastic, friction, rubber, and vinyl color electrical tapes. The many illustrations and accompanying text provide practical information to help users select the best tape suited to their own applications. **N-19**

• **R-Columbia Products Co., Inc.,** Highwood, Ill., has just issued a bulletin which explains how the company's TrolMaster cleans and lubricates radio-TV controls in 60 seconds from the front of the set without removing the chassis, or the back from the cabinet. It is equally effective for volume and tone controls in hi-fi systems. Also described is the specially formulated Kleentrol solvent recommended for use with the TrolMaster for positive cleaning and lubricating action. Requests for copy should specify Bulletin No. 22. **N-20**

RECORDS

(*from page 63*)

easily imagined. The rip-roaring Italian opera school as it now exists has little room for subtlety and nuance, but it makes up for these with lots of gusto and spaghetti.

This, then, is an energetic and fiery "Don," plenty entertaining, dizzily out of style, effective as musical theatre (the opera has that in it) but appallingly lacking in musical subtlety. Scout #2 especially deplores the coarse rendition of the lovely soprano arias in the work. You can practically hear them breathing down your neck, he says, only he didn't put it quite that politely.

Puccini: Madama Butterfly. De los Angeles, di Stefano et al.; Orch. of Rome Opera House, Gavazzeni.
RCA Victor LM 6121 (3).

This is another in the interesting series from Rome being issued on the RCA label, with a notable RCA star or two in each. Scout #1 likes this one, thinks de los Angeles is lovely, if rather monochromatic, feels that her musical intelligence and taste add greatly to a role that, perhaps, is not exactly her dish of tea (that last metaphor being, ugh, my own). I add that de los Angeles has one of the most sensitive musical ears of any singer alive and it is always a joy to hear her superb accuracy, in whatever form it takes. Scout #1 thinks di Stefano outdoes himself here, too, and finds the Rome orchestra very sure—perhaps a bit over-sure and literal-minded—under Signor Gavazzeni.

He likes this "Butterfly"—but, in sum, he still prefers the London version with Renata Tebaldi.

Puccini: La Rondine. Eva de Luca, G. Prandelli, V. Pagano; Antonio Guarieri Orch. and Chorus of Milan, del Cupolo.
Columbia EL 12 (2)

Here's Columbia's expeditionary force in Italy—everybody seems to be getting into the opera-in-Italy act. Both my scouts listened to this one, with complementary reactions. This is a lesser-known opera by a big composer and, these days, this always arouses interest among the fans. The work is a "lyric comedy," a two-acter almost on the operatta scale.

Scout #1 says it is "Puccini in a minor key," full of Puccini's lush harmonies and striking lyricism but lacking in the cohesion and emotional power of his larger works; Scout #2 adds that, yes, it is maybe not top Puccini but it has a special interest, revealing very beautifully the "one characteristic that makes the best of Puccini great, an incredible youthfulness, a sort of 'un-grown-upness,' sweet and attractive." He feels that, as in the childishness of children, you can ignore the immaturity as such in Puccini, taking it rather as a sort of naturalness—and this work is that way; sweet, romantic, and satisfyingly corny.

Scout #1 thinks the performance is not of a very high order, with soloists who are insecure and wobbly in their vocal production; but the job serves its purpose and gets the opera's sense over very well.

Verdi: Il Trovatore. Members La Scala Opera Company, Milan, Carlo Sabajno.
Camden CAL 289, 290.

A Camden reissue, lo-fi but adequate if you don't mind; Scout #1 says the performance is a "routine Italian job—which is not to say that it is without its good points." Hardly, this being the great La Scala company. This is the music that Italian opera companies are *supposed* to sing, and as the scout says, "the frequent shouting is par for the course." In this sort of opera the "shouting" does no harm and adds to the spaghetti, though the same technique applied to Mozart (above) is something else again.

Wolf-Ferrari: The Secret of Suzanne. M. Bariello, Ester Orel; Turin Symphony, Simonetti. **Decca DL 9770.**

Rossini: Il Signor Bruschino. Soloists, Milan Philharmonic Orch., Gerelli.
Vox PL 8460

Here are two of the short and lively opera miniatures that have long been popular in Europe—from well before Pergolesi's "La Serva Padrona" of the early 18th century. A handful of characters, a nice orchestra and an act or two, mostly comic.

Scout #1 finds Suzanne and her secrets not bad at all, if you like this sort of little jest. A perfervid Italian tenor, of the groan-sob sort, but he has a good voice, and the soprano has a lovely one; the orchestra is well paced. A good risk, this one, if you're out for vocal novelty.

As for "Signor Bruschino," Scout #1 says it has an awful lot of "buffa recitativo," but what music there is, in between, sparkles floridly and the ensemble numbers are utter delights. The subtitle, "The Accidental Son," may give you a foretaste of the incredibly complex and foamy plot. The printed synopsis is one of those marvelous hodge-podges that introduces six characters in every line and knocks you for a loop in the first paragraph. Can't make head or tail of it, but maybe you won't need to. Anonymous solos.

Sullivan: Incidental Music to "Henry the VIII"; Music to "The Tempest." Patricia Brinton; Vienna Orch. Soc., F. Charles Adler.
Unicorn UNLP 1014

Music of very special "antiquarian" interest—for this is the Sullivan and Gilbert-and, the composer of "Pinafore" and the rest, and here are actual samples of his famed and seldom-heard "serious" music.

It has long been acclaimed as pretty dreadful, this serious Sullivan (and there's plenty more); but it's one thing to hear about it and another thing, quite a novel experience, to hear the music itself, however bad. Echoes of Iolanthe! Scout #1 is obviousely no G & S fan. He is quite sour about the disc, saying merely that though "The Tempest" is a work of promise by an 18-year-old, "Henry VIII" is utter banality. Nevertheless, I suspect a good many G & S fans will find this record quite intriguing, as music utterly unfamiliar, yet composed by good old Sir Arthur himself. Give it a spin. Not much of a performance, but whaddya expect.

Busoni: Arlecchino. Glyndebourne Festival Soloists and Orchestra.
RCA Victor LM 1944

This "Theatrical Capriccio" in one act is an odd and interesting short item, not even clearly an opera. Busoni was the great pianist, teacher, arranger, half Italian, half semi-Bavarian, whose main reputation was out of Germany. This is a sort of reflective satire and homage combined, upon Italian opera—but with a German text. And the title role is a speaking one though the other characters sing.

Scout #2 finds the music very interesting, modern, lively, well put together, but arid, "up in the head." Busoni seems to worship Mozart, who is behind much of the music; he seems also to be anti-Wagner and pokes somewhat amusingly in that direction; but the work, Scout #2 feels, has too little genius in it to be great and inspired, yet isn't corny enough to be fun. Neat, tight, beautifully organized, superbly performed, but dead.

Strauss: Ariadne auf Naxos. Schwarzkopf, Seefried, and others; Philharmonia Orch., von Karajan.
Angel 3532C (3)

This is one I've just *got* to hear—and without having heard it yet, I can guarantee that it is a superb musical treat. The music is some of the best of the neglected Strauss (in this country, that is) and the cast is marvelous. I'll review it all over again when I've listened to it in full and at leisure; but meanwhile, Scout #1 (lucky bum!) has had the pleasure of a complete hearing that confirms the above. He finds it an all-over intelligent and sensitive performance and with a well-balanced German-Austrian cast, and his only mild complaint is a technicality—too many shades of German accent. Most of us won't know the difference.

I suspect that the Angel recording is technically nothing less than sensational and look forward to hearing it myself.

THE BETA-TRON

(from page 29)

cps at a slope of 18 db/octave, and for use in conventional systems, the crossover point may be varied.

The Beta-Tron amplifier is a ten-watt unit, and it might be questioned as to why it is necessary to have a ten-watt amplifier that only responds from 2,000 cps up. The answer is, of course, that while the mean energy distribution of sound is around 400 cps, this much depends on the sound source. There are many sounds (musical) that contain little low-frequency energy and much high-frequency energy. Naturally the mean energy in this type of sound is much higher. Also, as an amplifier must handle all possible combinations of sound, it must be prepared to handle "skewed" distribution sounds as well. We have found that anything less than a ten-watt amplifier will not do the job properly.

It might also be noted that the current trend is toward larger and larger amplifiers. Many of us have ten- and twenty-watt systems and would like to enlarge them, but do not relish the idea of throwing the present amplifier away. The Beta-Tron offers the possibility of enlarging a present system at a slight additional cost, plus getting a really new top end in the bargain. Add that to the pleasure of owning a (in facto) dual channel amplifier system, and the package becomes very attractive. *Our* conclusion to Experiment III is that motional feedback is here to stay.

AT HOME WITH AUDIO

(from page 27)

work. Savings can be even greater if, like our reader, you build it yourself. Furthermore, amplifiers in filter type systems need not be high power. In a binary channel such as this, two 10-watt amplifiers are about as effective as one 30-watt unit would be in a conventional cross-over system.

The over-powered amplifiers are for overpowering perfection at the peaks. As wife is (supposedly) to husband, so is the really dedicated buff to his hi-fi system: best friend, severest critic. A blastout at an unruly peak point, and the power vested in the watt is at once invoked. The 'watt-of-it" really matters.

Our reader's self-made amplifier amply supports and underpins any of the tweeter's flights along the highly directional orbits of the high-frequency octaves. Giant woofers have been known to respond adequately to the urgings and proddings of a 10-watt rated amplifier. But the hi-fier knows that it lies ever on the verge of distortion, the louder and more massive the passages get.

In the present state of the art of speaker engineering we all know that separation of speakers as to low high ranges is a sound method of avoiding distortion. In fact, its advantages are measurable and mentionable. But you ain't heard nothing yet without a level control to balance the parts of the speaker system to fit the room.

Ear-Conditioned Fanfare

This is not to say that this reader's gambit rules out the conventional audio separators. For are not these, below, the knowns of the benefits of the crossover network's functions in the two- or three-way or more, speaker system? As G. A. Briggs points out (and what follows has been adapted from his book, *Sound Reproduction*), we know that three-speaker systems are easily set up and a fragile h. f. unit is shielded from the onslaughts of high-amplitude low-frequency input. The chances of intermodulation distortion between bass and treble when combined in one speaker are largely avoided. And then, the bass speaker and treble unit can be designed and housed separately for maximum efficiency in the performance of their intended functions.

Moreover, they can be placed suitably for room-tempered listening; the bass near the floor, the treble unit some feet higher. Further, speakers of different impedances may be tried, as 16-ohm bass and 8-ohm treble, with attenuation or increase of output, in either case, as may be needed for the room or space of their location. (End of "quote" from Briggs).

The comparative virtues of the multiple speaker system stand. The advantages ascribed to the conventional crossover are simply augmented by those few claimed by reader Crofford.

He claims, for example, that with the conventional crossover network, speakers look back into the amplifier when in their pass band and see the correct impedance match. When they are outside their pass band, they look back into a reactive impedance; not necessarily disturbingly audible, but this is a condition or a liability that the filter-network system tends to eliminate.

Also, intermodulation distortion in the power amplifier is reduced with the filter network, as the low-frequency channel goes down from 300 cps, while the high-frequency channel goes up from the 300-

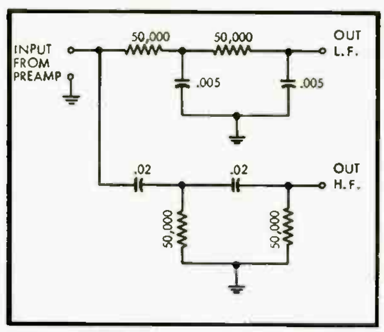
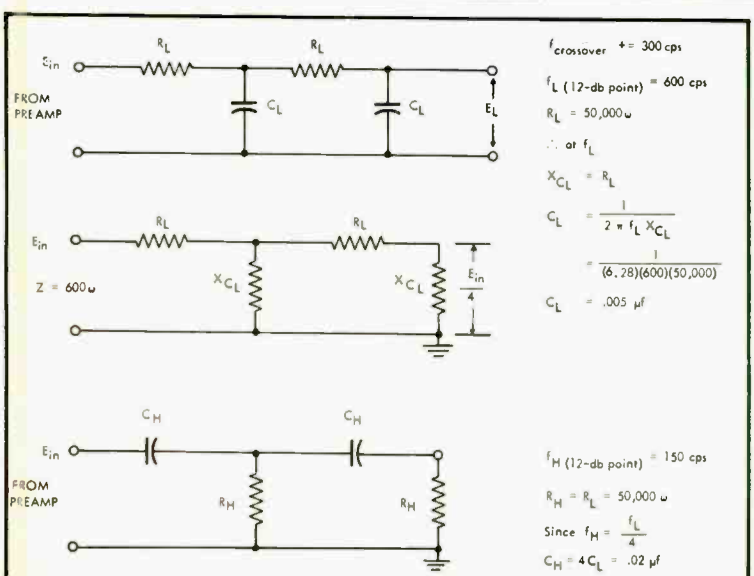


Fig. 13 (right). Configurations of filter network and the formulas by which they are calculated to produce (as in Fig. 14, below) completed filter network, as constructed and used in dual-channel system.



cps point. The speakers (he avers) are thus always loaded by the amplifiers and their distortion is therefore much less than with the conventional crossover. Also, the speaker damping factor in the filter system is more constant. All of this, in a manner of speaking, adds up to the equivalent of a polarized filter introduced to keep unwanted reflections and highlights from bothering and distorting the composition and balance of a "picture"—is sound, here. of course.

It would be doing our subject full and undeserved injustice to end this saga of the separate amplifiers right here. But in all fairness, we feel constrained to observe that the conventional crossover network is not exactly double-crossed out of consideration and use because of the turnabout to a filter network reported here. Nor are the many excellent all-in-one (concentric, co-, Diff- and Triaxial) units relegated to unexcursioned neglect. The professional who built himself this filter system is not opposing the offerings of the market place. His job of conversion is, let's face it, just one man's way of taking his hi-fi bearings anew as he learns, essentially empirically, to live at home with audio. In sum: the better than his, his best became.

Readers who are of a mind to bone up on the subject before obeying that impulse to take their workbench aprons off the hook might like to dig into an article expatiating on the theory, design, function, and advantages of the filter network in home hi-fi systems, as set forth in "The White Powrtron Amplifier," by Stan White, and reproduced in **the 3rd audio anthology**. The subject is handled from another angle in "A Discussion of Dividing Networks," by J. P. Wentworth, page 84, same **anthology.**

See, in *Fig.* 13, the configurations of the filter network and the formulas by which they are calculated. *Figure* 14 shows a schematic of the complete filter network used here, as constructed from these configurations.

A Precedential Year?

Exposed to this (perhaps) precedent installation, other hi-fi brethren may be expected to get into a "me-too" frame of go-getting, culminating (who knows?) in a spate of rig-conversions. It could be. This time it's the dual-channel amplifier with filter network workout; but, we dare ask, good for how many tomorrows before the next wave of what other kind of hi-fi retread jobs?

With some finality, we can say it is no skin off our nose to acknowledge that the complement of speakers in do-it-yourselfer Crofford's hi-fi rig owes its present format to some years' experience of making a living working with audio. As of now, there's a Jim Lansing DL175 tweeter atop of his enclosure; and enclosed in the folded-horn below are a Jim Lansing 375 mid-range unit, with an 18-inch Electro-Voice woofer. To these, the double amplifier-filter-network crossover combo (with filter between preamplifier and power amplifier to be sure) has brought improved transient response; greater flexibility of balance between the speakers; not to mention a clearing out of the cobwebs of intermodulation distortion—the filter network standing guard against invasion of the low-frequency amplifier by high-frequency signals, and vice-versa.

All of which adds up to a form of segregation that, in this instance at least, has turned out to be unquestionably beneficial to this (hi-fi) community.

Parts list, 60-watt power amplifier

R_1	0.5-meg level control
R_2	10,000 ohms, 1-watt
R_3	10,000 ohms, low noise
R_4	47,000 ohms, wirewound, 1-watt
R_5	316 ohms, wirewound, 1-watt
R_6	10,000 ohms, wirewound, 1-watt
R_7	0.1 meg 2-watt
R_8	10,000 ohms, 2-watt
R_9, R_{10}	22,000 ohms, wirewound, 1-watt, matched
R_{11}, R_{12}	0.5 meg low noise, matched
R_{13}	2,000 ohms, low noise
R_{14}, R_{15}	0.1 meg, wirewound, 2-watt, matched
R_{16}	20,000 ohms, 2-watt
R_{17}, R_{18}	25,000 ohms, 2-watt, bias balance control
R_{19}, R_{20}	0.47 meg 1-watt, matched
R_{21}	30,000 ohms, 2-watt
R_{22}, R_{23}	22,000 ohms, 2-watt, matched
R_{24}	10,000 ohms, 10-watt
R_{25}, R_{26}	1,000 ohms, 1-watt
R_{27}	50,000 ohms, wirewound, 25-watt
R_{28}, R_{29}, R_{30}, R_{31}	50,000 ohms, 1-watt
R_{32}, R_{33}, R_{34}, R_{35}	1,000 ohms, 1-watt
R_{36}	0.47 meg 2 watt
R_{37}	0.2 meg 2-watt
R_{38}	0.1 meg voltage control, 2-watt
R_{39}	50,000 ohms, 2-watt
R_{40}	0.15 meg, 2 watt
R_{41}	56,000 ohms, 2-watt
R_{42}	18,000 ohms, 2-watt
R_{43}	1,000 ohms, 5 watt
R_{44}	22,000 ohms, 1-watt
C_1	0.1 μf, 400 v.
C_2, C_5, C_{10}	40 μf, 450 v.
C_3, C_4	100 μμf, ceramic
C_6, C_7	0.25 μf, 600 v., matched
C_8, C_9	0.1 μf, 600 v., matched
C_{11}, C_{12}	0.1 μf, 600 v.
C_{13}	16 μf, 700 v.
C_{14}	32 μf, 700 v.
C_{15}, C_{16}	0.01 μf, ceramic, 500 v.
C_{17}	0.1 μf, 600 v.
C_{18}	50 μf, 50 v.
C_{19}	100 μf, 250 v.
C_{20}	0.1 μf, 600 v.
T_1	425-O-425 v., 275 ma; 5 v., 6 a.; 6.3 v., 5 a.
T_2	ACRO TO330
T_3	– 150 v. 50 ma.
T_4	– 6.3 CT. 10 a.
L_1	12 H. 300 ma.
V_1	12AY7
V_2	5692, 6SN7GTA
V_3	6SN7GTA
V_4, V_5	6550
V_6, V_7	5V4GA (or 5U4GB)
V_8, V_9	6080 (or 6AS7)
V_{10}	6SJ7
V_{11}, V_{12}	0B2
V_{13}	0A2
Rect.$_1$	180 v., 100 ma., Selenium

AUDIO TRANSFORMERS

(*from page 22*)

the primary winding to the secondary winding includes a small fraction of the effective load inductance in the feedback loop, and hence the change will not have any great *inherent* effect on performance.

Actually, the arguments connected with choice of feedback—whether to use the primary or secondary winding—are not so much concerned with whether cancellation of transformer distortion is effected, as whether the impedance and voltage level available is suited to the requirements of the feedback arrangement.

Feedback from the primary circuit provides a large voltage which can be attenuated by the feedback resistance, but this voltage is provided *at a high impedance,* which means the current through the feedback resistance will constitute a greater loss of the total power output than if the feedback resistance is connected to a lower impedance point. Using the secondary winding—particularly if its impedance is 16 ohms or higher—results in much reduced loss of power output in the feedback resistance network.

Although the resistances used for feedback are helping to reduce distortion, they still constitute a load on the output circuit which has to be supplied from the total available power output from the output tubes. If too much power is required by the feedback resistances, the reduction in available output power may offset the improvement in distortion achieved by the feedback.

Finally, the point in writing this article is not to urge a wholesale changeover from resistance/capacitance coupling to transformer coupling, but rather to take the ban off the use of transformers, so an audio transformer *can* get used where it does happen to be the best solution.

If your supplier of audio transformers does not help in this direction, by giving suitable circuitry to enable you to get the best performance from the transformers, it is suggested that you should look for a supplier who does. The chances are that a manufacturer who can not give circuits for his transformers doesn't know much about the design of audio transformers anyway, and has followed the popular practice of making a chinese copy of someone else's component. If his copy should in fact be a generation or two removed from the original, then the audio transformer may not be as good as advertised, so you will be better off going to a manufacturer who really knows about transformer design. In that way you should obtain an audio transformer that *will* be good and, by using it in the circuit recommended, the results will come up to expectations.

CARE OF AUDIO ATTENUATORS

(*from page 44*)

After cleaning, lubricating and mechanical checking, any interruption or sudden change in level as the control is moved through its range will then be due to internal electrical defects. This assumes, of course, that the external wiring is well soldered to the terminals. Internal broken connections are rare; they can sometimes be repaired in the field if care is taken not to cause other damage in the process.

Hum and R.F. Pickup

Speaking of connections, the ground connection of the shield covers of variable attenuators is usually made to the amplifier or console panel through the attenuator mounting screws. These should make good electrical contact with the metal of the panel. The shield cover is generally made of brass; as such, it is an electrostatic shield at audio frequencies and both an electrostatic and electromagnetic shield at radio frequencies.[1] While this does not protect against 60- and 120-cps electromagnetic fields, there is little likelihood of magnetic pick-up at power line frequencies in the control itself since the resistors are non-inductive at low frequencies and, in professional mixers, only low impedances are usually involved.

Noise is sometimes blamed on the control when it may actually be caused by other factors. A common example is direct-current leakage from a preceding coupling capacitor. If cleaning and lubricating the attenuator does not eliminate clicks, check for d.c. on the control, either by putting a scope across the control itself or by testing for grid current in the following tube. Replace leaky capacitors by molded types. Another example of noise wrongly charged to the control is r.f. pick-up in the leads to the attenuator or in associated elements such as poorly shielded transformers. In such cases, try a very small capacitor—perhaps 50 μμf—or a resistance of ten times the control impedance—across the input or output of the attenuator. A small r.f. choke, well shielded magnetically against hum, may also be tried in series with the input of the control. After applying any of these r.f. remedies, always check for possible degradation of audio performance. In cases of severe RF interference, more elaborate precautions may be necessary.[2]

Also make certain that circuit grounds are correctly applied. Potentials picked up on improperly grounded inter-connecting cables between audio components—such as those between preamplifier and main amplifier—can cause clicks in the attenuators. This is especially true of unbalanced amplifier inputs which require a firm ground on their "low" side. The circuit grounding of the attenuators themselves is likewise important. Poor connections, or grounding to the wrong point can cause noise, hum, and capacitive leakage of the higher frequencies from the wiring to ground.[3] Such leakage may also result in incomplete cut-off of the control, thereby permitting passage of some signal in the OFF position. Most attenuators used in broadcast mixers are of the unbalanced type, and as a result of their "low" sides being grounded, they are less susceptible to leakage effects than the balanced type. The latter have center taps which may be grounded but this should be done by trial as such grounding may occasionally increase the noise, depending on the configuration of the mixer circuit.

Noise attributed to the control may also be due to its position in the circuit. All attenuators generate some noise, and the unit should be located at a point where the circuit power level is high enough to mask the noise. Except in some portable equipment, the usual practice in professional gear is to put the individual channel gain controls after the preamplifier tube. Due to the aggregate insertion loss of all the attenuators of the mixer, additional amplification is provided between the mixer and the master gain control. Attenuators may also be noisy because of the use of a unit with too much attenuation per step. Broadcast and recording mixer attenuators generally do not exceed two db per step and some have only one and one half db.

In summary, satisfactory performance of variable attenuators depends not only on their proper maintenance but also on maintenance of associated elements, including the wiring and the grounding, and on the over-all circuit design. The writer would like to acknowledge the kindness of Mr. Chester F. Scott, Assistant Chief Engineer of The Daven Company in reading the manuscript and offering many helpful suggestions.

[1] Frederick E. Terman, *Radio Engineers' Handbook*, p. 128. First Edition, McGraw-Hill, New York.

[2] Eugene F. Coriell, "Elimination of r.f. interference in audio systems," *Radio And Television News*, June and July, 1954.

[3] Chester F. Scott, "Attenuator types and their application." *J.A.E.S.*, Vol. 1, No. 1, January, 1953.

AUDIO PATENTS

(*from page 2*)

relative to time. And to convert the thing into pure bedlam, as many of these rollers may be provided as the user decides are necessary for secure scrambling or the builder has money for. Note, too, that the position of the roller on each disc can be varied so that the amount of speed change of the tape per disc revolution can be changed. The result, of course, is a tape with wild and sudden speed changes; played back at constant speed, it might sound like one of these new-fangled symphonies for tape recorder (certainly no worse) rather than intelligible speech.

The trick now is to unscramble it, especially if you are an authorized auditor. You can do this only if you are given the settings for all the dials and for the positions of the rollers on the discs, so that you can duplicate the conditions under which the tape was made. But one more thing is necessary. The entire system must be phased as it was in the original, so that all rollers are at the same angular positions with respect to each syllable of speech as in the original. This you accomplish with the master phasing knob, which varies the phases of all discs together.

The speed adjustments of the discs can be made in several known ways. It is interesting to note, however, the inventor's use of differentials for the phasing adjustments. All the discs are driven from a common shaft rotated through a worm and wheel by the motor. This shaft is part of a differential mechanism controlled by the master phasing knob, and a differential, when you come to think of it, is of course the neat way to do the phasing job. Between the main shaft and each disc is another differential for individual phasing adjustment.

It seems to me that for really intelligible unscrambling, the reset accuracy of all the controls would have to be pretty good; this might present a problem, especially with known methods of continuous speed-ratio control. It's an interesting gadget and might eventually become known as the electronic substitute for disappearing ink!

WHAT MAKES A WOOFER?

(*from page 32*)

cone both in phase and out of phase. Frequency-response curves show great irregularity in this area because of this rim "hickey" as it is known in the trade. Very few speakers, woofers or otherwise, in which the compliant beads are integral with the body of the cone escape this abberration in response. In the Hi-C speaker the foam ring serves to absorb these longitudinal waves and prevents them from being reflected back into the main body of the cone. This suspension material functions as a damper or shock-absorber to smooth out the mid-range frequencies and eliminate the rim hickey.

It has been stated that a lightweight cone is required for efficiency and low transient distortion. However, if the cone becomes too light and thin, it may be subject to breakup at high volume levels. To prevent this breakup and yet maintain low mass and cone rigidity, the surface of the cone is reinforced by styrofoam struts. This consists of six "beams" of rigid plastic foam cemented radially to the rear surface of the cone, as shown in *Fig.* 4. This styrofoam plastic is extremely stiff and rigid yet has negligible weight. Its density is about 1/20 that of paper.

The decay modulus of a vibrating system is shown[2] by:

$$Decay\ Modulus/sec = \frac{2M}{R_m}$$

where,

M = weight in grams

R_m = mechanical resistance (damping) in grams/sec.

Since for good transient response the decay rate must be small, the damping should be large, and the weight low. The foam suspension ring which supports the cone has a large value of R_m inherent in its structure. This foam is a plastic formulation that has great resiliency or stretching quality to furnish the necessary high compliance without bounce or the storage of energy. It thus possesses inherent damping, follows only the force on the cone, and does not contribute vibration or energy on its own. Thus the cone moves only under the force of the voice coil which is what we are trying to reproduce in terms of acoustic effect.

The foam suspension which is a spe-

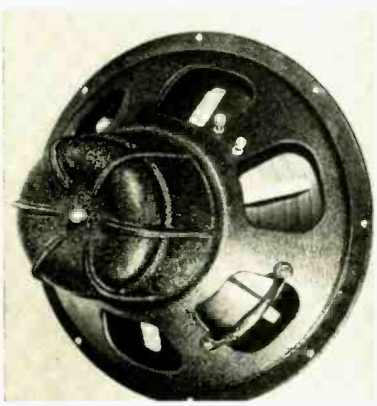


Fig. 4. The white strips on the rear surface of the cone are rigid styrofoam, acting as reinforcement against breakup of the cone at high volume levels. Six of these struts are used on each cone. They add rigidity to the paper cone with negligible weight.

[2] Kinsley & Frey: *Fundamentals of Acoustics*, p. 18.

cially developed formulation of polyvinyl chloride and latex, also performs an acoustic function in that it permits the passage of some air through its cells. Air passing through the minute openings presents a form of viscous damping to the mechanical motion of the cone particularly at low frequencies. The dimensions of these cells are small and the air flowing through them assumes an appreciable velocity which because of the changing or constricting passage will be a function of cone amplitude. This will result in self-damping which is automatic. The large amplitudes in the region of resonance cause the cells to become deformed by being narrowed and elongated increasing the amount of self-damping. The tiny cross-sectional openings together with their random and tortuous paths create a mass inertance and a high degree of viscous damping.

By carefully selecting the degree of porosity, size of pores, and density of the foam material, the inertance and resistance components will make the amount of cancellation between front and back radiation negligible under most operating conditions. This can be explained by reference to the analog diagram of *Fig.* 5 where M_s, R_s and C_s, represent the mass, resistance, and compliance, respectively, of the moving system. C_b is the compliance of the air in the enclosure; m represents the mass due to the inertance of the pores of the suspension material; r is the friction or resistance due to the passage of air through this material. If m and r are small in numerical value, as for instance, when the pores are large, then a severe shunting effect takes place across C_b and acoustical cancellation occurs between front and rear waves. However, by selecting m and r so that their values are relatively high, then acoustic cancellation is avoided for all practical cases. The characteristics of the foam suspension in the Hi-C speaker have been evolved from a long series of mathematical and experimental tests. m and r are specified in terms of material porosity, density and thickness so that acoustic cancellation will be just avoided at the lowest frequency for the smallest cabinet with which the speaker is likely to be associated. Thus a balance is observed between the conflicting requirements of self-damping and acoustic non-interference.

Damping Control

The value in good transient response lies in the accuracy of the speaker to reproduce tone bursts or sounds having a sudden start and abrupt stop. Any sound produced by the cone after the signal ceases is known as transient hangover and is commonly responsible for boominess. A cone should be moved only by the electrical signal fed to the voice

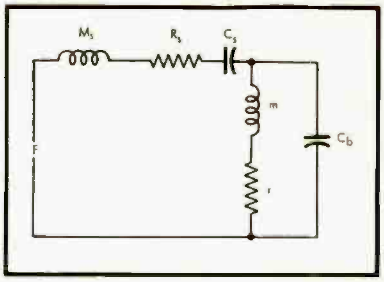


Fig. 5. Electrical equivalent of enclosed speaker having pneumatic inertance and damping incorporated into cone suspension.

coil and by nothing else. Unfortunately, a heavy moving system—which seems to be a popular but erroneous requirement in a woofer—destroys the cleanness of response. Thick or massive cones and heavy voice coils add momentum to the vibrating system so that vibrations may continue for a perceptible time after the signal has ceased. To counteract this hangover one must frequently resort to special damping measures in the cabinet or to introduce gimmicks to obtain clean bass. This practice of excessive cone mass explains why so few speakers show any change in cleanness of bass when the variable damping control on the newer amplifiers is adjusted over a wide range of damping factors. This lack of reaction to the amplifier damping is further aggravated in inefficient speakers having low magnetic flux density in the air gap.

Because the moving system in the Hi-C speaker is light in weight, its momentum is low and control of the back e.m.f. by the amplifier will prevent overshooting and improve the transient response. As a result bass is smart and clean, and there is no illusion of bass when there is none in the program. However, for best transient response we must have—along with low weight and damping—a high flux density in the gap because without this form of tight magnetic coupling between voice coil and flux field the amplifier can exert very little control on the overhang. Damping control by the amplifier increases with flux density. A density of 14,500 gauss is maintained in the woofer under discussion.

To summarize the requirements for a good woofer, the speaker should have, (1) high compliance, (2) low resonant frequency, (3) lightweight moving system, (4) high magnetic density in the gap, (5) inherent damping. The performance of such a speaker will be a close approach to realism without artificial coloration; it will have a smooth response down to 20 cps in any appropriate baffle or enclosure without introducing gimmicks or damping measures; it will show the most benefit and value from the newer high damping factor amplifiers.

The Racon Hi-C speaker comes close

to possessing these advantages. It's patented foam suspension could provide for a peak to peak excursion of 3 inches if this were permitted.

Unfortunately mechanical considerations necessary to prevent wobble or rubbing of the voice coil together with magnetic requirements and cost factors make an "ultimate" design impractical at this time. Without wild claims or the characterization of "revolutionary," it can be modestly stated that this speaker is a definite step forward toward more perfect low-frequency reproduction.

AUDIO CLINIC

(*from page 23*)

given in feet, V will be obtained in cubic feet.

To facilitate these calculations, two graphs are given in *Figs.* 1 and 2.

The first step is to decide upon a suitable volume, keeping in mind what has been said about the height and shape of the enclosure.

From this point, one may proceed in either of two ways. One may fix the length of a side and compute the corresponding height or fix the height and compute the corresponding side length. Examples will be given of both methods.

Assume a volume of 10 cubic feet and a side length (inside measurement) of 30 inches. Referring to *Fig* 1, draw a straight line directly upwards from $b = 30$ to intercept the graph line. Draw a horizontal line from there to intercept the vertical axis, and read 450 square inches. Referring to *Fig.* 2, extend a line upwards from 450 to intercept the $V = 10$ cu. ft. line and extend a horizontal line from this point to intercept the height axis, at 38.4 inches. This is the required height, measured on the inside.

If instead of deciding upon a side length of 30 inches, a definite height of 42 inches had been chosen, one would proceed in a similar manner, starting, however, with *Fig.* 2. From the axis marked Height in Inches extend a horizontal line to intercept $V = 10$. From this point, extend a line downwards to cross the axis marked b. In this case, the point so obtained is 410 sq. in. Referring to *Fig.* 1, a horizontal line from 410 intercepts the graph at a point corresponding to 26.1 inches, which is the required side length.

If instead of the side length, the width of the front panel had been desired, this would be 1.41 times as much or 36.7 inches.

Transistor Terminology

Q. When referring to transistors, what is meant by the terms emitter, base *and* collector? *Herb Morris, Nyack, N. Y.*

A. Each of these is analogous to one of the elements in a triode vacuum tube. The emitter corresponds to the cathode, as its name would seem to indicate, although it does not emit electrons to form a space charge as does its vacuum tube counterpart. The base performs the controlling action in a transistor similar to that of the control grid of the vacuum tube. Its name is derived from the fact that it is connected to the base layer of the germanium pellet. The collector corresponds to the plate of the vacuum tube, although it does not collect electrons from a space charge.

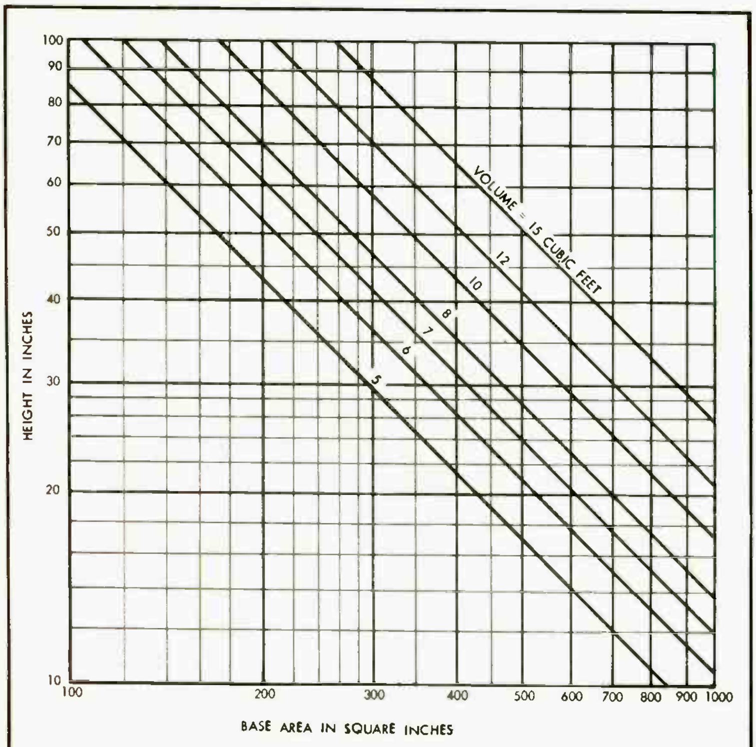


Fig. 2

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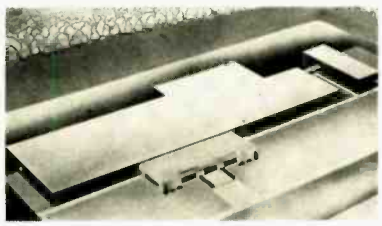
Industry Notes . . .

ALTEC LANSING SALES MEETING. National sales meeting of Altec Lansing Corporation was held in April at the New Orleans Roosevelt Hotel, with representatives of the company's nation-wide sales organization in attendance. Attending from Beverly Hills headquarters were **G. L. Carrington,** president; **A. A. Ward,** executive vice-president; **R. J. Carrington,** advertising manager; **G. L. Carrington, Jr.,** audio products manager; **E. S. Seeley,** engineering manager, and **A. K. Davis,** plant manager. Altec's New York office was represented by **D. C. Collins,** vice-president, and **H. S. Morris,** national sales manager. Regional sales managers who attended the annual conference included **Ed Grigsby** from Beverly Hills, Western sales manager; **Bob Amos** from Dallas, Southern sales manager; **Bill Johnson** from Chicago, midwestern sales manager, and **W. H. Hazlett** from New York, Eastern sales manager.



NEW ORRADIO TAPE PLANT. Plans for a new $300,000 plant designed expressly for the manufacture of magnetic recording tape have been announced by **John Herbert Orr,** president of ORRadio Industries, Inc., Opelika, Ala. The new facilities will increase the company's production capacity 400 per cent. Construction is scheduled to begin with the next thirty days and the new building is expected to be ready for occupancy sometime in October. In the new plant all working areas will he air conditioned to control not only temperature and humidity, but also to provide a dust-free atmosphere. Announcement of the new plant was made following the annual meeting of ORRadio stockholders. The stockholders re-elected all directors, authorized an increase in capital stock and approved plans to underwrite construction of the new plant.

AMI JUKE BOX HONORED. An American-made AMI juke box was selected as the only coin-operated phonograph to be demonstrated to 400 audio experts attending the Internationaler Musikwissenschaftlicher Kongress at the University of Vienna in April. The machine was programmed entirely with classical recordings to demonstrate to the assembled audio men the tonal range and performance possible in commercial phonographs incorporating a multihorn sound system. Introduced and used exclusively by AMI in commercial equipment, the multihorn system has been adapted to the firm's packaged home hi-fi radio-phonographs which were presented in prototype form last Fall at audio shows.

CLASSIFIED

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FOR SALE: BOZAK 3-way speaker system in blond mahogany. 4 woofers, 2 midranges, 8 tweeters. $350. Boston area only. 9 Edgehill Road, Winchester, Mass.

D42 Condenser Microphone, ±1 db 0–10 kc, low distortion, high sensitivity, rugged, $20. Write for data. C. Tendick, 900 Glenway Drive, Inglewood, California.

TAPE RECORDER. British Ferrograph; unsurpassed quality. 3 motors, 7½—3¾ ips; hysteresis-synchronous drive; $379 net. Have two and am buying third (for stereo); will sell one in excellent shape for the first $200 bid. Phone MUtual 1-0464, Belmar, N. J.

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SWAP: Ampex 350 heads, halftrack. Want fulltrack. Box 884, State College, Pa.

SACRIFICE McIntosh, Marantz, Fisher Jensen, Pentron, classical records. Guarantee. All or parts. Bru. 611 W. 158th St., New York 32, N. Y. LOrraine 8-4729.

WILL SELL—Two Berlant BRZ-2, one never opened, one used less than 100 hours. Write Ed Stanford, 5931 3rd Ave., Los Angeles, Calif.

JENSEN G-610, factory reconditioned, with crossover network, $155; BL151 blond back-loading enclosure, $75; 3-channel portable electronic mixer. Built-in thrower for continuous tape machine operation, $75. LS series UTC transformers, Daven T154 pads below net cost. M. E. Boyd, 903 Salmon Drive, Dallas, Texas.

EMPLOYMENT

HELP WANTED: Executive to handle technical correspondence and assist in general sales. Manufacturer. New York sales area. Technical background and experience in Hi-Fi and public address components and installations essential. Send resume. State salary required. Box CN-1, AUDIO.

SITUATION WANTED: Aggressive sales director, consumer and industrial electronic products. Capable administraror organizer and planner. Age 41. M.I.T. graduate. Excellent record of increased sales, increased profits. Seeks responsible opportunity. Box CN-2, AUDIO.

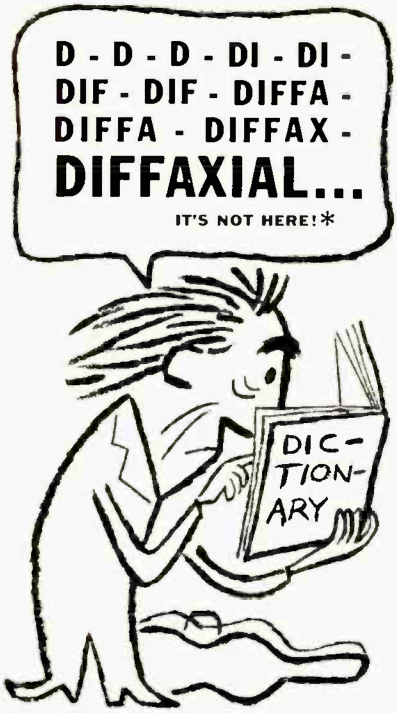
PROFESSIONAL DIRECTORY

SHURE IN NEW MILLION-DOLLAR BUILDING. Located just north of the Chicago city limits in Evanston, Ill., the new building recently occupied by Shure Brothers, Inc., was especially designed for the exclusive manufacture of microphones, phonograph cartridges, magnetic tape recording heads and other acoustical-electrical products. Representing an investment of more than one million dollars, the new plant will provide nearly 50 per cent more production capacity than the previous one, and provisions have been made for additional expansion when required. In announcing the new plant, **S. N. Shure,** president, remarked, "We have included in our new building many features designed by our own organization with the prime objective of providing products of fine quality at lower cost."

IRC-HYCOR MERGE. International Resistance Company, Philadelphia, has merged with three of its wholly-owned subsidiary companies—Hycor Company, Inc., Hycor Sales Company of California, and Ircal Industries. All three facilities have been transferred to a new plant at 12970 Bradley Ave., Sylmar, Calif., and will be operated under the name of Hycor Division of the parent company. Officers of the new division are **William I. Elliot,** president; **Kenneth T. Eckardt,** vice-president, and **Clarence G. Harding, Jr.,** treasurer.

PERSONNEL NOTES. Saul J. White, 25-year veteran in the audio industry, has joined Racon Electric Company, Inc., as chief engineer. He will assume responsibility for a complete new series of high-fidelity speakers and components . . . **Benjamin H. Ballard** has been promoted to manager of distribution for National Company, according to announcement from **C. G. Barker,** general sales manager. In his new capacity Mr. Ballard will be responsible for sales through distributors of communications receivers, components, and high fidelity equipment. . . . **Boyce Nemec,** executive secretary of the SMPTE, has announced his resignation effective June 15. He will establish a management consultation service in the East . . . **Frank Apple** has been appointed advertising manager of Centralab Division of Globe-Union, Inc.

Sidney Harman, president of Harman-Kardon, Inc., was elected Chairman of the Sales Managers Club at its April meeting, succeeding **Charles Golenpaul. Harry Estersohn** of the Jerrold Electronics Corporation was elected vice-chairman, and **Walter Jablon,** sales manager of Presto Recording Corporation was named secretary-treasurer. The Sales Managers Club is one of the three national organizations which sponsor the Radio Parts and Electronic Show staged each May in Chicago.



*ONLY UNIVERSITY MAKES THE DIFFAXIAL

University LOUDSPEAKERS, INC.
80 South Kensico Ave., White Plains, N. Y.
CIRCLE 84A

Capps CUSTOM-MADE STYLI

MRS BLACK SHANK — **ANM RED SHANK**

Your cutter head is only as good as your cutting needle. CAPP'S patented custom-made needles are manufactured to your exact specifications, depending on your requirements. Cutting angles are held within 2°, radii within ±.0001, and the burnishing facets to ±.00005. The advantages of CAPP'S precision ground Master Recording Styli (MRS), and Anti-Noise Modulation Styli (ANM), are many. They will record higher frequencies, cut cleaner grooves, especially important for mastering and processing. They insure perfect playback groove fit; thus allowing longer record wear. There is less distortion at any frequency. Perfect for instantaneous recording and immediate playback.

CAPP'S patented MRS and ANM styli can be purchased directly from our plant. Be certain—Record with a CAPP'S CUSTOM-MADE NEEDLE.

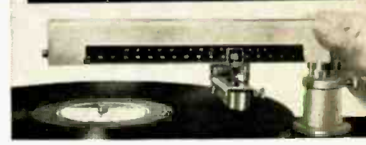
Write for Free Brochures and Technical Information on Capps Custom-Made Styli, Capps Hot Stylus Unit and Complete Line of Microphones.

Capps & Co., Inc.
20 Addison Place, Valley Stream, N. Y.
VAlley Stream 5-4413 - 4 - 5
CIRCLE 84B

ADVERTISING INDEX

NOW **ULTIMATE PERFECTION IN TONE ARM PERFORMANCE**

Ortho-sonic V/4
TRACKS COURSE OF ORIGINAL RECORDING STYLUS



VITAL ENGINEERING PRINCIPLE SOLVED!

Tracking error completely eliminated

FLAWLESS REPRODUCTION attained. Stylus moves in straight line from edge to center as in original recording.

INSPIRED DESIGN: Increases record life . . . fits smallest cabinet . . . plays all size records . . . no scratching possible . . . all popular cartridges fit.

NEVER BEFORE in the history of Hi-Fi development has the introduction of a single component created such wide interest, laboratory and editorial endorsement.

Get ORTHO-SONIC V/4 with its 10 incomparable features. ONLY $44.50

At Better Hi-Fi Dealers Everywhere

WRITE FOR ILLUSTRATED LITERATURE

ORTHO-SONIC INSTRUMENTS, Inc.
66 B Mechanic Street, New Rochelle, N. Y.
CIRCLE 84C

SOUTHWEST

First Public Annual

Hi Fi Show

weekend of
June 15, 16, 17
Rice Hotel
Houston, Texas

Here's *your* answer by leading manufacturers:

"Today's Hows Whys and Where to Buy Everything for Hi Fi"

Contact:
Office of Secretary
2410 West Alabama
Houston 6, Texas

CIRCLE 84D

SIMPLE AS

To make it just as easy as possible for AUDIO's readers to subscribe, order books, get further information about the new products and the new literature mentioned in the pages of the magazine, or to get catalog sheets and brochures describing articles advertised, we provide herewith three cards. We know that many readers are loath to cut coupons from the pages of their favorite magazine because they have told us so. And we know that many times one would like to have complete and thorough data about something he sees in these pages, yet he considers it too much trouble to hunt up paper and envelope—not to mention the stamp—and write a long letter detailing what he wants to know. This is just as simple as we know how to make it with the exception of stenciling each subscriber's name and address on each of the postcards—an operation which would be highly impractical from the printing standpoint. But from now on, when you want more information about something you have seen advertised or mentioned in AUDIO you need only indicate it on the appropriate card, print your name and address, and drop it in the nearest postbox. We pay the postage, and it goes without saying that we wouldn't include these cards if we didn't welcome your use of them. And, for the first time, you can enter your subscription without sending a penny with your order—we'll bill you later. For books, we'll have to ask for the money in advance, but only for books.

Readers have told us that they often want to know more about some of the items mentioned in the *New Products* and *New Literature* pages of the magazine, but that they do not want to take the time and effort to write to each one of the sources individually to get all the information they need. As a matter of fact, in an average issue there are usually ten items in the *New Literature* column, and between ten and fifteen on the *New Products* pages. It is conceivable that the average reader might want information on at least ten of these items, since they are selected with the interests of most of AUDIO's readers in mind. Thus one would have to have ten envelopes, ten sheets of paper, and ten three-cent stamps, together with the need for writing the ten letters and inscribing each with name and address. We do it all for you, assuming that you are willing to circle the items about which more information is desired and to write your name and address once. We will forward your inquiries to the organization involved, and you will receive the data you want with only one inquiry. Isn't that as simple as A B C?

In just the same way you can get more information about any product that is *advertised* in the pages of AUDIO. Note the page on which the advertisement appears and circle it on the back side of this card. When there are two or more ads on the same page, the page number is followed by a letter, and the designation appears under each individual advertisement. Write your name and address clearly—someone has to decipher it—and it is a good idea to mark the card for all the information you want the first time, for there is only one card in each copy of the magazine. Of course, you *could* subscribe to two copies.

Audio, P. O. Box 629, Mineola, N. Y.

GENTLEMEN:

PLEASE ENTER MY SUBSCRIPTION TO **AUDIO**

FOR:

FOR OFFICE USE

1 YEAR – $4 (FOREIGN–$5)	2 YEARS – $7 (FOREIGN–$10)	LIFE – $35 U.S.A. ONLY	BILL ME / PAYMENT ENCLOSED	CHECK / MONEY ORDER

NAME ______

ADDRESS ______

CITY ______ ZONE ______ STATE ______

CUT APART ON DASHED LINES

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY ENVELOPE
First Class Permit No. 142, Mineola, N. Y.

Postage Will be Paid by Addressee

AUDIO
P. O. Box 629
Mineola, N. Y.

Postage
Will be Paid
by
Addressee

BUSINESS REPLY ENVELOPE
First Class Permit No. 142, Mineola, N. Y.

AUDIO
P. O. Box 629
Mineola, N. Y.

No
Postage Stamp
Necessary
If Mailed in the
United States

AUDIO — Please send me further information about the items advertised on the following pages in the May issue:

N-1	N-11	N-21	2	13	42-43	61	71	79a	83d
N-2	N-12	N-22	3	14	45	62a	72a	79b	83e
N-3	N-13	N-23	4-5	15	47	62b	72b	80	83f
N-4	N-14	N-24	6	17	49	63	73a	81a	83g
N-5	N-15	N-25	7	18	51	64	73b	81b	83h
N-6	N-16	C-2	8	31	53	65	74	82a	83k
N-7	N-17	C-3	9	33	55	66	75	82b	84a
N-8	N-18	C-4	10	35	57	67	76	83a	84b
N-9	N-19	SB	11	37	59	69	77a	83b	84c
N-10	N-20	1	12	39	60	70	77b	83c	84d

NAME ____________________

ADDRESS ____________________

CITY ____________ ZONE ______ STATE ______

BOOK ORDER

Please send me the books checked below, postage paid. I enclose check ☐ money order ☐ for $ in full payment.

☐ **the 3rd Audio Anthology**
Board cover, $3.50

☐ **the 3rd Audio Anthology**
Paper cover, $2.50

☐ **Electronic Musical Instruments**
$7.50 in U. S. (All others $8.00)

☐ **Practical Electroacoustics**
Rettinger, $10.00

☐ **AUDIO—Bound Volumes—1955 issues**
$10.00 (In U. S. only)

Tape Recorders and Tape Recording
Harold D. Weiler
☐ Paper Cover, $2.95
☐ Board Cover, $3.95

NAME ____________________

ADDRESS ____________________

CITY ____________ ZONE ______ STATE ______

To start receiving **Audio** monthly without any effort on your part to locate one on the newsstands or at your jobber's, mark the appropriate boxes with crosses, tear out the card, and drop it into a handy postbox. If you are one of those who always pays in advance, we will accept your check or money order—we do not recommend cash to be sent through the mails—enclose the card in an envelope, and mail. This will cost you an extra three cents, so if you wait until we send you a bill, we'll enclose a business reply envelope for your convenience. We try to make it as easy for you as we know how.

NOW IT IS EASIER — ONLY ONE CARD

is necessary to get more information about any New Product or New Literature item, or about any product advertised in these pages.

At the end of each item of **New Literature, New Products,** or **Equipment Reports** you will notice a letter and a number—the letter indicates the month and the number indicates which item it is. All you have to do to get full information about the product or to get the literature described is to circle the appropriate number, add your name and address and mail it to us. We'll do the rest, and you may be sure that we'll be prompt because we are just as anxious for your inquiries to get to their destination as you are—and besides, we don't have room enough around the office to accumulate a lot of cards. Circle one item, if you wish, or all of them—we'll carry on from there. This whole system breaks down if there is a charge for the **New Literature** described, so if you can suggest any improvements in this service, we would appreciate hearing about them.

To get more information about the products that are advertised in each issue of AUDIO—use the new card at the left. Fill in your name and address clearly and circle the number of the page on which the advertisement appears. When there are two or more ads on a page, each one has under it a notation such as Circle 23a, Circle 48b, or Circle 76c and the same numbers appear on the card. Numbers C-2, C-3, and C-4 refer to the covers—C-2 is the inside front cover, C-3 the inside back cover, and C-4 is the outside back cover. SB is "The Sounding Board."

The only way to derive any benefit from this service is to use the card for all the information you want. We think you will find this new system more convenient and that you will use it more and more.

Model A20CL Music Control Center and 20-watt Power Amplifier. Features unique, exclusive "Presence" control. Response 20-20,000 cps. ±1.0 db at rated 20 watts, 40 watts peak. Controls include Playing Selector, Loudness, Bass, Treble, Volume and Power, Phono-Selector. Power Amplifier utilizes Circlotron Circuit and Variable Damping Control. Low-boy style. **Net, $124.50**

Model A15CL Music Control Center and 15-watt Power Amplifier. Similar to Model A20CL above except Power Output 15 watts rated, 30 watts peak. Controls include Power, Bass, Treble, Volume, Playing Selector and Phono-Selector. **Net, $99.50**

Model PC1 Music Control Center. Serves as control for line amplifiers. Has self-contained, shielded, low-noise power supply. Features exclusive E-V "Presence" control. Other controls include Playing Selector, Loudness, Bass, Treble, Volume, Power and Phono-Selector. **Net, $99.50**

Model PC2 Music Control Center. Serves as control for line amplifiers. Controls include Playing Selector, Bass, Treble, Phono-Selector, Volume and Power. Self-contained, shielded, low-noise power supply. **Net, $67.00**

Model A15 Circlotron Amplifier. Power output: 15 watts rated, 30 watts on peak. Response: ± .5 db 20-50,000 cps. **Net, $69.50**

Model A20 Circlotron Amplifier. Power Output: 20 watts rated, 40 watts on peak. Response: ± .5 db 20-60,000 cps. **Net, $85.00**

Model A30 Circlotron Amplifier. Power Output: 30 watts rated, 60 watts on peak. Response: ± .5 db 20-75,000 cps. **Net, $108.00**

Model A50 Circlotron Amplifier. Power Output: 50 watts rated, 100 watts on peak. Response: ± .5 db 20-75,000 cps. **Net, $169.00**

Model A100 Circlotron Amplifier. Power Output: 100 watts rated, 200 watts on peak. Response: ± .5 db 20-50,000 cps. **Net, $261.00**

Prices slightly higher west of the Rockies.

Featuring the new, vital PRESENCE CONTROL

With the thrilling new PRESENCE CONTROL, you take the leader's baton and conduct the orchestra to suit your own listening pleasure in the ELECTRO-VOICE MUSIC CONTROL CENTER. Balances vocals to orchestra and room acoustics for true high fidelity. Just like the network and recording studios, the PRESENCE CONTROL gives mid-range program equalization never before available in home systems. Low-boy styling is skillfully blended with mocha, satin brown, and brushed brass trim for a beautiful appearance that matches blonde or mahogany cabinets.

With ELECTRO-VOICE CIRCLOTRON AMPLIFIERS, you come closer than ever to perfection in high-fidelity reproduction. The famous Circlotron Circuit provides unity coupling between output tubes; eliminates switching transients and removes DC from output transformer. The exclusive Variable Damping Control greatly reduces loudspeaker low-frequency distortion and voice-coil override. Permits matching amplifier, speaker and enclosure to room...for the closest approach to reality of reproduction.

See your E-V High Fidelity Distributor or write for Bulletin 222–A65.

Electro-Voice® Producers of famous E-V High-Fidelity Speaker Enclosures and Systems

ELECTRO-VOICE, INC. • BUCHANAN, MICHIGAN