Theater Sound in a Small Package - See Page 19

AUDIO ENGINEERING

FEBRUARY
1953
35c

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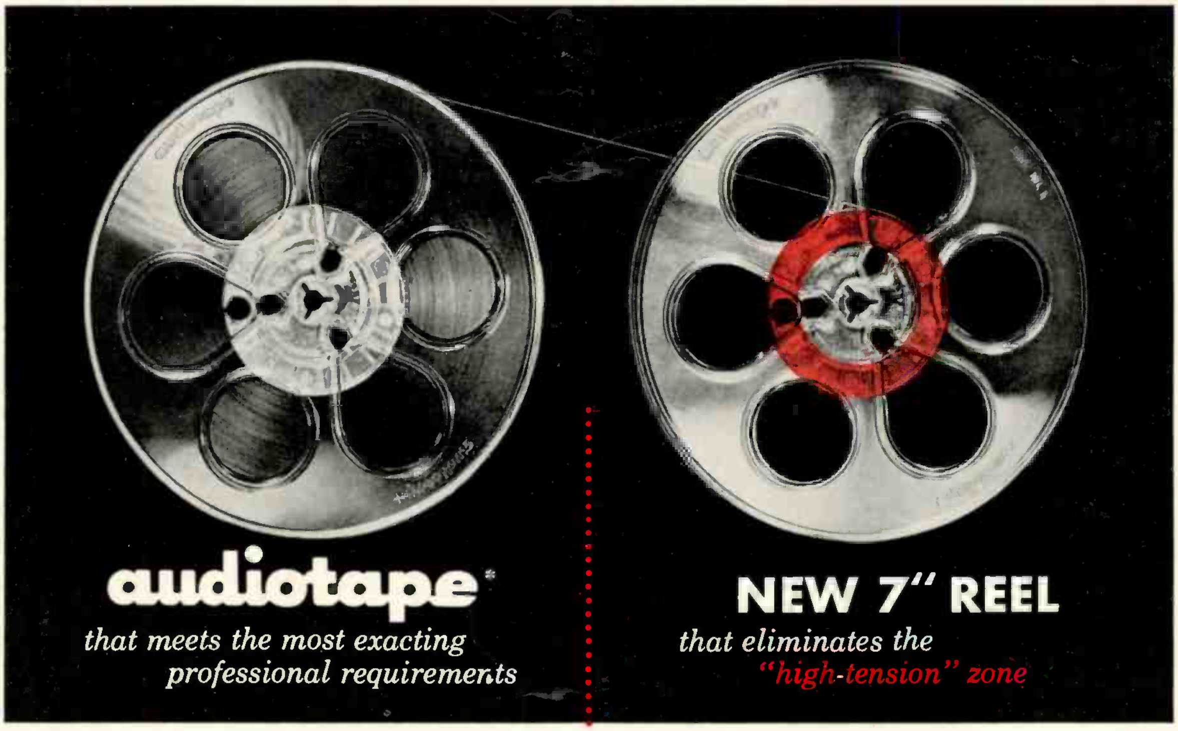
the RIGHT COMBINATION *for*
maximum performance at minimum cost



NO SPLICES. As always, plastic-base Audiotape in 1200 and 2500 ft reels is guaranteed *splice-free.*

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CONTENTS

FEBRUARY, 1953 Vol. 37, No. 2

COVER

Deems Taylor—noted music critic, composer, conductor, author—relaxes upon the completion of new music system installed by Asco Sound Corporation in his Fifth Avenue apartment. System consists of Magnecordette, Radio Craftsmen AM-FM tuner and amplifier, Rek-O-Kut turntable and Garrard changer—both with Audax pickups—and Electro-Voice speaker, latter behind grill over books. Doors in center hide 21-in. Radio Craftsmen TV tuner.

RADIO MAGAZINES, INC., P. O. BOX 629, MINEOLA, N. Y.

AUDIO ENGINEERING (title registered U. S. Pat. Off.) is published monthly at 10 McGovern Avenue, Lancaster, Pa. by Radio Magazines, Inc., Henry A. Schober, President; C. G. McProud, Secretary. Executive and Editorial Offices: 204 Front St., Mineola, N. Y. Subscription rates—United States, U. S. Possessions and Canada, $3.00 for 1 year; $5.00 for 2 years; elsewhere $4.00 per year. Single copies 35c. Printed in U. S. A. Entered as Second Class Matter February 9, 1950, at the Post Office, Lancaster, Pa. under the Act of March 3, 1879

AUDIO PATENTS

RICHARD H. DORF*

Volume compressors have found many uses in the audio field, especially among the more workaday appliances rather than in high-quality music systems. Broadcast and recording-system limiter amplifiers can, of course, be as elaborate as necessary, but there is a need for a very simple compressor for such devices as hearing aids, intercoms, and the like—devices with limited frequency range and general quality, but in which large amounts of distortion would still be objectionable.

Arthur W. Donelson is the inventor of such a compressor or automatic volume control. It is described in his patent No. 2,598,237, assigned to Raytheon, and is suitable for practically any two-stage amplifier (or the last two stages of any amplifier) where frequency-range requirements are moderate, say 100 to 6000 cps.

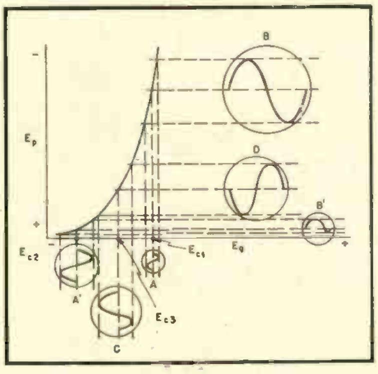

Figure 1.

Figure 1 is an E_g–E_p curve for a "typical" pentode audio amplifier tube. In this case it represents the characteristic of both tubes used in a two-stage amplifier, the first tube of which acts as a resistance-coupled voltage amplifier and the second as a transformer-coupled power amplifier. The single curve is used for both to simplify illustration, but the invention would be equally valid with tubes having different characteristics (as most likely they would because of the different methods of coupling for the two stages). In this case the tubes are such as would be used in a hearing-aid amplifier and operate with normal grid bias of zero volts. This is shown on the horizontal E_g axis as the point E_{c_1}.

When an undistorted sine-wave input voltage (A in *Fig.* 1) is applied to the grid of the first tube, which is biased at the normal E_{c_1} point, the result is the undistorted plate-voltage waveshape of B, since

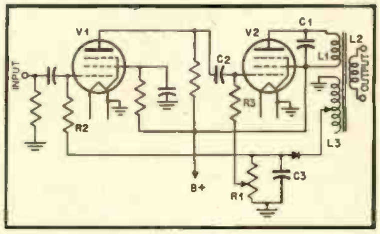

Figure 2.

the tube is operating on the straight portion of its characteristic. Suppose, however, that it is desired to use compression by applying a high negative bias to the first tube—indicated in *Fig.* 1 as E_{c_2}. When the same input wave is applied to it (A') the result at the plate is B'. Wave B' is indeed reduced in level, but because bias E_{c_2} places operation on the curved part of the characteristic, wave B' contains a large amount of second harmonic distortion; in fact, its negative excursion is twice the amount of the positive.

The key to elimination of the distortion, the inventor has found, is to control the bias of *both* tubes simultaneously with the a.v.c. voltage, and to bias them negative in a definite proportion. When tube 1 is biased negative by a certain amount, tube 2 must be biased negative by a certain large fraction of that amount.

Let us now consider that, having obtained distorted wave B' from the plate of tube 1, we apply it to the grid of tube 2, and that *Fig.* 1 now represents the characteristic of tube 2. Wave B', now relabeled C, is applied to the grid of tube 2. The a.v.c. voltage, being properly proportioned, has placed the bias of tube 2 at point E_{c_3}. The resultant output voltage at the plate of tube 2 is wave D, which is practically distortionless.

What has happened is that the original input wave has been distorted twice. First it was distorted in the first stage. Then the distorted wave was again distorted in the second stage. But because of the phase change and proper selection of negative biases (and thus positions on the curved,

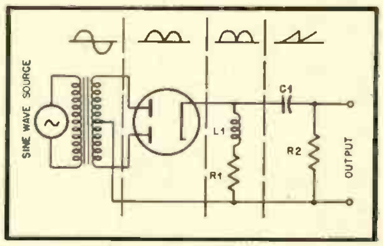

Figure 3.

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

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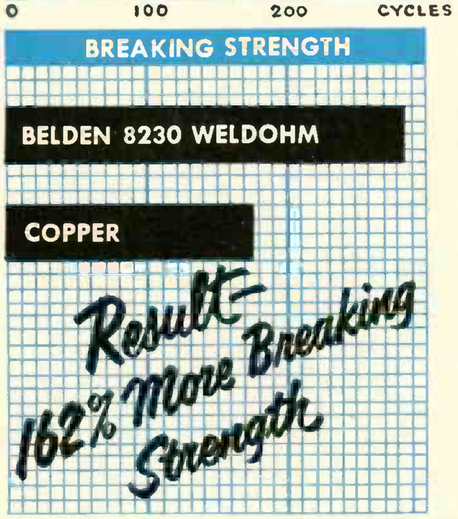

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distorting portions of the tube characteristics) on the two tubes, the distortion has been cancelled. The inventor states that once the ratio between the biases for the two stages has been determined, the same ratio will correct distortion at all actual levels of a.v.c. voltage.

Figure 2 shows a practical circuit. V_1 and V_2 are the two pentode stages. L_1 and L_2 are the normal primary and secondary of the output transformer. C_1 is shunted across the primary to cause response to drop off above perhaps 6000 cps. C_2 has small capacitance to limit response to above 100 cps.

Tertiary winding L_3 on the output transformer furnishes a.c. for compression control. It is rectified and applied across load resistor R_1, which is shunted by filter capacitor C_3. The d.c. is applied through grid leak R_2 to the grid of V_1 in the usual way.

At the same time, a portion of the same d.c. voltage is tapped from a point on R_1 and fed through R_3 to the grid of the second stage. Thus, whatever the rectified and filtered a.v.c. voltage level (depending on the signal), the full voltage is applied to V_1 and a fixed fraction of that voltage is fed to V_2.

To set the tap on R_1 for minimum distortion the inventor suggests the following procedure. Feed in a sine wave or other recurrent wave form and monitor both amplifier input and output on an oscilloscope (perhaps with an electronic switch). Increase input voltage until the negative a.v.c. bias on V_1 is at a maximum. Then adjust the taps on R_1 until distortion is at a minimum. From this point on, distortion should remain at a minimum whatever the input level and degree of a.v.c. action.

Though the author does not specifically so state, it is likely that the same design and procedure would be adequate for amplifiers using tubes not biased at zero, but with cathode bias.

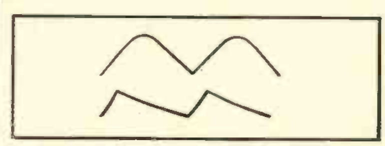

Figure 4.

Sine to Sawtooth

Sawtooth waveforms are used for a number of purposes in electronics, two of which common in audio work are for deflecting oscilloscope beams and in electronic musical instrument. Kurt Schlesinger has invented a method of converting sine waves to linear sawtooth form. The patent, No. 2,616,044, has been assigned to RCA.

The method is illustrated basically in *Fig.* 3. Sine waves from the source are full-wave rectified and differentiated. The full-wave rectifier is a standard circuit with a centertapped transformer and duo-diode. The load consists of L_1 and R_1 in series, rather than a simple resistor. This produces a parabolic waveform (shown directly above the L_1-R_1 combination) from the basic rectified sine wave. When the parabolic wave is differentiated by C_1 and

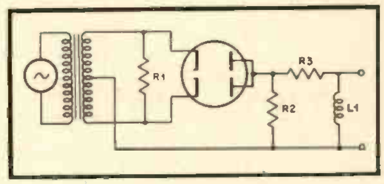

Figure 5.

R_2, the output is the linear sawtooth shown. In actual practice the sawtooth has a much larger flyback time than that shown, but the rise is linear. *Figure* 4 shows what would happen if the original rectified sine wave were differentiated. The conversion to parabolic form before differentiation. is needed to linearize the sawtooth slope.

Figure 5 shows another circuit for converting sine to sawtooth waves. Resistor R_1 in series with the transformer primary serves to convert the sine waves to parabolic form because of increased voltage drop across the resistor as the sine waves reach their peaks and draw maximum current through the rectifier; this tends to flatten off the tops of the waves. In this circuit the load resistor is R_2 and there are two similar differentiators—C_1 and half of R_3, and C_2 and the other half of R_3. Since the circuit is symmetrical with respect to ground, outphased sawtooth waves suitable for application to a push-pull amplifier are derived from the output.

Figure 6 shows still another circuit. In this one the parabolic shape is obtained by

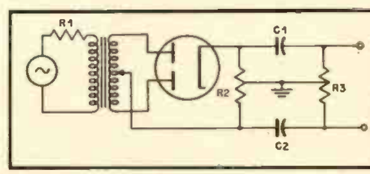

Figure 6.

loading the transformer and the source with R_1. The rectifier is connected opposite to the usual way—cathodes to transformer and commoned plates to load R_2. The differentiator this time is an R–L combination R_3–L_1.

A copy of any patent specification may be obtained by sending the patent number and 25 cents to The Commissioner of Patents, Washington 25, D. C.

FOCALIZING BAFFLE CLARIFICATION

In TECHNICANA—pages 83–84 of the November issue—the Focalizing Baffle was described, with reference to an article in *T.S.F. pour Tous*, of France. At the conclusion of this reference, it was stated that the baffle is patented and produced commercially by the firm *Film et Radio*.

While it is true that this firm does produce the baffle commercially, the original invention was the work of Monsieur Léon, of the *Firm Elipson*, and the patents were granted to him.

Film et Radio hopes that no misunderstanding was created by the omission of the inventor's name, since he is very well known in France. The commercial embodiment of M. Léon's invention is produced by agreement with Messrs. Elipson.

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*T.M.R.S.

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LETTERS

More Loudness

SIR:

In reference to your comments in the December issue, I submit this as a possible answer to the loudness-control issue.

You state that "no correction should be applied to the loudness control except that for the low frequencies." I entirely agree. Let the highs be produced flat and let the ear take care of them as in an actual performance. However, due to the varying degree of sensitivity of the human ear to the low frequencies, let the lows be boosted in accordance with a curve somewhere between a flat response and the complement to the low-frequency response of the ear. This, to me, would let the reproduction be as close to an actual performance as possible. Tone controls should still be available for those who want them.

After careful consideration, I have arrived at the solution to the perfection of my hi-fi desires. I am simply going to buy Sir Thomas Beecham and the Royal Philharmonic Orchestra and rent Symphony Hall in Boston. Try to top that. Of course, I shall accept reservations for back-row seats for those who want the quality of reproduction which would be heard at that distance. For a special price, I can get them standing room in Grant Park.

FOSTER L. SPAIN,
The Infantry School,
Fort Benning, Georgia

(We see no objection to any kind of control any given listener may enjoy. Nor to any response curve he may wish, irrespective of how much or how little it may resemble what is considered "normal" by the majority. After all, some people like asparagus and some don't. We like it, but not well enough to eat it. ED.)

SIR:

It seems to us that you have overlooked one very important factor in your recent comment on Loudness Controls. Fletcher-Munson curves are for pure tones, and do not necessarily apply to music which is a complex wave form. The various interactions in the human ear between the musical components are not entirely understood, but it is certain that masking and various other effects take place.

It has been our experience that loudness controls based qualitatively on the Fletcher-Munson curves provide altogether too much bass boost at low levels, giving a very boomy and unmusical result. This effect is further exaggerated when the effective relative program level changes, as for a close-up solo or for the inevitable loud announcer, for instance.

In developing loudness controls for our amplifier, we used the general shapes predicted by the Fletcher-Munson curves, but modified the actual changes on the basis of expanded listening tests. For these tests, a number of listeners—including both technical and non-technical, musical and non-musical persons—were used. They were asked merely to readjust the set of calibrated tone controls to give the same *apparent* quality and balance as the volume was reduced in discrete steps. We found a

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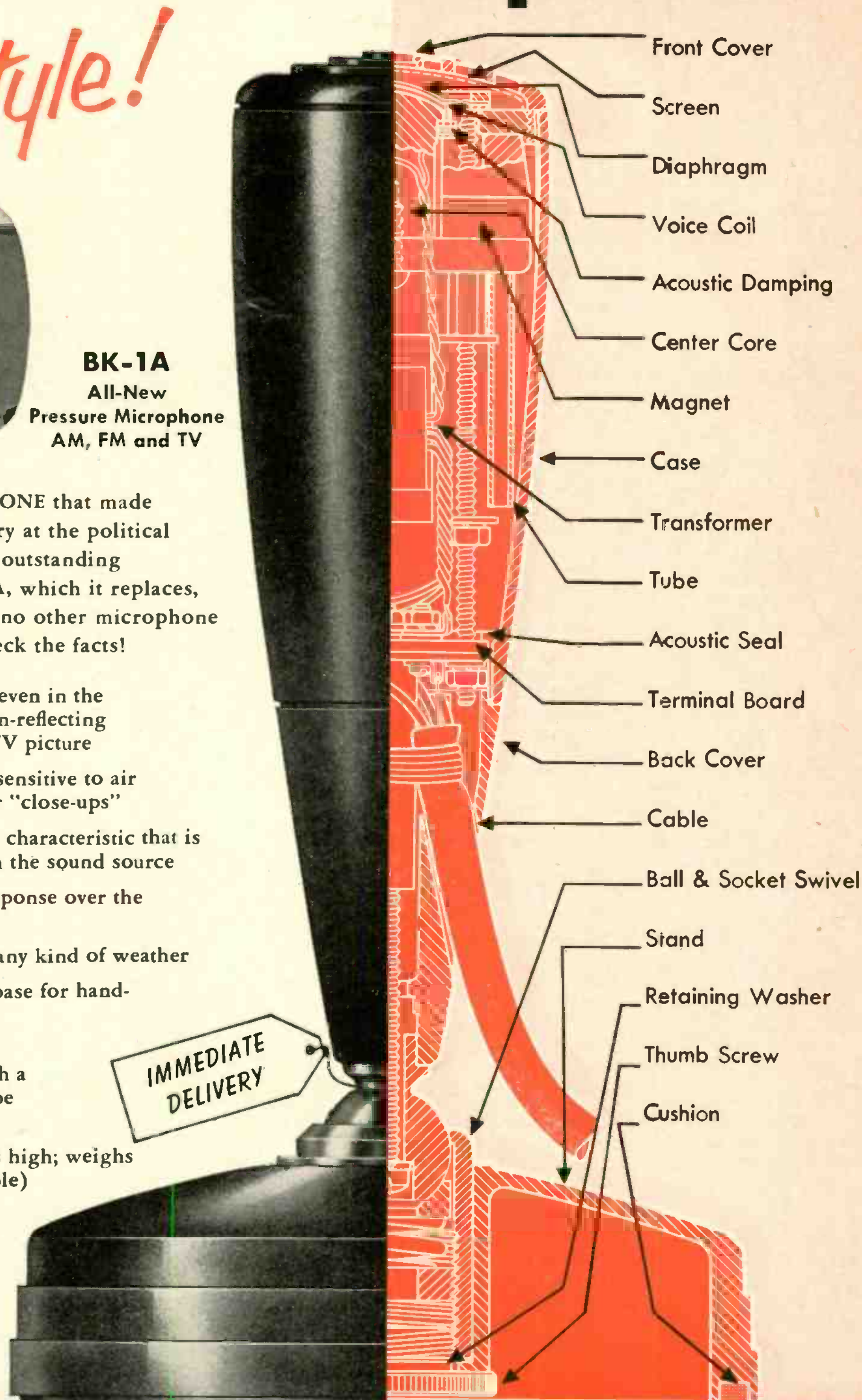
- Type BK-1A has a frequency characteristic that is independent of distance from the sound source
- Type BK-1A has uniform response over the essential audio range
- Type BK-1A can be used in any kind of weather
- Type BK-1A detaches from base for hand-announcing (it can also be mounted on floor stands)
- Type BK-1A is equipped with a ball-and-swivel mount—can be turned in any direction
- Type BK-1A is only 8 inches high; weighs just 19 oz. (less base and cable)



For details and delivery information on this new remarkable semi-directional microphone, call your RCA Broadcast Sales Representative

RCA

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ENGINEERING PRODUCTS DEPARTMENT CAMDEN, N.J.

surprising degree of unanimity both on the amount of bass boost required and on the fact that treble boost was required to a degree which would not be predicted by the curves. In other words, at very low levels, compared to the correction predicted by the F-M curves, the average listener wants less bass (to reduce boom) and more highs (to improve definition).

Our loudness controls have all been designed on the basis of these results and their acceptance has been mor than satisfactory. Many listeners previously—and often quite rightfully—prejudiced against loudness controls have agreed that ours are indeed very good.

May I respectfully point out, therefore, that your editorial is misleading for the simple reason that it is based upon the assumption that the Fletcher-Munson curves should be used slavishly in designing a loudness control, whereas there is considerable experimental evidence that this is not the case.

H. H. Scott,
Hermon Hosmer Scott, Inc.,
385 Putnam Ave.,
Cambridge 39, Mass.

(Our favorite axiom—originally stated by C. J. LeBel in 1938—is, "If it measures good and sounds bad, it is bad." This should work in its converse form—If it sounds good, it is good, and it would appear that public acceptance of Mr. Scott's products would bear out his observations. Ed.)

Needle Force Terminology

Sir:

The question raised by Mr. Lager in December Letters regarding stylus "force" *versus* "pressure" touches upon a subject which has been creating confusion for many years.

It is fairly obvious that a spring balance measures force, not pressure. In English units, force may properly be expressed in ounces. Therefore, it seems proper to say "needle force—2 ounces." The advent of of the fraction-of-an-ounce pickups has brought about the erroneous practice of stating needle force in grams.

In the C.G.S. system force is measured in dynes, not grams. However, pickup users do not seem to like the expression "needle force—5880 dynes" for example. Instead, they would much rather say "6 grams."

To ensure correct terminology, we have recently been using the term "vertical pickup load." "Load" is a rather general term which may take on the units of force, mass, or weight. It seems perfectly proper, therefore, to say "stylus load—6 grams."

Needle pressure is calculable in terms of needle load and the contact area. On the basis of the data presently available, we have estimated that average stress in pounds per square inch at the point of contact between a spherical 1-mil radius stylus and a Vinylite record is around 50,000 pounds per square inch for a needle load of ¼ ounce (7.1 grams.).

B. B. Bauer,
Vice-President—Engineering,
Shure Brothers, Inc.,
225 W. Huron St.,
Chicago 10, Ill.

[*Continued on page 61*]

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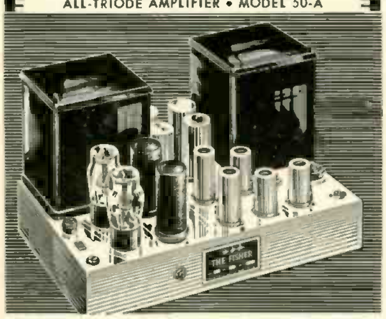


75th Anniversary of the First Dynamic Loudspeaker

MURLAN S. CORRINGTON*

A brief discussion of the device which was the predecessor of all present-day sound reproducers.

THE FIRST PATENT on a dynamic loudspeaker was issued to C. H. Siemens on December 10, 1877. It is British patent No. 4685, class 40-IV. It is interesting that this loudspeaker was developed long before there was an amplifier to operate it and before the days of the phonograph and radio. It was to be used in telephone equipment.

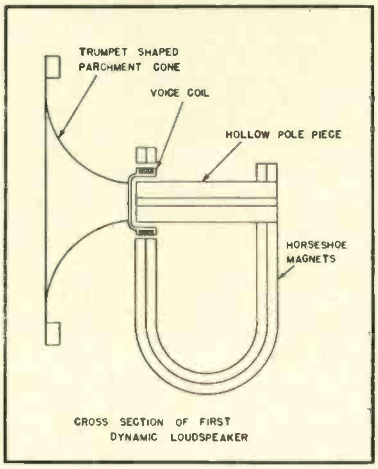


Fig. 1. The loudspeaker covered by Siemens' 1877 patent.

As shown by *Fig.* 1, two horseshoe magnets were used, one inside the other, to produce the magnetic field. One leg of the magnet was longer than the other and a hole was drilled in it slightly larger than the voice coil. A hollow pole piece was then placed inside the voice coil and extended to complete the circuit to the other leg of the magnet. The voice coil was wound on a form which was connected to the trumpet-shaped parchment cone.

The outer edge of the cone did not have the flexible corrugations used today, but because of the flatness at that point was fairly flexible.

It is surprising that modern loudspeakers have not changed very much. We have improved the magnet structure by using more powerful permanent magnetic materials and have added a more flexible rim suspension to lower the resonant frequency. The first design operated with an enclosed back with a compartment the diameter of the cone and extending back as far as the voice coil. Now we use a much larger acoustic enclosure.

As Chester W. Rice said to Edward W. Kellogg, during their development of the modern inertia-controlled loudspeaker nearly fifty years later (1925),[1] when they discovered that one of their ideas had been anticipated, "The ancients stole our invention."

* *RCA Victor Division, Camden, N. J.*

[1] Chester W. Rice and Edward W. Kellogg, "Notes on the development of a new type of hornless loudspeaker," *Jour. A.I.E.E.*, vol. 44, pp. 982–991; Sept. 1925, Disc. pp. 1015–1020.

Coming EVENTS

February 5, 6, 7—AUDIO FAIR—LOS ANGELES, Hotel Alexandria, Los Angeles, Calif.

March 23–26—INSTITUTE OF RADIO ENGINEERS, convention and 1953 RADIO ENGINEERING SHOW. Grand Central Palace, New York City.

April 28–May 1—Seventh Annual NATIONAL ASSOCIATION OF RADIO AND TELEVISION BROADCASTERS' convention and 1953 BROADCAST ENGINEERING CONFERENCE. Burdette Hall, Philharmonic Auditorium, Los Angeles.

April 28–May 1—1953 ELECTRONIC COMPONENTS SYMPOSIUM. Presented through cooperation of AIEE, IRE, RTMA, and WCEMA. Shakespeare Club, Pasadena, California.

May 7–9—ACOUSTICAL SOCIETY OF AMERICA. Philadelphia, Pa.

May 18–21—1953 ELECTRONIC PARTS SHOW. Conrad Hilton Hotel, Chicago.

August 19–21—WESTERN ELECTRONIC SHOW AND CONVENTION, sponsored jointly by WCEMA and Western Sections of IRE. Municipal Auditorium, San Francisco, Calif.

September 1–3—INTERNATIONAL SIGHT AND SOUND EXPOSITION. Palmer House, Chicago.

October 14–17—Fifth Annual Convention of the AUDIO ENGINEERING SOCIETY, and THE AUDIO FAIR. Hotel New Yorker, New York City.

October 15–17—ACOUSTICAL SOCIETY OF AMERICA. Cleveland, Ohio.


SCOTCH
Magnetic Tape


Scotch
Magnetic Tape

BOOK REVIEWS

APPLICATION OF THE ELECTRONIC VALVE IN RADIO RECEIVERS AND AMPLIFIERS. VOL. 2—A.F. AMPLIFICATION, THE OUTPUT STAGE, POWER SUPPLIES. Book 5 of the Philips' Technical Library. xviii + 431 pages. By Dr. B. G. Dammers, J. Haantjes, J. Otte, & H. van Suchtelen. Translated from the Dutch by J. Jager & Harley Carter. 1951.

In this latest addition to the Philips multilingual texts on the electron tubes, three chapters treat the important function of the vacuum valve—as amplifier, both voltage and power, and as power source for the receiver. The treatment is distinctly European, and the American reader will have to accommodate himself to new sets of nomenclature and circuit symbols.

The various factors entering upon the performance of voltage amplifiers and the means used to overcome their deficiencies are more than adequately covered. Such matters as adequate bypassing and decoupling and the effect of over-all frequency response come in for detailed study. Phase splitting in many unusual forms is discussed, but as the tubes considered are European types. it is difficult to relate them to American types currently available.

The power output stage is thoroughly discussed for both single-ended and push-pull forms. Inverse feedback is not covered until a later volume. however. The various classes of operation and comparisons thereof, when under load, receive a full exposition not customarily found in texts of this sort.

The power supply is analyzed from both the heater and plate requirements, and mathematical treatment of the design parameters will enable the reader to predetermine any specific power supply component list. Stabilization of the plate supply is discussed as applicable to stable operation of the amplifier as a whole.

A useful bibliography and an adequate index complete the volume. This reviewer cannot but be amazed at the one omission from this book—appearing as it does in more than one language—a comparison of U.S. and European valve types.

—*L. B. Keim*

RADIO INTERFERENCE SUPPRESSION. G. L. Stephens. London: Iliffe & Sons, 1952. 132 pages, $2.50 (British Book Center, New York City).

The suppression of radio interference in America is handled at best in a lackadaisical manner, but in Britain the law protects the listener, and wilful failure to prevent such disturbance can mean prosecution. Her Majesty's Government derives a sizable revenue from each user of a wireless installation, so proper steps are taken to ensure satisfactory use of the equipment in the home.

This is a second edition of this text brought up to date, with especial emphasis upon proper filter design to cover the video frequency band as well as the general spectrum. Designed as a text to give practical assistance to both the design engineer and the serviceman, the many forms of interference are first discussed as to origin, and then their practical elimination taken up in detail. Automobile, traction cars, fixed machinery, and household appliances are all discussed, and the separate methods of treating them are clearly shown. Much is made of the "cut and try" process so often

[*Continued on page 69*]

EDITOR'S REPORT

RELIEF!

MANY TIMES during a lifetime, humans are likely to estimate a time for the completion of a project and then find, to their chagrin, that they are unable to finish the job by the specified date. In fact, the common expression "Time is of the essence"—which in itself seems to be meaningless—is often used in lieu of more definitive legal terminology to indicate that an enforced fulfillment of a completion date is envisaged in the signing of a contract or in a statement of a date of performance.

We have just come through a period for which the above is an introduction. 'Way back in September, we estimated that *the 2nd audio anthology* would be ready for delivery around November 1—which it wasn't. The circulation department has been pestered—and, we might say, rightfully—with pithy comments about our estimates of the delivery date. We are more pleased than our readers to be able to say that the entire manuscript is finally in the hands of the printers, and that delivery may be expected during the last half of February.

Æ's staff is small, and the work of preparing the copy for *the 2nd anthology* naturally devolved upon one person—who had all his regular other duties to carry on with at the same time. In spite of all this, this one man had no work allotted for the hours from two to six a.m. Those were simply wasted in sleeping.

In all seriousness, however, we do wish to thank those who have ordered *the 2nd anthology* and who have been patient for several months while they waited for delivery. It won't be long now.

SCIENTIFIC MIRACLES

Of all the publications and house organs that cross our desk each month, the *Mueller Clipper* is near the top in our list of favorites. Published by the Mueller Electric Company, of Cleveland, makers of clips—big clips, little clips, middle-sized clips—this little sheet is always read from front to back, since it intersperses its bits of wisdom with bits of wit. In fact, most of its short paragraphs combine both. Since there is no copyright notice on this sheet, we trust Skipper Ralph Mueller will not mind if we "clip" this item from the current *Clipper*.

> "What a series of scientific miracles is involved in the electronic organ! A lump of coal is fed to a boiler, which makes steam, which drives a turbine, which drives a generator, which makes current, which goes out over miles of copper lines to the organ, which sends forth beautiful music. A lump of coal magically transformed to a great series of pleasing sound waves."

A block diagram of similar comparisons would be mightily interesting.

THE AUDIO FAIRS

Looking at the schedule for 1953, we note that there are to be three Audio Fairs, which gives rise to some thoughts about the past years, and to those in the future. With three Fairs in '53, two in '52, one in '51, what do we have to look forward to in '54? In '59?

Well, you may ask, Why not? Aside for the expense of exhibiting, which increases to astronomical figures as the number of Fairs is multiplied, it is certain that more and more familiarity of the public will result in more and more sales of equipment—and, in general, will result in better equipment at lowered cost per unit because of manufacturing economies which would naturally follow a mass market. Even with the increase in sales of audio equipment over the past six years, we are pleased that quality standards have not been lowered—if anything, they have climbed steadily. In general, audio manufacturers have held quality up, even though they have embarked on mass production to a small degree. This is a good sign, and we feel sure that it will continue in the future.

But there is a limit to how many exhibits can be staged annually—even on a regional basis—by the manufacturers. The cost of exhibit space is only the beginning—that of the exhibit attendants' time and that of shipping the exhibits all over the country is likely to be ten times the cost of the room in which the exhibit is set up. It is our feeling that the regional shows—such as those in Philadelphia, Memphis, Cleveland, San Antonio, and a few other cities—are better handled by the local distributors. There is certainly a need for three or four major annual exhibits in widely separated parts of the country—The Audio Fairs—but the smaller one- and two-day affairs might better be the result of local get-togethers of distributors.

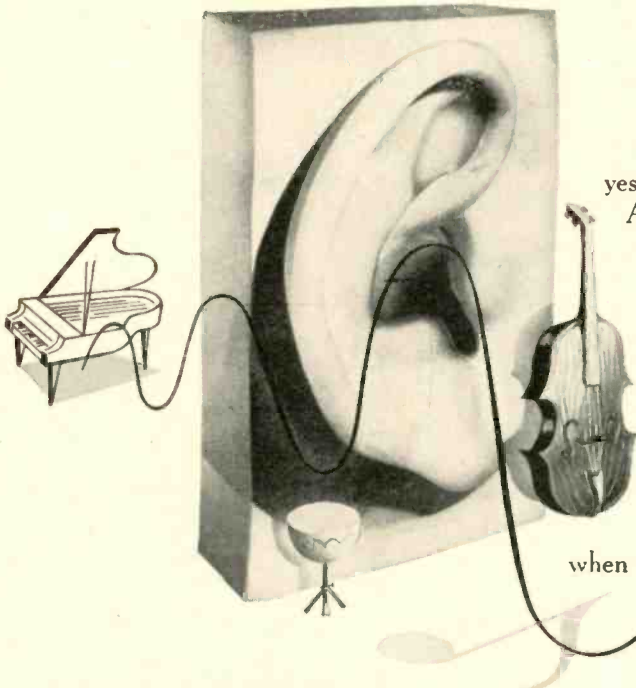
THE BLACK SIDE

It seems a shame, in view of the generally high level of integrity in the audio industry, to have to comment on a practice that seems to us to be slightly pernicious. But closing one's eyes to a condition rarely causes it to go away, nor does general acceptance of an unfair—and in some states, illegal—practice make it right. We have in mind the case of a manufacturer who offers a prize to the distributor's salesman who makes the most sales of that manufacturer's products over a given period. If the salesman's employer—the distributor—wishes to give such a prize, that's his business, and it is fair and entirely legal, no matter whether it is for sales of one manufacturer's equipment or as a percentage on *all* sales. But when the outsider steps into the picture and offers prizes, it borders on bribery and is in many states illegal.

Let's start from scratch and give everyone an even break.

"For those who can hear the difference"

Listen....

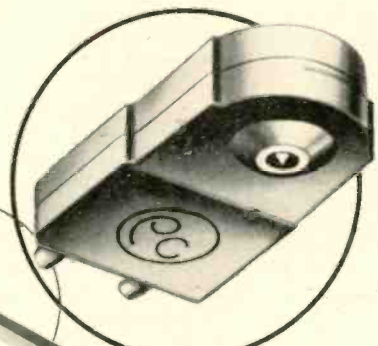


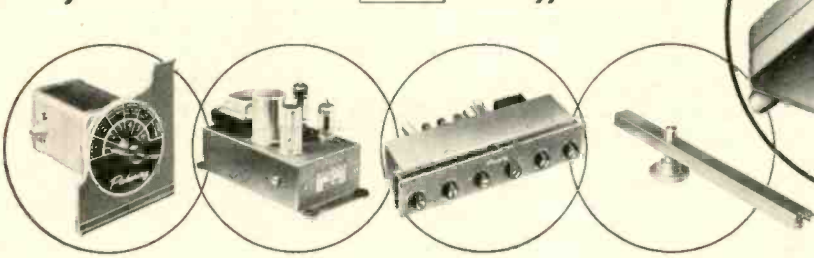
. . . it comes to you
in the subtle shading of a piano . . .
in the clean brilliance of violins,
the purity of a flute. Your ear detects
the sweet mellowness of cellos,
the roundness of a clarinet . . .
yes, even the iridescense of clashing cymbals.
And, as the symphony swells to crescendo,
its dynamic energy adds a flood of color
to your musical canvas.

For those who can hear the difference,
these are the elusive pleasures
that often remain hidden
in the grooves of fine recordings.
These are the thrilling
new listening experiences
that are released for your enjoyment
when you use quality components by Pickering.

PICKERING COMPONENTS

"for those who can hear the difference"





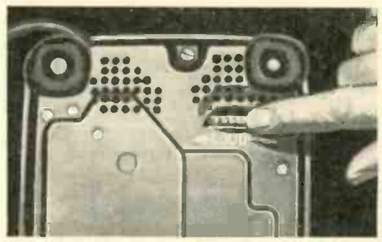
PICKERING *and company, incorporated*

● *Pickering High Fidelity Components are available through leading Radio Parts distributors everywhere; detailed literature sent upon request. Address Department A 1*

Oceanside, L. I., New York

It adds miles to your voice

New "500" telephone. It has already been introduced on a limited scale and will be put in use as opportunity permits, in places where it can serve best. Note new dial and 25 per cent lighter handset.



Adjustable volume control on bottom of new telephone permits subscriber to set it to ring as loudly or softly as he pleases. Ring is pleasant and harmonious, yet stands out clearer.

For years the telephone you know and use has done its job well—and still does. But as America grows, more people are settling in suburban areas. Telephone lines must be longer; more voice energy is needed to span the extra miles.

Engineers at Bell Telephone Laboratories have developed a new telephone which can deliver a voice ten times more powerfully than before. Outlying points may now be served without the installation of extra-heavy wires or special batteries on subscribers' premises. For shorter distances, the job can be done with thinner wires than before. Thus thousands of tons of copper and other strategic materials are being conserved.

The new telephone shows once again how Bell Telephone Laboratories keeps making telephony better while the cost stays low.

BELL TELEPHONE LABORATORIES

Improving telephone service for America provides careers for creative men in scientific and technical fields.

QUICK FACTS ON NEW TELEPHONE

Transmitter is much more powerful, due largely to increased sound pressure at the diaphragm and more efficient use of the carbon granules that turn sound waves into electrical impulses.

Light ring armature diaphragm receiver produces three times as much acoustic energy for the same input power. It transmits more of the high frequencies.

Improved dial mechanism can send pulses over greater distances to operate switches in dial exchange.

Built-in varistors equalize current, so voices don't get too loud close to telephone exchange.

Despite increased sensitivity of receiver, "clicks" are subdued by copper oxide varistor which chops off peaks of current surges.

Real Theater Sound in a Small Package

THOMAS R. HUGHES*

Part 1. The author, after years of analysis and desire, has reshuffled old facts and ideas to make a fresh approach.

To those who have followed the articles on loudspeakers and enclosures in radio magazines it must seem that the subject has long been exhausted. There are as many different suggested ways of enclosing speakers and as many extravagant claims for the set-ups as there are pages in the dictionary but we know that in many cases our ears and memory are just deceiving us.

The ears, after a good night's rest, are too ready to tolerate anything in the musical sound that is stimulating and different. But the very divergence of design and choice in speaker systems is proof that no satisfactory standard has been achieved.

The speaker system we have developed solves, for the first time, all of the speaker problems connected with high-quality music reproduction in the average size living room. This has been accomplished by a departure from the rut designers have been in for several years—that of trying to adapt theater-type speakers to living room use.

In order that you will not assume this is just another speaker enclosure that happened to charm the ears of its master, we ask you to bear with us in a thorough discussion of the principles involved, before we finally give you the details of construction and accomplishment.

* *3721 Hillcrest Drive, Los Angeles 16, California*

Our objective is to reproduce (as accurately as is physically possible) fine music, of all types, in the average size home. The problems which have to be solved for most of us are: the high cost of available systems; their large bulk and difficulty of fitting into the decorative scheme; the problem of having to operate recommended systems at too high a volume level in order to achieve the effect called "presence"; the problem of obtaining life-like definition of instruments and effects when the musical score explores a polyphony of superimposed parts and melodies: and lastly the problem of extra amplifier capacity required for the available high-quality systems.

Engineers conquered the problems of adequately reproducing fine music in the theater many years ago, but there has been a lack of realistic approach to the needs of the normal home listener. Having played in both symphony and dance orchestras in younger years and being an engineer by profession, the writer has been struggling with these problems for many of his older years. Having dozens of music-loving acquaintances who would be in the market for the proper article, if it were available, we determined to develop a stock item that could be moved into any room without disrupting it. Since the problems are so interwoven, we will not take up their solution in any regular sequence but will refer to them at relevant points.

Fig. 1. The completed three-horn corner reproducer in a typical living-room setting.

A Fresh Approach

The solution of all our problems starts with the proper generation of the lower frequencies and here is where we part company with the designers and authorities. We are not so interested in a flat response down to 40 or 50 cps because musical scores rarely call for fundamentals so low, nor do orchestras or ears provide a flat response. What we demand is the clear generation of the full harmonic structure of the cello, with its rugged vigor, or that of the bassoon, with its alluring intensity, and the jungle vibrance of the marimba bass notes.

Someone has said that most speaker designers listen to music through their slide rules. However, the effects we are interested in can not be distinguished by instruments in a laboratory. Furthermore, they are difficult to achieve in the home with normal speakers. So we will give you our specifications for simple solution.

In spite of the fact that many folded-horn corner-speaker enclosures are being built for home use with 15-in. woofers, the sales points for a large woofer are only applicable when it is used in a box or baffle enclosure. And it should never be used for symphonies in an average size living room.

Where it is used in a bass-reflex cabinet or any other box resonator, the prime objective is to have the natural lower cone resonance fall below the cutoff point of the program material. This can only be accomplished with a large cone of careful design. But, with horn loading of our woofer, we are not much concerned with resonant points because a horn levels them out to a great extent and still maintains acoustical coupling below these points.

On the other hand, there are many factors against the use of the large woofer in a home installation. The most important one is that, when it is worked at its intended amplitude, it produces outraged cries from family and neighbors. You don't get the robust timbre of bass instruments or singers from a large speaker that is just coasting along at comfortable room level.

Another factor against the large woofer is its cost. If you are determined to hear and feel the impact of that bass drum beat and you open up the input to your big cone, you will have to have a heavy field magnet for proper attack and decay at full amplitude. That's when the cost starts mounting but that isn't the main factor in the cost of a really fine woofer of theater proportions. Unless many details are considered in proper shaping, strengthening, and suspending of the large cone, you will not get a clean attack and decay—even with the heavy field magnet.

These are problems you have to accept in producing adequate volume for a theater or auditorium. but why should the home owner have to be saddled with them? By the use of a small, light, but stiff cone, we have avoided all these difficulties to a great degree.

Therefore, we will start with a woofer which has a small hard cone—not over an 8-in. nominal size with a 6-in. effective working diameter. Phenolic impregnated paper works very well for the material of the cone. The angle its surface forms with the axis is smaller than in the normal speaker because we are not concerned with direction of sound projection. In other words, it is a steep cone.

This is contrary to all the literature on the subject, but we want it to work as a piston right up to the 1000-cps crossover, and only a small cone will do that. When a larger cone is used, it ceases to work as a piston at much lower frequencies, and trouble is likely to be encountered with spurious vibrations in the walls of the cone, producing subharmonics and the familiar buzzing on sustained low notes.

To drive the cone, we use a voice coil with a relatively large diameter for an 8-in. speaker—not less than 1¼ in. and preferably 1½ in. or larger. This places the thrust more nearly in line with the outer suspension ring and, with the steeper sides of the cone, prevents generation of subharmonics. The coil is round copper wire, as we are more concerned at low frequencies with low resistance to signal currents and proper heat dissipation than we are with mass.

Another important feature of our speaker is its heavy magnetic field. The first woofer we used consisted of the field pot from an old RCA 104 loudspeaker, with a new cone made of phenolic-impregnated paper. This was an electromagnetic speaker which required around 25 watts of field excitation.

Both the spider and the outer surrounding suspension ring must be freely compliant to avoid distortion from mechanical nonlinearity. However, the outer surround must be sufficiently tough to endure the rigorous punishment it receives, since the stiff cone does not absorb any of the flexing as an ordinary felted paper cone would. A ring of imitation leather similar to plastic materials used in upholstering makes an excellent surround.

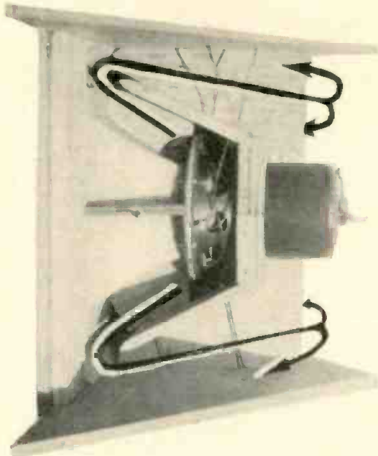


Fig. 2. View of the structure described by the author in early stage of construction. The back wave from the cone passes to the front of the cabinet, back around a partition to the rear, thence out through the side passages shown in Fig. 1, as indicated by the arrows.

Harnessing the New Creature

The loading of this driver is accomplished with two horns. The outer mounting ring of the speaker frame bolts to the sheet metal horn, pictured along with the speaker. This horn has a 4½-in. square throat and an exponential flare that doubles in area every 1¾ in. of axial length and ends in a mouth about 13 in. square. From the formulas for exponential flare and size of mouth opening, it is seen that this gives a low-frequency cutoff at around 450 cps.

Since the woofer is designed to work as a more-or-less rigid piston throughout its range, its response falls off rapidly for signals at much above 1000 cps, but the dividing network is designed for 1000-cps crossover. Thus the working range from this center horn is approximately 450 to 1000 cps.

The back of the woofer is loaded with a folded horn which depends on the walls and floor at the corner of a room for extension of its mouth and flare. Designers know from long experience that frequencies above 450 cps will not follow the tortuous path of a folded horn, so this horn handles the frequencies from 450 cps down to the lower extremity of its response.

Speaker expense is held to a minimum by the absolute simplicity and foolproof design of the woofer. It sounds too simple and easy to construct but it really works. And, for use in a small house, any good low-priced horn tweeter can be matched to it.

We are not concerned with direction of sound projection in a normal living room for it bounces off the walls at us from all directions. And, when the speaker system is placed in a room corner, there is no use in talking about 120-deg. spread of a multihorn tweeter, because the walls only allow 90-deg. spread.

Advantages of Horn Loading

The greatest advantage of a horn over all forms of boxes and resonators is the much smoother response curve with its freedom from sharp peaks and dips as different frequencies are reached. The only difficulty of reproduction or transmission by horns is in the natural nonlinearity of the air column when the greater amplitudes of the low frequencies are impressed upon it.

The nonlinearity of air coupling applies equally to any form of box or resonator. At the same time there is trouble in boxes and resonators from both the mechanical resonance points of speakers and the acoustical resonance points of enclosed air, as well as that of standing and reflected waves. Standing waves are set up by the meeting of equal waves reflected from opposite sides of an enclosure, such as a bass-reflex cabinet.

Standing waves are only produced when the wave length is shorter than the internal dimensions of the enclosure and when the sides of the enclosure are parallel. Thus, it is easy to produce standing waves in a living room with two bare walls facing each other and the speaker axis parallel and centrally spaced with these walls. Standing waves produce overemphasis or de-emphasis of certain harmonics so that a clear rounded voice or tone structure is not heard.

Reflected waves at high frequencies (the wavelength shorter than the internal dimensions of the box) cause distortion within any enclosure because they are out of phase with the direct-radiated frequencies. Thus the box must be lined with loose hair felt or other acoustical material which will effectively trap such unwanted high frequencies within the box. The larger the enclosure the more out of phase these paths become and the more important their trapping becomes. This is especially true in a labyrinth passage for a single wide-range speaker.

But we are not concerned with either standing or reflected waves in our system because we don't generate any short wavelengths within our large horns. The shortest wavelength that can be generated at the crossover region is slightly under one foot, and could cause none of these troubles in the small passages of the folded horn. It is the combination of low crossover frequency, horns, and corner position in the room that removes these problems.

Before you can appreciate the happy set of circumstances which makes this design so ideal for music reproduction

[*Continued on page 58*]

The Wide Range R-C Oscillator

LEWIS S. GOODFRIEND*

A description of a practical instrument built on the principle of the Bridged-Tee oscillator developed at the National Bureau of Standards.

SOME TWO YEARS AGO the National Bureau of Standards issued a news release on an oscillator developed in their laboratory by Peter G. Sulzer. This writer built two versions of the circuit and has tested the second one for about a year under both shop and laboratory conditions. The major features of the circuit are: a range, with small phase shift, from 20 cps to 2 mc; low output impedance; good frequency stability; compactness; and constant output voltage. At least that is what the release claimed for the circuit. All the claims were finally achieved but not without considerable care. When finished, however, the Sulzer oscillator has provided a useful laboratory instrument for checking wide-range audio circuits which were formerly checked with two oscillators. Mr. Sulzer has discussed elsewhere the specific design advantages of the bridged-Tee over other R-C circuits for the purpose of frequency control of oscillators.[1]

The original news release showed a circuit using two 6AG7 tubes and stated that the oscillator might be mounted in a cabinet with a small power supply and an output amplifier, if proper shielding were employed. This circuit is shown in *Fig.* 2. It was built as shown and was tested with an external power supply. It proved to have all the features that were claimed for it but required the use of a wide-band buffer amplifier stage between the oscillator and the load or circuit under test to prevent varying output loads from causing both frequency and level changes. To be effective the amplifier must have about the same characteristics as the second stage. Therefore the second stage was duplicated and added to the original circuit. At this point the plate and filament current requirements were increased by fifty per cent. A power supply transformer to supply 67 ma at 250 v. for three 6AG7's is not small, nor are the rest of the components. It was decided to examine the circuit for possible changes which might permit a reduction in both plate and the filament currents. Since the second tube as a cathode follower must feed a varying impedance—the Bridged-Tee network—without a change of output level, it was deemed unwise to modify the circuit at that point. The output tube faces a similarly varying load since it is called upon to operate into a wide variety of systems that have a wide range of impedances. This leaves only the front end. Here, however, all that the tube must supply is gain. A quick look at the characteristics of the 6AC7 and the 6AG7 shows that the 6AC7 draws less than half the plate current of the 6AG7, but has only 82 per cent of the gain of the larger tube and slightly less output capacitance. The use of careful interstage wiring will allow the use of the smaller tube even with the requirement of a larger plate resistor to maintain the stage gain. The saving in capacitance is important because the second tube is a cathode follower. Thus the interstage capacitance is made up mainly of the first stage output capacitance. Actually, gain is not the whole story. The high-frequency phase shift is important also, but if the R-C product remains the same there will be no change in phase shift either. The substitution was made along with the required changes in first stage circuit parameters. The final circuit with the modified first stage is shown in *Fig.* 3.

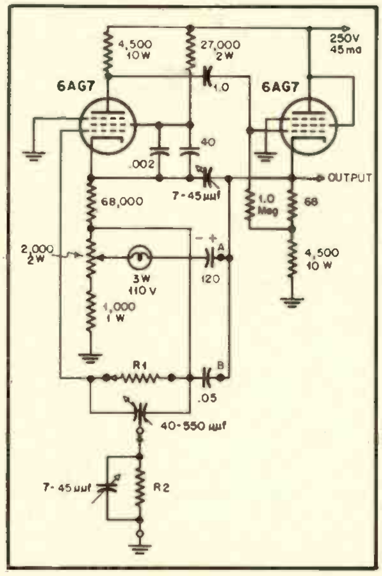


Fig. 2. Original circuit described in a report from the National Bureau of Standards.

The Components

The most important part in this oscillator is the variable capacitor. It has two sections each having a nominal range of 40 to 550 μμf, but capacitors of this range are hard to find. The minimum capacitance of some of the variable capacitors examined was frequently very small, and if they are used must be padded out to about 40 μμf or more so that the tuning range will make maximum use of the angular motion of the capacitor. If the capacitance does reach extremely small values, and the two halves of the variable capacitor are not closely matched, erratic operation may

[*Continued on page 68*]

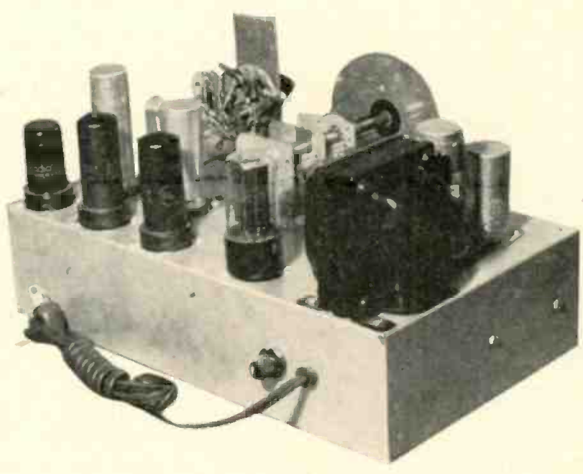


Fig. 1. The author's version of the Bridged-Tee oscillator in chassis form.

* *404 Riverside Drive, New York 25, N. Y.*

[1] Peter G. Sulzer, "Wide range R-C oscillator," *Electronics*, pp. 88, 89, Sept. 1950.

Circle Diagrams for Resistance-Capacitance-Coupled Amplifiers

OLAN E. KRUSE*

A discussion of the circle diagram method for the solution of certain amplifier problems encountered in the design and analysis of amplifiers.

DESIGN AND ANALYSIS procedures for resistance-capacitance-coupled amplifiers are available in most textbooks on electronics. A convenient circle diagram method for design and analysis will be developed.

Figure 1 shows a conventional single-stage resistance-capacitance-coupled amplifier and its low- and high-frequency equivalent circuits. In the circuits of *Fig.* 1, r_p represents the plate resistance, C_s is the plate-circuit wiring capacitance to ground plus the plate-to-cathode capacitance of the amplifier tube and the input capacitance of the succeeding stage, and R_g is the grid circuit resistance of the succeeding stage.

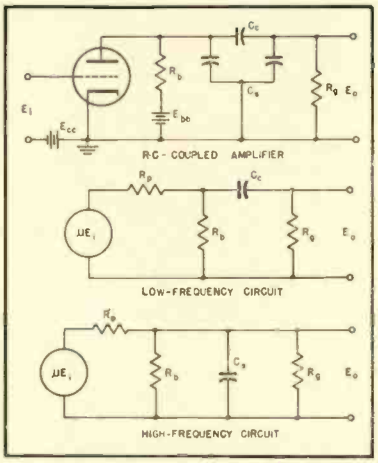


Fig. 1. Resistance-capacitance-coupled amplifier circuits, with equivalents for high and low frequencies.

Low Frequency Circle Diagram

It may be shown that the amplification at low frequencies as derived from the low-frequency equivalent circuit of *Fig.* 1 is given by[1]

$$A_l = \frac{-g_m R_p}{1 - j\dfrac{1}{\omega C_c R_e}} \qquad (1)$$

where R_p is the equivalent resistance of r_p, R_b, and R_g in parallel; R_l is the total resistance measured from the terminals of C_c and is the equivalent of R_g in series with the parallel combination of r_p and R_b; g_m is the grid-to-plate transconductance of the tube used; and ω is the angular frequency in radians per second, i.e., $\omega = 2\pi f$, where f is the signal frequency in cycles per second. Eq. (*1*) may be written as

$$\frac{A_l}{-g_m R_p} = \frac{1}{1 - j\dfrac{1}{\omega C_c R_e}} \qquad (2)$$

Letting $T = C_c R_e$ and rationalizing the denominator of Eq. (*2*) gives

$$\frac{A_l}{-g_m R_p} = \frac{\omega^2 T^2 + j\omega T}{1 + \omega^2 T^2} \qquad (3)$$

Multipling both members of Eq. (*3*) by T^{-1} yields

$$\frac{A_l T^{-1}}{-g_m R_p} = x + jy = \frac{\omega^2 T^2}{1 + \omega^2 T^2} T^{-1} + j\frac{\omega T}{1 + \omega^2 T^2} T^{-1} \qquad (4)$$

from which

$$x = \frac{\omega^2 T^2}{1 + \omega^2 T^2} T^{-1} \qquad (5)$$

From Eq. (*4*) it follows that

$$\sqrt{x^2 + y^2} = \sqrt{\frac{\omega^2 T^2}{1 + \omega^2 T^2} T^{-2}} \qquad (6)$$

Squaring both members of Eq. (*6*) and employing Eq. (*5*) yields

$$x^2 + y^2 = \frac{\omega^2 T^2}{1 + \omega^2 T^2} T^{-2} = T^{-1} x \qquad (7)$$

By rearranging, Eq. (*7*) may be put into the form

$$(x - \tfrac{1}{2}T^{-1})^2 + y^2 = \tfrac{1}{4}T^{-2} \qquad (8)$$

Eq. (*8*) is the equation of a family of circles whose parameter is T, with centers on the X axis $\frac{1}{2}T^{-1}$ units to the right of the origin, with radii of $\frac{1}{2}T^{-1}$ units, and passing through the origin. Each circle may be thought of as a "constant-T" circle. There then exists a "constant-T" circle for the low-frequency end of every resistance-capacitance-coupled amplifier. It follows that any resistance-capacitance-coupled amplifier must, at low frequencies, operate on its own "constant-T" circle.

The existence of the "constant-T" circle would be of no value by itself. However, a set of "constant-ω" circles will be derived and the combination of the two families of circles will prove to be of considerable value. The relative phase angle at low frequencies, ϕ_l (as related to the mid-frequency phase), is, from the definition of the phase angle and Eq. (*4*), given by

$$\phi_l = \arctan\frac{y}{x} = \arctan\frac{1}{\omega T} \qquad (9)$$

From Eq. (*9*) it follows that

$$T^{-1} = \frac{\omega y}{x} \qquad (10)$$

Substituting the expression for T^{-1} given by Eq. (*10*) into Eq. (*7*) yields

$$x^2 + y^2 = \omega y$$

or, transposing ωy and adding to both members $\frac{1}{4}\omega^2$ gives

$$x^2 + (y - \tfrac{1}{2}\omega)^2 = \tfrac{1}{4}\omega^2 \qquad (11)$$

Eq. (*11*) is the desired family of "constant-ω" circles. These circles pass through the origin, have their centers on the positive Y axis removed from the origin by a distance $\frac{1}{2}\omega$, and have radii equal to $\frac{1}{2}\omega$.

Figure 2 is a first-quadrant plot of Eqs. (*8*) and (*11*) with appropriately chosen ranges of T and f (for convenience, "constant-f" circles are used instead of "constant-ω" circles, being obtained from the relation $f = \frac{\omega}{2\pi}$). The radial lines shown give relative phase angle and low-frequency amplification relative to the mid-frequency amplification.

The circle diagrams may be used for both analysis and design. For example, in the case of analysis one may know T for a particular amplifier (recall that $T = C_c R_l$) and wish to determine the lower half-power frequency. Since the relative phase angle at the lower half-power frequency is 45 deg., and since the amplifier must operate on its "constant-T" circle, it follows that the intersection of the 45-deg. line and the appropriate "constant-T" circle will determine the "constant-f" circle from which the lower half-power frequency is obtained. By using the circle diagrams the amplification and relative phase angle may be determined for any desired f, and, conversely, it is easy to find the frequency at which the amplification or phase angle is any specified value.

* *Dept. of Physics, Stephen F. Austin State College, Nacogdoches, Texas.*

[1] See, for instance, Cruft Electronics Staff, "*Electronic Circuits and Tubes,*" McGraw-Hill Book Co., 1947.

High-Frequency Circle Diagram

By employing the high-frequency equivalent circuit of *Fig.* 1 it may be shown[1] that the high-frequency amplification of a single-stage resistance-capacitance-coupled amplifier is

$$A_h = \frac{-g_m R_p}{1 + j\omega C_s R_p} \qquad (12)$$

Let $T = R_p C_s$. Then by rationalizing, Eq. (*12*) may be witten as

$$A_h = -\frac{g_m}{C_s}\left(\frac{T - jT^2\omega}{1 + \omega^2 T^2}\right) \qquad (13)$$

or

$$\frac{A_h C_s}{-g_m} = x + jy = \frac{T}{1 + \omega^2 T^2} - j\frac{T^2\omega}{1 + \omega^2 T^2} \qquad (14)$$

from which it follows that

$$x = \frac{T}{1 + \omega^2 T^2} \qquad (15)$$

From Eq. (*14*) we may write

$$\sqrt{x^2 + y^2} = \sqrt{\frac{T^2}{1 + \omega^2 T^2}} \qquad (16)$$

Squaring both members of Eq. (*16*) and employing Eq. (*15*) gives

$$x^2 + y^2 = Tx \qquad (17)$$

By transposing Tx and adding $\frac{1}{4}T^2$ to both members of Eq. (*17*), we have

$$(x - \tfrac{1}{2}T)^2 + y^2 = \tfrac{1}{4}T^2 \qquad (18)$$

Eq. (*18*) is the equation of a family of circles whose parameter is T, with centers $\frac{1}{2}T$ units to the right of the origin on the X axis, with radii of $\frac{1}{2}T$ units, and passing through the origin. This family of circles may be thought of as a family of "constant-T" circles similar in sense to the "constant-T" circles derived for the low-frequency case.

Again, as in the low-frequency discussion, a family of "constant-ω" circles will be obtained. The relative phase angle is, from the definition of relative phase angle and Eq. (*14*),

$$\phi_h = \arctan\frac{y}{x} = \arctan(-T\omega) \qquad (19)$$

from which it follows that

$$T = -\frac{y}{\omega x} \qquad (20)$$

Substituting Eq. (*20*) into Eq. (*18*) and simplifying yields

$$x^2 + \left(y + \frac{1}{2\omega}\right)^2 = \frac{1}{4}\left(\frac{1}{\omega^2}\right) \qquad (21)$$

Since ω is the parameter in the family of circles given by Eq. (*21*), it follows that the circles are "constant-ω" circles. The circles pass through the origin and are centered $\frac{1}{2\omega}$ units below the origin on the Y axis.

Figure 3 is a fourth quadrant plot of Eqs. (*18*) and (*21*), covering ranges of f (again "constant-f" circles are substituted for the "constant-ω" circles) and T typical for resistance-capacitance-coupled amplifiers. Also shown in *Fig.* 3 are radial lines indicating relative phase angle and normalized magnitude of the

[*Continued on page 51*]

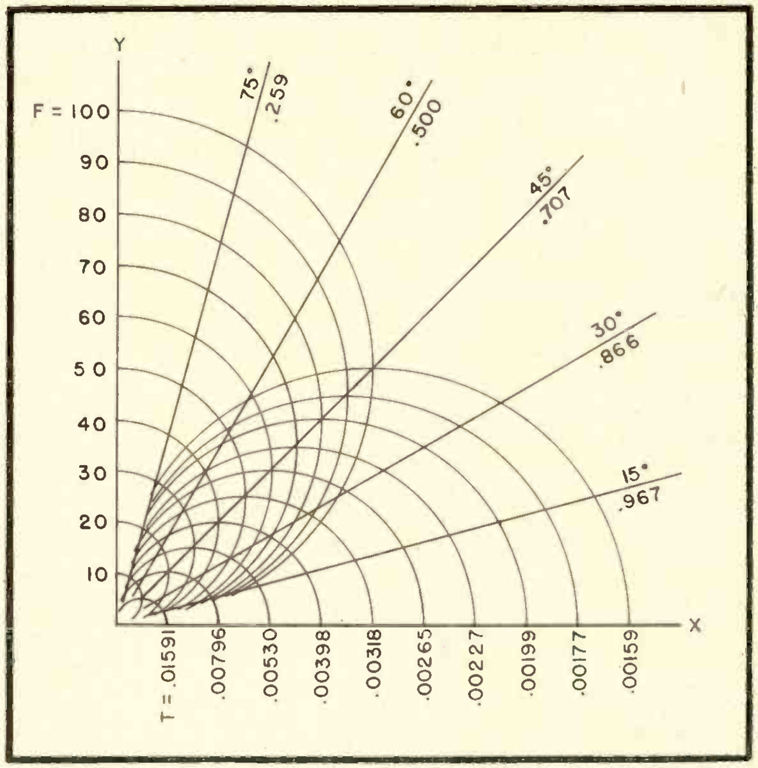


Fig. 2. Low-frequency circle diagram.

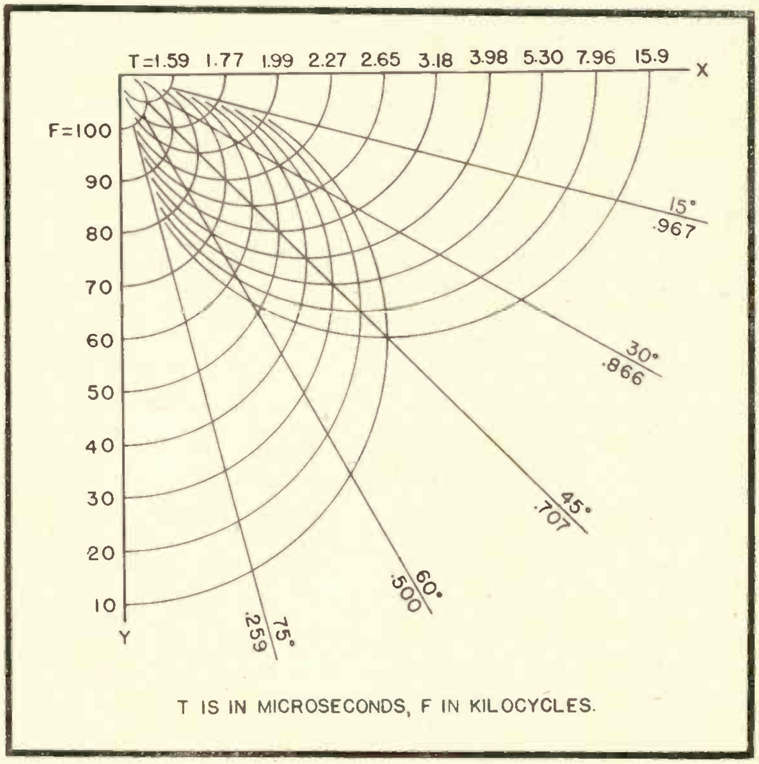


Fig. 3. High-frequency circle diagram.

Binaural Public Address

CHARLES F. ADAMS*

Opening a new vista for further expansion of binaural sound reproduction to p.a. applications, the author relates his experiences with one such installation.

WHETHER ONE WORKS with sound as a hobby, as a business, or as a part time occupation, eventually there arrives that one certain occasion on which even the best will not be quite good enough.

For the winter this occasion was the presentation of a musical not only performed by local talent, but with story, lyrics, and music written and composed by local people. The plot—based on the nearby construction of a huge dam—the lyrics, and the music, all fitted together so perfectly it was immediately apparent that mikes not only would have to be hidden on the stage, but so arranged as to avoid motivation of characters. Studio or minstrel type pick-up would spoil the story.

Conventionally, a compromise with all the factors involved would require three hidden mikes, and probably two hung above stage for full chorus. Six scene changes, all as rapid as possible, indicated cable trouble and probable mike damage.

As plans progressed, difficulties assumed considerable proportions. Somewhere along the line Mr. Canby's articles on binaural tape recording became positively fascinating. Why not binaural public address? Two mikes suspended about 20 in. apart somewhere above stage, each feeding a separate amplifier and speaker, and, presto! what might prove the perfect answer to a very trying set of requirements.

Two identical, highly directional mikes equipped with shields, two 30-watt amplifiers, and two speaker systems were installed in the high school auditorium a couple of days before rehearsals were scheduled to start. The amplifiers were arranged on a table to the right of the stage. The mike on the right was connected to feed the amplifier driving the speaker on the right; the other mike, of course, fed the remaining amplifier and speaker.

For the first test the two mikes were placed about 20 in. apart on the front of the stage just back of the footlights with the stands extended about seven feet off the floor. The gain on both mikes was then advanced to a conventional level. Immediately the auditorium came alive with sound. Workers on the stage who were putting up scenery, lighting, and other accessories could be distinctly heard. Even the slight noise made by the rubbing of a pair of overalls against a step ladder was clear and natural. All of the sound seemed to come directly from the stage, unless the listener were in an area of about ten to fifteen feet immediately around each speaker. In this section speaker projection was audible at a level somewhat below that which seemed to come from the stage. Actually it was more in the nature of "directed" sound rather than the "natural" sound heard in other parts of the auditorium.

With one mike cut off the familiar pattern of hollowness and reverberation occurred; those near the single mike riding above everything else as in a typical single-channel pickup. The effect of cutting the second mike in and out was so startling that everybody had to take time out and listen.

* *1107 Mulberry Road, Martinsville, Va.*

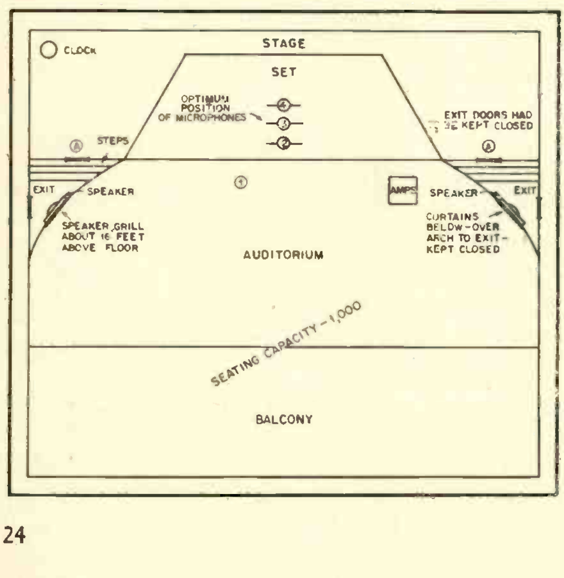


Fig. 1. Floor plan of the auditorium and stage in which the author conducted his experiments.

Second Attempt

In the second test run the mikes were suspended just above the inside edge of the front stationary curtain, approximately 18 ft. from the stage floor with the mikes tilted about 45 deg. In this position the sound pickup was slightly less than that of the first run. Increased gain was indicated which at once brought up the problem of feedback.

It developed that this was not at all the obstacle anticipated. The point at which feedback began, while far more critical than with single-channel operation, still was appreciably advanced beyond the level possible with a single mike. Even the slightest advance beyond this certain point, however, resulted in feedback of a peculiarly penetrating nature. Equally interesting was the fact that a level just slightly below this position was safe regardless of the level of noise or shouting on the stage.

Soon it became apparent that one's position on the stage did not materially affect the volume of reproduced sound. The difference in level from extreme right to extreme left, and from back stage to the footlights was negligible. A fairly quiet clock placed in the far corner of the stage could be heard clearly in every part of the auditorium.

Even had the auditorium been blessed with an orchestra pit, it became reasonably certain after further tests that the mike position behind the edge of the front stationary curtain would not be tenable. The orchestra would almost certainly cover even those singers with plenty of volume and resonance. This premise was essentially correct with the exception that it was surprising how well the voices came through.

Keeping the mikes about 18 ft. off the stage floor, they were next tried about six feet upstage with the angle of tilt and shields the same. From this point the pickup of the solo singers was appreciably better as to balance with the orchestra, but still not sufficient for a youngster with a solo part whose voice, while clear and of reasonably good quality, had very little resonance or volume. After considerable experimentation a position about half way between the footlights and the back of the stage (position 4 on sketch) was judged to be optimum as far as front to back was concerned. Further movement toward the rear wall gave a curious and not quite describable reflection of sound.

Over the range from 16 to 18 ft. above

[*Continued on page 49*]

A Simplified Program Switching Panel

HAROLD REED*

For installations where the cost and complexity of more complicated switching arrangements are not warranted, this system may be found advantageous.

COMMERCIAL TYPE program switching or dispatching panels are quite costly, and although the system described in this article is not equipped with relays and indicating lights, nor is otherwise as elaborate as those purchasable, it nevertheless offers flexibility, ease of handling, and low cost, and it has performed without failure over a number of years. The majority of radio stations are not engaged in Radio City type of operations, and therefore, the elaborateness of the expensive units is usually not required.

The switching system presented here is built around the Western Electric type 553-A key and can be mounted on a seven-inch standard relay rack panel. This key actually consists of four keys built up on a supporting strip and having five buttons, the fifth of which is the OFF position. Mechanically interlocking, all plungers lock in the operated position, but operation of any one plunger releases any other operated plunger. In this way, any one of four program sources may be selected and dispatched to its scheduled destination. The OFF button releases all plungers, preventing any program material from passing through the key strip to the circuit across the key output. This key is a reliable, high-quality mechanism and can be depended upon to give efficient service in this application. To dispatch six program sources to output circuits or lines, the 554-A key can be used. Incidentally, these keys have recently been advertised by surplus parts distributors.

A diagram of the complete system is given in *Fig.* 1. The 600-ohm outputs of the studio control consoles are each terminated in 600-ohm resistive loads. Line amplifiers with high-impedance bridging inputs are employed. Any one or all line amplifiers can be switched across any of the four console outputs. Each 600-ohm line-amplifier output terminates in a 600/600 resistive H pad, providing 6 db attenuation for line isolation. The pads are followed by repeating coils or transformers connected for 600-ohm impedance facing the pad. The line side of the coil can be strapped for 600 or 150 ohms according to the requirement. Coils similar to Western Electric 119C should be employed. Jacks facing inputs and outputs of all component parts of the system contribute to further flexibility, and in case of failure in any unit, the defective part can be isolated by means of patch cords and an equivalent section in another unused branch of the system can be patched into the branch in trouble. In *Fig.* 2 is presented some detail of the wiring of one switch strip, with the front panel designation shown in *Fig.* 3. Console output-level variations when switching from one up to four of the line amplifiers across these outputs, is within 1.0 db.

* *Chief Engineer WOL, WOL-FM, 1000 Connecticut Ave., N.W., Washington, D. C.*

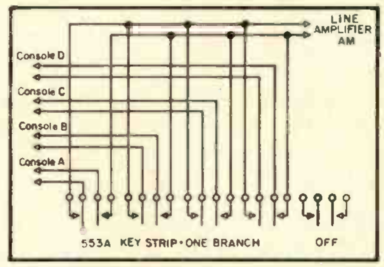


Fig. 2. Wiring of each 553A key strip follows the plan shown. As many as necessary may be used together.

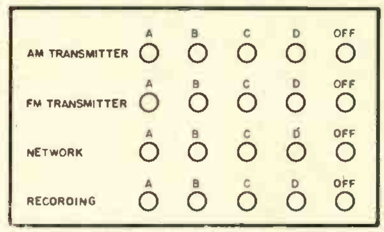


Fig. 3. Arrangement of front panel, with four key strips mounted together. Letters above buttons designate studio consoles, and designations to left indicate channels being fed. One or all consoles can be fed to one or all lines.

Proper level to each line is maintained with a VU meter bridged across each line-amplifier output. One or more monitor amplifiers are also across these outputs. For simplicity in *Fig.* 1, a monitor amplifier is shown across only the AM transmitter leg. The inputs of the monitor amplifiers must, of course, be of the high-impedance, bridging type, or a separate bridging coil can be employed for feeding into an amplifier having a low input impedance. The loudspeakers being fed by these monitor amplifiers are equipped with selector switches so that any of the four channels may be monitored at will. Terminating resistors, equivalent to the load represented by the speaker transformer are automatically substituted for the speaker to effect a constant load across each monitor amplifier, avoiding volume-level variation, which would occur with speaker switching.

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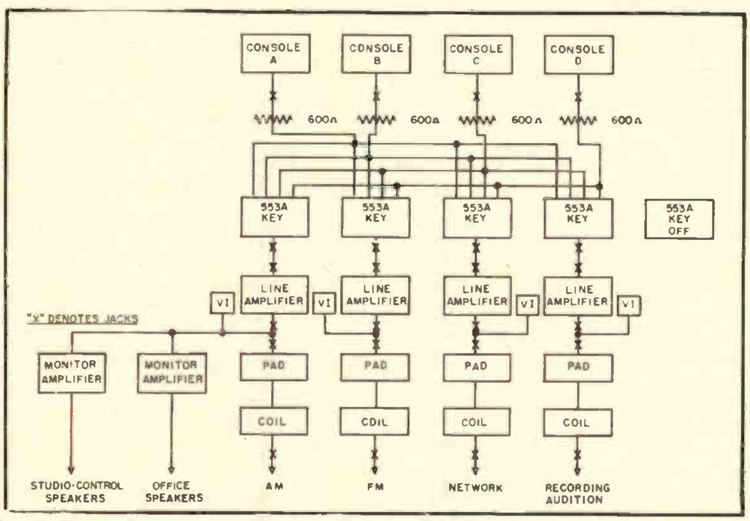


Fig. 1. Block schematic of equipment typically used in a studio, together with the output circuits required.

Audio Transformer Design

N. H. CROWHURST*

Continuing his discussion of transformers, the author covers several less known considerations in the arrangement of windings to obtain good performance over the entire audio-frequency spectrum.

POWER TRANSFORMER design has long since been reduced to a scientific process based on well established principles of economics. Only comparatively recently, however, has the appreciation begun to dawn on many transformer manufacturers that audio transformer design can be reduced to a similarly exact art.

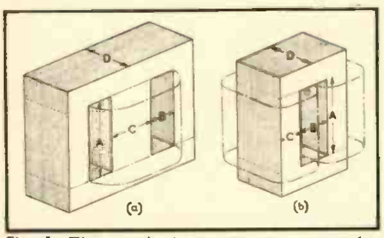


Fig. 1. The two basic core arrangements for audio transformers, with dimensions used for economic comparison indicated. (These shapes can also apply to C-core construction.)

The earlier method and one still used by quite a number of manufacturers was to work on a convenient rule of thumb. Any new design required was worked out as a kind of logical compromise based upon previous designs—"we used 10,000 turns on transformer A which was such and such a size and 6,000 turns on transformer B which was so much smaller, so 8,000 turns should be about right for this job," was typical of the kind of reasoning used. The important aspect of economics—comparison on a cost basis—has always been in the background with successful enterprises, but there are other aspects which need consideration to produce the best products of any particular type.

Choice of Core Shape and Material

The first step in the design of a transformer is the choice of a suitable core shape and material. The best shape to use will depend upon: the type of transformer; whether frequency response, efficiency, or working signal level are the predominant factors in the design; whether or not the core will be polarized by unbalanced d.c.

The two basic forms of core construction are shown at *Fig.* 1, the position occupied by the winding being indicated by chain dotted lines. Although both arrangements are pictured as built up of stampings, either of them can also be applied to C-core construction. The essential dimensions as referred to in the graphs given in this article are clearly marked.

If the transformer is to provide the maximum energy transfer in the available space, *Fig. 2* shows suitable relative dimensions plotted against the relative cross section of winding and core, B/C. It will be noticed that the combination of values given represent elongated window shapes and large stacks of laminations. These proportions are based upon perfect winding facilities and the assumption that no space is lost due to the tendency of the wire to remain curved on inside corners. In practice this tendency will slightly modify the ideal dimensions.

Figure 3 shows the economic proportions for achieving maximum frequency band when d.c. components are balanced so the core is not polarized, based on the ratio of primary inductance

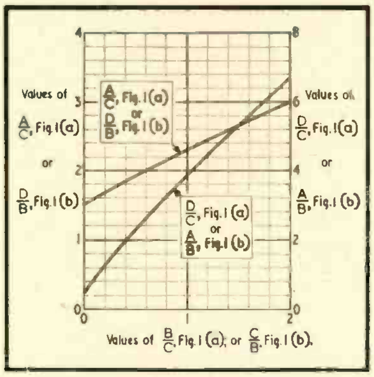


Fig. 2. Theoretical economic proportions of cores for maximum energy-transfer efficiency.

to leakage inductance of a simple layer-wound transformer. This does not take into consideration the effect of winding capacitance—no general presentation could be derived to include this because of the variety of winding forms that can be adopted for reducing both leakage inductance and winding capacitance, and the variation in relative importance of these quantities with individual applications. As a general principle, a smaller component gives the best chance of reducing over-all winding capacitances.

Figure 4 shows the economic proportions for components where d.c. polarizing is present. These proportions are based upon the attainment of specified inductance in a given physical bulk with maximum efficiency.

Another factor that may influence choice of core shape and material is the maximum signal level. The core must be able to handle this at the lowest frequency required without producing distortion due to saturation of the core. Where a large component is no disadvantage for other purposes, a large cross section of ordinary-grade transformer iron provides the simplest and cheapest solution. For some applications, size and/or weight may be of importance in the over-all design of the equipment, while size can also adversely affect available frequency response at the high-frequency end particularly where step-up to a high impedance is required. In such cases, it is advisable to use one of the special alloys developed for high maximum flux density.

At the opposite extreme, transformers required for low-level input circuits

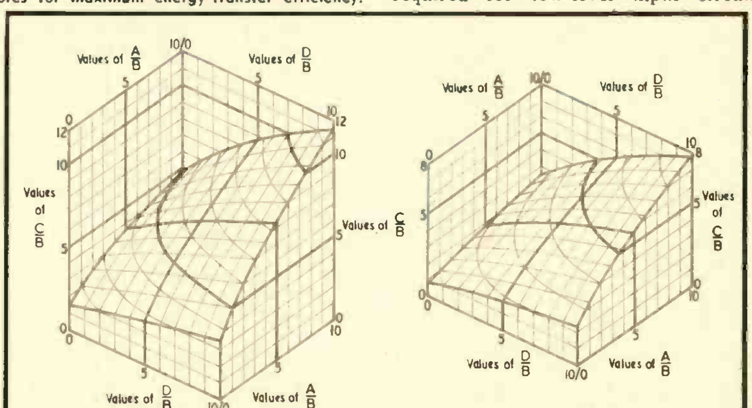


Fig. 3. Economic proportions for maximum ratio of primary inductance to leakage inductance.

* 82, Canterbury Grove, West Norwood, London, S.E. 27, England

should use a core material providing maximum initial permeability. Special alloys are available for this purpose.

Components required to carry appreciable polarizing d.c. will usually gain little by using an expensive core material. Ordinary transformer iron is usually the economic choice for these.

Another feature influencing choice of core may be the necessity for providing maximum discrimination against stray field pick-up. Astatic construction, using the arrangement of (b) in *Fig.* 1, with both windings of the transformer equally divided on both limbs, gives best possibilities in this direction. Where this requirement is not present, the construction of (a) will usually provide maximum efficiency and the best possibility of wide frequency range, whether laminations or C cores are used.

Toroidal construction is technically better than either of the constructions shown at *Fig.* 1 but has the disadvantages for the majority of applications of greater cost and bulk. The more conventional designs lend themselves to more compact construction.

Winding Arrangement

Having chosen a suitable core, the next question is how to arrange the winding. *Figure* 5 shows the two basic arrangements of winding disposition applied to the core of (a) in *Fig.* 1. For audio transformers a low value of leakage inductance combined with high primary inductance is always a necessity, for which purpose the layer arrangement of (a) in *Fig.* 5 is invariably many times better than the slab arrangement of (b). Each winding may be further sectionalized in order to provide improved coupling, particularly at the high frequencies.

Sectionalizing can influence two of the electrical properties of the transformer which exert a control on high-frequency response in varying proportions with different applications: leakage inductance and winding capacitance.

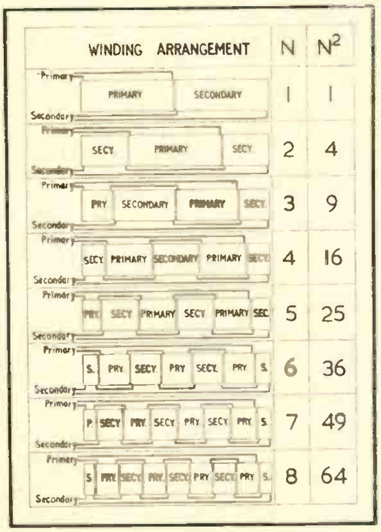


Fig. 6. Economic sectionalizing arrangements for producing a maximum reduction of leakage inductance. N signifies the effective reduction of spacing thickness between sections, and N² the effective reduction in total winding depth.

Reducing Leakage Inductance

To reduce leakage inductance only one method of sectionalizing has any effect —sandwiching the windings. The first step is to divide one of the windings into two equal parts and place one half below and the other above the other winding. The next step is to divide one winding into two parts and the other into three. Sometimes the winding divided into three parts uses equal parts, but this is not the best arrangement for leakage inductance reduction; the part sandwiched between the other winding should be half of the total turns in the winding, the other two parts each being quarters.

Figure 6 shows a succession of economic arrangements from the viewpoint of leakage inductance reduction. Series connection is shown for simplicity. Parallel or series/parallel connection will not alter the over-all leakage inductance referred to a specific number of turns.

In the simple arrangement where each winding is in one section, the effective leakage flux path cross section is one-third of the total winding depth, plus the thickness of insulation between the windings. Usually the thickness of insulation between the windings is negligible compared to one-third of the total winding thickness, so its relative effect on leakage inductance can be ignored. As the windings are split successively into more sections, the effective winding thickness is divided by the factor N^2. The thickness of the effective space between windings is equal to the thickness of each layer of insulation between sections divided by N. Values of N and N^2 are shown in Table I. These figures mean that if the winding occupies the same total space and the same insulation thickness is always used between winding sections, the original total winding thickness and insulation thickness can be divided by the factors shown and the results added to give the effect of the arrangement on leakage inductance.

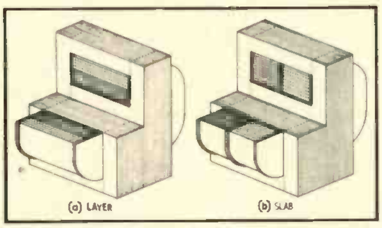


Fig. 5. The two basic dispositions of windings. The layer arrangement at (a) results in very much lower leakage inductance than the slab arrangement of (b).

Example: Total winding thickness 0.75 in., and insulation thickness .02 in., then the leakage flux cross-section for the simple winding is 0.25 in. plus .02 in., a total of 0.27 in. An arrangement giving $N^2 = 25$, and $N = 5$, will reduce the leakage flux cross-section to .01 in. plus .004 in., a total of .014 in. Leakage inductance will be reduced in the proportion 0.270 : .014. Notice that the proportion of leakage inductance due to spacing between sections rises as a greater number of sections is used; this fact limits the useful reduction in leakage inductance that increased sectionalizing can achieve.

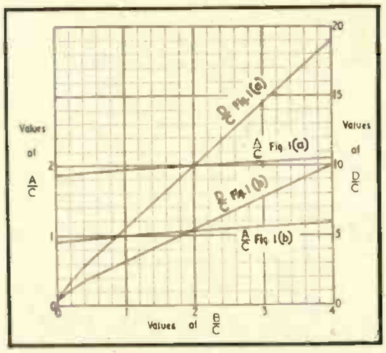


Fig. 4. Economic proportions for components carrying polarizing d.c.

Reducing Winding Capacitance

The second purpose of sectionalizing windings is to reduce winding capacitance. A different form of sectionalizing is effective for this reduction. To estimate the effect of sectionalizing on winding capacitance, its consideration must be divided into two sections: capacitance due to the internal structure of the winding; and capacitance to adjacent sections of the other winding or to interwinding screens.

In transformers with high ratios, the low-impedance winding is usually so near to ground potential throughout, from the viewpoint of the high-impedance winding, that screening would be an unnecessary refinement except perhaps for the purpose of avoiding capacitance transfer, which can occur if the low-impedance winding is not grounded at all. Where the impedance of both windings is more nearly equal, interwinding screens can be very useful in avoiding undesirable capacitance between high-signal-potential parts of both windings. However, with the simpler arrangements it is still possible to avoid the necessity of screens by ensuring that the high-signal-potential turns of one of the adjacent windings are near to a grounded, or zero-signal, point in the other winding.

Figure 7 shows the method of sectionalizing one of the windings to reduce its capacitance to others, and Table I shows the effect of different numbers of vertical sections on capacitance to the adjacent winding and on the internal capacitance of the winding itself for both constructions shown. The arrangement at (a) represents the simple arrangement where only one side of the winding is sufficiently close to the screen or other winding to contribute appreciably to resultant capacitance. That at (b) shows a winding sandwiched between two effectively grounded layers, equally spaced from it.

[*Continued on page 46*]

Distortion in Voltage Amplifiers

W. B. BERNARD*

A discussion of the distortion characteristics of commonly used low-level tubes in typical voltage amplifiers employed to drive low-distortion output amplifiers.

THE ART OF DESIGNING and building audio output amplifiers has been developed to the point where it is not difficult to obtain full output from the amplifier with 1 or 2 per cent intermodulation. Many constructors are building high-quality power amplifiers and feeding them from preamplifier-and-tone-control stages which may produce as much as 10 per cent intermodulation distortion when they are driving the output amplifier at a high level. A discussion of the difficult question of what is a tolerable amount of distortion may lead to arguments and recriminations, however, it seems safe to say that there is no advantage in spending considerable time and money to build a good low-distortion output amplifier if we are going to drive it with a high-distortion input amplifier.

Having constructed an intermodulation analyzer, the author used it on some of his own creations and on the creations of some of his acquaintances. After checking the results of these tests and curing a number of input stage difficulties it seemed that a systematic study of distortion in voltage amplifiers might be worthwhile. A very comprehensive survey of this field seemed out of the question for an individual study so the measurements were limited to the following types which comprise a high percentage of the audio voltage amplifiers encountered:

6SN7 6SL7 6SJ7 12AU7 12AX7

* *Commander, USN, 123 Elwood Ave., Norfolk, Va.*

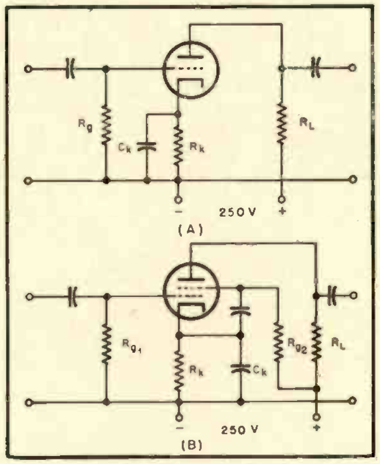
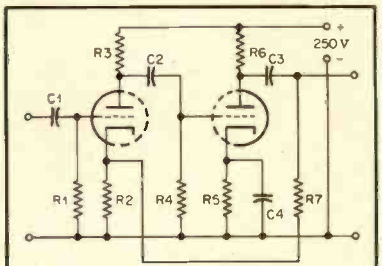


Fig. 1. Typical circuits used in making measurements. (A), for triodes; (B), for pentodes.

Figure 1 shows the test set up for these individual tubes. Five units of each type were tested using circuit constants generally recommended in tube handbooks. Readings were taken with and without a cathode by-pass capacitor and the 6SL7 and 12AX7 were also tested with grid-leak bias instead of cathode bias. All tubes were operated with a 250-volt plate supply.

In order to determine what negative feedback could accomplish in the way of distortion reduction, the 6SN7 and 6SL7 were connected to make a two-stage feedback amplifiers as shown in *Fig 2.* Since these feedback amplifier measurements were intended only as a comparison and because of the great many variables which might be introduced, only one set of circuit constants was used in each test and only one tube, selected from the previously tested group, was used. The tube selected in each case was the one nearest the average of the five tested. All tests were made to determine the percentage intermodulation produced in the circuits under test using a combined 50- and 5000-cps signal, the level of the high-frequency signal being 12 db below the level of the low-frequency signal. The residual reading of the set up when fed directly into the intermodulation analyzer was about 0.1 per cent except when the level control was at very low settings when it rose to about 0.25 per cent. It is thought that the contact in the level control might be non-linear at very low signal levels. This condition has been noted in a number of potentiometers, both carbon and wire-wound, when they were operated at levels of less than 50 millivolts.



	6SN7	6SL7	6SL7 (Gridleak bias)
R1	1.0 meg	1.0 meg	1.0 meg
R2	4,700	4,700	4,700
R3	0.27 meg	0.27 meg	0.27 meg
R4	1.0 meg	1.0 meg	5.6 meg
R5	2,700	2,700	0
R6	0.1 meg	0.1 meg	0.27 meg
R7	47,000	0.22 meg	0.22 meg

Fig. 2. Two-stage amplifier typical of common practice, with values used in making measurements.

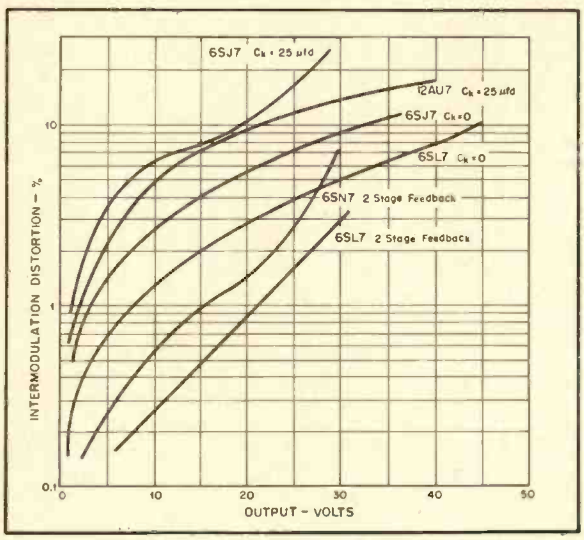


Fig. 3. Distortion measured on various tube types in circuits of Figs. 1 and 2.

Results

Figure 3 shows representative curves for several tubes and circuits. The 6SN7 and 6SL7 two-stage feedback amplifier curves are shown. The 6SL7 with unbypassed cathode was selected as the triode with lowest distortion. The 12AU7 with bypassed cathode was the triode of the highest distortion. Since the 6SJ7 was the only pentode tested its highest and

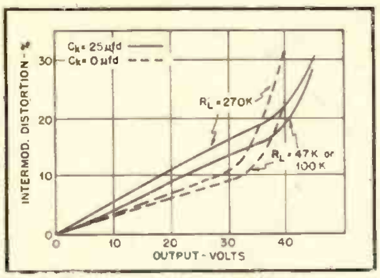


Fig. 4. Distortion measured on 6SN7 with and without bypassed cathode resistor.

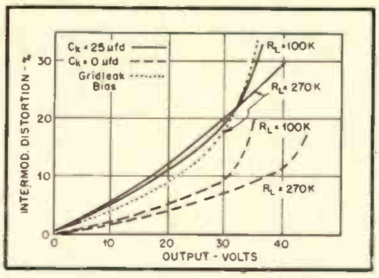


Fig. 5. Measurements on 6SL7 in several conditions of operation.

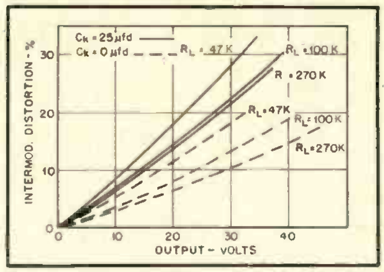


Fig. 6. Measurements on single sections of 12AU7 with different load resistors and both with and without bypass capacitor across cathode resistor.

lowest distortion modes are shown. From these curves it can be seen that the 6SL7 two-stage feedback amplifier is superior to the 6SN7 two-stage amplifier and that either of these two-stage amplifiers is considerably superior to any of the single units. The triode units are somewhat better than the pentode 6SJ7. Also, for maximum output without clipping the 6SJ7 was much more sensitive to operating conditions than the triodes were.

It was noted during the tests that when the input signal was increased until grid clipping began, the intermodulation distortion might fall below the amount which existed just before clipping began. This occurred because the clipping counteracted to some extent the distortion caused by curvature of the plate characteristic of the tube. This could correspond to a decrease in second harmonic distortion and an increase in higher-order harmonics. In the two-stage feedback amplifiers there is very little distortion present until clipping begins so the distortion begins to increase rapidly once this level is reached. Under such circumstances it cannot be said that a given percentage of intermodulation distortion would necessarily give the same results in a listening test if in one case it were caused by the gentle curvature of the tube characteristic and in another case by a sharp bend in the characteristic such as might occur because of clipping at the grid or by cutting off the plate current.

Figures 4 to 9 show the result of the tests on the individual tubes. The peak-to-r.m.s. value of the complex intermodulation signal is about 20 per cent greater than the peak-to-r.m.s. value of a sine wave. The voltage values plotted in *Figs*. 4 to 9 are the r.m.s. values of the intermodulation signal. The voltages plotted in *Fig*. 3 are increased 20 per cent to indicate equivalent sine wave voltages since these are the ones usually used in amplifier design work.

A comparison of the curves shows that leaving the cathode resistor unbypassed on a single unit, resulting in negative current feedback, reduced the intermodulation distortion encountered over the usable range of output voltages. This also cuts down the gain and raises the output impedance of the stage which may be undesirable in some cases. Leaving the cathode resistor of the second stage unbypassed in the two-stage feedback amplifier makes little difference in the gain and distortion, but it does raise the output impedance of the stage.

Negative feedback will not, to any great extent, reduce the distortion caused by a sharp bend in the characteristic of a circuit since the incremental amplification of the circuit may go to zero if the grid clipping or plate current cut-off are absolute. For this reason the two-stage feedback amplifier using gridleak bias on the second stage does not reach as low a level of distortion as do the same amplifiers using cathode bias.

Conclusions

Although the measurements made do not cover the complete field of voltage amplifiers the amount of data obtained seems adequate to come to a few conclusions:

1) A voltage amplifier tube should not be used without negative feedback when a plate signal level of more than 1 or 2 volts r.m.s. is desired.

2) Grid leak biased units should not be used, even inside feedback loops.

3) More negative feedback can be used in amplifiers using high-mu triodes than in amplifiers using low-mu triodes. Since the triodes without feedback give comparable amounts of distortion, the feedback amplifier using the high-mu triodes should give lower distortion.

4) Treble- or bass-boost circuits which operate on a voltage-divider principle, thus dropping the level between one plate and the next grid 15 to 20 db at flat response setting, should be operated at a very low level or should be replaced by circuits which obtain boost from selective negative feedback.

Horrible Example

Figure 10 shows one of the authors early efforts which violates most of the rules listed above. Unfortunately one still finds similar circuits being described and recommended for construction. The voltages indicated at the various points are the voltages resulting from a 10-mv, 1000-cps signal impressed at the GE type preamplifier input. The volume control is set to give an output of 1.0 volts from the tone-control circuit.

The GE type preamp shown in *Fig*. 10 was tested by the application of an intermodulation signal consisting of a 2.5-mv high-frequency signal and a low-frequency signal which was set to give an output from the preamp in which the low-frequency component was 12 db higher in level than the high-frequency component. The GE type preamp introduced 4 per cent IM at this signal level. This is higher than would be anticipated considering the signal levels involved but the tubes are operated with very low plate voltage and the plate load resistors are lower than would normally be used with high mu triodes. The same 6SL7 tube was moved to a feedback type preamp and the same signal was applied. In this case the IM reading was 0.1 per cent which is the minimum reading of the meter.

The portion of the amplifier to the right of the volume control was tested with the regular intermodulation test signal as was used for testing individual tubes. The results of this test is shown in *Fig*. 11. For comparison the IM curve for one of the later input amplifier-and-tone-control circuits built by the author is also shown in *Fig*. 11. This newer

[*Continued on page 55*]

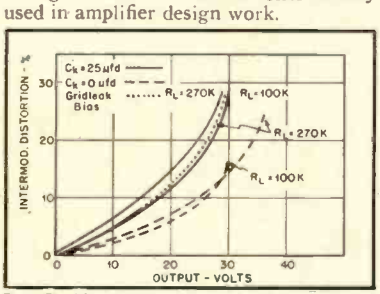


Fig. 7. Measurements on single section of 12AX7.

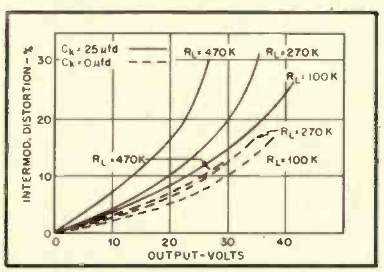


Fig. 8. Measurements on 6SJ7 in circuit of Fig. 1 (B).

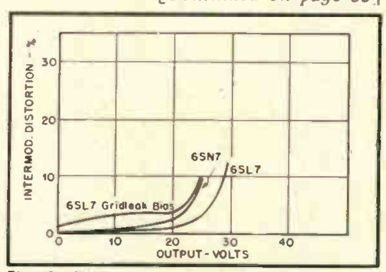


Fig. 9. Distortion measurements on tw-stage feedback amplifier of Fig. 2 with 6SN7 and 6SL7.

Handbook of Sound Reproduction

EDGAR M. VILLCHUR*

Chapter 9. Disc Recording

A discussion of the essential elements of the recording process—bass turnover, treble pre-emphasis, and the conditions which affect distortion in the recorded signal.

THE FUNDAMENTAL PRINCIPLE underlying all sound recording is the conversion of acoustical alternations, successive in time, to alternations of groove dimension, light value, magnetization, or other index, which are laid out in *spatial* sequence. The mystery of "frozen sound" is the abstract concept of any mathematical graph plotted on a time axis. The recorded symbolic pattern, of course, must be of such a nature that a reproducing mechanism sensitive to the varying impressions may be devised; and a retranslation from the space pattern to a time pattern is then achieved by allowing the reproducer to "scan" the symbols in a regular motion.

Since this book is primarily concerned with reproduction, the discussion of recording will be brief. It will deal with those aspects of recording which are most directly related to reproducing procedures, omitting the actual mechanics of recording technique, and will confine itself to the most common recording medium, the grooved disc.

Bass Turnover

The cutting stylus which engraves the groove modulations is part of a mechanical oscillatory system of the forced vibration category, highly damped to remove as far as possible the effects of its natural resonance. As was seen in Chapter 1, the relationship between frequency and displacement of such a vibrating source, for the same applied force and hence for the same power, is an inverse one. The groove displacement required to record signals of the same power but varying frequency will therefore decrease as the frequency goes up and increase as the frequency goes down, as shown in *Fig.* 9—1. When this direct relationship is left untampered the recording is called *constant velocity*, because the average velocity of stylus motion during a cycle of any frequency remains the same.

The period of each successive cycle of *Fig.* 9—1 is shorter, so that it takes less time for the stylus to traverse the path of each higher-frequency signal. The average stylus velocity perpendicular to the groove during a cycle is equal to the distance travelled divided by the time of travel. The progressive decrease of travel time associated with increase of frequency is matched by a progressive decrease of amplitude, and the quotient *Distance/Time* remains constant.

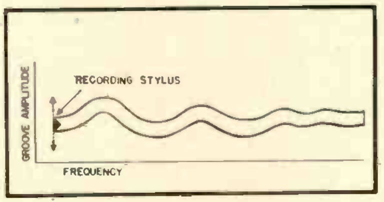


Fig. 9—1. Groove amplitude versus frequency in constant-velocity recording.

In constant-velocity recording the groove deviation required for a signal of the same driving force on the stylus doubles with each lower octave, so that the space required for bass notes becomes very great. The *land*, or space between the grooves, would therefore have to be made very large to avoid overcutting or crosstalk between adjacent grooves carrying bass notes, and the number of grooves per inch (the *pitch*)[1] would be too small for adequate playing time. Also, the recording stylus would be displaced excessively in the bass.

[1] The pitch for 78 r.p.m. commercial records in America is normally 96 grooves per inch; microgrooves are commonly recorded at 224 grooves per inch and higher, up to about 300.

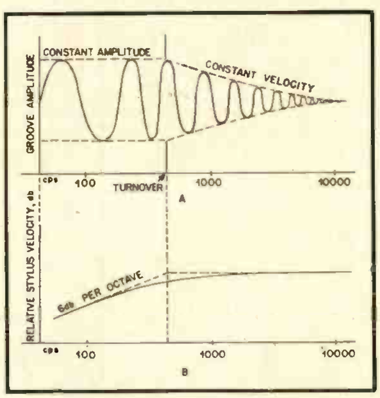


Fig. 9—2. (A) Constant-amplitude recording below turnover. (B) Bass attenuation required for (A).

All of these results are undesirable, and are counteracted by a doctoring of the bass-frequency content of the signal, to be compensated for in playback. Progressive bass attenuation is introduced below an arbitrarily chosen point, called the *turnover* frequency, in such an amount that the amplitude of groove deviation for all signals below this frequency remains the same for the same signal amplitude. This last relationship defines *constant amplitude*, and is illustrated at (A) in *Fig.* 9—2.

The amount of bass attenuation required to produce constant-amplitude recording is approximately 6 db per octave.

In order to keep the groove amplitude constant for signals varying only in frequency the oscillatory velocity of the cutting stylus must be halved with each octave. This attenuation rate may be expressed as 6 db per octave—a velocity ratio of 2 to 1 is actually represented by 6.021 db—and is plotted at (B) in *Fig.* 9—2. The sharp corner of the dotted line cannot be achieved in practice, so the actual recording curve rounds off this corner and is asymptotic to the straight lines.

Since constant-amplitude recording for the bass is probably universally accepted by modern recording companies, the 6 db/octave rate of bass attenuation, which is determined by the nature of a damped vibratory system, is also a universal practice. Unfortunately, however, there is little agreement about the selection of a turnover frequency. In the early days of recording all of the sound that could possibly be channelled through the recording horn against the diaphragm was kept, and the bass was severely attenuated by the deficiencies of the apparatus anyhow. As recording was improved a constant-amplitude characteristic for the bass was introduced, but without industry-wide standards being agreed upon. Turnover frequencies between 250 and 800 cps have been used.

Treble Pre-emphasis

A special problem is also created in the treble regions with regard to surface noise or "scratch," which is annoying in its own right, and in addition masks the treble signal frequencies. Random

* *Contributing Editor*, AUDIO ENGINEERING

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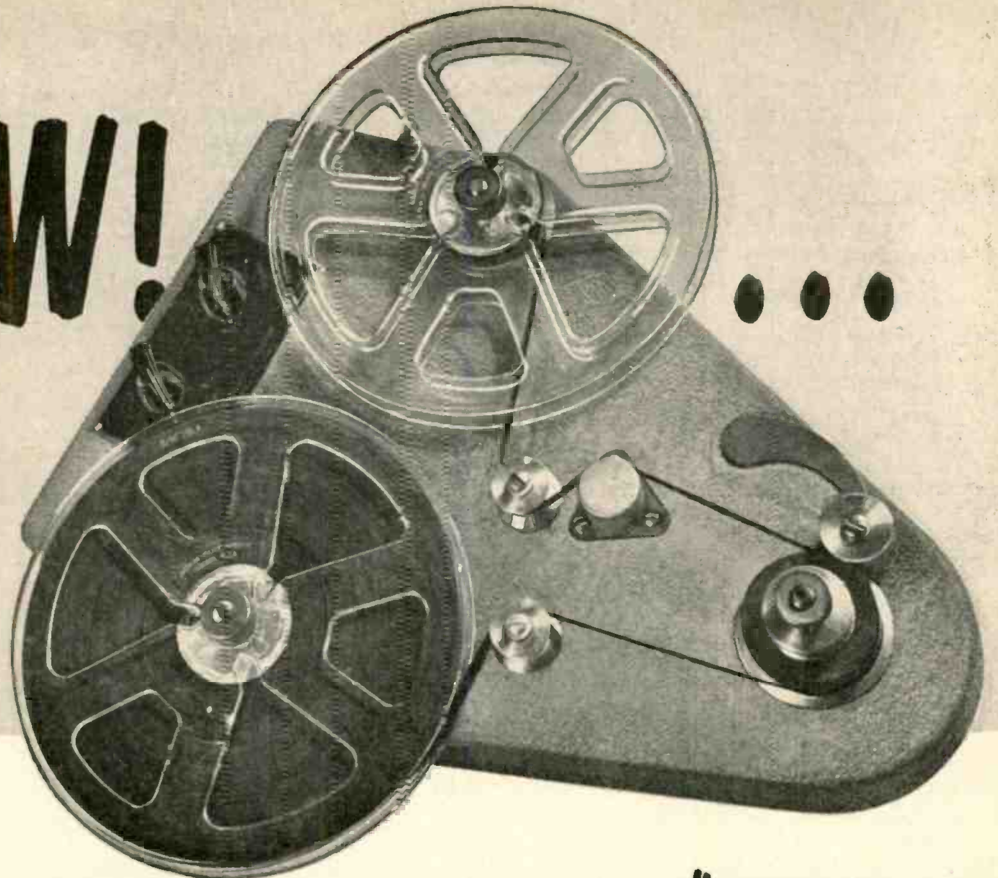

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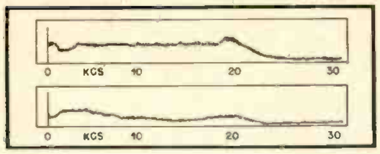

Fig. 9—3. Frequency distribution of surface noise in standard Decca (British) record, outside groove.

irregularities in the groove wall surfaces, and dirt and dust collected in the grooves, modulate the reproducing stylus and produce a noise output whose energy is fairly evenly distributed over the entire frequency spectrum, as illustrated in *Fig*. 9—3. This even distribution, however, is on the basis of energy content per cycle—note that the horizontal *scale* of *Fig*. 9—3 is not logarithmic but arithmetic—and since the treble octaves include a greater number of cycles, surface noise may be considered to increase with frequency.[2] The Fletcher-Munson effect reduces the apparent intensity of the low-frequency noise and of the extreme-high-frequency noise.

To reduce the effects of surface noise the frequency distribution of the signal is again doctored, this time in the treble. Progressive treble boost, beginning at a point referred to as the pre-emphasis transition frequency, is introduced into the recording. This increases the ratio between the amplitude of the treble modulations of the groove and the amplitude of the random irregularities. Treble attenuation in playback brings the signal back to normal, and simultaneously reduces the surface noise.

As in the case of bass attenuation, there are no uniform recording standards concerning the type of pre-emphasis to use, and current practice varies considerably with regard to both transition frequencies and rates of boost. Although the greater the pre-emphasis the better the final noise reduction, too much treble boost creates new difficulties. As will be seen a little later in this chapter, the sharp groove modulations associated with high-frequency signals of large amplitude increase harmonic distortion.

The final curve of frequency discrimination that is applied to the signal engraved into the grooves of the record is called the *recording characteristic*. Although complete agreement on the best recording characteristic has not been reached, the goal of the ideal curve is agreed upon; it is to achive a suitable compromise between the particular evils associated with each portion of the frequency spectrum. The Audio Engineering Society has promulgated a Standard Playback Curve which is rapidly becoming accepted.

Correctly compensated playback equipment must have a frequency response which is the mirror image of the recording characteristic in both bass and treble.

[2] B. B. Bauer, "Crystal pickup compensation circuits", *Electronics*, V. 17, p. 138, Nov., 1945.

Dynamic Range in Discs

The dynamic range capable of being recorded by disc grooves is limited at the low-intensity end by surface noise, and at the high-intensity end by the groove deviation permissible before the danger of overcutting or of over-sharp groove curves occurs. Even with the recording characteristics previously described this range has in the past been quite restricted. Surface noise masked the very soft passages, and loud passages had to be compressed by special amplifiers to a restricted amplitude. (*Compression* reduces the amplifier gain for loud signals over a given period of time, but ideally leaves the wave form of the individual cycles unchanged.) The only way that *fortissimo* passages could be recorded without compression was to cut the whole record at a very low level of groove modulation, requiring added amplifier gain in playback and increasing the relative background surface noise.

Modern records have a greatly increased dynamic range. Improved materials and procedures of recording and pressing records have reduced surface noise and permitted a lower recording level, while the use of greater groove deviation is made possible by several new techniques. These include:

1. Variable-pitch recording, a technique that increases the distance between grooves for signals of large amplitude and low frequency.

2. "Quality Control," a system which instantaneously controls the frequency content of the signal when there is danger of overcutting in the bass or of too steep a recorded modulation in the treble.

Amplitude Distortion in Disc Recording

There are certain types of distortion which are inherent in the current system of groove recording and reproduction. Fortunately they can be kept to relatively low values.

Tracing distortion (not to be confused with tracking distortion) is associated with the imperfect replica of the groove modulation created by stylus motion, and is the result of using a reproducing stylus different in shape from the one that did the cutting. *Figure* 9—4 illustrates the path traced by a wax recording stylus, a curve whose shape corresponds to that of the groove walls. This correspondence may be demonstrated by projecting the groove onto a graph scale; the dotted line traced by the center of the stylus is merely the curve of the wall on a shifted horizontal axis.

In reproduction, however, the groove is traced by a sphercial stylus tip. At various positions along the groove wave form the contact between groove wall and stylus occurs at points which are at different angles to the stylus center. (See *Figs*. 9—5 and 9—6.) The reproducing stylus is thus guided in a path which is an inaccurate imitation of the curve of the groove walls. This path, for a sinusoidal groove wave shape and for a single guiding surface as in vertical recording, is called a *poid*.[3]

It is interesting to note from *Fig*. 9—6 that in laterally cut records the two groove walls apply tracing distortion in opposite phase, because the concavity of one wall is always matched by the convexity of the other. The total distortion must therefore be symmetrical relative to the two cycle halves of the wave, eliminating even harmonic orders. The even harmonic components are literally "squeezed" into vertical motion of the reproducing stylus.

Since the lateral recording stylus has been held constantly at the same angle, it has cut a groove of greater width when it was perpendicular to the walls than when it was oblique. When this varying width channel is used to guide a reproducing stylus with a spherical tip (which rests on the groove sidewalls, not on the bottom) the stylus will be raised vertically at the narrower passages, and lowered again at the wider ones, giving it the vertical oscillation which takes up the even harmonics of the poid. If the pickup has vertical response spurious signals will be produced, characterized by a lack of fundamental, and harmonics which are exclusively of even orders.

This narrowing of the laterally cut groove is called *pinch effect*. It may be seen that pinch effect is merely an accompanying phenomenon to the "push-pull" action of the two sides of the groove, and is in the nature of potential relief from, rather than a source of distortion. The groove is able to channel most of the tracing distortion into vertical stylus motion; the designer of the reproducer can then render this motion innocuous by providing a pickup with a maximum of vertical stylus compliance and a minimum of vertical response. Elimination of even harmonic distortion is an important advantage of lateral recording over vertical, and results in reductions by 75 to 90 per cent of the amount of vertical r.m.s. distortion under equivalent conditions.[3]

[3] J. A. Pierce and F. V. Hunt, "Distortion of sound reproduction from phonograph records", *J. Soc. Mot. Pict. Eng*. V. 31, p. 157, August, 1938.

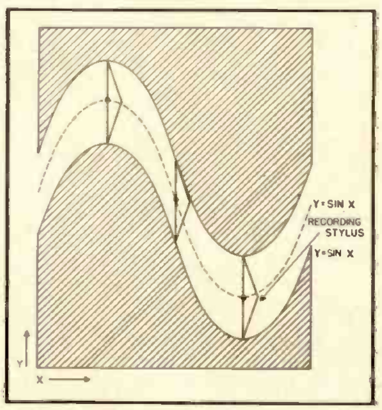

Fig. 9—4. Path of a recording stylus (without burnishing facets) in relation to the groove.

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The explanation of the relationship between symmetry and cancellation of even orders of harmonic distortion (a relationship which will be seen to operate advantageously in push-pull amplifier stages) lies in the phase relationships between a fundamental wave and its various harmonics. Consider, for example, a fundamental sine wave form. All even harmonics will produce an integral number of cycles in the space defined by the first half of the cycle. The phase of any even harmonic will therefore be the same at the fundamental mid-cycle as it was at the start. But the phase of the fundamental itself at mid-cycle is 180 deg. out from what it was at the start, and the combination of the second half of the fundamental with any even harmonic cannot produce the same resultant as in the first half. Unequal vector quantities added to equal quantities cannot produce equal resultants.

The same type of analysis will indicate that odd harmonics, all of which shift their phase over the fundamental half-cycle by 180 deg., must produce distortion which is symmetrical in the positive and negative cycle halves. The conclusion is that any symmetrical wave form (or symmetrical components added to any wave) may or may not contain odd-order harmonics, but *cannot* contain even-order harmonics.

A further suggested source of tracing distortion is a radius of curvature of the recorded groove signal which is too small for the stylus to fit into. Although the physical half-wave length of the signal in the groove may become less than the dimensions of the reproducing stylus, inability of the stylus to fit into the groove modulation does not occur until the radius of curvature of the convolution becomes less than the radius of the stylus at the point of contact with the groove wall. If the amplitude is restricted the stylus can fit into half-wave lengths smaller than itself. Since groove displacement becomes progressively smaller as the wave length is decreased, the above effect has been considered to occur only rarely, if at all. If operative it would produce a severely distorted, pointed wave form, as in *Fig.* 9—7.

Tracing distortion is affected by relative stylus tip radius, and by the relative values of those factors that determine the sharpness of the groove convolutions; groove displacement amplitude, signal frequency, and groove speed.

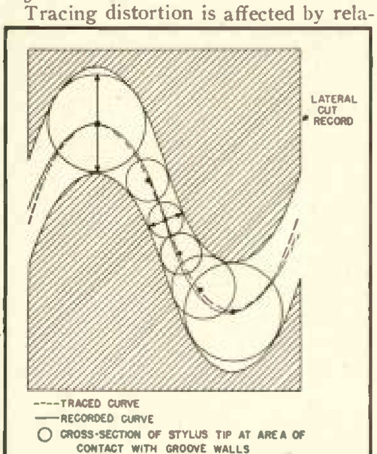

Fig. 9—6. Path of spherical stylus tip in laterally cut sinusoidal groove. (Drawing should show stylus making close fit with inside curve of the sine-wave groove.)

The speed of the groove past the reproducing stylus depends upon the r.p.m. of the turntable and the circumference of the groove being traced. For the same amplitude of groove modulation and for the same frequency, reduction of groove speed reduces the length of groove allotted to each cycle, and thus increases the radius of curvature of the groove modulations, that is, makes the groove curves more abrupt.

It is evident from *Figs.* 9—5 and 9—6 that the shift in point of stylus contact, and the consequent distortion, will be increased by the steepness of the recorded curve. It may also be seen that the difference between the traced and recorded curves widens as the center of the stylus is moved farther away from the groove wall by larger stylus radii. For lateral recording tracing distortion varies directly as the square of the amplitude, the square of the frequency, the square of the stylus tip radius, and inversely as the square of the groove speed.

Varying any one of these factors will not have any significance, of course, if a compensatory change is made in one or more of the other factors. This is illustrated by the data in *Fig.* 9—8, which gives an idea of the actual values of distortion involved at peak recording levels.

Treble Losses

Tracing difficulties also create high-frequency losses. These losses, associated with inadequate stylus excursion relative to the actual groove modulation, are called *translation* or *playback* losses.

Other factors being equal, a reduction of groove speed creates playback losses, due to an increased tendency of the heightened stylus pressure to deform the groove walls. It is to be expected, then, that progressive deterioration of high-frequency response will occur as the reproducer moves toward the inner grooves, where a much smaller circumference is traversed for each revolution of the turntable.

Playback loss has sometimes been explained on the basis of the "tight fit" theory referred to previously. The effect of a radius of curvature of the groove modulation smaller than that of the stylus tip, however, would create intolerable distortion of the traced wave form long before treble losses became significant. This is illustrated in *Fig.* 9—7, where the pointed distortion of the wave form is extreme even through the peak lateral displacement of the stylus is not much less than that of the groove. Less than 2 db of loss at the fundamental is accompanied by unacceptable amplitude distortion, whereas the normal playback treble loss in a standard uncompensated disc is higher.

An additional source of treble losses at low groove speeds lies in the recording process itself (*recording loss*) produced by the action of the burnishing facets on recording styli designed for lacquer. These effectively dull the cutting edge for the sake of a smoother, quieter cut. They may be made much smaller, without sacrificing smoothness of the cut, when the hot-stylus technique is used.[4]

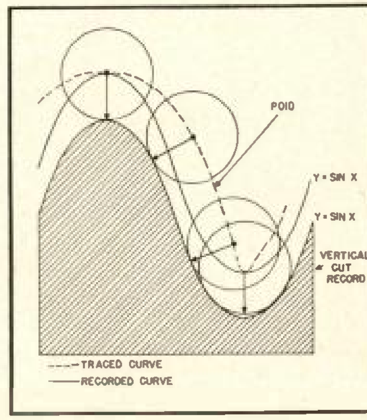

Fig. 9—5. Path traced by a spherical stylus tip sliding along a vertically cut sinusoidal groove.

Compensation for treble losses at the inner grooves, called *diameter equalization*, may be provided by a gradually increasing treble boost calibrated to the motion of the recording head across the disc. This method, of course, does not relieve the tendency towards distortion caused by the crowding of the inner groove modulations, but increases it, and is one of the factors that must be considered in choosing a treble recording characteristic.

In general it may be expected that the quality of a given record is in greatest danger of degradation when signals of large amplitude and high frequency are recorded at the inner grooves. The orchestral flourish that ends the record may be quite inferior in quality to the one that begins it, either because of amplitude distortion, or treble losses, or compression which is designed to remedy distortion but which robs the sound of its vitality.

Microphone Pick-up Technique

Microphone use and placement for phonograph recording is far from uniform. One practice is to rely on a multimike set-up for orchestras; different microphones pick up various components of the music, and the channels are re-assembled (monaurally) in the desired proportion. Reverberation components are also picked up by a separate microphone, which is used for the purpose of adding liveness to the sound. The particular microphone layout is affected by the recording hall and the type of units employed.

Such a technique is especially useful in motion picture scoring, where it may be necessary to emphasize some particular section of the orchestra for dramatic considerations of the moment.

[*Continued on page 56*]

[4] William S. Bachman, "The Columbia hot-stylus recording technique", Audio Engineering, V. 34, p. 11, June, 1950.

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ASCO Unveils Flexible Sound Display Room

New Manhattan showroom introduces several innovations in method of controlling equipment for sound demonstrations.

At almost regular intervals, a new sound showroom opens its doors—each vying with all that went before in method of operation, in display of equipment, and in the means employed to choose the desired set-up for each demonstration.

Organized a few months ago as Allied Sound Corporation, the name has just been changed to ASCO Sound Corporation coincidental with the opening of the new studios. Located in the heart of New York's mid-town business district, and occupying some 6000 square feet of space on the third floor at 115 W. 45th Street, ASCO is making a strong bid for the sound-conscious shopper who wants to determine which components he will use to make up his own home music system. With Herbert Borchardt as president and Irving Greene as vice-president and general manager, ASCO has put together an attractive and effective display room.

Heart of the entire system is the Audiomat, which bears slight resemblance in appearance but considerable in flexibility to the famous Automats in New York. With the Audiomat, all selection of the components required for a given system is made from the console in the center of the room. Offering more than 9000 combinations for A-B tests, the Audiomat, shown in *Figs.* 1 and 2, controls several banks of relays which perform the actual switching, thus eliminating long leads from amplifiers, pickups, and tuners. The relay banks are located behind the equipment racks, readily accessible from the back, and are d.c. operated to avoid the possibility of hum pickup. Plug-in relays have been used exclusively to permit quick changes in case of failure, although the relays were specially made for this application, and employ gold-plated contacts for minimum noise.

For those interested in the technical aspects of the switching circuits, *Fig.* 5 is the block diagram of the system. For tests of various pickups, the input selector makes the required connections between pickup and amplifier, and between amplifier and speaker. Similar relay circuits permit the selection of tuners, so that they can be compared readily, with switching between any desired components quickly performed. This provides the facility for making true A-B tests between two speakers, two amplifiers, two tuners, or two pickups—the only truly reliable method of testing. In many test set-ups, it is not possible to change only one component of the system at a time, but if a fair evaluation is to be made, this type of test is necessary.

Equipment Mounting

Most sound display rooms heretofore have consisted mainly of a number of shelves on which amplifiers, changers, and other components are placed, without regard for their appearance. This is no handicap when the customer is a real "bug" for he derives as much pleasure from seeing a well-built chassis as he does from hearing its performance. But with the increasing popularity of high-quality sound reproduction in the home, more and more customers are bringing their wives with them when they go shopping for equipment, and appearance is likely to mean as much as —or even more than—performance to the lady of the house.

In ASCO's display studio, all equipment is mounted in "drawers," with finished hardwood panels on the front, and with the controls and escutcheons installed just as they would be in the home, as shown in *Fig.* 3.

However, should the prospective buyer want to see the equipment, the drawer is simply pulled out, exposing the chassis to view. The drawers are

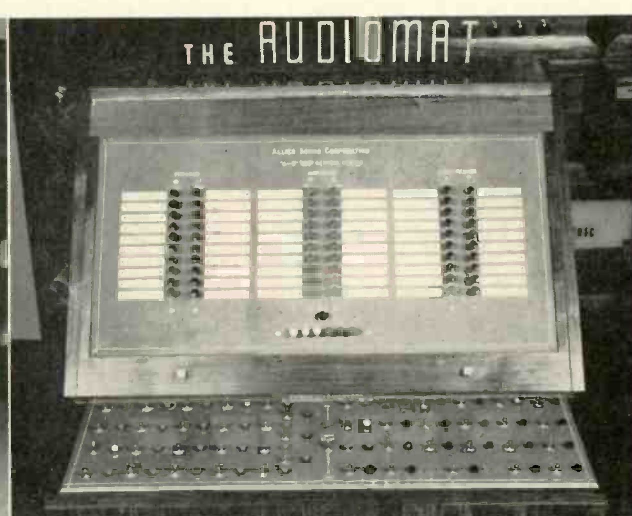


Fig. 1 (left). The Audiomat—heart of the ASCO demonstration facilities—stands in the center of the studio. Space is provided in the base for storage of records and tapes used in demonstration of equipment. Fig. 2 (above). Close-up of the Audiomat panel. Indicator lights on the panel show what equipment is in operation as push buttons controlling the switching relays are actuated. Power circuits are controlled directly from the Audiomat panel.

Fig. 3. One section of the equipment rack, which consists of separate drawers faced with finished hardwood; panels are simply pulled forward to permit inspection of the equipment. Note name panels which are illuminated when the equipment is being demonstrated

constructed in the same manner as a typical phonograph changer or turntable drawer is in a furniture cabinet, with standard metal drawer slides commonly used for this purpose.

Every unit of equipment on display is mounted in the same fashion, so that all of it is available for immediate use, or for visual inspection, as the customer may wish. The loudspeakers are mounted in typical cabinets, and all are selected from the Audiomat. Pads in the speaker lines permit adjustment for different efficiencies, so that with a given tuner and amplifier, the sound output is the same on all speakers compared.

In addition to controlling the switching of audio circuits, the Audiomat also controls signal lights which indicate the equipment being demonstrated. This applies to pickups and the associated changer or turntable, amplifiers, tuners, and loudspeakers. For the equipment rack, these illuminated panels are on the front of the individual drawers, as seen in *Fig.* 3; for the speakers, the illuminated signal panels are located at one end of the studio, in the area occupied by the speakers themselves. The speaker indicator panel is shown in *Fig.* 4, with two of the speaker enclosures flanking the panel. The door below the indicator is also used to mount one of the speakers, a common location in homes where space for a conventional cabinet is not available.

With each new sound studio to be opened, more and more interesting innovations are being employed. When it is considered, however, that the requirements of completely flexible demonstration facilities are rather complex, it is no wonder that much time and energy has been devoted to the design and construction of studios of this type. It does give rise to the observation, however, that "the first guy doesn't have a chance," for each new installation is likely to adopt the good points of all those that went before in addition to including whatever improvements may come to mind.

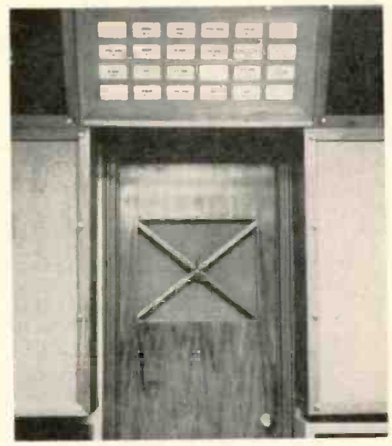


Fig. 4. The loudspeaker indicator panel, with individual speaker housings to right and left, as well as below.

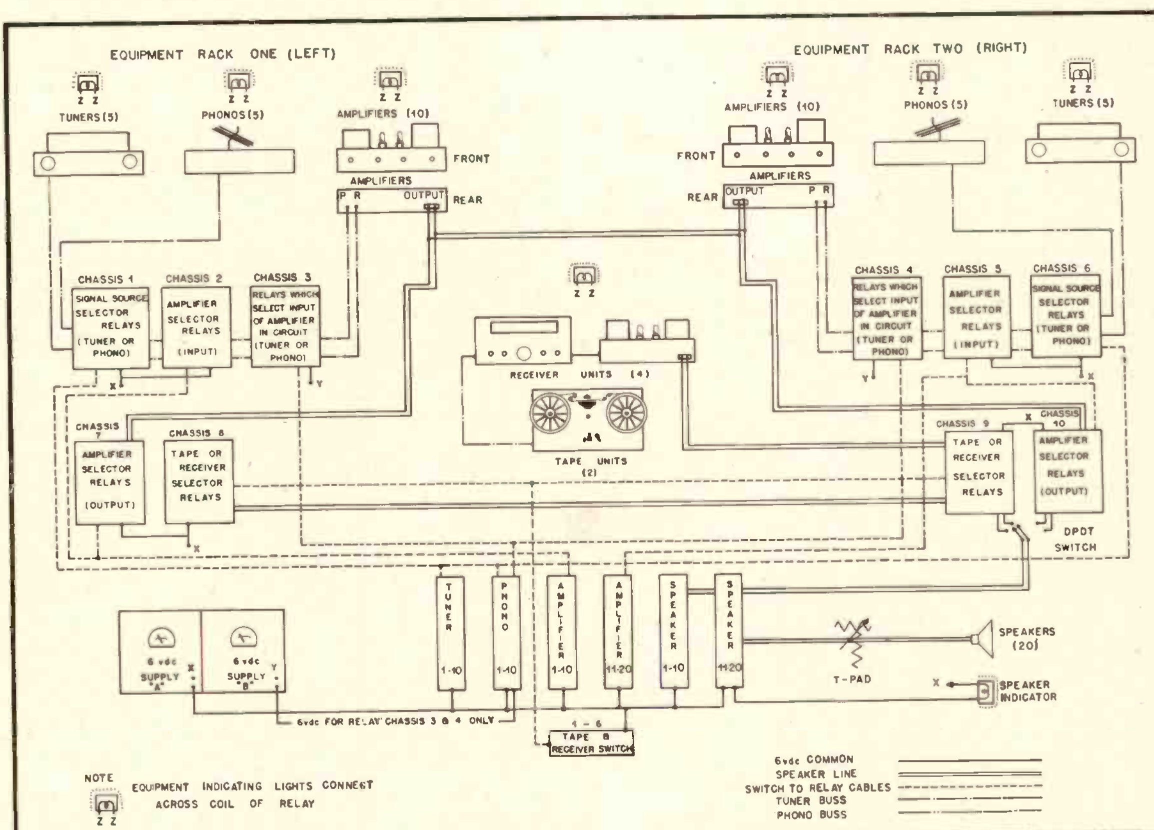
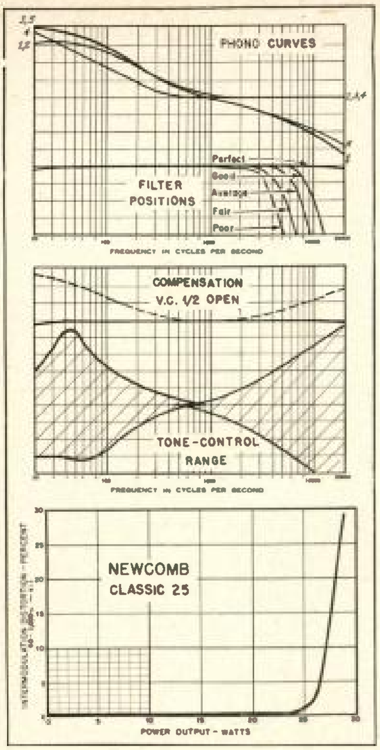
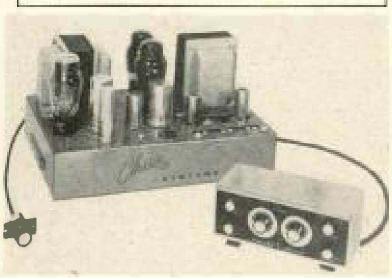


Fig. 5. Simplified block schematic of the Audiomat switching circuits and the associated relays. Note that audio circuits are not fed out to the Audiomat—thus eliminating difficulties resulting from long leads.



Equipment Report

NEWCOMB CLASSIC 25 AMPLIFIER



MOST COMPLETE and most powerful of the entire line of Newcomb custom home-music amplifiers, the Classic 25 provides a more than adequate power output for the listener's normal requirements and at an extremely low distortion figure. Continuing Æ's tests, the submitted unit was checked for IM distortion at all output levels from 1 watt to 30; response curves were measured for all phono-equalizer positions and for the four cut-off filter positions, as well as for the limits of tone-control action; and the frequency response was measured with the volume control at the half-way position to determine the amount and type of loudness compensation that was employed. The curves are shown in *Fig.* 1, and the over-all schematic is reproduced in *Fig.* 3. *Figure* 2 shows the external appearance of the amplifier with its remote control.

Power-output measurement is accomplished by use of a thermocouple ammeter in series with the load resistance, adjusted so that the total resistance offered to the amplifier is that for which the output tap is normally intended. The indicated power is then multiplied by a factor of 1.47 to obtain the equivalent-sine-wave power output, as outlined by Aston (Æ, Sept. 1948). This is the first amplifier on which measurements were made in this manner—those rated heretofore had power-output curves plotted against the *average* power output as measured by the thermocouple ammeter.

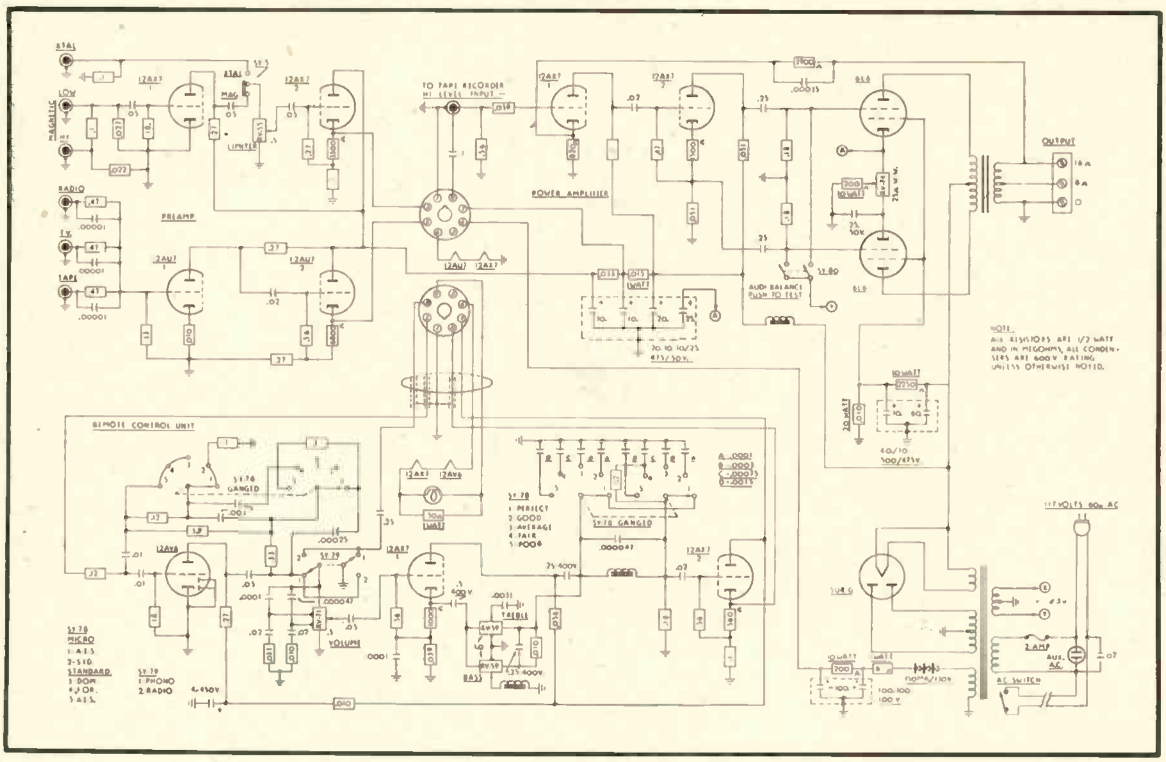
It will be noted that the distortion of the Classic 25 is extremely low—ranging from 0.1 to 0.3 per cent—up to an output of 24 watts, with the normal increase beyond that power as would be expected from any feedback amplifier.

The types of equalization provided are suitable for almost any type of recording now encountered, and provide a wide range of adjustment without resorting to the use of tone controls for either high- or low-end compensation. Once adjusted for average output level in the listener's home, the compensation in the volume control circuit offers satisfactory correction for loudness.

One particularly desirable feature is the adjustable low-pass filter, which operates on both radio and phono. The arrangement of the two chassis simplifies installation in the home and permits locating the amplifier in any convenient position with the control unit placed where it will be most accessible. All inputs are connected at the main chassis, with switching between phono and the various high-level inputs being accomplished at the remote-control unit.

Some of the amplifier's features are not apparent from either performance curves or from the schematic. The control unit is built with the "Adjusta-panel" so that it may be installed with no panel at all or with up to a ¾-in. panel with the assurance that the knobs will be positioned close to the panel for neat appearance. The "Audi-Balance" control makes it possible to adjust the two tubes in the output stage for

[*Continued on page 63*]



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EDWARD TATNALL CANBY*

GRIND THE GRIT MERRILY

A JOINT LETTER from two Æ readers brings up anew one of those "hopeless causes" that constantly get thrown to the record reviewers—for help that seems impossible to find elsewhere. This cause is an old and irritating one: damaged, defective, scratched records that are sold as new. Maude and Howard Linkert of Indianapolis sign their quite eloquent complaint, suggesting that perhaps this column's occasional "key" of superscript letters might be expanded to include the following information:

d *dirty records*—lint and the like.
dg same, plus *gritty particles* that scratch.

They suggest that unpleasant pops and crackles on new records be indicated as to type by:
SP *Scratch-pop;* due to (a) grit-made scratches on the new record or (b) needle-made scratches, perpetrated by a former experimenter.
DP *Defect-pop*—due to pits, bubbles, grit, in the record material. ("Blow holes, shrink and dross" in another area, foundry work.)

A good idea, in theory, but unfortunately it is not practical because these defects, obviously, vary from disc to disc. That's the trouble. (I have often used such a phrase as "off-center, my copy" to indicate the possibility of trouble in some, but not necessarily all copies of the recording.) The question of bad records transcends all such minor variations—the possibility may be said to exist in almost every record issue now on the market. A major problem, side-stepped in this department only because there is no good way of coping with it in record reviews, which must be true for *all* copies of a given recording.

As these people ask, why is it that record companies put such fabulously careful and expensive work into the preliminary processes of recording, from the rehearsal and the microphoning right through to the cutting of the disc master—and then consign the precious result to a relatively careless sort of packaging and handling that, undeniably, brings large quantities of imperfect discs to the record buyers? It does seem strange.

Milk for Babies

And yet I'm not sure we can do much about it in a hurry. First because of the technology of record manufacture and distribution. And second, more important, because of the existing vast organization for record sales, a formidable system that, necessarily, has the inertia of a colossus, such that none but the largest and strongest manufacturers have ever dared challenge it to quick change. Right or wrong, it exists and must be reckoned with—and no amount of high-minded editorializing will change that. Yet it could be changed, via the weight of public (record buying) opinion and awareness, for the benefit of all.

Take milk. In Europe it is still sold in bulk. And in Europe the well informed keep away from it. Dangerous. Yet look at our dairy system. Milk in some places, I wager, is safer than water—though it breeds bacteria beautifully, won't keep unless cold, must be parboiled ahead of time, tested this way and that, sealed up and dated, with government specifications met. If so much trouble can be taken by us to make milk safe for babies, why isn't scientific ingenuity up to the job of selling records in damage-minimizing form?

Custom. Records are selling very well on the present wide-open system. There is no apparent boycott going on; people don't demand better service and they'll pay for the present arrangement. Better records—*sealed* records, guaranteed like a million other products as untouched by hands or free air (and its loading of dirt)—would cost more, would require a drastic change of selling policy *everywhere*—not just in a few stores. If the people don't object to the present system very strenuously, the dealers will certainly object to any radical change and no such change would have a chance of succeeding commercially unless there were general agreement everywhere —or unless one of the major companies forced it through by sheer weight of authority. We've had that twice already, at 33 and 45; we can scarcely fail to understand the dealers' jaundiced viewpoint in the face of more varieties of fundamental change, even though (many of us think) the dealer would be the first man to benefit.

And so it goes. Slide the brand new manufactured records into their wide-open cardboard cases, unsealed, sucking in the dirt and the lint; stack them up in the hundreds, grinding the grit merrily into the grooves; let the customers sample this one and that on those splendid miniature monsters with all-groove metal needles that grace our listening booths, let 'em take 'em home to try on their own broken needles—then go ahead and sell them as "new" records. A vicious system in all truth—for if there were as much variation from bottle to bottle in our milk as from record to record at present, we'd all be down at the corner store pulling milk out of the refrigerator, sticking our tongues in a dozen bottles or so to choose the one that tasted best.

Sealed Records

The ultimate answer fairly shouts at us. What we need is sealed records! Records packaged as are almost all the products we buy in this vast and complex civilization of ours, so that an unbroken container would guarantee a fresh, uniformly satisfactory product; so that in a given batch we customers would have no more compunction in taking the top record on the pile without looking at the rest than we do in buying a tube of toothpaste or a portable radio. They're all alike. Or nearly enough alike so that we feel no urge to search for "the best one." That, after all, is the very basis of this, our age of mass production. A mass product like records which gets into the present mess of try-as-you-go selling is an anomaly, an anachronism.

Let's have less of the vegetable cart system, then, where milady picks and hauls at the piles of carrots, onions and potatoes, looking for the ones that aren't rotten. That's no way to sell records.

But how?

Space allows only this much more to be said. A constructive approach to this problem involves two aspects. First, the mechanism of protection must be worked out—and

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that brings up the all-important matter of static electricity in the present records, which accounts for a large part of the present trouble, both before and after sales. Static removers help—usually too late—and are a nuisance; only one company has done the inevitable, so far, and introduced a static-free record: RCA Victor, which is remaining strangely silent about this really revolutionary innovation. Don't ask me why. Second, a new and *universal* sales mechanism must be worked out—it will have to operate everywhere or not at all, as with every other sealed product you can think of. Demonstrator records, *not* to be sold. Replace the demonstrators as often as need be, but sell *only* sealed, untouched copies.

Too, too simple

It sounds so easy! In a way, it is. No great technical problem. All you have to do is persuade a very large number of people who don't want to be persuaded, who prefer doing things the way they know. As easy, say, as it once was to convert us to Daylight Saving Time. Took decades. Or to Women's Suffrage. All that needed was a little law-passing—and about a century of militant, adamant, unceasing agitation.

We'll have more on this subject in later issues. Maybe something can be done, after all.

SHOWS

Oklahoma! (Complete score). Virginia Haskins, Key Ballard, Wilton Cary, Less Cass, etc. Cho. & Orch. Lengel.
Columbia ML 4598

Paris '90. Cornelia Otis Skinner, Cho. & Orch., Nathaniel Shilkret.
Columbia ML 4619

Columbia's recorded shows roll on under Goddard Lieberson's enthusiastic direction; the technique of referring an elaborate stage production to the one-point audible medium of the LP has been developed to a precision art perhaps more specifically adapted to the LP medium than any other audible entertainment. In these LP's there is the now familiar contrast of voices very close and distinct, with orchestra in a grandly cavernous background—an unstage-like but pleasing effect which is strangely unlike the usual radio program way of mounting the same sort of material. The hi-fi sibilants, the soft, natural quality of the spoken and sung words, is a pleasure and a credit to Columbia engineers. (Paris '90 features spoken dramatic monologues by Skinner, lavishly iced up with show music for orchestra and chorus. I'd prefer them plain, minus icing.)

Dancers of Bali. Gamelan Orch. from Indonesia. **Columbia ML 4618**

This show, a touring sensation of the last season, is represented by its music—which turns out to be super stuff for the hi-fi phonograph. Nothing like these bells and drums has been heard in the hi-fi area for a long time. But don't expect to "understand" the music. The sounds are exotic, colorful, wonderfully rhythmic, fascinating in small doses, but if you can get to tell one dance from another you're pretty sharp. A stunningly good recording technically, and fine exercise for woofers and tweeters.

SYMPHONY

Brahms: Symphony #1. NBC Symphony, Toscanini. **RCA Victor LM 1702**

Prokofieff: Classical Symphony. Gershwin, An American in Paris. NBC Symphony, Toscanini. **RCA Victor LM 9020**

Two more in the expanding late-Toscanini repertory on discs. The Brahms is first-rate—and this applies even to those who, like me, cannot find appeal in a good many Toscanini offerings, notably the Beethoven works. The recent and much-acclaimed 1st and 9th symphonies in Toscanini's version are not for my ear. But some


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strange subtlety of character, of artistic affinity, gives Toscanini's Brahms an advantage over his Beethoven. The finest Brahms First of past days was Toscanini's, on RCA Victor 78's. No one could beat it. This replacement retains the basic quality of the old performance. For reasons unfathomable, the driving hurry of the Beethoven Toscaninis becomes in Brahms an ideal intensity that carries on the somewhat heavyweight music, livens it, intensifies it, without pushing too hard. Haven't got the old version at hand but this one shows a bit of the metronomic tempo of much recent Toscanini and there are some few ragged spots. The old one is probably preferable musically, if not technically. (It was one of the best of the earlier 78 Victors.)

The Prokofieff Classical is a gem—its Italianate music is, paradoxically, treated to a leisured interpreation, much slower than most of the frothy whirlwinds evoked from this pleasant score. Particularly good in the last movement—which is usually a good natured shambles! I'm afraid I can't quite enjoy Gershwin in tails. Toscanini's Gershwin is somehow faintly embarrassing. The solid vulgarisms, the wonderfully enjoyable blurps and blats, are uncomfortable here, like a belch at a dinner party. A brilliant performance, of course, but it doesn't blat, and it ought to. (Toscanini, by the way, gets live recording now, with good tonal range; not as big or full as many current symphonic recordings, but easily satisfactory. The typically explosive Toscanini drums may or may not be due to recording technique; I suspect the drums themselves, and/or their placement vis a vis the mikes.)

Dvorak: Symphony #5. Cleveland Orch., Szell. **Columbia ML 4541**

As compared with the Toscaninis above, this one shows an intriguingly subtle superiority of sound. How? The dominant impression is (a) a better ensemble—not as many too-close individual noises; and (b) a wider apparent dynamic range, a bigger sound in the climaxes. Apparent effects, note well—but apparent effects are the ones that count in recording. A matter of ingenuity in the mike technique; Columbia has got its miking down to a fine point by this time. This is (incidentally) as nice a performance as you'll find, what with Szell in his own native musical medium. It has that excited freshness that stamps the best Czech music—and is too often lost in this over-played symphony.

Schumann: Symphony #2. Paris Conservatory Orch., Schuricht. **London LL 638**

Some ffrr discs have been too "stunty" in their extraordinary recording technique for the good of the music—not this one. A splendidly alive performance, tense, rapid, but never less than warm (and cold Schumann is ultra-deadly), the great golden liveness of the ffrr technique blending its tones perfectly for the music, the typically sharp-edged individual instruments in this case helping to define an otherwise rather muddy score. Some will prefer a more relaxed tempo—I feel that Schumann's underlying anxiety is for once really well expressed here. Good, and a very exciting recording all the way around.

ITEMS FOR THE ROVING EAR

Cathedral Voluntaries. E. Power Biggs, organ of Symphony Hall, Boston. **Columbia ML 4603**

A splendid organ record technically, even if Mr. Biggs doesn't hit the bottom pedal every other measure, as some would wish. First side has a musically excellent selection of well-registered music; the second side degenerates into organist's stuff—though from some very well known composers.

Beethoven: Ruins of Athens (Complete), op. 113. Soloists, Netherlands Philharmonic Choir and Orch., Goehr. **Concert Hall CHS 1158**

The overture to this occasional work is one of those sometimes-performed oddities that invariably gets run down as worthless; the rest is unknown (except for the famed Turkish March, here included). But listen here and you'll understand that our mistake is in judging intentions. This is no Great Music, but it is excellent for its original purpose of celebration and, taken as a whole, is

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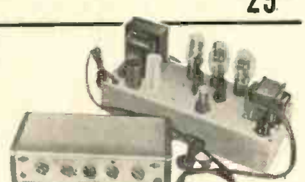

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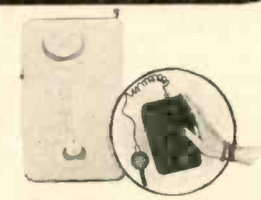

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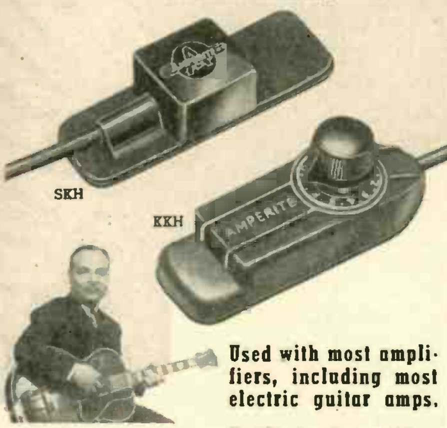
SPEAKER SYSTEMS

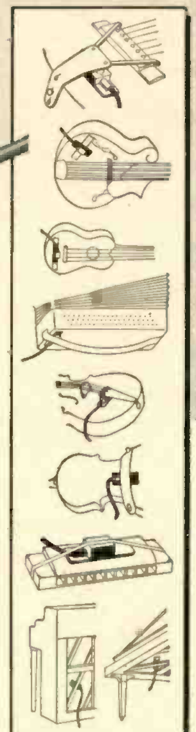
The **Regency** is a Klipsch-licensed corner horn enclosure, suitable for either corner or flat wall location. Superlatively styled in low-boy design, the Regency is available in either hand-rubbed mahogany or blonde Korina, and may be used with single 15" speakers, two-way, or three-way systems.

The **Regency II** consists of the Regency enclosure together with the EV 114A two-way system composed of a 15W-1 LF driver, an X-8 800 cycle crossover network, and a T-25 25 watt treble driver with 8-HD Hoodwin diffraction horn. The **Regency III** consists of the Regency enclosure together with the EV 114B three-way system, composed of a 15W-1 LF driver, an X-8 800 cycle crossover network, a T-25 treble driver with 8-HD Hoodwin diffraction horn, an X-36 3600 cycle crossover network, and a T-35 Super Sonax VHF driver.

REGENCY (enclosure only)	Mahogany	$114.00
	Blonde Korina	120.00
REGENCY II with 2-Way System	Mahogany	285.00
	Blonde Korina	291.00
REGENCY III with 3-Way System	Mahogany	314.70
	Blonde Korina	320.70

hrc **HARVEY RADIO COMPANY, INC.**
103 W. 43rd Street, New York 36, N. Y. • LUxemburg 2-1500





decidedly enjoyable to follow along. Nice choruses, simple solos and musical interludes. The singers, Dutch, mouth their German; otherwise they are good and the recording is good too, except for some overly cut loud passages that may buzz a faulty stylus.

Handel: Water Music Suite, arr. Harty; Royal Fireworks Music, arr. Harty. London Philharmonic, Harty.
Columbia Entre RL 3019

Here's one of the previously announced cheap Columbia LP reissues—this combines the two favorite "X" series recordings of these suites and still the two best performances I've heard of the music. Shocking to find how limited in tonal quality these recordings were—as heard on new equipment; I always used to think they were fine! But on today's "average" phonograph they'll still be up to average, and well worth the low price, far less than in the days of the 78 originals.

Christmas Music. (Corelli, Scarlatti, Vivaldi, Torelli, Boccherini). Virtuosi di Roma.
Decca DL 9649

Christmas! I take delight, each year, in reviewing an Xmas number or two during the February thaw; I figger that if Xmas music can't stand up in February it wasn't worth giving as an Xmas present. (After all, we've gotta play them after Xmas, those fancy records we found under the Xmas tree. . . .) Anyhow, this is a potpourri of 18th century concertos, a type now increasingly popular after a long eclipse. These Italian performances employ the current Italian anachronisms, piano in the place of a harpsichord, a rather romantic style of playing; but the music gets through and the variety here is pleasing. Recording is excellent—where many discs of this sort from Italy have been decidedly mediocre. Acoustics on the dead, close side.

AUDIO TRANSFORMER

[*from page 27*]

The effective capacitance of the adjacent winding will depend upon what point in the high-impedance winding is grounded, or at zero signal potential. Only two positions for the zero signal point are commonly found: at one end, or at the center point of the winding. The tabulation of *Fig. 7* shows the effect of sectionalizing for both conditions.

From the foregoing it appears that the exact arrangement as regards sectionalizing of windings depends upon its effect upon leakage inductance and winding capacitance. The final choice of arrangement now depends upon three main factors: the distribution of circuit components, the position of zero-signal points, and the mode of operation.

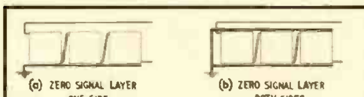


Fig. 7. Vertical sectioning employed to reduce winding capacitance. Its effect, as shown in Table 1, depends on the disposition of screens or adjacent windings at sensibly zero signal potential.

Distribution of Circuit Components

The external-circuit values with which the transformer operates determine the relative importance of leakage inductance and winding capacitance.

An output transformer designed to feed conventional loudspeaker loads will be feeding an inductive load, so leakage inductance in the transformer will be relatively unimportant as regards frequency response. Even the simplest winding arrangements will result in a leakage inductance that is quite small compared to the voice-coil inductance of the loudspeaker(s) used as load. Attention to reducing the capacitance of the primary winding is likely to be more important, although for many applications, using tetrode or pentode output stages, a fair degree of capacitance is required, so the simple winding arrangement is no disadvantage.

For input, interstage, or line transformers, leakage inductance and winding capacitance assume varying degrees of importance according to the operating impedance used. In some instances the upper end of the frequency band will be controlled by the LC product of leakage inductance and winding capacitance, in which case both qualities require to be reduced so as to produce a minimum product value. In applications where all circuit impedances are lower, leakage inductance may be the most important factor. in which case perhaps winding capacitance can be ignored. In other cases, such as input transformers design for operation from dynamic transducers, the leakage inductance will be swamped by the inductance of the transducer, so winding capacitance is the limiting factor which must be reduced to a minimum.

Where capacitance assumes important relations, the position of the zero signal point in the high-impedance winding will be an important factor in deciding what winding arrangement to use.

Figure 8 shows a number of winding arrangements of the type employed to reduce leakage inductance, together with their effective capacitance, expressed in terms of the capacitance between the high-potential side of the high winding and an adjacent winding or screen connected to ground. These values are listed for both center-point and one-side zero-signal arrangements.

As shown in the Table I, choice of vertical sectioning for reducing capacitance will also depend upon the position of zero-signal point in the high-impedance winding.

Mode of Operation

Output transformers may be for application in circuits employing either Class A or Class B operation of the output tubes. For Class A applications, it

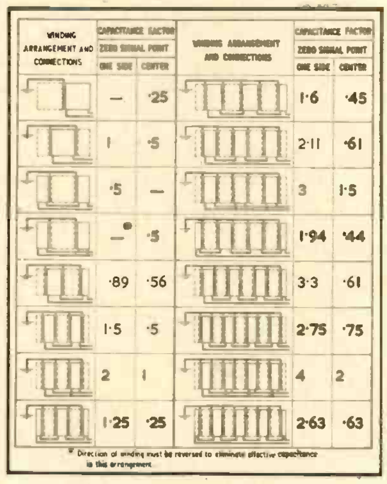


Fig. 8. The effect of different winding arrangements and connections, used for leakage-inductance reduction, on winding-to-winding or winding-to-screen capacitance. The capacitance factor shown gives the effective over-all capacitance in terms of that between average adjacent windings, or winding and screen.

is important only that the whole of the primary should be uniformly well coupled to the secondary. For Class B applications, one half of the the winding is out of action during each half cycle, so the coupling must be a maximum for each half winding to the whole of the secondary. This means that the method of connecting up the sections, combined with the sectionalizing arrangement used, should be such that no part of the secondary winding is spaced away from either of the halves of the primary winding.

Figure 9 illustrates this with a simple example. The arrangement at (a) provides uniform coupling between the whole primary and the whole secondary and would, from this viewpoint, be satisfactory for class A operation; but for Class B operation, one half of the secondary winding is always sandwiched in the middle of an inactive half of the primary winding; so the space occupied by the intervening portion of inactive winding will add an unnecessarily large proportion of leakage inductance between whole secondary winding and the active half of the primary winding.

The arrangement of (b) maintains uniform coupling between the whole primary and the whole secondary, but in this case the coupling between the whole secondary and each half primary is reduced to a minimum. It may not at once be obvious that the coupling between both half primaries and the whole secondary is identical in this arrangement. The half primary sandwiched between the secondary sections forms a coupling similar to the second arrangement shown in *Fig*. 6. The arrangement for the half of the primary made up of the two outside quarters with respect to the whole secondary is also equivalent to the same basic arrangement, but it would appear at first sight that the total winding thickness is greater in this case. However, the inactive half primary now occupies a place in the secondary winding which is at zero-leakage-flux potential from the viewpoint of coupling with the active half primary, so the space occupied by the inactive half primary, can be ignored in computing the leakage inductance for the active half.

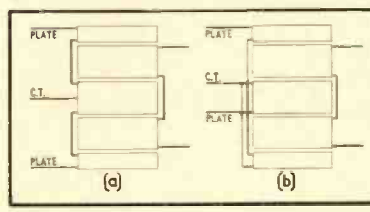


Fig. 9. An example of coupling arrangement suitable for Class B or alternative winding operation. (For explanation see text)

For other types of transformer, alternative windings may be required for different purposes. In such designs the arrangement should be devised so that maximum coupling is achieved between each of the alternative windings and the common winding. The same principle as that just outlined for the design of Class B transformers can also be applied here by placing each of the alternative windings in such a position that it occupies a region of zero-leakage-flux potential in relation to coupling with the other alternative winding.

TABLE I

Capacitance Factors for Vertical Sectionalizing

Number of Vertical Sections	Capacitance Factors				
	Distributed Capacitance Component	Inter-winding, or winding-to-screen			
		Figure 7 (a)		Figure 7 (b)	
		Zero signal point		Zero signal point	
		One side	Center	One side	Center
1	1	—	.25	1	.5
2	.25	.125	.125	.75	.25
3	.11	.185	.102	.703	.204
4	.063	.219	.094	.688	.188
5	.04	.24	.09	.68	.18
6	.028	.255	.088	.676	.176

BINAURAL PUBLIC ADDRESS

[*from page 24*]

the stage, very little difference in coverage could be heard, the sound pickup from all parts of the stage being about equal. The critical point, however, was found to be about 16 ft. As the mikes were lowered beyond this point the difference in the outer perimeter became appreciable, the effect being much the same as if a spotlight were suspended and lowered with the resultant closing in of the circle of light. Within the circle, though, the intensity of sound pickup remained the same. The portion of the stage occupied by the set was fully covered with the mikes 12 ft. above the floor. Lower positions increased the sound pickup within the confines of the circle, but there was a marked rise or fall in volume as the performers moved in or out of the circle. The unchanging level within the noted limits held true even when the players were up stage and facing the back wall. Those who have worked with plays will remember the constant attention necessary during rehearsals to have the actors remember to raise their voices for lines spoken while facing upstage.

Where dialogue alone occurred, ordinary conversational volume was used, yet each word, even to lip sibilants, was clearly heard in every part of the auditorium.

Results with Music

The songs with orchestral accompaniment, though, were still unsatisfactory. Changes in tilt both laterally and vertically made an appreciable difference, but not in the desired way. Still too much orchestra. It was decided to try a very hard cardboard shield about two by three feet painted to blend in with the set, and suspended directly forward of the mikes. This provided a solution which, while not acceptable from a perfectionist point of view for the low voices, did present a very satisfactory compromise. It was felt that a further improvement could be realized with an increase in gain as soon as the auditorium became full.

This was still another surprise. The gain could not be increased at all. And, with the auditorium full, the apparent loudness was the same, even though a thousand people can, and do, absorb a lot of sound. Actually, once set, the gain required no further attention at all.

Early in rehearsals another benefit which had not been anticipated or even imagined became evident and was quite startling. The chorus consisted of seventeen voices. The orchestra of three violins, three saxophones, one trumpet, one guitar, bass, and drums. What one heard was a chorus of at least fifty or sixty voices, and an orchestra of at least double the actual number. This, of course, was feedback, but not of the type ever encountered before. Its effect was simply that of increasing the sound without any trace of echo or out-of-phase distortion. As a contrast, one mike was used during several full chorus and orchestra passages. The result was about normal for a single-channel p.a. system. When the other mike was switched in, the reproduced sound changed from a hodge-podge to complete naturalness.

Not quite as astonishing, but still a little on the unbelievable side was the contrast between those same passages with and without sound pickup. The chorus would suddenly change to only seventeen voices, and the orchestra to the actual number of pieces.

During the course of the play two sound-effect records were used; one of crickets and night noises, the other of a siren. These were fed in the conventional manner from turntable to phonograph input on the amplifier feeding the speaker on the left. Here again the peculiar type of feedback occurred with the result that the sound of the crickets and night noises, for instance, was about equal in *both* speakers, and the total propagation as pervasive as that experienced from the stage. At each performance a great many people, while not prepared to say just how the sound of the crickets *was* made, were still a bit skeptical even though they were looking right at the record.

Even though high-quality amplifiers and speakers were used, the "realness" of the resulting sound was still astonishing and proved to be the most rewarding part of the whole experiment. Those who came to talk about the crickets were about as unbelieving when they found that the whole performance had come to them through loudspeakers.

Actually, this came as no particular surprise, since spot checks made all over the house during the week of rehearsals proved that the sound seemed to come right off the stage. As noted before only in the immediate section around each speaker did one become conscious of sound being projected from the side, and not entirely from the stage.

Two points were found to be vital. The speakers must be in phase, and the mike on the right must feed the speaker on the right. Any other arrangement resulted in a peculiar separation, which while not unpleasant, was still unreal enough to prove disconcerting and, of course, make it immediately apparent that the sound was coming from loudspeakers. This applied only to solo singers and dialogues, when, obviously, one *sees* one person talking and singing, and *hears* two.

Even though the results of this experiment were so completely satisfactory, it is not intended that any of the data given will be taken as applicable to a similar set of dimensions or conditions. So little is known of this type of sound pickup that the writer fully realizes the results achieved may be due to factors which were not even considered.

However, it is not at all difficult to see countless instances in which binaural pickup could make a tremendous difference, not only in the "realness" of the projected sound, but in the ease of monitoring. In both radio and TV studios where the audience hears primarily through loudspeakers, it would no longer be necessary to have p.a. mikes near each performer; only two swung at the optimum point above the stage, and no monitoring; for speakers, particularly those who speak best when not tied to a stationary mike; for lecturers who depend on charts and other accessories to illustrate their talks, and find it extremely bothersome to carry a mike at the same time. The possibilities are, of course, endless.

It is hoped that this report will prove an added incentive to everyone who has considered this idea and wanted to try it. The writer finds it difficult to wait until time is available for further experimentation.

CIRCLE DIAGRAMS

[*from page 23*]

amplification (referred to the mid-frequency amplification).

As in the low-frequency circle diagram, *Fig.* 3 may be used for either analysis or design. As an example of its use in analysis assume the upper half-power frequency to be known and the value of the shunt capacitance (wiring and tube capacitance) to be desired. The intersection of the 45-deg. phase-angle line and the known f circle will indicate the value of T for the amplifier in question. Since $T = C_s R_p$, and since R_p will undoubtedly be known or easily determined, the determination of C_s follows immediately. Again, as in the low-frequency circle diagram, the schemes whereby *Fig.* 3 can be useful in analysis and design are several.

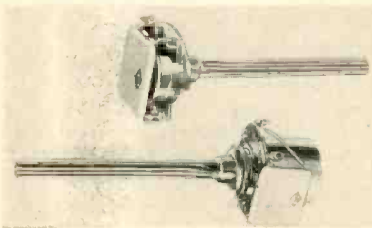
Conclusion

It should be mentioned that the diagrams drawn are not restricted to the ranges of T and f indicated. From the previous development it will be noted that, in both the low- and high-frequency circle diagrams, the parameters T and f are related by $T = \left(\frac{1}{2\pi}\right)\frac{1}{f}$. Thus, either the T's or the f's may be multiplied by a factor of 10, 100, etc., while the other parameter is multiplied by 0.1, 0.01, etc., respectively, and the ranges of T and f proportionately changed.

With a few minutes study of the diagrams the reader will realize their possibilities as fast design and analysis aids. The circle diagrams also contain considerable qualitative information on resistance-capacitance-coupled amplifiers.

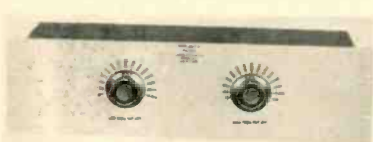
NEW PRODUCTS

• **Printed Circuit Loudness Control.** "Compentrol" is the trade name of the new compensated loudness control being manufactured by Centralab, 900 E. Keefe Ave., Milwaukee 1, Wis. The unit is a combination dual-tapped control and a printed-circuit plate which contains the compensating network. Since all components in the Compentrol are in shunt, there is no insertion loss. Designed as a direct replacement for



standard controls in all audio equipment, the unit effectively compensates for Fletcher-Munson hearing characteristic curves. Two types of Compentrol are now available, ½- and 1-megohm in value, in both switch and non-switch models. The units are completely assembled and ready for installation in place of most standard-size volume controls. Descriptive booklet may be obtained free of charge at Centralab distributors, or by writing the company.

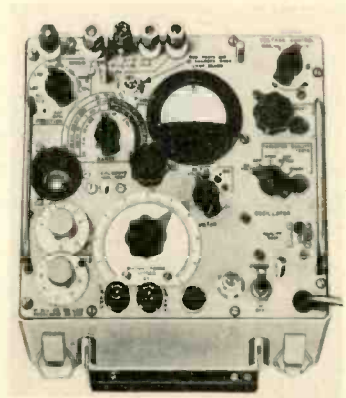
• **Sound Effects Filter.** Independent control of both ends of the audio spectrum is inherent in the new Type 6517-D sound effects filter recently introduced by Cinema Engineering Company, 1510 W. Verdugo Ave., Burbank, Calif. Technically speaking, the 6517-D is a variable high- and low-pass filter with zero phase distortion over its entire transmission range. Toroidally wound inductances permit use in low-level



circuits without fear of hum pickup, and insertion loss is zero. Input level ranges from minus 70 dbm to plus 28 dbm. Low-frequency control has ten steps permitting cut-off from 70 to 7500 cps; high-frequency control also has ten steps, permitting cut-off from 300 to 10,000 cps. Full-frequency transmission is afforded with both controls in OFF position. Built for standard rack mounting, the unit is 5¼ in. in height and 6¼ in. deep.

• **Audio Amplifier.** Less than one per cent distortion at full rated output of 30 watts characterizes the excellent performance of a new audio amplifier recently announced by Summit Electronics, Inc., Summit, N. J. Frequency range of the new unit is 30 to 15,000 cps within ± 0.2 db. Normally supplied with high-impedance input, the amplifier is also available with input for bridging or low-impedance termination. Output impedance is switch controlled from 4 to 600 ohms. Supplied in a choice of attractive carrying cases or for rack mounting. Specifications and additional information may be obtained upon request to the manufacturer.

• **Capacitance - Resistance - Inductance Bridge.** Created essentially for the design engineer and the laboratory technician, the new Clough-Brengle Model 712 instrument is capable of a variety of measurements which will permit accurate evaluation of almost any component in an electronic circuit. Among its functions are the measurement of capacitance of paper, mica, electrolytic, ceramic, and air capaci-



tors; stray capacitance of bushings, switches, and wiring; dissipation factor of capacitances; leakage current of electrolytic capacitors; resistance of components inductance of coils and transformers; storage factors (Q) of inductances; turns ratio of transformers; d. c. leakage current of capacitors, and quality test of capacitors shunted by resistance or inductance, without removal from circuit. Despite all these functions, the 712 is only 5½" high by 8⅞" long by 8⅜" wide, and weighs but 14 lbs., and is extremely moderate in price. Manufactured by Clough-Brengle Co., 6014 Broadway, Chicago 40, Ill. Address requests for further information to Dept. AE.

• **Strip-Wound Transformer Cores.** Newest product of Permoflux Corporation, 4900 W. Grand Ave., Chicago 38, Ill., is a line of strip-wound transformer cores manufactured from grain-oriented silicon steel strip to exacting mechanical and electrical

tolerances. Wound from 1-, 2-, 4- and 12-mil stock, the new cores are available in a range of standard window sizes and build-ups. High efficiency and permeability are characteristic of the new cores, which are especially suited to designs where weight and space are critical factors. Requests for full technical information should be addressed to the manufacturer, Department C-1.

• **Wireless Intercom System.** Bogen's new Model TWIN intercom system employs existing power lines as a transmitting medium, and utilizes an exclusive line-noise suppression circuit which is said to provide the most reliable and the quietest operation yet achieved in equipment of this type. The system can be used with two or more stations, with all conversations heard by all units in the system.

Each station comprises a transmitter and receiver operating at 175 kc. A unique feature of the TWIN is the "Silent Watchman," which permits a station to be locked in TRANSMIT position for use in various applications where continuous listening or aural supervision is required. Stations are placed in operation simply by plugging into a standard 117-volt a. c. or d. c. outlet. The only additional requirement is that all stations must be fed through a common meter. Complete information will be supplied by the manufacturer, David Bogen Company, 29 Ninth Ave., New York 14, N. Y.

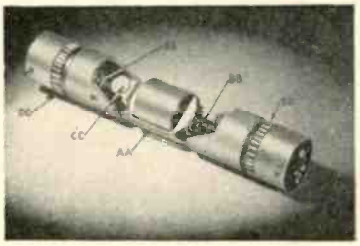
• **Small Spotwelder.** Tweezer-type electrodes and a stepless energy-storage control are featured in the new Unimatic spotwelder, designed to produce welds of instrument quality at production line efficiency. Welding pressure is fully adjustable. Power consumption is 300 watts and maximum energy storage is 20 watt-sec-

onds. Firing control is automatic at pre-set pressure. The small hand-fitting electrode-switch assembly is well designed for making welds rapidly, and in confined or difficult locations. For application data, literature and further details write Unitek Corporation, Pasadena 8, Calif.

• **Variable Transformer.** Users of small variable-voltage step-down transformers will welcome the new Model 226 recently introduced by Pacific Transducer Corp., 11921 W. Pico Blvd., Los Angeles 64, Calif. With a 50-watt input at standard line

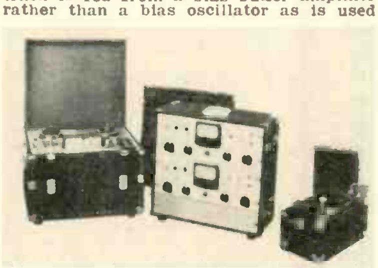
voltage, the unit affords secondary output continuously variable from 7 to 13 volts at 4 amps. Weight is only 3 lbs. Rated for continuous duty, the 226 is well-suited for operation of 6- to 12-volt lamps, small motors, heater elements, and a.c. relays and solenoids.

• **Improved Meter Movement.** Exceptional sensitivity and accuracy, along with stability and ruggedness, characterize a new type movement developed by Dr. Emil Greibach, which is featured in meters recently introduced by Columbus Products Corp., 1010 Saw Mill River Road, Yonkers,



N. Y. In the form of a removable and replaceable cartridge, the Greibach movement is a refinement of the classic d'Arsonval principle. Its movable coil, suspended on twin wires, eliminates the frictional losses encountered in conventional jewel-and-pivot bearings, permitting extreme sensitivity—as great as 1 microampere full scale. Accuracy is 0.5 per cent. Available in laboratory, portable, and panel-mounting models.

• **Stereophonic Tape Recorder.** Among the unique features of the new Ampex Model 403-2 stereophonic (tape recorder is a stacked dual-track head assembly which permits editing and splicing of recorded tape in the same manner as is used with conventional single-track recordings. Two complete amplifier-record-erase assemblies are identical except that the second sound track is fed from a bias buffer amplifier rather than a bias oscillator as is used



for the first sound track. The buffer amplifier is driven by the bias oscillator, thus assuring exactly the same bias frequency on both recording heads. Performance characteristics of the new Ampex include 7½ and 15 ins./sec. recording speeds; push button actuated solenoid control of all functions, permitting full remote control; built-in preamplifiers for microphone and for bridging low-level lines; frequency response to 15,000 cps at 7½ ins./sec. tape speed, and noise level down more than 55 db. The unit is supplied as a three-case portable or for rack mounting. Complete information is available on request from Ampex Electric Corporation, 934 Charter St., Redwood City, Calif.

• **Loudspeaker Enclosures.** The new line of River Edge speaker cabinets is now being delivered to jobbers, and includes both modern and traditional designs in models of conventional rectangular cabinet form as well as for corner installation. The wide variety of styles includes large and small cabinets for speakers alone, along with a selection of models designed to accommodate the speaker in addition to a record changer, tuner, and amplifier. All of the rectangular cabinets incorporate the Flex-O-Port, which permits adjustment of the cabinet resonance for optimum performance with practically any type of loudspeaker, and all models are constructed of ⅝ to ¾ in. wood, and are finished in a number of colors to suit any decor. Further information may be obtained from River Edge Industries, River Edge, N. J., and models are on display in the New York showroom at 192 Lexington Ave.

NEW LITERATURE

• **Thordarson-Meissner,** Dept. 2., Mt. Carmel, Ill., includes listings of interest to servicemen, industrial engineers, and amateurs alike, in Transformer Catalog 400-K. Many special transformers, including types for photo-flash, vibrator, isolation, and band-pass speech filtering are described. Of particular interest to hams is complete information, including schematics, for building variable d.c. power supplies. Will be mailed on request.

• **Jensen Industries, Inc.,** 329 S. Wood St., Chicago 12, Ill., frankly discusses the damage caused to records by worn-out needles of the "permanent" type in a new booklet listing Jenson diamond styli for replacement purposes. Included in the booklet is a chart which shows standard phono cartridges by make and number, the corresponding Jensen diamond replacement, together with retail prices.

• **Allen-Bradley Company,** Milwaukee, Wisc., will supply on request a copy of a new 16-page booklet featuring the company's complete line of timing relays. Contained are data covering operation and engineering features, as well as a selector chart for use in the selection of timing relays for various applications.

• **Cast Optics Corporation,** 1 Post Road, Riverside, Conn., features descriptive and functional data on optically clear rigid plastic sheets, as well as on UHF insulation sheet and rod, in a new 8-page illustrated bulletin which will be mailed on request. In addition, the booklet contains tables of properties of four types of plastics, brief fabrication instructions and some of the accepted uses.

• **Cornell-Dubilier Electric Corp.,** South Plainfield, N. J., is distributing Bulletin Nb-147 listing basic styles available in the new C-D Demicon series of capacitors. Demicons are miniaturized tubular metal-cased units designed to meet severe operating requirements, especially where space limitations are an important factor.

• **Dow Corning Corporation,** Midland, Mich., is distributing an interesting booklet which describes many of the unique properties of the company's Class H Silicone electrical insulation. Included are many case histories which cover a wide variety of applications. Thermal properties of silicone are shown to lower motor maintenance costs greatly, also to increase by as much as 50 per cent the power-per-pound ratio in motors, transformers, and solenoids. Available on request.

• **Barber-Colman Company,** Rockford, Ill., describes a complete line of unidirectional, reversible, and synchronous shaded-pole motors for servo mechanisms, projection equipment, advertising devices, and other small appliances in Bulletin F-4271-2. Described in Bulletin F-4344 are permanent-magnet motors with electrically balanced armatures. Both sheets will be mailed free on request to the company's Motor Division.

• **Insulation Manufacturers Corporation,** 565 W. Washington Blvd., Chicago 6, Ill., thoroughly describes cotton, glass, and asbestos woven tapes, braided sleevings, and cords for electrical insulating purposes in a new 28-page illustrated catalog. Information on applications, properties, technical data, sizes, types, and packaging is included. Copy will be mailed free on request to the Publications Department.

• **William Brand & Company, Inc.,** North and Valley Streets, Willimantic, Conn., in a booklet titled "Here's How Turbonics Will Assist You in Solving Your Complicated Wiring System and Insulation Problems," describes a new process developed by the company for determining insulation characteristics to insure lasting performance. A thoroughly interesting booklet; it will be supplied upon request to engineers, architects and designers.

DISTORTION IN VOLTAGE AMPLIFIERS

[*from page 29*]

amplifier uses one more tube than the earlier version but it seems well worth while to put this extra effort into the early stages to insure that they are at least as good as the output stage on which we spend considerable time and money to achieve low distortion.

It is hoped that the information set forth in this article will dispel any notions that voltage amplifier stages operating at low signal levels do not introduce distortion. Fortunately it is not difficult or expensive to remedy these conditions; voltage amplifiers are cheap and we are not limited too greatly in the amount of feedback we can apply when we have no transformers in the circuits. Good engineering practice is all that is needed to stop the feeding of 1-per cent IM output amplifiers from 5- to 10-per cent IM input amplifiers.

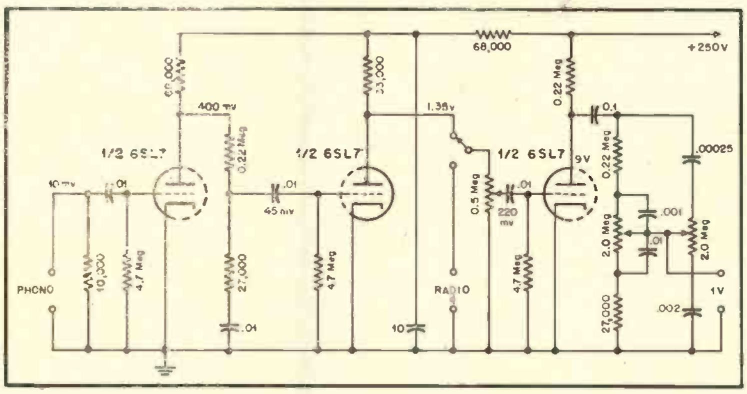


Fig. 10. Typical circuit encountered in "front end." Measurements indicate this to be the "Horrible example."

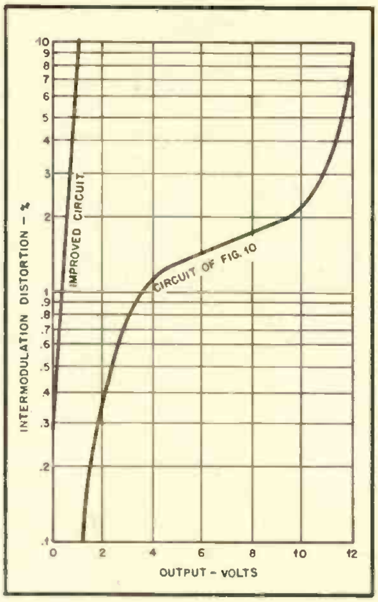


Fig. 11. Distortion of portion of circuit to right of volume control in Fig. 10, compared with similar circuit after using IM tests to make improvements.

SOUND HANDBOOK

[*from page 34*]

Auditory perspective in motion pictures, to match the visual perspective of the picture, is usually eliminated (by having the mike boom follow the speaker) in favor of increasing the ratio between the recorded intelligence and background studio noises. In this way sounds originating at various distances are recorded at the same intensity.

There is a danger, in phonograph recording, of placing too much emphasis on picking up each group of instruments with maximum individual clarity, and submerging the total effect of an orchestra in a concert hall. Acoustically "dead" recording gives the writer the impression of musicians playing in an airless studio, of an electronic technique which has lost sight of the original musical conception. It is reasonable to infer that the composer who chose the instruments, and the craftsmen who designed them, had in mind the quality of sound that would be evident in a musical chamber. This quality involves timbres softened by the reverberation time versus frequency characteristics of the hall. Reverberation also blends the various sounds and creates an effect that may be subjectively described as a "roundness"

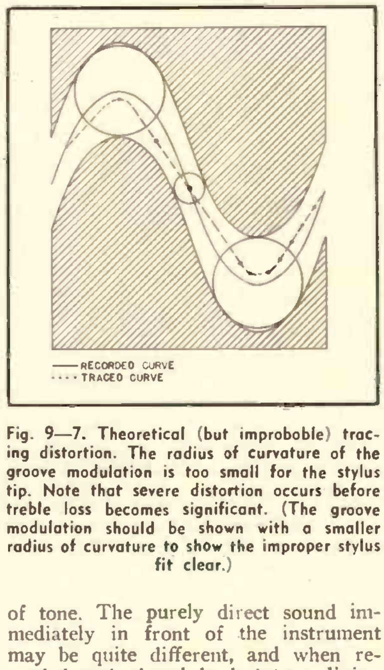


Fig. 9—7. Theoretical (but improbable) tracing distortion. The radius of curvature of the groove modulation is too small for the stylus tip. Note that severe distortion occurs before treble loss becomes significant. (The groove modulation should be shown with a smaller radius of curvature to show the improper stylus fit clear.)

of tone. The purely direct sound immediately in front of the instrument may be quite different, and when recorded and played back into a living room it sometimes has an over-hard, sometimes even shrill quality.

Recording technique employing a single microphone, (which receives the same proportion of direct and reflected sound as would a listener at that position), has been used extensively in Europe, to this writer's ears with great success. More recently single-mike or predominantly single-mike recording technique has been favored in this country. Such a technique makes much greater demands upon the microphone, which must be very sensitive since it is further from the source of music, and which requires an exceptionally smooth omni-directional response pattern that does not vary the frequency response at different angles of reception. It is also necessary to guard against too much reverberation, which not only blends the different tones but homogenizes them.

When the acoustics of the hall and the characteristics of the microphone make single-mike technique possible there is a further advantage, in that the problem of balance between the various parts of the orchestra is taken out of the hands of the recording engineer (except as regards location of the microphone) and given back to the conductor. The recording engineer is expected to be a man of musical sensitivity and knowledge, who works closely with the conductor in regard to such matters, but the story is told of one engineer who complained that a certain musical passage was overloading his microphones, and demanded that it be played more softly. "The passage is marked *forte, forte!*" explained the conductor indignantly. "Take it down to thirty," snapped the engineer.

Disc Materials

The cutting of the original of a commercial pressing, nowadays normally recorded from tape, is usually on an "instantaneous" lacquer disc, so called because it can be played back immediately without processing. These originals may have a surface noise, with the treble equalized, as low as 50 to 60 db below

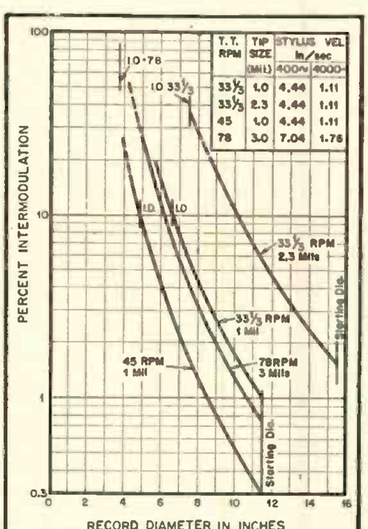


Fig. 9—8. Per cent intermodulation distortion related to turntable r.p.m., groove diameter, and reproducing stylus tip radius.

a high-level recorded signal.[5] They may be played many times without appreciable degradation of quality, although the pliability of the lacquer causes relatively higher playback loss than that of the pressing. This loss is accentuated by the use of a pickup with low compliance.

The pressing, or molded record, can be made of materials that have greater resistance to deformation and wear, but some loss in quality from the original is to be expected. Surface noise is higher; Vinylite pressings show a minimum of 5 to 10 db more of surface noise, and shellac may show an increase of as much as 20 to 30 db. Vinylite and similar materials are easily charged electrostatically, and attract small dust particles that create annoying background noise.

[5] The NAB recommended reference level for evaluating surface noise is a 1000-cps tone, recorded with a velocity of 7 cm/sec. Noise is to be measured on a standard volume indicator.

THEATRE SOUND

[*from page 20*]

the process of sound transmission through horns at different frequencies must be understood.

Sound waves are longitudinal in motion and tend to disperse in all directions in the form of a spherical wave. If originating between two buildings, for example, the wave readily bends or diffracts around corners and disperses in all directions. This is true mainly for the longer wavelengths, however, as they tend to cause actual compression and dilation of the air with enough energy to overcome the friction of changing direction.

The formula for surface area of a sphere is $4\pi r^2$ while that for the portion of a spherical wave subtended by the walls and floor around our speaker location is $\pi r^2/2$. Thus the sound generated in the corner is eight times as effective as it would be if generated outdoors on the top of a tower. By similar comparison it is apparent that the same sound source would be many times more effective if its wave propagation were confined to the almost parallel sides of a long horn.

The function of a horn, then, is to start the sound wave out as a minute sector of a spherical wave and gradually allow the sector to increase in surface area till it is finally turned loose in the atmosphere. The lower the note the stronger the walls have to be to contain it and the more readily it spreads and diffracts around the edge of the horn mouth when released. By using the corner of the room as an extension of the horn, the wave is never allowed to diffract around the edge and, consequently, the volume of those low notes is conserved for the listener to enjoy, in balance with the high notes.

It is not so simple as it sounds, though. Tests have proven that the greatest movement of the air particles takes place along the walls of a large horn when low notes are being transmitted. This is known as "annular movement" and is comparable to "skin effect" when high-frequency currents travel an electrical conductor. This effect diminishes as notes of higher frequency are transmitted. If we start low notes down the sides of a large horn and have higher notes taking a more direct course down the axis of the horn, it is easy to see that there is going to be considerable turmoil.

The solution to this problem is to hold the large horns to a relatively narrow range of transmitted frequencies. This is what we have done by having two horns to handle the frequencies below 1000 cps. The tweeter, for use at a higher crossover, can use a simple horn, with considerable saving in price.

But, not only do you have distortion between a wide range of frequencies in a large horn—you have distortion between single low notes and the outside atmosphere. Naturally, if you send a burst of annular ripples down the side walls and then allow them to suddenly diffract around the mouth of the horn, outside air is going to try to rush inward along the axis and cause both reflected waves toward the speaker and distorting eddy currents with the outcoming sound.

Natural Distortion from Instruments

Next time you are near some brass instruments, if you listen carefully you will notice that the lowest notes from the bass horns have a crackling sound. Like a series of sharp pops—similar to the crackling noise from exhaust pipes of large truck engines as they accelerate. To a lesser degree, you can distinguish the same crackling in vigorous low notes of the baritone horn and follow up through the alto horn, trombone, and low notes of the trumpet. You don't get completely away from the crackling effect till you listen to the smaller "toy" trumpet used in much of Handel's music.

Examine a mute for use in one of these instruments and you will see that it is designed to close out the outside air from the center but permit the annular passage of the fundamental notes along the walls of the horn. Thus it suppresses the upper harmonics of the fundamental notes and kills the eddy currents set up in the mouth by outside air.

These brass horns can not take advantage of the walls of the room to extend them, so they have exaggerated flares or "bells" at their mouths, to soften the sudden release of annular wave motion as it reaches the end of their restraining walls and to achieve better acoustical coupling. Thus musicians live every day with this harsh distortion of the brasses, and the expression "brassy" has an understood significance. The enthralling rustic vibrance of a "brass choir" would be lost without this effect.

All of these features of the horn work to advantage in this system. The fundamental ranges of the brass horns fall below 400 cps and therefore are in the range of the folded horn. The annular effect is what makes it possible for us to bundle the whole works up in a small cabinet and bring the bass notes out of narrow slits along the wall.

It is these very bass notes that will readily swing around the folded passages of our horn while the higher notes are snuffed out by loss of energy in acoustical resistance. Thus we have an acoustical filtering and less worry about interfrequency distortion. At the same time, we have the effect of a large horn mouth without the distortion from eddy movements, because the center of it is taken up by the main body of our cabinet.

You may say that since we are essentially using the corner of the room beyond our cabinet as the mouth of our horn, we have theoretically reproduced the same features we said caused interfrequency distortion in a large horn. For we bring the higher frequencies of our center horn out into the same mouth with the annular movement of bass notes. But there is little comparison here—as a plan view will show—for the angle of spread in a 90-deg. corner of a room is so great that their mixing is hardly of consequence. In fact, this is where the nonlinearity of the surrounding air works to our advantage. Remember that the low notes are trying to expand sidewise to form a sphere and have no tendency to move inward to mix with notes from the center horn, while the bulk of our cabinet in the center prevents the eddy movements in the same way the mute does in a trombone or other brass horn.

In the room with our speaker system one has the feeling of sitting in the orchestra with the instruments playing all around him. Within a few feet of it you are, in effect, sitting in the mouth of the horn. If one wants to hear a symphony with the feeling of being in the twentieth row of a concert hall, he can place the speaker in a room next to the living room and let the notes blend before coming through a door into the living room.

With this long discussion of the merits of our system, we hope we have prepared the reader to tolerate its mechanical complexity and the greater pains required in its construction, which will be covered in full detail in the next issue. No special test equipment or machinery is required but the builder should be reasonably experienced in work with wood and sheet metal. The availability of a power table saw and an electric hand drill will save a lot of effort and time.

LETTERS

[*from page 10*]

Stereophonic Reproduction

SIR:

Stereophonic recording—in tape form, at least—we have now, and the advent of stereophonic reproduction in the near future vitally interests me. With a near hopeless expectancy, I have watched the slow beginnings of the usual muddle and mush that seem to accompany a new development. If stereophony is to be other than a money-making scramble, some relationship to sanity must be maintained.

There is one other factor I would like to comment on. It could be assumed safely, I believe, that the possessor of a stereophonic reproducer would devote a short end of the listening room to his acoustic darling. Seeing that he has two wide frequency bands to contend with, it is likely that he would use two- or three-way speaker systems. So the two corners of this end of the room would, rationally, be used for the low-frequency horns. The remainder of the sound spectrum would come from a point at, or near, center. To obtain the maximum effect from this arrangement, orchestra seating should follow fairly closely. That is, bass instruments should be located at the ends of the stage. Such is my dream, and I can hope mightily that stereophonics will avoid the Topsy procedure and leap, fully matured, to near perfection.

A. M. BAIN,
Camp 106, Edmonton,
Alberta, Canada

(*1. Current custom is to place the two speakers "flat" with the wall, rather than in corners.*

2. The greatest effect from stereophonics would seem to come from the high-frequency end of the spectrum. We think, therefore, that the tweeters would more logically be placed with the greatest separation, with the woofers—possibly—closer together, if there was to be any separation of the elements of two- or three-way speaker systems. ED.)

Help Wanted

SIR:

We are requesting ideas on a medical research problem we are considering. We are investigating the tremor rate of the tongue during moments of stuttering. The way the problem was handled before was to insert a pneumatic pressure bulb in the mouth and have the resulting changes in pressure actuate a recording device to obtain amplitude and frequency. The size of the bulb, its mechanical inertia, distracting tubes, and so on, limited the usefulness of this system. However, data of definite clinical and therapeutic value were obtained.

It has been suggested that a drop of paint containing iron filings could be placed on the tongue, and by magnetic or electronic means movements could be recorded. Metal in the teeth would have to be accounted for. Amplitudes ranging from .01 to 2 or 3 inches and frequencies from 1 to 100 cps seem to be about the necessary range of instrumentation.

We would like suggestions from your readers on possible systems and procedures and other methods that may come to mind. Full credit will be given on publication. Please forward replies to Dr. Van Riper, Speech Clinic, Western Michigan College, Kalamazoo, Michigan.

JULIUS LUCOFF, P. E.,
4905 E. 68th St.,
Seattle 5, Washington

More Anent Frudd

SIR:

I should like to make a few crisp comments on the fan mail, calls, and discussion pertinent to our "Frudd" article.

Constructive ideas may come out of nonsense and satire, judging by some of the letters. Is it possible that such stuff could be taken in deadly earnest? Yes, it is. Ten or twelve letters and calls requested more details and discussed the "merits" of the "system" with the solemnity of boiled owls. Perhaps this should be a lesson to us. Perhaps Æ should not assume that all readers are professional experts, and that there should be, in the future, articles written on extremely elementary levels from time to time. It is a fact that Æ articles are often slanted toward highly select economic and professional brackets, thus holding only vicarious interest to many —including myself—whose current budget for hobby #1 is about $1.00 per week.

Some of the responses show kindred minds tearing along in the same channels— the "Frudd" article came as a release for them. I found them quite funny. Since I can't find time to answer all the letters individually, I trust this may answer many *en masse*.

At the moment, Frudd is sitting by my side, happy and gibbering. In a moment he will be dead as a doornail, since I have put strychnine in his ginger ale. It will be a perfect crime. Now let the audio world rise to new heights.

ERIC WINSTON,
7814 Provident St.,
Philadelphia 19, Pa.

(*We are sorry to see Dr. Frudd go—he was so original. However, we have a few similar articles in our files, in case we need some release ourselves.* ED.)

Maybe He Has Something Here

SIR:

In reading Mr. Barritt's article on "Speaker Treatment for Improved Bass" in the December issue, my attention was called upon the fact that he used dibutyl phthalate as a softening agent for paper. The compound being an excellent plasticizer for plastics has, however, hardly any effect on paper. Glycerol or ammonium lactate are good softening agents where paper is concerned, and I think better results would be obtained with them.

Another magazine recently presented a method for improved treble—simply cement the pointed half of an eggshell in the center of the speaker cone.

Everyman can hence alter his old speaker to a hi-fi one with these two ideas.

ÅKE S. STENIUS,
Kolmårkdvägen, 9,
Lidingö, Sweden

EQUIPMENT REPORT

[*from page 38*]

optimum dynamic balance without the need for any measuring instruments. Heaters of the preamplifier and control unit tubes are operated on d.c. and the amplifier may be said to be hum free—hum and noise being more than 65 db below maximum output for magnetic phono input, or more than 80 db blow maximum output on the high-level outputs.

Construction is exceptionally sturdy—with many of the components—such as tubular coupling capacitors and all resistors over 5-watt rating—being held in place in spring clips rather than being supported solely by their leads. The chassis is adequately ventilated by perforations.

Table I shows the input signal required for 1-watt output with the volume control at maximum, tone controls at flat. For the phono inputs, the equalizer was set on "AES Microgroove"; the filter was set on "Perfect."

Three high-level inputs are provided—for tape recorder, TV, and AM-FM radio. One high-level input is provided for crystal pickups, and two low-level inputs are provided for magnetic pickups. The output circuit provides for 8- and 16-ohm loads. In addition to these normal inputs and outputs, a jack is also provided to furnish a signal to the tape recorder.

Listening quality is considered excellent, and the operation of the controls provides a wide variety of adjustment to suit practically any type of input signal.

TABLE I
Signal Required for 1-watt Output (Measured at 1000 cps)

Input Jack	Signal
Radio-TV-Tape	0.4 v.
Crystal pickup	0.15 v.
Lo-magnetic pickup	0.0016 v.
Hi magnetic pickup	0.009 v.
Signal available at Tape Recorder feed jack at 1-watt output	0.78 v.

SWITCHING PANEL

[*from page 25*]

The advantages of this program dispatching system are low cost, simplicity, and flexibility. In fact, branches have been switched from one program channel to another, during speech, between sentences, without a word being lost. It has served a 5-kw AM transmitter installation, a 20-kw FM plant, a coast-to-coast radio network, (it was installed at one of the key stations of the network) and recording and audition-rehearsal activities for several years.

The Audio Fair—Los Angeles
DIRECTORY OF EXHIBITORS

The following is a listing of the exhibitors as of January 19 at the Alexandria Hotel in Los Angeles in the West's first Audio Fair, February 5, 6, and 7.

ALTEC LANSING CORPORATION 620–621
9356 Santa Monica Blvd., Beverly Hills, Calif.
Products: Loudspeakers, amplifiers, radio tuners, microphones, broadcast consoles, speech input equipment, transformers.
In Attendance .... A. A. Ward

AMPEX ELECTRIC CORPORATION 718
934 Charter St., Redwood City, Calif.
Products: Magnetic tape recorders and reproducers.
In Attendance .... Harrison Johnston

AUDAK COMPANY INC. 679
500 Fifth Avenue, New York 36, N. Y.
Products: Electronic recording and reproducing apparatus.
In Attendance .... Maximilian Weil

AUDIO DEVICES, INC. 687
444 Madison Ave., New York 22, N. Y.
Products: Audiodiscs, Audiopoints, Audiotape, Audiofilm.
In Attendance .... Alan H. Bodge

AUDIO ENGINEERING SOCIETY 678
Sponsors of the Audio Fair and Technical Sessions.
In Attendance .. Richard Hastings, Sec'y. L. A. Section
11056 Cumpston St., North Hollywood, Calif.

THE AUDIO FAIR—LOS ANGELES, INC. 666
4245 Normal Ave., Los Angeles 29, Calif.
Show Manager .... William L. Cara
Fair Director .... Harry N. Reizes

BELL SOUND SYSTEMS, INC. 660
555 Marion Road, Columbus 7, Ohio
Products: High-fidelity amplifiers, tape recorders.
In Attendance .... Floyd W. Bell

BERLANT ASSOCIATES 681
4917 W. Jefferson Blvd., Los Angeles, Calif.
Products: Concertone magnetic tape recorders.
In Attendance .... Bert Berlant

BRITISH INDUSTRIES CORP. 615–618
164 Duane St., New York 7, N. Y.
Products: Garrard record changers and accessories, Leak amplifiers, Wharfedale speakers, KT-66 tubes, R-J enclosures.
In Attendance .... Franklin Hoffman

BROOK ELECTRONICS, INC 787
34 DeHart Place, Elizabeth 2, N. J.
Products: High-quality audio amplifiers.
In Attendance .... Max Baume

BROWNING LABORATORIES, INC. 649
750 Main St., Winchester, Mass.
Products: AM and FM tuners.
In Attendance .... Henry Feldman

CAPITOL RECORDS 781
Sunset and Vine, Hollywood, Calif.
Products: Full-Dimensional Sound recordings (FDS).
In Attendance .... Lloyd Dunn

CINEMA ENGINEERING COMPANY 729
1510 West Verdugo Ave., Burbank, Calif.
Products: Audio equalizers.
In Attendance .... Art Davis

CONRAC, INC. 623
19217 E. Foothill Blvd., Glendora, Calif.
Products: Fleetwood and Conrac television receivers, Conrac tuner Kleen'r.
In Attendance .... W. J. Moreland

CRAWFORDS, INC. 712
456 N. Rodeo Dr., Beverly Hills, Calif.
Products: Klipschorn reproducer, Telemusic speakers, tuners, amplifiers, changers, recorders.
In Attendance .... Art Crawford

BING CROSBY ENTERPRISES, INC. 737–738
9030 Sunset Blvd., Los Angeles, Calif.
Products: Ampex magnetic recorders for instrumentation and data recording.
In Attendance .... Francis C. Haley

THE DAVEN COMPANY
191 Central Ave., Nework 4, N. J.
Products: Attenuators, wire-wound resistors, rotary step-type switches, distortion and noise meters, transmission measuring sets, etc.
In Attendance
Ash M. Wood, Tom Wallace

ELECTRO-VOICE, Inc. 779
Cecil & Carroll Sts., Buchanan, Mich.
Products: Microphones and accessories, phonograph enclosures, high-fidelity components, TV boosters, TV distribution systems, public-address loudspeakers, UHF converters.
In Attendance .... Howard Souther

FIGART'S RADIO SUPPLY CO. 639
6320 Commodore Sloat Dr., Los Angeles 48, Calif.
Products of Altec Lansing, David Bogen, Jim Lansing, Electro-Voice, Stephens, Magnecorder, Concertone, Newcomb.
In Attendance .... Jim Pelham

FISHER RADIO CORP. 681
45-41 Van Dam St., Long Island City 1, N. Y.
Products: High-quality tuners and amplifiers, and the Master audio control.
In Attendance .... Avery R. Fisher

GATEWAY TO MUSIC 706

3089 Wilshire Blvd., Los Angeles 5, Calif.

In Attendance .... Alfred Leonard

GENERAL ELECTRIC COMPANY 721

Electronics Park, Syracuse, N. Y.

Products: Cartridges, loudspeakers, record compensator, and phone accessories.
In Attendance .... T. J. Nicholson

HIGH-FIDELITY HOUSE 657

536 S. Fair Oaks, Pasadena 1, Calif.

Products: All standard lines of high-fidelity audio equipment.
In Attendance .... John H. Cone

HIGH-FIDELITY MAGAZINE 738

1052 W. 6th St., Los Angeles 17, Calif.

(Great Barrington, Mass.)
Publishers of **Communication Engineering Magazine**; **Television and Radio Engineering Magazine**.
In Attendance .... Eddie Brand

HOLLYWOOD ELECTRONICS 684

7460 Melrose Ave., Los Angeles 46, Calif.

Products: All famous brands of hi-fi equipment.
In Attendance .... Harry Shaffer

KIERULFF SOUND CORPORATION 786

820 W. Olympic Blvd., Los Angeles 15, Calif.

Products: High-quality home music system installations, public-address and inter-communication equipment.
In Attendance .... Frank Gonzalez

KITTLESON COMPANY 642

7614 Melrose Ave., Los Angeles 46, Calif.

Products: Fairchild Recording Equipment Corp., tape recorders, disc recorders, turntables, cartridges, arm, amplifiers; Collaro, record changers and turntables; Welwyn, resistors; Tech Labs, EdiTall, attenuators, switches; Transformer Technicians, Inc., transformers. International Instruments, miniature instruments; Spencer Kennedy Labs, 302 Filter.
In Attendance .... H. A. Kittleson

KLIPSCH & ASSOCIATES 712

Hope, Arkansas

Products: Klipshorn sound reproducer.
In Attendance .... Paul Klipsch

W. BERT KNIGHT COMPANY 656

10373 W. Pico Blvd., Los Angeles 64, Calif.

Products: Microphones, General Industries phono turntables, Quam hi-fi speakers.
In Attendance .... Wes Alderson

JAMES B. LANSING SOUND, INCORPORATED 760

2439 Fletcher Dr., Los Angeles 39, Calif.

Products: Loudspeakers and enclosures.
In Attendance .... William H. Thomas

MAGNECORD, INC. 761

225 W. Ohio St., Chicago, Ill.

Products: Professional tape recorders and amplifiers.
In Attendance .... C. G. Barker

MAGNETIC RECORDERS COMPANY 601

7120 Melrose Ave., Los Angeles 46, Calif.

Products: Complete line of hi-fi equipment and a wide variety of tape recorders.
In Attendance .... Ernie Van Leewuen

J. W. MARSH COMPANY 714

4216 West Jefferson Blvd., Los Angeles 16, Calif.

Products: V-M automatic record changers. Permo phonograph needles. Acousti-Craft speaker baffles.
In Attendance .... J. W. Marsh

MARSHANK SALES COMPANY 708

672 S. Lafayette Park Place, Los Angeles 5, Calif.

Products: David Bogen Co., hi-fi amplifiers and tuners; Hallicrafters Co., hi-fi amplifiers and tuners; Turner Co., microphones; University Loudspeakers, Inc., loudspeakers.
In Attendance .... David N. Marshank

McINTOSH LABORATORY, INC. 768

320 Water St., Binghamton, N. Y.

Products: Audio amplifiers and loudspeakers.
In Attendance .... Gordon Gow

McSHANE AND COMPANY 634

6903 Melrose Ave., Los Angeles 46, Calif.

Products: Hartley-Turner loudspeaker, Hartley-Turner amplifier, Hartley "True-Bass" Boffle, McIntosh amplifier, The "Master" amplifier.
In Attendance .... Charles L. McShane

NEWCOMB AUDIO PRODUCTS CO. 784–785

6824 Lexington Ave., Hollywood 38, Calif.

Products: High-fidelity home music amplifiers, portable and table model phonographs, transcription players, public-address amplifiers, rack equipment.
In Attendance .... Robert Newcomb

THE PENTRON CORPORATION 633

221 W. Cullerton St., Chicago 16, Ill.

Products: Tape recorders, tape playback units, electronic mike mixers, basic tape mechanism, preamplifiers, AM tuner, speaker and baffle, continuous tape magazine, large-reel adapter, telephone pickup, and other accessories.
In Attendance .... Irving Rossman

PERMOFLUX CORPORATION 659, 663, 665

236 S. Verdugo Rd., Glendale, Calif.

Products: Speakers, transformers, baffles, electro-mechanical components, headphones, recording equipment.
In Attendance .... Les Leo

PERLMUTH-COLMAN & ASSOCIATES 612

1335 S. Flower St., Los Angeles 15, Calif.

Products: Alpha Wire Corporation, multi-conductor cable; Carter Motor Co., DC-AC converters; Crescent Industries, record changers; Masco Electronic Sales Corp., amplifiers; Raytheon Mfg. Co., tubes.
In Attendance .... J. J. Perlmuth

PICKERING & COMPANY, INC. 781

309 Woods Ave., Oceanside, N. Y.

Products: Pickups, tone arms, equalizer-preamplifiers, compensators.
In Attendance .... E. H. Uecke

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4401 N. Ravenswood, Chicago, Ill.

Products: Television, chassis, radio tuners and amplifiers.
In Attendance .... Edw. S. Miller

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P.O. Box 629, Mineola, New York

Publishers of **Audio Engineering, Audio Anthology, The 2nd Audio Anthology.**
In Attendance .... C. G. McProud, J. C. Galloway

RADIO PARTS COMPANY 732

2060 India St., San Diego, Calif.

Products: Sound equipment, tape recorders, amplifiers, speakers, etc.
In Attendance .... Frank Zurek

RADIO PRODUCTS SALES, INC. 614

1501 S. Hill St., Los Angeles 15, Calif.

Products: High-fidelity sound equipment.
In Attendance .... T. A. Lynch

RADIO RECORDERS EQUIPMENT CO. 643

7007 Melrose Ave., Los Angeles 38, Calif.

Products: Magnecord, Bell, Califone, Pentron, Lansing Sound, Electro-Voice.
In Attendance .... Wayne Graham

REK-O-KUT COMPANY 650

38-01 Queens Blvd., Long Island City 1, N. Y.

Products: Recording and playback turntables, Challenger Deluxe disc recorder, Rythmaster variable speed portable phonograph, Recitalist 3-speed portable phonograph, 12" and 16" overhead cutting lathes.
In Attendance .... George Silber

"THE REPRESENTATIVES" 766

Trade Association, Los Angeles Chapter, Los Angeles, Calif.

Featuring: "Hospitality and Service."
In Attendance .... John T. Hill

REVERE CAMERA COMPANY 743

320 E. 21st St., Chicago 16, Ill.

Products: Magnetic tape recorders and accessories.
In Attendance .... E. J. McGookin

E. V. ROBERTS & ASSOCIATES 638

5068 W. Washington Blvd., Los Angeles, Calif.

Products: Pedersen amplifiers, Telex headsets.
In Attendance .... E. V. Roberts

D. J. ROESCH COMPANY 659

Los Angeles, Calif.

Products: Custom "Chairside Control" Television.
In Attendance .... D. J. Roesch

THE SARGENT-RAYMENT CO. 715

1401 Middle Harbor Rd., Oakland, Calif.

Products: AM-FM tuners, audio amplifiers, tone-control preamplifiers.
In Attendance .... Will Rayment

HERMON HOSMER SCOTT, INC. 649

385 Putnam Ave., Cambridge 39, Mass.

Products: Amplifiers, preamplifiers, Dynaural noise suppressors, sound-level meters.
In Attendance .... V. H. Pomper

L. J. SMITH COMPANY 647

3270 Stoner Ave., Los Angeles 34, Calif.

Products: Tannoy Dual-concentric speakers, Barker Duode reproducers, Vidaire audio amplifiers (Phono-TV), Wagner recorders, (16 1/3–33 1/3 RPM), Salesmaster tape reproducer.

In Attendance .... LeRoy J. Smith

STEPHENS MANUFACTURING CORP. 723

8538 Warner Dr., Culver City, Calif.

Products: Loudspeakers, speaker enclosures, microphones, wireless microphones, 500-ohm O. T. L. amplifier.

In Attendance .... Robert L. Stephens

CONRAD R. STRASSNER CO. 661

1865 N. Western Ave., Los Angeles 27. Calif.

Products: Ozark Wood Products Co., speaker baffles (kits); Lowell Mfg. Co., metal speaker baffles; Pilot Radio Corp., FM-AM tuners, amplifiers, preamplifiers.

In Attendance .... C. R. Strassner

STROMBERG–CARLSON CO. 609

1225 Clifford Ave., Rochester 21, N. Y.

Products: Complete line of high-fidelity components, complete line of furniture assemblies, "Custom 400" line of audio equipment consisting of AM-FM tuners, hi-fi amplifiers, coaxial loudspeakers, record changers, and cabinets.

In Attendance .... E. V. Goodwin

THORDARSON–MEISSNER 756

7th and Bellmont, Mt. Carmel, Ill.

Products: Complete home hi-fidelity sound systems, transformers, tuners, kits, amplifiers, chokes, coils.

In Attendance .... R. M. Hardie

GEORGE S. TIVY COMPANY 685

1148 S. Grand Ave., Los Angeles 15, Calif.

Products: Jensen Mfg. Co., high-fidelity loudspeakers and enclosures; Webster-Chicago Corp., "Webcor" tape and wire recorders. Fonografs, and Diskchangers.

In Attendance .... George S. Tivy

UNIVERSAL RADIO SUPPLY CO. 740

1729 S. Los Angeles St., Los Angeles, Calif.

Products: Sound and audio equipment.

In Attendance .... G. Harry Braverman

UNIVERSITY LOUDSPEAKERS, INC. 709

80 S. Kensico Ave., White Plains, N. Y.

Products: Loudspeakers, woofers, tweeters, crossover networks, cabinets.

In Attendance .... Robert Reiss

WEATHERS INDUSTRIES 765

66 E. Gloucester Pike, Barrington, N. J.

Products: Frequency-modulated phonograph pickup and associated accessories.

In Attendance .... Paul Weathers

WEINGARTEN ELECTRONICS LABS. 637

7556 Melrose Ave., Los Angeles 46, Calif.

Products: Amplifiers, tuners, tape recorders, speakers, record changers, cabinets.

In Attendance .... T. Weingarten

THE WILCOX-GAY CORPORATION 734

1776 S. Robertson Blvd., Los Angeles 35, Calif.

Products: Wilcox-Gay Recordio line of tape recorders. Combination tape and disc recorders, recording discs and accessories.

In Attendance .... Wedge Weber

R-C OSCILLATOR

[from page 21]

result. Also, the capacitor must be mounted on an insulator. Here a lucite block was used and the screws holding the capacitor to the block were deeply counterbored. The 1.0-µf coupling capacitors should be good-quality oil-impregnated paper capacitors, preferably not in metal cans. The capacitance to ground is too high in the metal cased units and lowers the high-frequency response of the coupling network. The resistors used for the Bridged-Tee network should be selected if possible by using a Wheatstone bridge and, if necessary, pairs should be picked having required resistances. In this case the resistors were also rechecked on the bridge after they were mounted on the switch. Since a thermal shunt was used in soldering them in place their values had not changed. If cost is no object, one per cent deposited-film resistors can be used to good advantage. In soldering the film type resistors, some hope can be held that they will return to their marked value even under the undesirable conditions of soldering without the use of a thermal shunt. Mounting the resistors for S_1 between the decks of the switch permits use of the shortest leads. If care is exercised the oscillator can be assembled on a smaller chassis than the 7 × 12 × 3-in. size used here. The power supply should be shielded from the rest of the circuit in either case.

If conservation of space is important tubular electrolytics could be used in place of the twist-prong type shown in the photograph.

Adjustment

If the circuit is broken at points A and B and an oscillator connected between ground and the grid of the first stage, the gain of the amplifier may be trimmed correctly with C_f. The trimming merely adjusts the amplifier for flat frequency response out to two megacycles. How far beyond two megacycles the response will remain flat is a function of the geometry of each particular design. After the circuit is reconnected at points A and B, the low-frequency end of each band should be checked. If the resistances were accurately selected, these points will be correct and the high-frequency end of each band should then be checked. Each of the high-frequency trimmers C_h can be used to bring the upper end of each band into line. With the aid of a frequency counter or a primary standard the oscillator dial may be calibrated and a chart or new dial scale prepared. The circuit is applicable to ranges other than 20 to 20,000 cps and other variable capacitors may be used. To obtain the resistor values for use with any capacitor—variable or fixed—it is only necessary to drop the value into the equation

$$f_o = \frac{1}{2\pi C\sqrt{R_1 R_2}}$$

where C is the capacitance of one section. It should be remembered that the Q should be kept high which means that R_1/R_2 should be high since

$$Q = \tfrac{1}{2}\sqrt{R_1/R_2}$$

for the same circuit conditions. Also the value of the lowest resistor in the shunt arm should be greater than about five hundred ohms or the second stage will be loaded too heavily.

One final change is anticipated in the design for the next model of this excellent oscillator and that is the substitution of a 6AH6 for the 6AC7 and the use of a 6CL6, which is an improved, miniature version of the 6AG7. This should further reduce the volumetric requirements.

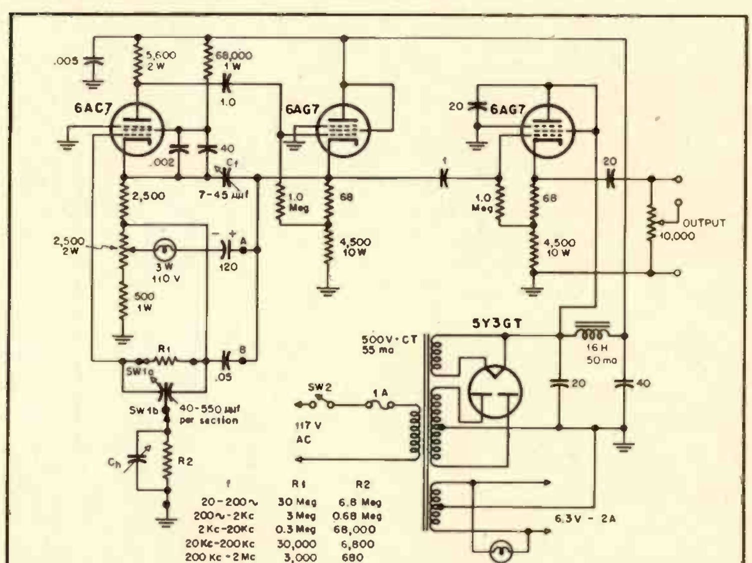


Fig. 3. Complete circuit of practical version of the oscillator and cathode-follower output stage.

BOOK REVIEWS

[from page 14]

needed to handle stubborn cases of interference effectively.

Actual procedures of locating the source of interference, the components required for construction of effective filters, and the proper installation of the filters all come in for detailed study in this short but effective text. It is to be highly recommended to all those who are plagued with problems of noise reduction and elimination, for despite the fact that this book was written in England, the problem in itself is universal and its solution is the same around the world.

—*L. B. Keim*

FUNDAMENTALS OF ENGINEERING ELECTRONICS, 2nd edition, by William G. Dow. New York: John Wiley & Sons, Inc., 1952. 627 pp., $8.50.

The reviewer remembers the first edition of Professor Dow's book well, as the text in which an analysis of the basic principles of "dry" rectification was finally found after a long and fruitless search. It is natural that such an analysis should have been found here, because the primary objective of the author has been to provide an understanding of the *internal* functioning of the electron devices that serve as active elements in electron circuits. Thus, chapters on electron ballistics, space-charge control of current, and electrons in metals and semi-conductors are included, in addition to the usual chapters on vacuum-tubes, circuit analysis, electron devices, and related topics.

Since the text is intended for electrical engineering students (in particular for those who intend to specialize in work with electronic circuits) the calculus is continually employed. This use does not, however, exclude clear, physical analysis and lucid diagrams.

—*E. M. Villchur*

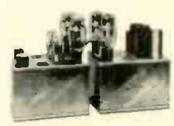
ELECTRICAL ENGINEERING, THEORY AND PRACTICE, by William H. Erickson and Nelson H. Bryant. New York: John Wiley & Sons, Inc., 1952. 523 pp., $6.00.

This is a survey book, a general view of the field of electrical engineering meant for mechanical, civil, and chemical engineering students. The subjects covered are d.c. and a.c. circuits, electrical machines, and electronics. The small section that relates specifically to audio amplification, by reason of its brief and undetailed treatment, will probably have less interest for the audio technician than will the book as a whole, which may serve as a reference for various fundamental electrical subjects. The analysis throughout stresses physical descriptions rather than mathematical formulas, although simple algebra and trigonometry are used.

—*E. M. Villchur*

Helipot Readies East Coast Plant

Helipot Corp., South Pasadena, Calif., has opened temporary quarters at 57 State St., Newark, N. J., for development and limited production, as a preliminary to moving into its New Jersey plant on Route 29 at Summit Road, in Mountainside. The new plant will contain 20,000 sq. ft. of floor area in a single-story fireproof building, which will be completely air conditioned. It will provide space for laboratories in addition to production and assembly lines.



A MONTHLY SUMMARY of product developments and price changes of radio electronic-television parts and equipment, supplied by United Catalog Publishers, Inc., 110 Lafayette Street, New York City, publishers of Radio's Master.

These REPORTS will keep you up-to-date in this ever-changing industry. They will also help you to buy and specify to best advantage. A complete description of most products will be found in the Official Buying Guide, Radio's Master—available through local radio parts wholesalers.

Miscellaneous Radio, TV and Electronic Parts

BELDEN MFG.—To their wire series No. 8018 added 50', 500' and 1000' lengths and also added 100' and 500' lengths to their series No. 8235.

EBY SALES—Added laminated miniature sockets No. 49-6H at $2.25 each list and No. 49-7H at $3.00 each list.

FEDERAL TEL. & RADIO—Added kit No. 3, all-purpose selenium rectifier assembly kit at $19.95 net.

ILLINOIS RESEARCH LABS.—Introduced Sta-clear, at $1.00 net for 4 oz. bottle, chemical solution that keeps static attracted dust from accumulating on picture tube and that also masks permanently.

INSULINE CORP.—Decreased price on transmitter racks No. 3865 to $43.38 net . . . No. 3866 to $53.95 net and No. 3867 to $64.35 net.

LITTELFUSE—Increased price on No. 342008, dust-proof, drip-proof in their 3AG fuse extractor post series to $.75 list.

MALLORY & CO.—Added No. PS54010, motor-starting capacitator at $4.89 net . . . No. FF45052, photo-flash capacitator at $13.50 net . . No. U-67, 5-meg carbon control at $.75 net . . . No. U-82, 10-meg carbon control at $.75 net . . . No. WF252-T23, 2500-ohm wire wound control at $1.50 net and 3 new control kits, Models 3735, 3755 and 3810.

MERIT TRANSFORMER—Added No. A-3100, high-fidelity output transformer at $10.80 net. Decreased price on No. P-3177, isolation transformer to $16.50 net.

Recording Equipment, Speakers, Amplifiers, Needles, Tape, Etc.

ASTATIC CORP.—Increased price of "scanafar" booster, Model CT-1 to $21.00 net.

BELL SOUND SYSTEMS—Added Model 3728MB, 30-watt mobile amplifier at $165.00 net. Discontinued Model PA-3710P, phono-p.a. system.

FISHER RADIO CORP.—Increased price on Model 50-C master audio control to $97.50 net.

MINNESOTA MINING—Added sound recording tape No. 111AP, plastic prof. reel, ¼" × 1200 feet and 7" (1200') professional reel and box (plastic) at $1.25 list.

SHURE BROS.—Discontinued multi-impedance super-cardioid microphones Model 55 and Model 556.

STROMBERG-CARLSON—Added No. AP-51, power amplifier at $157.50 list and No. TR-13, line transformer at $3.50 list. Discontinued No. RD-22, driver unit. Increased price on No. MD-38S, dynamic microphone to $70.00 list.

UNIVERSITY LOUDSPEAKER—Added Cobreflex-2 at $21.00 net. Discontinued No. 4407, co-axial tweeter adapter assembly.

UTAH RADIO PRODUCTS—Added Model SP15R at $41.70 net to their line of wide-range and p.a. group loud-speakers.

Test Equipment

CHICAGO INDUSTRIAL INSTR.—Discontinued Model 453, featherweight miniature volt-ohm-milliammeter.

ELECTRONIC MEASUREMENT—Added oscilloscope, Model 600 at $99.50 net.

Tubes—Receiving, Television, Special Purpose, etc.

R.C.A.—Added radio receiving tubes 6AR5 at $1.65 list . . . 6AX4GT at $2.40 list . . . 6K8G at $3.30 list . . . 3C45 at $17.80 list . . . 5718 at $8.65 list and 6211 at $2.95. Increased price on power tube fittings 202F1 to $23.85 list . . . 211F1 to $28.00 list and 228F1 to $67.60 list. Decreased price on 6L6G to $3.00 list and 5654-t to $4.90 list.

SYLVANIA—Introduced 6 new special purpose tubes . . . radio receiving tubes 1XRB at $2.65 list . . . 40B2 at $2.05 list and 6SN7GTA at $2.20 list and sub-miniature tubes 1T6 at $2.65 list . . . 6BF7 at $1.85 net and 6BG7 at $1.85 net.

CLASSIFIED

Rates: 10¢ per word per insertion for noncommercial advertisements; 25¢ per word for commercial advertisements. Rates are net, and no discounts will be allowed. Copy must be accompanied by remittance in full, and must reach the New York office by the first of the month preceding the date of issue.

THE AUDIO EXCHANGE, INC. buys and sells quality high-fidelity sound systems and components. Guaranteed used and new equipment. Catalogue, Dept. AE, 159-19 Hillside Ave., Jamaica 32, N. Y. Telephone OL 8-0445.

30% DISCOUNT ON ALL LP RECORDS! Best mail order service in the country. All records brand new and guaranteed. Specializing in Hi-Fi records. Send for free catalog and literature. Southwest Record Sales, Dept. AE-1, 4710 Caroline, Houston 4, Texas.

BEFORE buying High-Fidelity equipment, wise buyers check with the Hi-Fi Guild. Send for list. Box CF-1, AUDIO ENGINEERING.

PRESTO RECORDING EQUIPMENT—USED

6N in carrying case, excellent condition $450
85A Amplifier $100
40A Preamplifier $35
PT-900 Tape Mechanism, factory reconditioned $175

UNITED RADIO, 22 N.W. 9th Ave., Portland 9, Oregon

FREE HI-FI CATALOG and Bargain Price List. Chicago Electronics, 420 East 87th St., Box 171, Chicago 19, Illinois.

FOR SALE—Rek-O-Kut B5 overhead cutting mechanism with Brush RC-20 cutter and dual-speed RDK-16 Rek-O-Kut turntable, $160. Write A. Marko, 429 East 70th St., New York 21, N. Y. or call RE 4-3573 after 6:00 p.m.

SEND FOR DATA, photos, liberal discounts on our 30-watt dual-chassis Williamson Amplifiers. Dr. Nicely, Kenton, Ohio.

FOR SALE: Rek-O-Kut T12 turntable; Gray viscous-damped arm with Pickering diamond microgroove cartridge; new condition, used 4 months. Best offer over $90. G. E. Luecker, 212 Audrey Lane, Washington 20, D.C.

FOR SALE: My personal tape library, recorded on Ampex. All or part. Will trade for other high-quality tapes. D. R. Steele, 78 Shearer Dr., Atherton, California.

FOR SALE: $135 DuMont 224 Oscilloscope practically new condition. N. Y. Metropolitan area. Box CF-2, AUDIO ENGINEERING.

WANTED: FM tuner, REL model 646-B or HARVEY model 193-R. Box CF-3, AUDIO ENGINEERING.

FOR SALE: Browning RV-31 FM tuners, $88.50; Rek-O-Kut T-12, $74.50; Gray 108-B arms, $48.50; Gray 106-SP arms, $39.50; Craftsmen C-800 AM-FM tuners, $143.50. Guaranteed new equipment. Skalamer. Box CF-4, AUDIO ENGINEERING.

SOUND SALES ENGINEERS

New York City contractor for commercial sound systems has opening for top-flight executive-type sales engineer. Sales experience essential. Metropolitan market is fabulous and earning limitation is the measure of the man. Salary and profit-sharing basis of compensation. Write or phone for appointment.

SOUND SYSTEMS, INC.,
216 W. 14th St., New York 11, N. Y.

FOR SALE: Rek-O-Kut M-12. Perfect condition with new LP feedscrew, Astatic W.R. 40 microphone, chip chaser, $75.00. TR-12 optional, $75.00. BEekman 3-5687, or Box CF-5, AUDIO ENGINEERING.

SELL: Altec 603B speaker in Stephens 52D mahogany cabinet. Perfect condition. Both $100. W. Tannenbaum. Phone (New York) TOmpkins 7-1698.

PROFESSIONAL DIRECTORY

Industry Notes--

Motorola's president, Paul V. Galvin, announces formation of a wholly-owned company subsidiary, **Motorola Communications and Electronics, Inc.**—will act as distributor for products manufactured by communications and electronics division of parent corporation . . . **RCA** discloses plans to build new plant for production of phonograph records, record players, and TV home receivers in Spain—completion date set for late 1953 . . . **Neely Enterprises**, Los Angeles, is new West Coast representative for **Telefunken** microphones . . . **Minnesota Mining & Manufacturing Co.** has purchased 125-acre tract on edge of St. Paul for construction of new multi-million dollar research laboratory . . . **Cinema Engineering Co., Burbank, Calif.**, early in January broke ground for new 18,000-sq.-ft. building—owner A. C. Davis and general manager James L. Fouch officiated at the initial spading . . . **David Bogen Company** is now occupying new 6-floor building at 29 Ninth Ave., New York 14—expansion of all departments planned for immediate future.

Industry People--

Norman Pickering, inventor of the pickup bearing his name, and Eric Bender, M.D., set off a chain reaction which will long be felt, in their discussion of binaural sound before the January 13 meeting of the New York chapter of the AES—one of the best prepared and most lucidly presented papers the Society has entertained since its founding . . . **Edward Tatnall Canby's** new book, "Home Music Systems—How to Build and Enjoy Them" is scheduled for March publication by Harper & Brothers . . . **Blair Foulds** is new vice-president of General Precision Laboratory, Inc., Pleasantville, N. Y.—was formerly with Brush Development Company.

W. S. Parsons, president of Centralab, announces appointment of **Walter E. Peek** as sales manager of Mechanical Electronics Products section . . . I. R. E. Board of Directors met January 7 and appointed six officers and directors for 1953—**Haraden Pratt**, presidential advisor, **W. R. G. Baker**, vice-president of General Electric Co., and **Alfred N. Goldsmith**, consulting engineer, were reappointed secretary, treasurer, and editor, respectively—directors selected were **Ralph D. Bennett**, technical director, U. S. Naval Ordnance Laboratory; **William R. Hewlett**, vice-president, Hewlett Packard Company, and **Arthur V. Loughren**, vice-president, Hazeltine Electronics Corporation.

Raymond V. Buivid has been named radio sales manager, and **Thomas J. Nicholson** parts sales manager in General Electric Company's receiver department . . . **Leon Golder**, in the speaker field for more than 25 years, is new sales manager for Carbonneau Industries, Inc., Grand Rapids, Mich. . . . Radio Craftsmen, Inc., among first clients to be announced by **Jack Berman**, recently resigned vice-president of Shure Brothers, who is now acting as factory representative in Southern California . . . Election of **Emanuel (Manie) Sacks** as vice-president and general manager of RCA Victor Record Department announced by **Frank Folsom**, RCA president.

W. Walter Jablon has been appointed vice-president in charge of sales by the David Bogen Company—formerly held same post at Espey Manufacturing Company for 20 years . . . **Robert F. Halligan** has been upped to assistant operations manager of the Hallicrafters Company . . . New vice-president in charge of electronics operations for Sylvania Electric Products, Inc., is **Arthur L. Chapman** . . . New executive appointments at Mark Simpson Mfg. Co., Inc., include **Ralph Aasen**, chief engineer, and **G. Leonard Werner**, director of sales engineering.

New representatives for **Bell Sound Systems, Inc.**, of Columbus, Ohio, include **W. J. Doyle** in the Chicago-Wisconsin territory and **H. A. Moyer** in the eastern part of Pennsylvania, Delaware, Maryland, D. C., and the southern part of New Jersey. New appointees succeed **P. H. Miles** and **R. T. Schottenberg**, respectively, both deceased. . . . **Gilbert B. Devey** appointed to Application Engineering staff of **Sprague Electric Co.**, North Adams, Mass. Mr. Devey comes to Sprague from the Office of Naval Research, in Washington.

ADVERTISING INDEX

POWER AND IMPEDANCE MEASUREMENTS

DAVEN

OUTPUT POWER METERS

of unexcelled accuracy and reliability

have many applications

TYPE OP-182

Impedance Range: 2.5 ohms to 20,000 ohms. Remains essentially resistive over frequency range of 30 to 10,000 cps. Accuracy ±5%.

Power Range: 0.1 mw. to 5 watts in steps of 0.1 mw.

Indicating Meter: Calibrated from 0 to 50 milliwatts and from 0 to 17 db. —Zero level: 1mw.

Meter Multiplier: Will change reading of indicating meter by ratios of 0.1:1, 1:1, 10:1, 100:1, or decibel reading by —10, 0, +10, +20.

The DAVEN Output Power Meters are designed to measure the actual power delivered by an audio signal system to a given load. However, because of the characteristics of the circuit, they are admirably suited to other applications, namely:

1. Determination of Characteristic Impedance of an A.C. Source.
2. Effects of Load Variation on a Signal System.
3. Transmission Line Equalization Measurements.
4. Measurement of Insertion Loss in Multi-channel Mixer and other complex circuits.
5. Filter and Transformer Measurements.
6. Radio Receiver Measurements.

The equipment shown on this page is built to DAVEN'S well-known standards of precision. Please write for more detailed data. Let our engineering department help you on specific problems.

TYPE OP-962

Characteristics similar to OP-961, except that it can measure up to 100 watts.

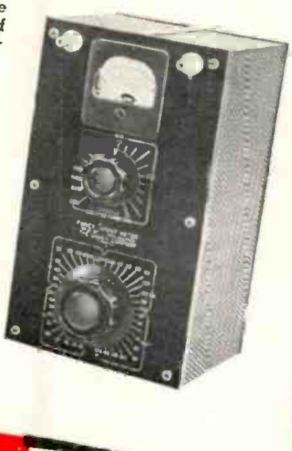
Impedance Range: 40 selected impedances between 2.5 and 20,000 ohms. Accuracy ±2% over frequency range 30 to 10,000 cycles.

Power Range: 0.1 mw to 100 watts in 0.1 mw steps. Range may be extended below 0.1 mw by use of external amplifier.

Indicating Meter: Calibrated from .01 watt to 1 watt and from —10 to +10 db. Zero level: 1mw.

Meter Multiplier: Extends range of meter from 0.01 to 100 times scale reading.

TYPE OP-961



Impedance Range: 2.5 ohms to 20,000 ohms. Remains essentially resistive over frequency range of 30 to 10,000 cps. Accuracy ±2%.

Power Range: 0.1 milliwatts to 50 watts in steps of 0.1 milliwatts.

Indicating Meter: Calibrated from 1 to 50 milliwatts and 0 to 17 decibels. Zero level: 1mw.

Meter Multiplier: Extends the power reading of the indicating meter from 0.1x to 1,000x scale value, or the db. reading from —10 to +30 db. in steps of 2 db.

★ LIMITED NUMBER AVAILABLE FROM STOCK.

THE **DAVEN** CO.

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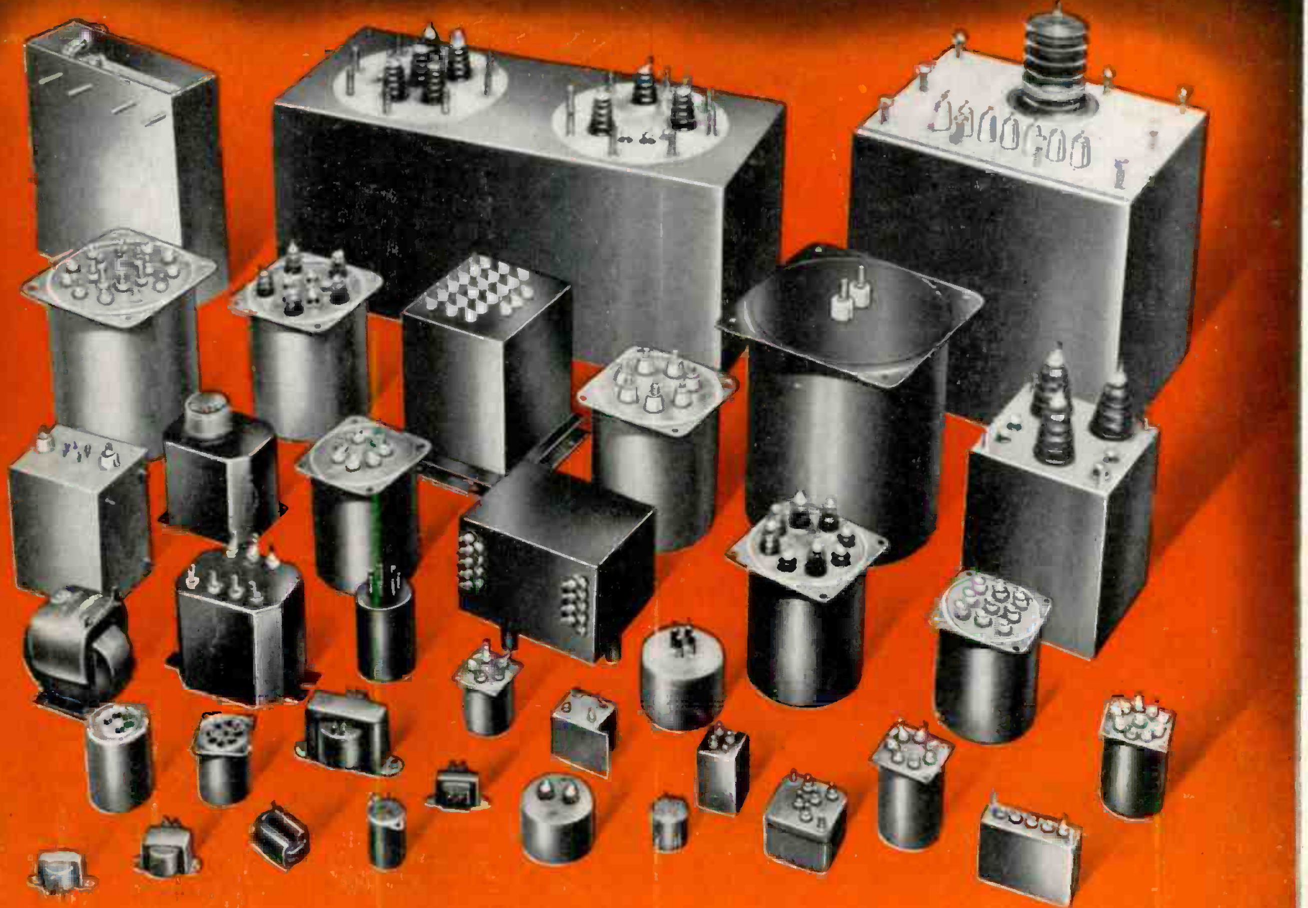

Precision Production to Military Requirements

The manufacture of transformers and associated devices for military requirements has been one of the specialties of United Transformer for the past fifteen years. Thousands of military designs are in present production and a few examples are illustrated above.

In this photograph you will find transformers, reactors, filters, high Q coils, and magnetic amplifiers. Types illustrated include units to MIL-T-27, JAN-T-27, and ANE-19.

If you have a tough problem in an Hermetic or Fosterized unit, UTC is your logical production source.

United Transformer Co.

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