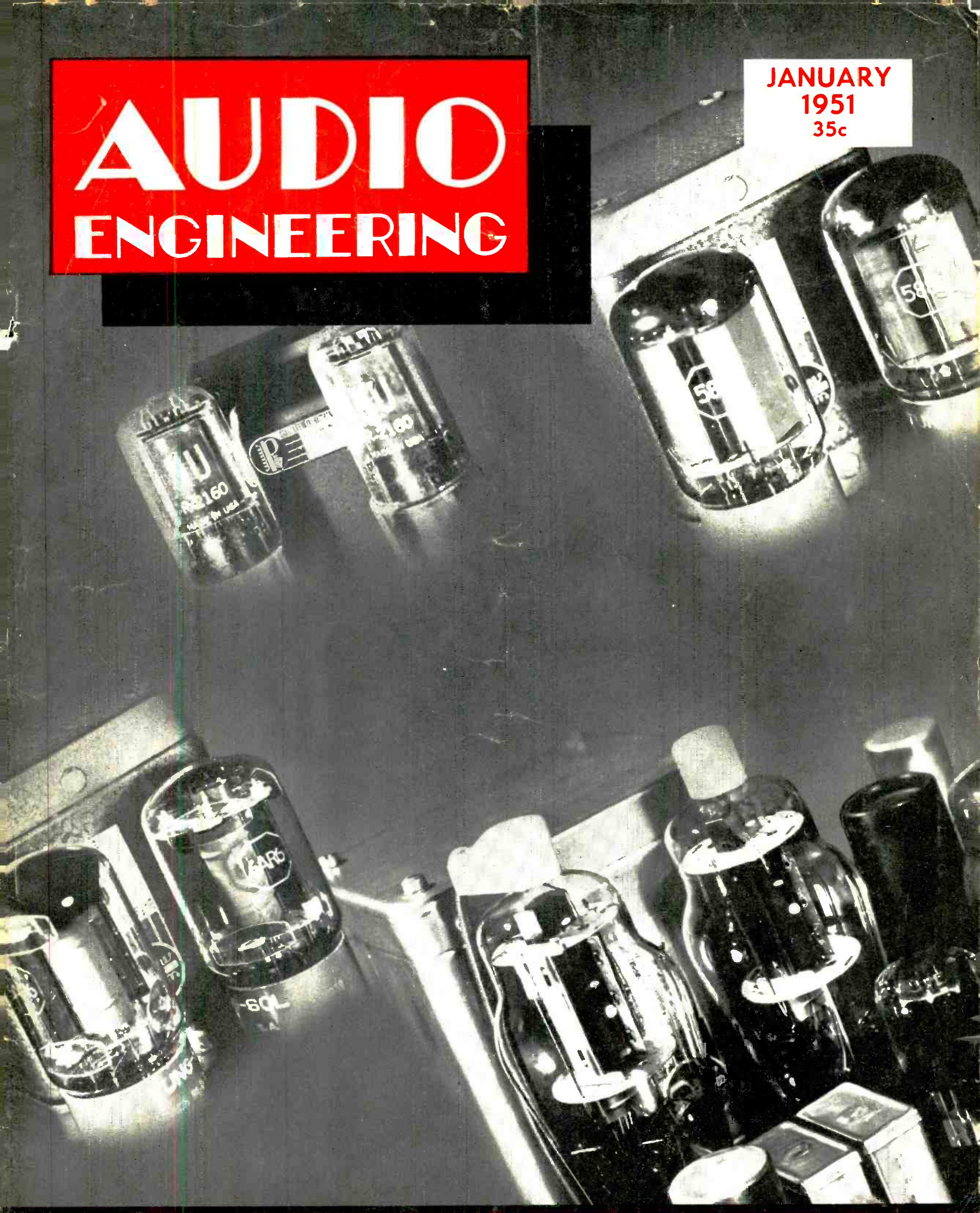
# AUDIO ENGINEERING

JANUARY
1951
35c



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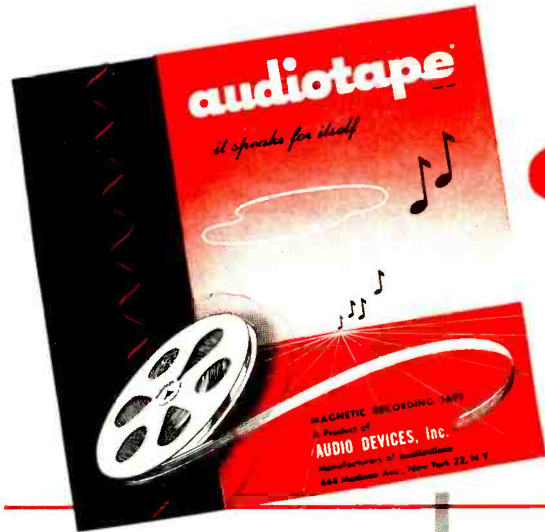
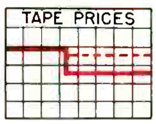



# Here's What These audio "Firsts" Have Done for You

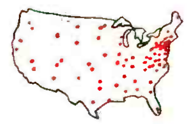
*. . . to lower the cost and improve the quality of magnetic recording tape*

**First with liberal discounts to professional users**




—enabling radio stations, recording studios and educational institutions to save as much as 33⅓% on the cost of magnetic tape.

**First with attractive resale discounts**



— and a nation-wide network of helpful, coöperative sound-equipment distributors in principal cities from coast to coast.

**First with red oxide tape on paper base**

— offering recordists a high-quality tape designed to match the characteristics of the vast majority of recorders, at *lowest possible cost.*

**First with supercalendered kraft paper base**

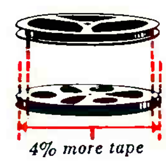
— providing maximum smoothness of texture and minimum noise, without the use of fillers which tend to come out or stiffen the paper.

**First with all-aluminum 7-inch reels**

— mechanically strong, light in weight, and permanently free from warping or twisting even under adverse conditions.

**First to give extra footage on standard size reels**

Audio's "full measure" of 1250 ft., 2500 ft., and 5000 ft. give *4% more tape* on every reel.

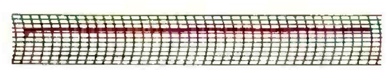



**First with black oxide tape on plastic base**

— offering highest fidelity of recording and reproduction for machines designed to use a high coercive-force oxide.

**First to offer paper base tape in 2500 and 5000 foot rolls**

— permitting maximum economy for professional applications where premium quality recordings are not required.



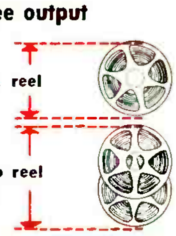
**First to produce a constant output tape**

— made possible by Audio's specially designed coating machinery which controls coating thickness to within 5 *millionths* of an inch.

**First to guarantee output uniformity of**

± ¼ db for 2500 ft. reel

± ½ db from reel to reel in 2500 ft. size



**First to produce a splice-free 2500 ft. roll**

— to *guarantee* that the tape is all one piece, with absolutely no splices in the entire length.

**First to develop the safe-handling package for professional-size rolls**

— permitting tape on hub to be transferred to or from turntable without danger of spilling — and simplifying the attachment of side flanges.

These "Firsts" are proof of the continuous research and development that keeps Audiotape foremost in the field. They are the result of more than a decade of experience — by the only company specializing solely in the manufacture of fine recording materials — both tape and discs.

That's why you can always look to Audio for the latest developments in the recording art. A trial order of Audiotape will speak for itself. Or send today for a free 300-foot sample.

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**444 Madison Ave., New York 22, N. Y.**

Please send me a free 300-foot sample reel of ☐ plastic base or ☐ paper base Audiotape.

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# AUDIO ENGINEERING

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## CONTENTS JANUARY, 1951 Vol. 35, No. 1



### COVER

Montage of three pairs of new audio output tubes and a pair of 807's in a version of the Musician's Amplifier. The 5881 is electrically equivalent to the 6L6 except for a 20 per cent increase in dissipation ratings. The 6AR6 is a beam power amplifier designed for applications requiring relatively high peak plate currents. These tubes, of ruggedized construction, are being used in amplifiers built by Electronic Workshop. The R-2160 is the commercial version of the space charge grid tube described in these pages in October 1947, and soon to reach the market.

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# AUDIO PATENTS

RICHARD H. DORF*

ENTIRELY ASIDE from loss of audio quality in record changers caused by incorrect stylus angle, arm resonances, and the like, the writer strongly objects to the contraptions largely because of the succession of clicks, thumps, and miscellaneous noises accompanying the change cycle. Some of those can be eliminated by enclosing the changer in a good cabinet and closing the lid, but little is usually done about the thump of the needle as it hits the disc. Even with changers that have "muting" switches, the hiss of the run-in grooves begins abruptly and does little to enhance the illusion of a performance.

Julius W. Buchholzer and Robert B. Drabenstott have patented an electric fade-in system that should help considerably to lessen the mental impact of record changing. The device is essentially a sound-controlled cutoff which silences the system when no music is coming through and smoothly fades it in as the music starts. The patent number is 2,515,111 and the complete schematic is shown in the *Fig.* 1. The circuit is to be used with, and in addition to, any standard audio amplifier.

Signal from the phonograph pickup (or the preamplifier, in the case of magnetic cartridges) goes to the signal grid—grid No. 3—of a 1612. (The 1612 is the white-tie-

[*Continued on page 4*]

* *Audio Consultant, 255 West 84th Street, New York.*

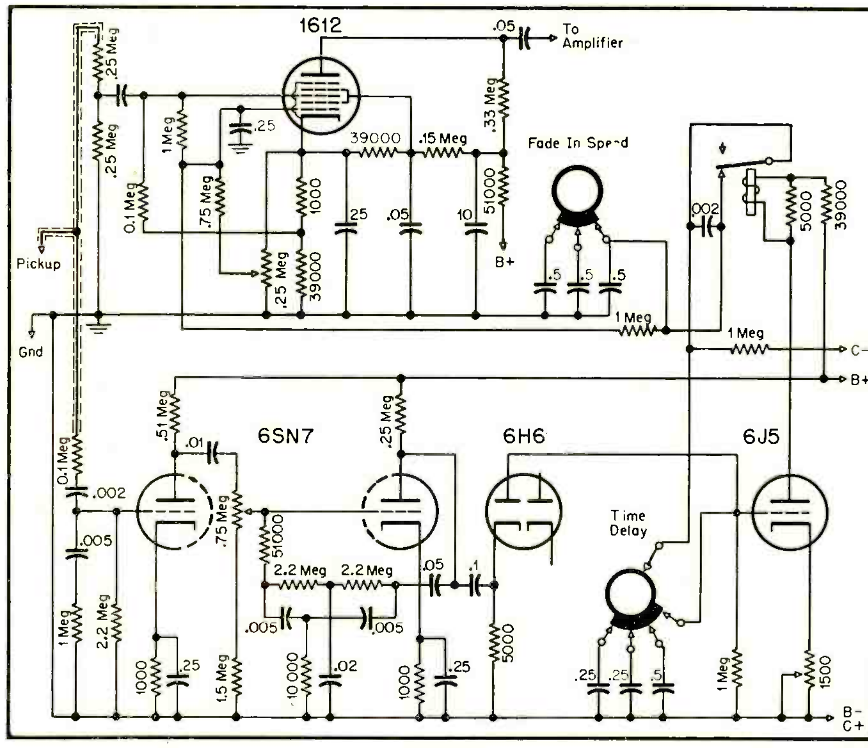
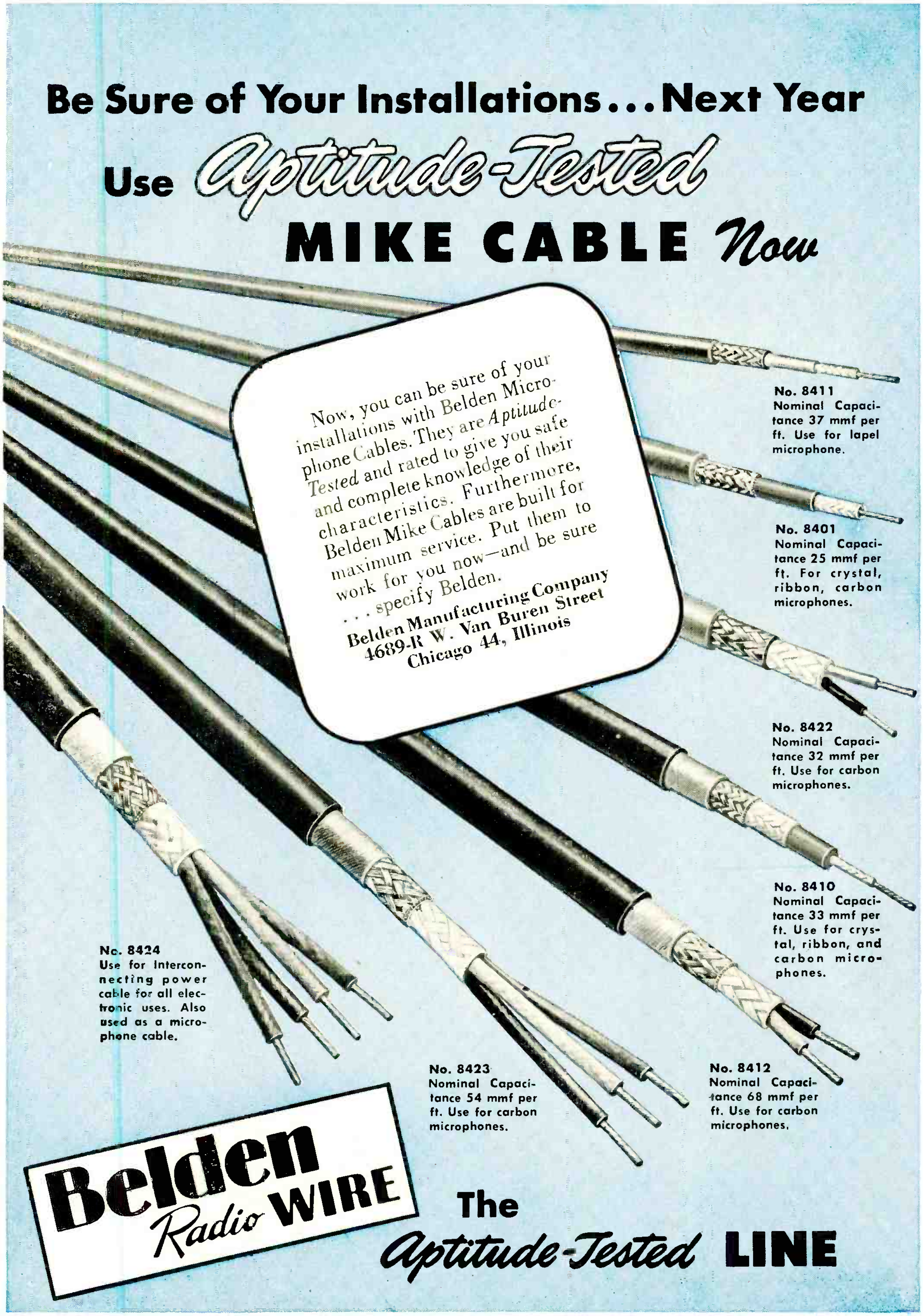



Fig. 1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Now, you can be sure of your installations with Belden Microphone Cables. They are Aptitude-Tested and rated to give you safe and complete knowledge of their characteristics. Furthermore, Belden Mike Cables are built for maximum service. Put them to work for you now—and be sure . . . specify Belden.
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No. 8411
Nominal Capacitance 37 mmf per ft. Use for lapel microphone.
No. 8401
Nominal Capacitance 25 mmf per ft. For crystal, ribbon, carbon microphones.
No. 8422
Nominal Capacitance 32 mmf per ft. Use for carbon microphones.
No. 8410
Nominal Capacitance 33 mmf per ft. Use for crystal, ribbon, and carbon microphones.
No. 8424
Use for Interconnecting power cable for all electronic uses. Also used as a microphone cable.
No. 8423
Nominal Capacitance 54 mmf per ft. Use for carbon microphones.
No. 8412
Nominal Capacitance 68 mmf per ft. Use for carbon microphones.
Belden Radio WIRE
The Aptitude-Tested LINE

## AUDIO PATENTS

[*from page 2*]

and-tails version of the 6L7, which would probably do just as well.) Output from the 1612 is *R-C* coupled to the first tube of whatever amplifier is used with the system.

A negative bias voltage is fed to the No. 1 grid of the 1612. This voltage is more than sufficient to cause cutoff. The *C*-voltage passes through a pair of relay contacts and an *R-C* time-delay network so that when the relay opens and the *C*-voltage is removed, it dies away gradually and the sound fades in. The switch labelled FADE-IN SPEED adds capacitors in steps of 0.5 μf to vary the fade-in speed as the operator desires. Grid No. 1 of the 1612 also goes through a 0.75-meg. resistor to a 0.25-meg. potentiometer across the cathode to set the bias on the grid when the tube is operating. Screen and cathode voltages are provided through a divider network.

Signal from the pickup also goes through a dual-triode 6SN7-GT amplifier, the gain of which is controlled by a 0.75-meg. potentiometer at the grid of the second triode. Signal from the amplifier is rectified by one section of a 6H6 to provide negative voltage for the grid of a 6J5.

This negative voltage is not present when there is no signal and the 6J5 is so biased that its plate current in the absence of any grid signal is sufficient to hold the relay in its plate circuit closed. Thus, under no-signal conditions, the *C*-voltage always appears on the No. 1 grid of the 1612 and the system is silent. The volume control at the grid of the second 6SN7-GT triode is adjusted so that record hiss will not furnish enough rectified signal at the 6J5 grid to have any effect.

After the needle is down and the run-in grooves have been traversed, the first note of actual music, amplified by the 6SN7-GT and rectified by the 6H6 appears at the grid of the 6J5. It is negative and reduces the plate current of the 6J5 enough to open the relay. The *C*-voltage line to the 1612 is broken. The voltage dies away gradually through the delay network and the music fades in. For home record playing, the fade-in should be quite fast, which may require some adjustment of the component values as shown in the schematic. The 0.5-μf capacitors on the FADE-IN SPEED switch may have to be reduced in value.

The music may contain some pauses in itself and the relay should not pull in during those pauses. To provide for that, there is capacitance across the grid of the 6J5. When the music stops, the negative voltage at the 6J5 grid does not disappear until the capacitance has discharged, which takes time. The amount of time is controlled by the capacitor value, selectable with the switch labelled TIME DELAY. Depending to some extent on what kind of music is being played, capacitance can be adjusted in steps of 0.25 μf to provide for the maximum pauses which are to be expected.

When the record has finished, the negative voltage at the 6J5 grid dies away, the relay closes again, and the *C*-voltage builds up on the No. 1 grid of the 1612 again. The build-up, like the decay, is gradual, and the hiss fades out; the system is then silenced until the music starts on the next record.

An extra position is provided on the TIME DELAY switch to disable the fade-in system and keep the 1612 operative when that is desired. In that position, the 6J5 grid is connected directly to the *C*-voltage supply and the relay remains open.

# *Book Reviews*

**Encyclopedia on Cathode-Ray Oscilloscopes and Their Uses,** by John F. Rider and Seymour D. Uslan. 992 pages. New York: John F. Rider Publisher, Inc., $9.00.

An overwhelming compilation of information about c-r 'scopes, including their applications in audio, radio, power supply, vibrator system, u.h.f. and pulse techniques. Since the data obtained from 'scopes involves visual patterns, this book is replete with typical patterns to illustrate the voltages obtained from tests on various types of electronic equipment.

The accuracy of the information given by 'scopes is discussed, and in conjunction with the circuit arrangements required for making measurements with the 'scope, it is obvious that the term "Encyclopedia" was well chosen for the title of this book.

This volume is well suited for anyone using 'scopes in his work or as a tutorial material for schools or colleges. The usefulness of the book is enhanced by the inclusion of complete circuits and parts lists for most of the commercial 'scopes available, from which the student will obtain much of value in the appreciation of constructional practices.

**Electrical Engineers' Handbook, Volume II,** edited by Harold Pender and Knox McIlwain. 1646 pp. New York: John Wiley & Sons, Inc., $8.50.

A new edition of the old standby for audio and acoustic engineers, brought up-to-date by the addition of much new material on radar, pulse techniques, and communications. While this volume contains much new information, it is regrettable that references in the field of audio and acoustics do not seem to be more recent than 1945. Thus the book—valuable as a basic reference work on many subjects—is not as modern as it should be in the field of applied audio.

For those interested in building up a reference library in this field, this volume deserves a place on the bookshelf. Volume I of the Wiley Handbook Series treats with Power Generation and Distribution, Transportation, and general electrical material in "heavy" industry. This volume, also a new edition brought out in 1950, carries the same price.

**Fundamentals of Acoustics,** by Lawrence E. Kinsler and Austin R. Frey. 516 pp. New York: John Wiley & Sons, Inc., $6.00.

This volume is admirably suited as a basic textbook for the student who desires to obtain a working knowledge of the principles of acoustics. This material appears to be written with a slant which makes it understandable without a prerequisite of a degree in physics, although a working knowledge of mathematics is necessary in the study of acoustics in any form.

# LETTERS

### Acoustics

Sir:

A discerning, realistic Englishman—P. G. A. H. Voigt—has rescued a group of befuddled audio enthusiasts from a lifetime of banging their heads against a wall of audio perspective. I am not sure that the concept of the "hole in the wall" is especially new, or peculiar to Mr. Voigt alone, but his remarkable analysis is convincing and exciting in its promise.

Thanks for Mr. Voigt's discussion, and for Robert H. Tanner's important article "Impact of Acoustics on Music." I would like to read more along the line of Mr. Tanner's article, but more particularly relating to the design of listening rooms, a subject which is soon apt to become important as broadcasters become aware that the effectiveness of their finest programs depends to an extent on the facilities of their listeners. Would you agree that someday new houses generally will be built with their living rooms designed around a sound producing system?

Vernon Yeich,
39 E. Cassilly,
Springfield, Ohio

### Edison Cylinder Records

Sir:

Thank you for answering my inquiry about vertical pickups for the Edison Phonograph. I have duly noted your suggestion.

I am an ardent experimenter in wide-range equipment, but my closest hobby is collecting old cylinder phonographs and records. Since I would like to listen to these cylinders using electrical means, I tried—screwdriver mechanic style—to construct my first pickup, which seemed easy enough except that the stylus chewed up the wax record because of insufficient compliance of the vibratory system. To get an idea of what actually was on the cylinder (hard) I used a W. E. 9A head, and discovered that the annoying screechy acoustic reproduction was not present with electrical reproduction. This seemed logical, as the old acoustic head had many faults. It is apparent that Edison had recorded a much wider range than he had means to listen with.

Continuing, I next set up some standards: 1) the pickup should not add to the distortion that was naturally recorded; 2) the unit should not be bulky or mar the general appearance of the machine; 3) it should be able to track any off-center cylinders; and 4) should track with a minimum of pressure so the records could be played over and over without the loss of any of the limited frequencies that are present. Obviously, most of these records are irreplaceable. To date I have had some success with a modification of the GE variable reluctance cartridges, both for this use and for use with flat Edison "Diamond" discs as well as the Pathe discs, although the latter require a blunter stylus.

This entire project is based on nostalgia, but there may be other engineers who would be interested in a similar pastime. At any rate, visitors would undoubtedly get a chuckle or two from a modified instrument of this type—especially after they hear it with considerably better tone than was built into the original models.

J. F. Geilenkirchen,
35 Church Lane,
Scarsdale, N. Y.

NOW

# 15,000 cps · 7½ inches per sec. HALF TRACK!

. . . also available with FULL TRACK HEADS


## REVOLUTIONARY ADVANCE IN TAPE RECORDING EFFICIENCY

- At 7½ inches per second Model 400 plays music essentially flat to 15,000 cps!
- Half-track record, erase, playback at 15 and 7½ i.p.s. Plays back full-track recorded tape.
- Has built-in record and playback amplifiers as well as a 4-inch "VU" meter.
- Fast forward and rewind require but 90 seconds for a full 2400-foot reel!
- Tape cost savings of 4 to 1 over any 15 i.p.s. single-track recorder of comparable fidelity!

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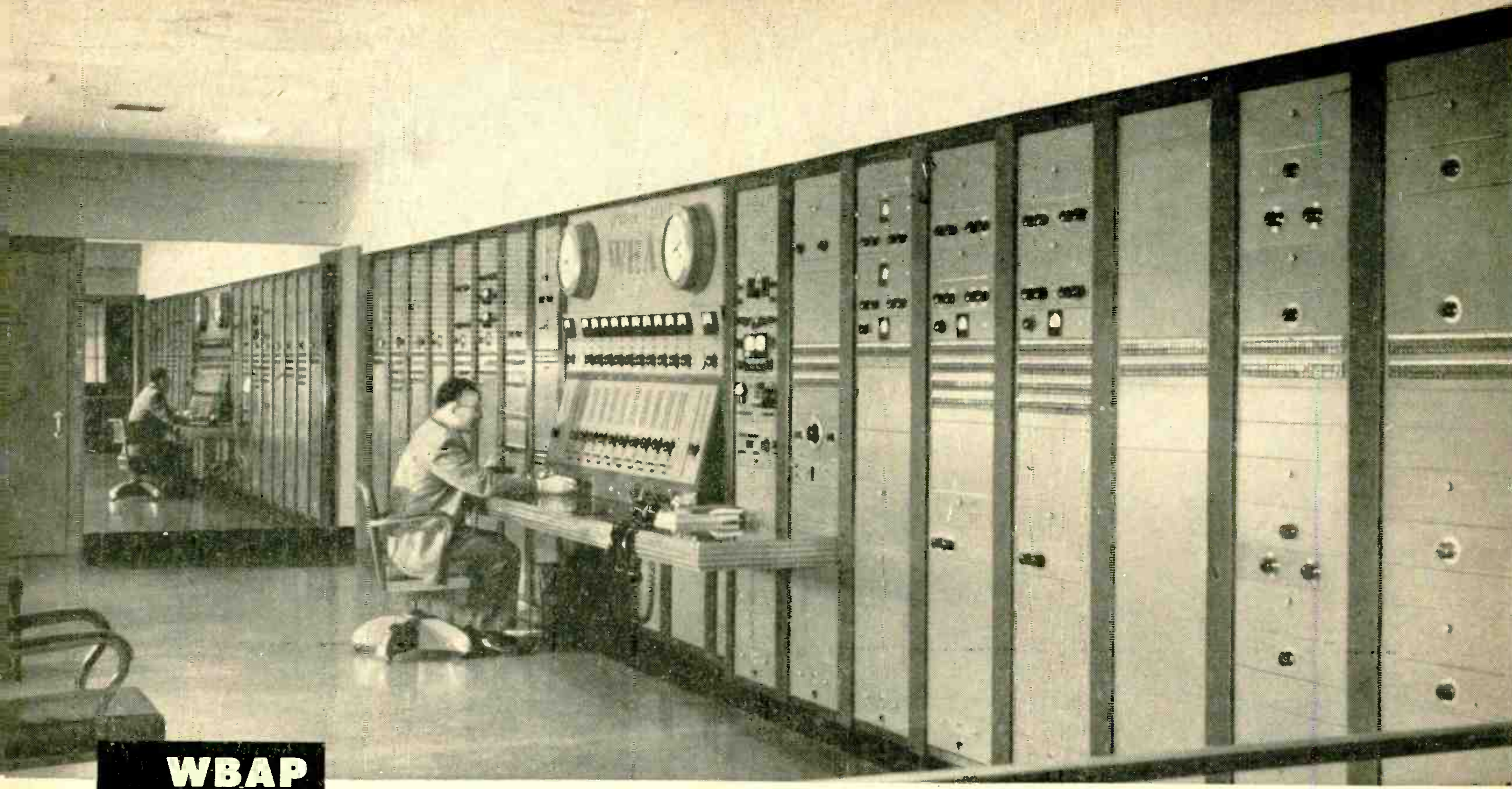

**WBAP**
**FT. WORTH, TEXAS**

This master control console, including 16 de luxe audio equipment racks, is part of a modern 6-studio layout—custom-built by RCA. Designed for AM, FM and TV operation, this "In-Line" design handles 16 studio inputs and feeds 10 output channels—simultaneously, or individually, by a pre-set relay system.

# *Unlimited* audio

Two supervisory positions like this one handle 4 studios, 2 outgoing lines. It includes telephone ringdown, remote switching, talkback, monitoring, and cueing. This set-up uses existing RCA Consolettes—makes studio and master control functions possible in one location.

**WJAC**
**JOHNSTOWN, PA.**


Master control handles 4 studio inputs, 4 output channels, 2 remote inputs, 3 turntable inputs, cueing, monitoring, talkback. This master control and one sub-master handle all program needs.

## A few of the many de luxe units available

- Supplementary equipment for Consolettes—switching systems, extra inputs and outputs, jack strips, ringdown, sound-effects filters, and line equalizers
- Master control equipment—to handle any number of studios
- Matched custom wings for consolettes—for studio and master controls
- Custom racks for relay switching
- "One-man" control layouts
- Master control console combinations
- Studio control consoles
- Custom recording—for separate or simultaneous recording
- Custom recording control turrets
- Mobile recording equipment—disc recorders, tape recorders, record playbacks. Everything including the motor vehicle.
- Audio/Video equipment—custom audio, plus video switching, monitors, stabilizing amplifiers.

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# *RCA fine custom-built studio control systems*

With RCA Custom-Built equipment you can extend your audio facilities almost without limit. No matter what size the system, experienced RCA design assures instant, fool-proof switching without program level "pops" or "breaks." Fidelity of sound meets the requirements of the world's severest critics.

Suitable for every AM, FM, and Television station—small, medium, or large—RCA Custom-Built Systems are "individualized" to handle all the studio-control operations anticipated by the individual plant. Any number of station studios may be provided for . . . any number of remote lines . . . any type of master control . . . all the monitoring, talkback, and cueing facilities needed . . . every conceivable facility for controlling program operations and reproducing high-fidelity sound. True cabinet craftsmanship combines durability with function. Handsome styling and finish enhance station prestige.

Consultation on Custom-Built equipment is provided without obligation to every station—any size. Service includes detailed layout proposals, diagrams of equipment and facilities, artist's sketches by RCA functional design experts, thorough counsel by RCA's experienced staff of broadcast specialists. Where plans are already down on paper, RCA will be glad to work from these—co-operate closely with your principals.

Your RCA Broadcast Sales Engineer can tell you about this service. For complete information call him, or write Department 7A, RCA Engineering Products, Camden, New Jersey.

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**RADIO CORPORATION of AMERICA**
**ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.**

In Canada: RCA VICTOR Company Limited, Montreal

# EDITOR'S REPORT

## RECORDING CHARACTERISTICS

STANDARDIZATION of recording characteristics is a subject with which this column has been concerned for some time—principally because the record manufacturers collectively have done little or nothing to settle the problem. The original LP curve adopted by Columbia at the introduction of the long-playing record has apparently been followed quite closely by Columbia, but not all LP manufacturers have used the same curve consistently. This variation has made it mandatory that manufacturers of amplifiers provide adequate equalization facilities to accommodate all of the existing characteristics, and individual constructors have encountered some troubles in trying to secure optimum response for all makes of records.

The Standard Playback Curve recently adopted by the Audio Engineering Society *could* solve this problem completely for the future. Unfortunately, many hundreds of record titles have already been released with various high-frequency pre-emphasis characteristics and nothing can be done about them, but in the years to come there will be many more thousands of record titles made. A change should be made some time, and the sooner the better.

The idea of standardizing the *playback* curve rather than the recording curve is based on the general need for standardization of monitoring facilities in recording studios and elsewhere. If every manufacturer were to judge record quality and equalization under listening conditions as nearly as possible identical, the resulting product would then reflect only the individual preferences of musical directors. These differences are normal, and would be expected even if all companies made their records on the same equipment. However, there would not be any variation in the records technically, and all would reproduce with the same equalization. Changes made by the listener to suit his own preferences would be equally effective on all records, and the need for constant shifting of turnover frequency or the amount of roll-off would be eliminated entirely.

A few record companies are already using a curve which is essentially that chosen by the AES, and others have indicated a willingness to cooperate. As a definitely progressive step in simplifying the reproduction of recorded music with a minimum of complication in the equipment, the work of the Standards Committee is to be praised, and if sufficient approval of the idea is manifested by record buyers, manufacturers will fall into line. Details of the curve and a number of suggested equalizer circuits are presented in the article on page 22 in this issue.

## SHORTAGES

As we commence the new year, it seems certain that we are to be faced with shortages in many of the components of audio systems—if not already. Cobalt is scarce, and will show up as a shortage in speaker magnets—especially in the larger models which require strong fields; steel is scarce, which means that chassis and transformers will be harder to get; resistors have been short for over a year with delivery time quoted as high as forty-five weeks. Some of these shortages are natural, some are caused by limitation of end use. It has been suggested facetiously that we include in each copy of Æ a coupon which could entitle the holder to purchase from his jobber—with a reasonable amount of accompanying cash—a one-watt resistor.

Shortages created by stepped-up military requirements are unavoidable, and no serious-minded individual would register an objection anyhow, but shortages should not be brought on unnecessarily by scare buying nor by watered orders nor by a desire to lay in an overabundance of spares. Already the activities of some opportunists have been observed and prices on 5U4G's, for example, have been as high as $5 on the slightly off-white market.

It is probable that broadcast stations and recording studios will be granted the necessary tubes and repair parts to permit continuance of "normal" operation, but new construction will certainly be limited. It is unlikely that priorities will be granted to individuals, and we again suggest the perusal of the Classified column for listings of equipment needed.

## THE AUDIO FAIR IN CHICAGO

Many of our midwest readers have expressed a desire for The Audio Fair to become a road show so that they too would be able to attend. Moving a complete set of exhibits around over the country is impossible from the standpoint of cost, naturally, but plans are well underway for the staging of the Audio Fair in Chicago sometime during the month of May.

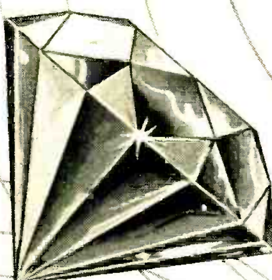
Exact date, time, and place are not yet settled, but you may expect further information in this column next month.

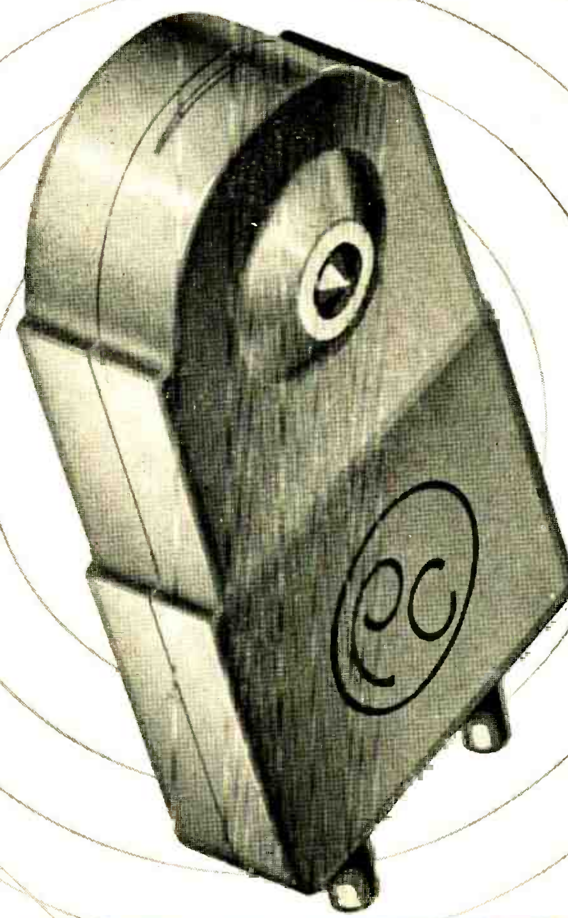
# PICKERING

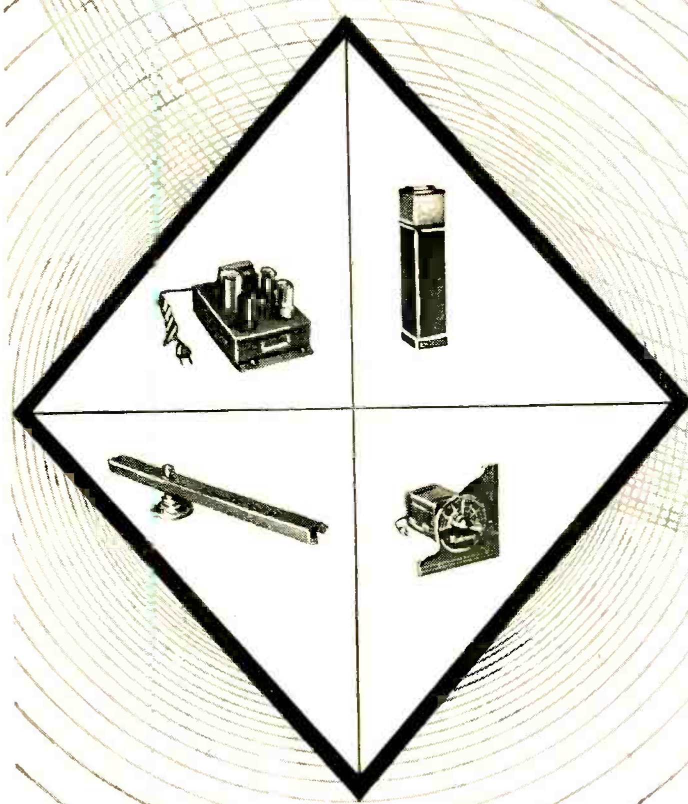
## diamond stylus pickups

**ACKNOWLEDGED BY ENGINEERS AS THE FINEST AVAILABLE!**

- The superiority of diamond styli to styli of other materials has been thoroughly established.
- Exhaustive tests prove resistance to abrasion of diamond styli is many times greater than that of the next hardest material.
- Great resistance to abrasion means a minimum of record wear, longer record life and concert hall quality music all the time.







Pickering pickup cartridges, equipped with diamond styli, may cost more than cartridges with other stylus materials but the useful life of a diamond stylus cartridge is so much greater than is represented in the cost differential that from all practical viewpoints—length of service, listening pleasure, and record life — Pickering diamond stylus cartridges cost less.

The diamonds used in Pickering cartridges are whole diamonds, not splints. They are well cut, gem-polished to high accuracy and precisely mounted to ride free and smooth in the groove walls, recreating all the fine tones and modulations pressed into modern recordings.

The supremacy of Pickering Diamond Cartridges is unchallenged. They meet every exacting requirement of the most critical record playing enthusiast who insists upon the finest musical reproduction; who wants the realism and brilliance of a live performance and who is anxious to maintain the useful life of his record collection.

**PICKERING & COMPANY, Inc.**
**Oceanside, L. I., N. Y.**

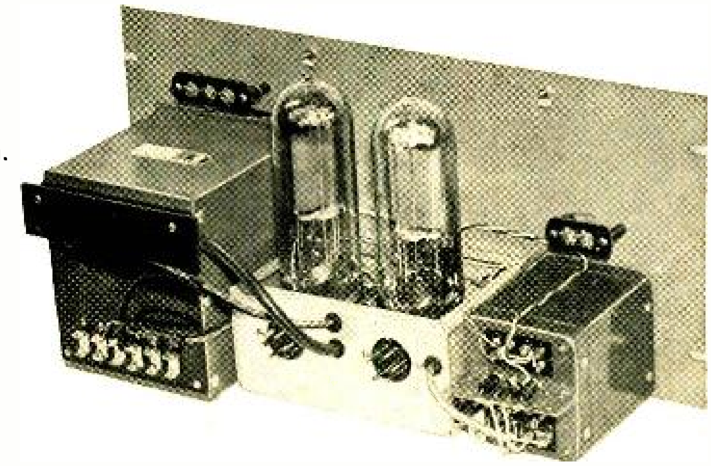


Fig. 1. Rear view of rack-mounted amplifier, showing simplicity of construction.

# The Musician's Amplifier Senior

DAVID SARSER* and MELVIN C. SPRINKLE**

**Constructional details on a "Big Brother" to the original Musician's Amplifier described in these pages over a year ago, and suitable for high-power applications.**

JUST A LITTLE over a year ago, the authors brought to the attention of the American audio world an amplifier that had gained an enviable reputation in Europe and Australia for its excellent fidelity. In an Americanized, and now fully naturalized version, the Musician's Amplifier has caused a sensation in this country. Literally thousands of these amplifiers have been built and all those who did not cheat on the quality of the parts used have been hearty in their praise. It is not amiss to mention at this time that "The Musician's Amplifier" has been installed in the homes of some of the world's great names in music and they have been just as impressed with its performance as the audio enthusiast whose mouth drops open when he measures one. As a matter of fact, one world famous musical figure insisted on having a Musician's Amplifier with him on his travels, so that at no time would he be without his music.

While the Musician's Amplifier has been setting new standards for performance, the authors in their constant search for perfection have unearthed the one application in which it is a little deficient—cutting disc recordings.

While we like to attend the live concerts and recitals in New York, time and financial considerations prevent us from attending them all. The next best thing to live concerts is a live FM broadcast or a good recording. However, there is an increasing paucity of live concerts on the networks, and in spite of all the professional skill of recordists, many commercial recordings leave much to be desired in the way of fidelity and interpretation. In view of the above circumstances we have spent much time and money in making disc recordings for our own use in reliving the performances we have heard, either of FM broadcasts or in recital halls.

Someone will raise the question of why we are interested in disc recording when fine tape machines are available. Of course we are familiar with tape and we often use it, but for our purposes the disc is still supreme. There are several reasons: (1) the cost of disc recordings is less than an equivalent time on tape; (2) the storage space for microgroove disc recordings is less than an equivalent playing time on tape; (3) not all of our friends are equipped with tape machines but all of them do have microgroove disc reproducing equipment so that sharing the recordings does not become a problem; (4) with the hot stylus technique and the amplifying system to be described, we have made discs which cannot be distinguished from tape. As a matter of fact many of the visitors at the Audio Fair who heard the Musician's Amplifier Senior playing one of its own recordings swore that we were using tape. Therefore, we make disc recordings.

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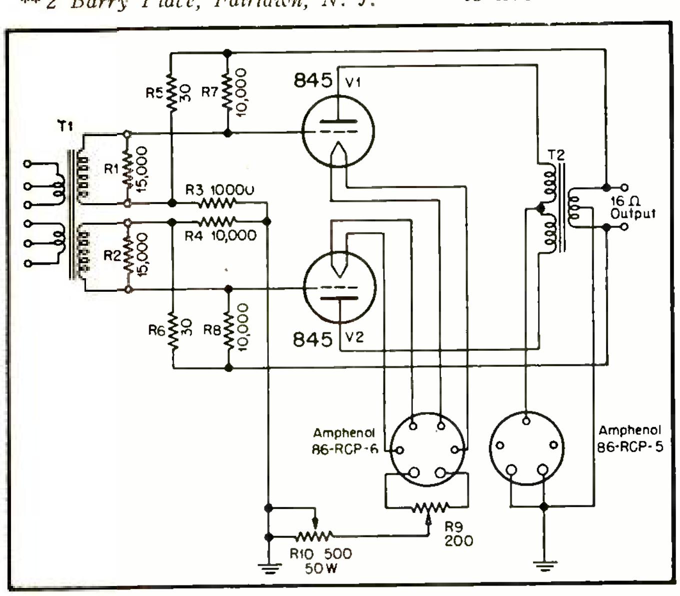


Fig. 2. Schematic of amplifier section.

### Need for More Power

Naturally, one of the first things done was to use the Musician's Amplifier to

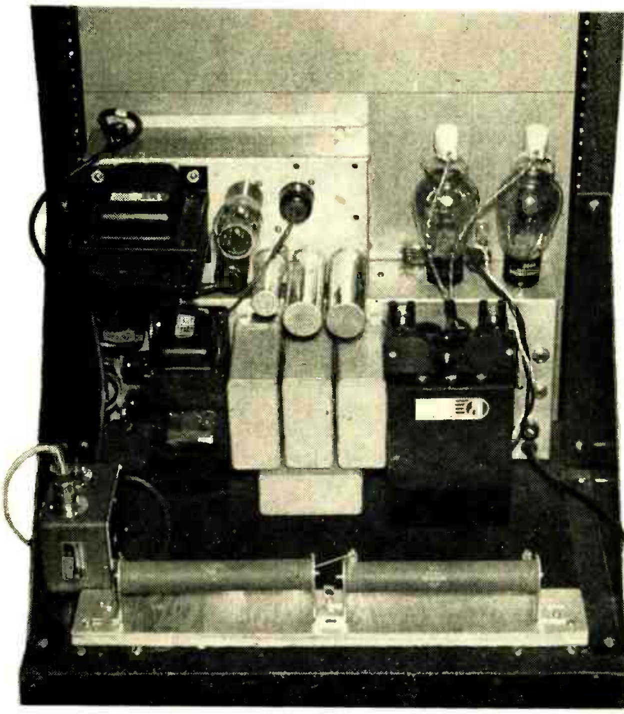

Fig. 3. Rear view of power supply section, with space provided for mounting the power supply for the driver amplifier.

drive a magnetic cutting head. Here the output power of the amplifier was just a little inadequate to give the equalization that makes a disc recording sound good to musical ears. There have arisen also a few cases where someone wanted to have his music at ear shattering levels (these individuals for some reason live away out in the country) and then there have been certain installations where it was necessary to drive a system of speakers throughout an entire home. Thus there is a need for a power amplifier which will deliver more power than the Musician's Amplifier but yet maintain the same or possibly even higher standards of naturalness in reproduction.

The power level desired was 40 watts, *clean*. This figure was arrived at from disc recording considerations as follows: Most modern cutting heads make excellent microgroove recordings when fed with ¼ watt average level as read on a VU meter. We feel that the pre-emphasis at 10,000 cps should be no more than 10 db but preferably 6 db as mentioned in Æ April 1948, page 15. In addition, we wanted at least 10-db reserve power to handle the peaks in the music and speech. The total power required comes to 25 watts on a 10-db reserve power basis, while 40 watts gives 12 db of reserve power. For cutting 78-r.p.m. records, little or no pre-emphasis is required so that when an average level of +31 dbm is fed to the cutter in cutting 96 lines per inch, there is a reserve of 15 db to handle peaks.

Having arrived at the desired power output, we examined the several possible ways in which the power output of the Musician's Amplifier could be increased. We came to the conclusion that the simplest and best way was to use a push-pull power amplifier stage of more than adequate capacity and drive it from the Musician's Amplifier as is. The possibility of push-pull-parallel 807 stages was considered and several models were built but the results were not too satisfactory. An advantage of the method decided on—the booster stage—was that it does not in any way make obsolete one's investment in equipment. This is an important consideration in these days of high prices. Conventional receiving tubes were ruled out by the power level desired, and from the list of transmitting tubes available to our pocketbook the 845 was selected. This old standby can give 75 watts in push-pull Class $AB_1$ and so would be coasting at 40 watts Class A. Operation in Class A was arrived at by the fact that an increase in bias to Class $AB_1$ conditions caused the IM distortion to jump to values considered excessive for recording work. Class B operation would, of course, produce even higher IM distortion.

#### Transformer Selection

Selection of the output transformer was relatively easy, since there are only a few types available. The one chosen—Peerless S-275S—has a gain-frequency response within 1-db limits from 20 to 20,000 cps, and the power delivery is no more than 3 db down from its rated power of 80 watts at these frequencies. Since the 3-db power drop-off point at low frequencies is determined by the magnitude of the a.c. exciting current in the primary, we were assured of 40 watts clean at 20 cps. Leakage reactance and shunt capacitances are controlled so as to give 40 watts at 20,000 cps. Subsequent measurements proved that this transformer would provide us with a flat power-frequency characteristic from 20 to 20,000 cps.

The input coupling could have been resistance-capacitance, but this would have involved high-impedance leads with consequent frequency errors. Thus the elimination of an input transformer would have been poor economy. The Peerless S-281Q input transformer is made to operate at 30 db above 6 milliwatts, or at a level of 6 watts, and so can drive a 250-watt booster. The drive for 40 watts just "tickles" the transformer. Primary impedances are provided for 14 ohms as well as for 250 and 500 ohms, and the 14-ohm primary impedance is used with the 16-ohm output of the conventional Musician's Amplifier. A 500-ohm input is available for those who have a 500-ohm output on their amplifiers. The secondary of the input transformer is loaded with two 15,000-ohm, 5-watt resistors to absorb the drive power and to terminate the Musician's Amplifier properly. Non-inductive resistors should be used if at all available. The only other circuit components required for the amplifier proper are resistors, as shown in the schematic, *Fig. 2*.

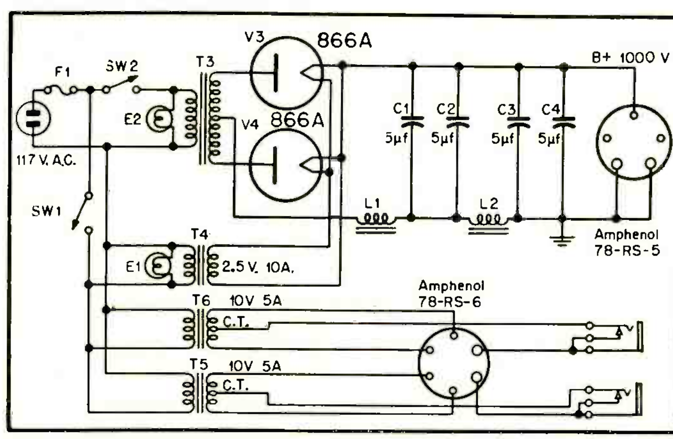


Fig. 4. Schematic of power supply section. Connections between amplifier and power supply are made with cables which plug into the two units.

[*Continued on page 30*]

# How Far Can I Mismatch?

SAUL J. WHITE*

**A discussion of output stage regulation, and of the load characteristic and damping factors of typical amplifiers employed in audio systems.**

The questions often arise, "Can I connect the 8-ohm output on my amplifier to a 16-ohm loudspeaker?" or "How would my performance be affected if I connect my 8-ohm amplifier output to two 8-ohm speakers in parallel?" Thus the problem of matching amplifier output to speaker has always seemed to be present with most audio enthusiasts. At the outset it can be stated that under certain conditions mismatching up to several hundred per cent can be tolerated. Under certain other conditions an almost perfect match is essential.

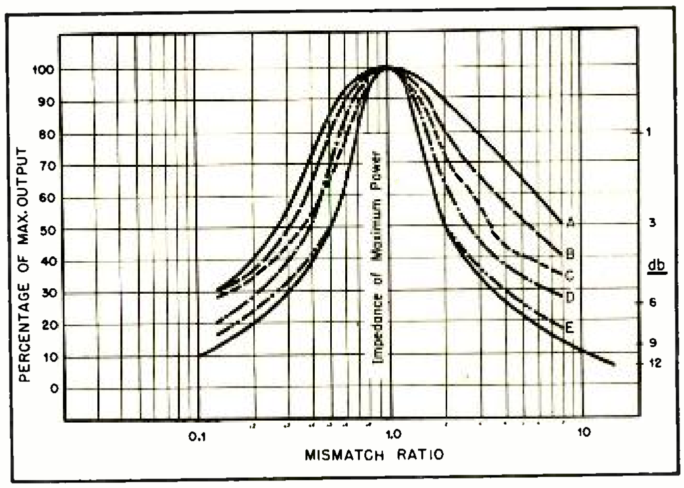


**Fig. 1. Curves showing the relationship between output power and the load impedance.**

The extent of permissable mismatch depends upon what is known as the "load characteristic" of the amplifier output stage. This expresses the relationship between output power (watts) and impedance of the load. Such curves are shown in *Fig.* 1. Studies of several commercial amplifiers show, as a rough average, that a 100 per cent mismatch results in a reduction in output power of 25 to 50 per cent. Curves A, B, and C were made on popular priced phonoamplifiers. Curve D shows the regulation on a Langevin 101-D amplifier. Curve E represents the relationship obtained on a McIntosh 50-watt amplifier. Expensive amplifiers with low internal impedance will fall between curves C and E. Curve F is the computed load characteristic from a true constant voltage amplifier, having a theoretical internal impedance of zero ohms.

Thus, an 8-ohm output may be connected, on an average medium-priced amplifier, to a 16-ohm speaker whereby the *maximum* available power between the ideal match and the mismatch will be reduced by 25 per cent (1¼ db). Where the loudspeaker is intended to be operated at only a fraction of the available power inherent in the amplifier, then wider mismatches can be tolerated, and there is no noticeable effect upon the performance. According to data published on a Stromberg-Carlson amplifier,[1] it is shown that a mismatch of 100 per cent dropped the maximum available power from 32 watts to 25 watts. However, if the application requires that this particular amplifier operate below 25 watts, then there is no apparent effect upon the performance with 100 per cent mismatch.

Actually, the degree of mismatch that can be tolerated, as stated above, depends upon how much of the amplifier power output it is desired to use. If one must utilize the *absolute maximum* of power of which the amplifier is capable, then an accurate match is necessary. A load impedance which does not vary by more than 25 per cent from the rated output impedance may be considered a close match for all practical purposes and will absorb practically 100 per cent of the amplifier energy when fully driven.

On the other hand, the less power to be utilized, the greater may be the mismatch. In the case of most quality phonograph systems, these usually have an output power of 10 to 15 watts. For

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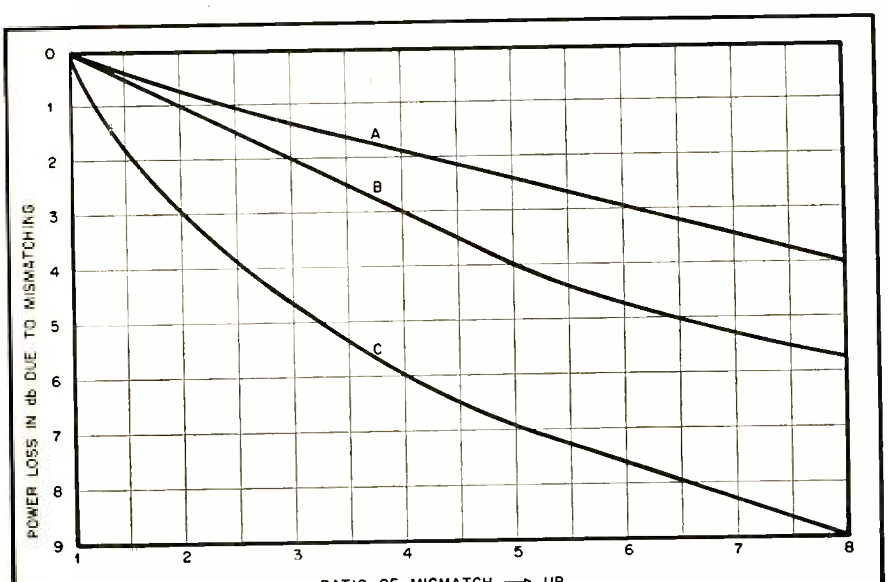


**Fig. 2. Chart showing mismatching losses on a conventional 6L6 amplifier without feedback. (A) Unregulated output stage at ¼ of full power; (B) same amplifier at full power; (C) theoretical constant-voltage output.**

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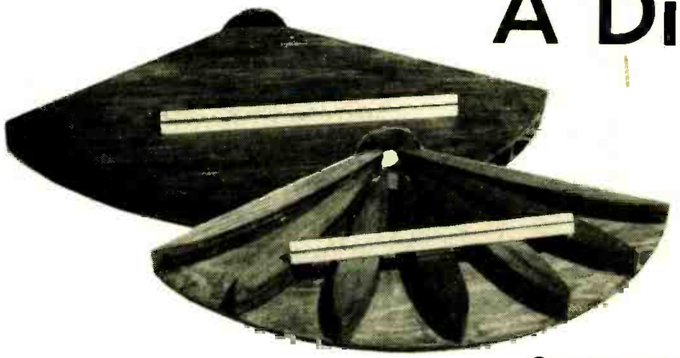
[1] "Impedance Matching" by O. L. Angevine, Jr., Audio Engineering, December, 1947.



# A Distributed-Source Horn

BOB H. SMITH*

**Constructional data for a high-frequency horn which is particularly well suited for home building by the audio enthusiast.**

**Fig. 1 (above). Sound appears to originate from the entire area of the horn rather than from the throat as in a conventional horn. Fig. 2. With the top removed, the simplicity of construction is apparent.**

One obvious difference between reproduced music and the original is the difference in spatial distribution of the sound. This difficulty can only be eliminated through the medium of a binaural system, which is not economically feasible at this time. Thus, until now we have been restricted to point-source reproductions. The sound emerging from a distributed source horn (DSH) appears to originate from an area rather than a point and is thus a step closer to the desired spatial distribution than conventional multicellular horns. In addition, the DSH described here provides much broader directivity patterns, is much more easily constructed, and takes up less space than the multicellular type.

The explanation of the apparent distributed source is evident from the field plot shown in *Fig.* 3. In the vertical plane the lines of flow do not diverge until they reach the mouth of the horn, thus to an observer a few feet from the horn they appear to be originating at the mouth of each cell of the horn. Of course, in the horizontal plane the lines of flow diverge at the throat of the horn and so in this plane the apparent source is at this point. Thus, there are seven apparent sources of sound in the DSH described here. The sources tend to blend together and give the impression of the sound originating from the area of the horn rather than at each point.

The broad directivity pattern in the vertical plane is a result of the fact that the vertical dimension of the mouth is small compared to wavelength through most of the frequency range of interest. In the horizontal plane the directivity pattern is broad because a large portion of a circular wave is generated. The directivity characteristic of the DSH is shown by the solid line in *Fig.* 4. The broken line represents the characteristic of a standard eight-cell multicellular horn.

*Figure* 5 shows the dimensions of the DSH tested. It has sufficient mouth area to prevent reflection for frequencies greater than 750 cps. The expansion is approximately exponential and provides a cut-off frequency of 375 cps. Thus, the mouth area is the limiting factor and the horn should not be used below 750 cps.

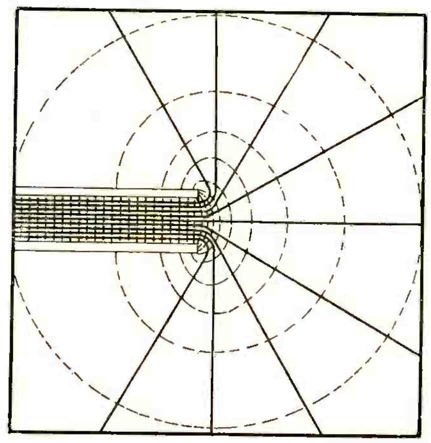


**Fig. 3. The apparent source of sound in the vertical plane is just slightly in front of the mouth of each cell, as indicated by the lines of flow (solid lines). In the horizontal plane the source is near the throat.**

#### Construction

The construction of the DSH is much simpler than that of the multicellular horn. Since there is no vertical expan-

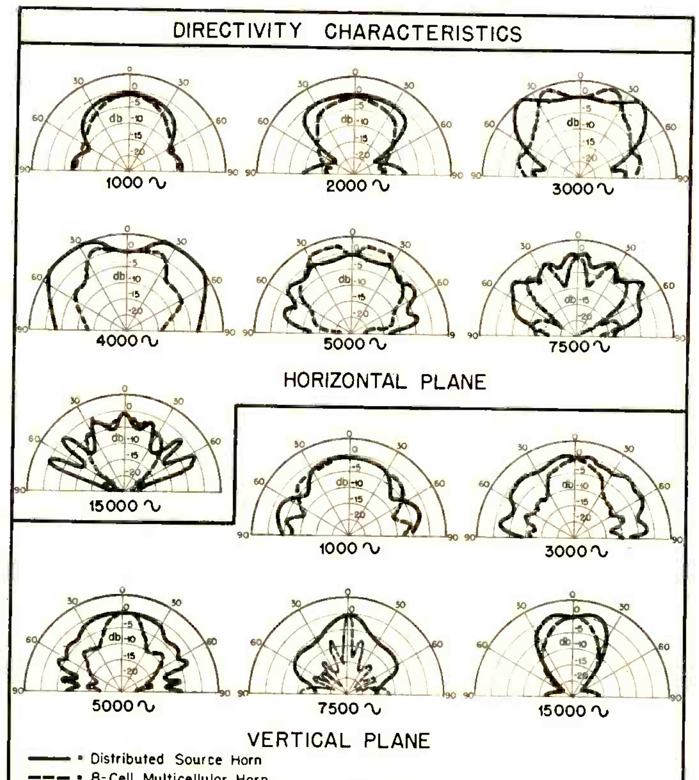



**Fig. 4. The directivity patterns of the DSH (solid lines) are considerably broader than those of the conventional 800-cps multicellular horn (dotted lines).**

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sion the islands may be cut from a flat sheet of one-inch plywood with a band saw. The top, bottom, and flange for mounting the driver are cut from ¼-inch plywood and the transition from circular to rectangular cross section near the throat is accomplished by means of plastic wood.

The type of finish is unimportant acoustically; the one shown in *Figs.* 1 and 2 was finished with orange shellac to better illustrate the construction. If the horn were to be mounted on top of the cabinet, or otherwise exposed, it could be made of one of the veneered plywoods. If it is to be mounted within the cabinet no finish would be required.

Plywood is a very satisfactory material for the horn; it provides adequate strength and contains sufficient mechanical resistance to damp any resonances and prevent appreciable motion of the horn walls. Thus, the performance of the horn is strictly a function of the geometry. Since the cut-off frequency, determined by the rate of taper, is well below the lowest frequency for which the horn is intended to be used, the dimensions of the islands are not critical. (Slight variations in the rate of taper of an acoustic horn only affect the performance near the cut-off frequency.)

If the horn is to be mounted within the cabinet, the top and bottom pieces need not be cut off along the arc but can be extended to the walls of the cabinet without impairing the performance of the horn. In this case, however, the inside width of the cabinet should be equal to the maximum width of the horn. (See *Fig.* 6.)

Fundamentally the design considerations are the same as those for any exponential horn—i.e., the mouth area must be large enough to prevent reflection at the lowest frequency for which the horn is intended to be used and the rate of taper must be chosen to provide a satisfactory low-frequency cut-off. In addition, there are the directivity considerations which are primarily a function only of the geometry of the mouth of the horn. They are: (1) The smaller the vertical dimension the broader will be the vertical directivity pattern. (2) The larger the arc of the mouth the broader will be the horizontal pattern. One is limited in the first case by the fact that if the vertical dimension is made too small the viscosity losses will be appreciable. Since they are proportional to the square root of the frequency, attenuation may occur at the higher frequencies. In the second case difficulty may be encountered in exciting each of the horn throats equally at the higher frequencies if the arc is made too large. Experimental investigation indicated that neither of these difficulties were appreciable for the horn described in this paper.

The required mouth area is given by the following expression:

$$S_m = \frac{\pi}{36}\left(\frac{c}{f_o}\right)^2 = \frac{1.6 \times 10^7}{f_o^2} \text{ sq. in.} \qquad (1)$$

where $f_o$ is the lowest frequency for which the horn is to be used and $c$ is the velocity of sound.

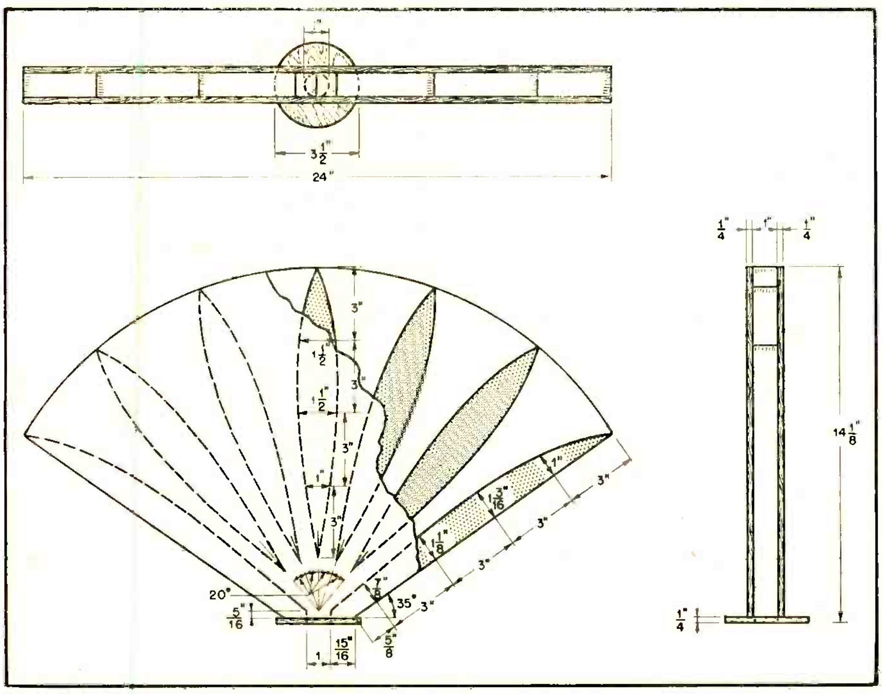

**Fig. 5. Construction of the DSH is extremely simple since there is no vertical expansion.**

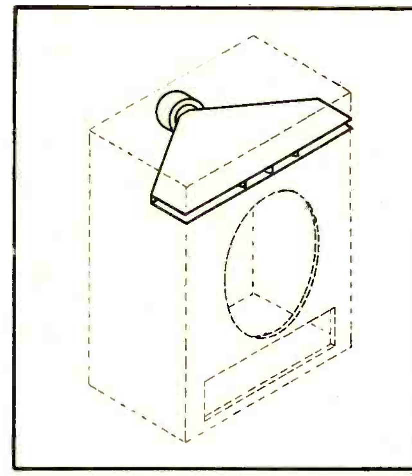

**Fig. 6. The top and bottom pieces need not be cut along the arc, but may be cut off at the edges of the cabinet without impairing the performance of the horn.**

The length of the horn is given by:

$$L = \frac{5}{\theta t}\left(\frac{c}{f_o}\right)^2 = \frac{9.2 \times 10^8}{\theta t f_o^2} \text{ inches} \qquad (2)$$

where $\theta$ is the angular arc of the mouth in degrees, and $t$ is the thickness of the mouth in inches.

The cut-off frequency $f_c$ must be less than or at most equal to $f_o$, and is given by:

$$f_c = \frac{\theta t f_o^2}{20\pi c} \ln \frac{S_m}{S_o} = \frac{\theta t f_o^2}{3.7 \times 10^5} \log_{10} \frac{S_m}{S_o} \qquad (3)$$

where $S_o$ is the area of the throat.

The distance in inches for the cross sectional area of the horn to double is given by:

$$d = \frac{750}{f_c} \text{ inches} \qquad (4)$$

The design procedure is as follows:

1. Choose $f_o$, $S_o$, $t$, and $\theta$.
2. Calculate $S_m$ from equation (*1*).
3. Calculate $L$ from equation (*2*).
4. Calculate $f_c$ from (*3*). In the event that $f_c$ is greater than $f_o$ choose a smaller value of $t$.
5. Calculate $d$ from equation 4.
6. Draw a straight exponential horn starting from the cross section $S_o$ and doubling the area each $d$ inches.
7. Choose the number of cells required to fill the chosen arc $\theta$ without allowing the mouth of each cell to have a dimension greater than about 5 inches.
8. Draw the center lines of each cell.
9. At equal intervals along the axis of the straight exponential horn measure the cross sectional dimension. Divide this equally between each of the cells, thus determining the dimensions of the islands. (i.e. superimpose this information on the center lines of step 8).
10. Complete the drawing of the horn.

Sometimes vertical expansion is nec-

[*Continued on page 44*]

# Receiver Bandwidth and Its Measurement

HOWARD T. STERLING* and ALAN SOBEL**

**A discussion of the methods of measuring bandwidth in FM receivers to ensure optimum fidelity, and the effect of bandwidth on over-all distortion.**

THE MOST CONVENIENT method of aligning a receiver is to use a frequency-modulated signal generator and an oscilloscope, as in *Fig.* 1. Here the oscilloscope displays the response curve of the receiver, which can be set to the desired shape by manipulating adjustments. This procedure, while it gives a qualitative picture of the response curve, does not give quantitative data about the receiver bandwidth, separation of peaks or troughs, or symmetry of the curve. Furthermore, unless the signal-generator modulator is linear, the oscilloscope curve will not have a linear frequency scale. For accurate information about receiver bandwidth, then, some device in addition to the wobbulator and oscilloscope must be used. In this paper we shall discuss the usual methods of measuring receiver bandwidth, describe a new method which has certain advantages over existing systems, and comment on the receiver bandwidth desirable for undistorted reception of frequency-modulated signals.

The simplest method of measuring bandwidth does not require an oscilloscope. A calibrated signal generator and a receiver tuning indicator, such as a limiter grid-current meter in FM receivers, are all that we need. The signal generator is tuned over the passband of the receiver between 3 db (or whatever limiting values are chosen) points and the frequencies of these points noted. For an FM receiver, the bandwidth at signal frequency is of the order of 0.2 per cent (200 kc at 100 mc). Since the better laboratory-type signal generators are usually rated as ±1 per cent, such a measurement is obviously going to be rather inaccurate. The best of these signal generators provide vernier increments of frequency of 0.01 per cent—with such a signal source, our error will not be less than 5 per cent. In any case, this is a point-by-point measurement, and the results are not available at the same time the alignment is being carried out, since a separate operation is required for bandwidth determination.

This objection can be overcome by using some sort of marker which will produce a trace on the same screen used to trace the response curve. Either live or passive markers can be employed. The latter are high-$Q$ circuits which are usually loosely coupled to the receiver input circuit. They draw energy at their resonant frequency and thus cause a "hole" in the response curve, as at A in *Fig.* 2. For the bandwidths and frequencies usually employed in frequency modulation, crystals represent the most practicable method of obtaining the requisite high $Q$.

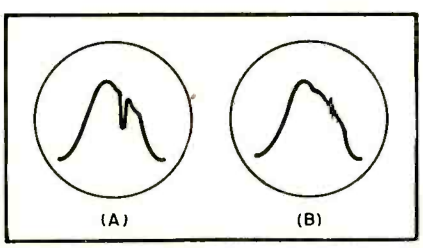


**Fig. 2. Types of displays obtained with (A) passive, and (B) live markers.**

A live marker is simply an oscillator, crystal-controlled or variable in frequency, the output of which is fed into the receiver input circuits along with the wobbulator output. The resulting trace is shown at B in *Fig.* 2.

Both of these marker systems are subject to the same accuracy limitations as the first method. A signal generator with an adequate vernier dial can of course be used as a live marker. Crystal markers have the advantages of stability and high effective $Q$, with the disadvantage that they cannot be varied in frequency.

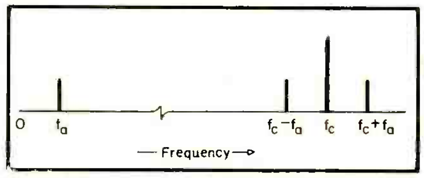


**Fig. 3. Spectrum of an amplitude-modulated wave.**

#### A More Flexible Method

The new method we propose makes use of the spectrum of an amplitude-modulated signal. As is well known, this consists of a carrier and two sidebands, one on each side of the carrier and distant from it by the modulating frequency. (See *Fig.* 3.) Such a spectrum provides a simple and convenient method of providing live markers for bandwidth measurement. The equipment required consists of an r.f. oscillator and an audio oscillator. The audio oscillator is readily available in most laboratories or shops. The r.f. oscillator may be crystal-controlled, where a known frequency of operation is desired, or may simply be a tunable variable-frequency oscillator if the frequency on which the passband is to be centered is not of primary importance.

In operation, the response curve is centered on the pip produced by the r.f. oscillator. Modulation is then applied to the r.f. oscillator and the frequency of the audio oscillator varied until the sideband pips have reached the edges of the passband. Bandwidth is then twice the audio frequency. This system also provides an excellent check on the symmetry of the response curve, a factor which is particularly important in dis-

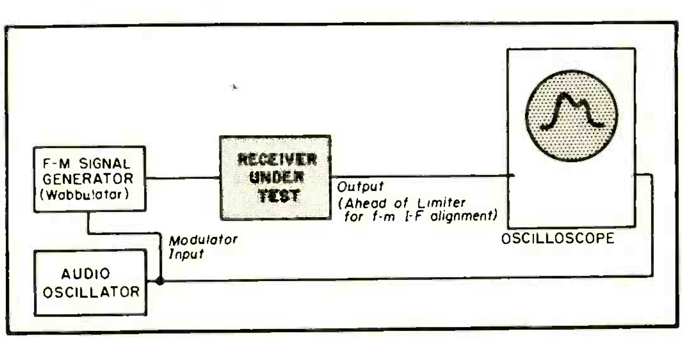


**Fig. 1. Block diagram of receiver alignment procedure.**

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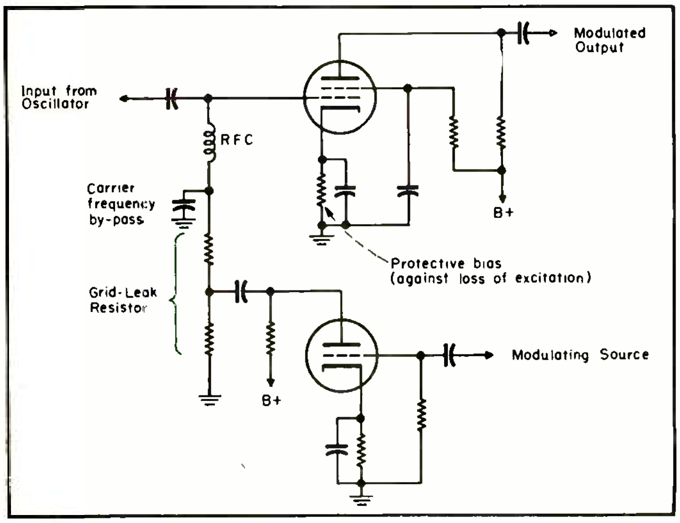



**Fig. 4. Possible modulation circuit for test work.**

criminator alignment. (A good limiter will wipe out the marker if the signal introduced ahead of it—for discriminator measurements it will probably be necessary to couple the signal into the system at the limiter plate.)

Accuracy of the bandwidth measurement thus made is evidently not dependent on the r.f. oscillator, since we are measuring only the side band separation, which is a function only of modulating frequency. The precision of measurement will therefore be as high at the signal frequency as it is at the intermediate frequency, permitting accurate checks on the bandwidth of the r.f. circuits. The accuracy of the usual audio oscillator is ±2 per cent, and this is the accuracy of the measurement, subject to the definition of the oscilloscope trace and the stability of the receiver local oscillator and of the r.f. oscillator. Distortion in the modulation process will not affect our result, since it can only produce higher harmonics of the audio frequency, which will either be so far beyond the receiver passband that they are not visible, or else can be readily detected by their lower amplitude and further separation from the carrier than the desired sidebands.

Where wider bandwidths are involved than can be measured with an audio oscillator, an r.f. signal generator can be pressed into service as a modulating source. In this event a wide-range, untuned modulator will probably be desirable. Although 100 per cent modulation of the carrier is not necessary, a modulation-frequency amplifier ahead of the modulator will probably prove useful, since the output of the usual signal generator is only about a volt. A suggested solution is grid modulation of the oscillator itself or of a buffer amplifier (see *Fig.* 4). A diode modulator might prove a simpler solution.

**Bandwidth of Frequency Modulation Receivers**

Earlier, we made the statement that the bandwidth of an FM receiver is of the order of 200 kc. It is quite true that the carrier swing of an FM broadcast transmitter is only ± 75 kc, but a fact too often overlooked is that the bandwidth of an FM signal is *always* greater than twice the carrier swing.

Mathematically, the spectrum of a frequency-modulated wave consists of a carrier and an infinite number of sidebands, spaced from each other by the modulating (audio) frequency. For practical purposes, the bandwidth of an FM signal cannot be considered infinite. Where $m$ is the modulation index (ratio of maximum carrier deviation to audio frequency), sidebands of order higher than $m+1$ will be less than 15 per cent of the unmodulated carrier in amplitude.[1] Since in all frequency modulation systems, modulation supplies no additional energy (as it does in amplitude modulation), but merely shifts some of the carrier energy into the sidebands, the sidebands of order greater than $m+1$ will contain less than 1.25 per cent of the energy available. Apparently, then, for 100 per cent modulation at 15,000 cps, substantially all the energy of the signal is contained in a band 180 kc wide. Considering sidebands down to 10 per cent of the amplitude of the unmodulated carrier, the bandwidth of a broadcast FM signal at full deviation varies from about 165 kc to 200 kc for signal frequencies from 30 to 15,000 cps.[2] (*Figure* 5 shows the width of the frequency-modulation spectrum as a function of modulation index for different limiting amplitudes.)

Unfortunately for the receiver designer, the picture is not quite as simple as this. In the first place, restricting the bandwidth of the FM signal to be detected introduces distortion.[3, 4] This distortion is due largely to the phase shift introduced in the higher-order sidebands (even those well inside the 3-db points of a band-pass, "flat-topped" circuit). Where the passband is determined by one single-tuned or double-tuned circuit, Jaffe[3] recommends that the band between half-power points be four times the peak-frequency deviation, for a 15 kc audio range. Gladwin[4] has investigated the problem of distortion when

[*Continued on page 46*]

[1] Austin V. Eastman, "Fundamentals of Vacuum Tubes," 3rd ed., McGraw-Hill Book Co., New York, 1949; pp. 538–547.

[2] Herbert J. Reich, "Theory and Applications of Electron Tubes," 2nd ed., McGraw-Hill Book Co., New York, 1944; pp. 327–331.

[3] David L. Jaffe, "A theoretical and experimental investigation of tuned-circuit distortion in frequency-modulation systems," *Proc. I. R. E.*, v. 33, pp. 318–333; May, 1945.

[4] A. S. Gladwin, "The distortion of frequency-modulated waves by transmission networks," *Proc. I. R. E.*, v. 35, pp. 1436–1445; December, 1947.

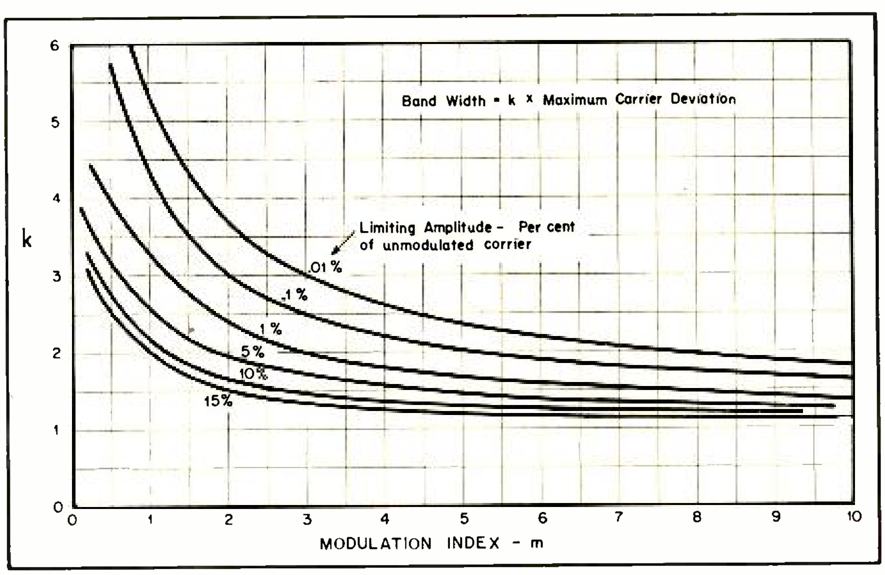



**Fig. 5. Variation of bandwidth with modulation index.**

# The Terminal Impedance Of An Attenuator

HERBERT I. KEROES*

**Part I. Presenting a graphical method for calculation of problems involving resistive attenuators in audio circuits.**

Fixed and variable attenuators are often used in communication networks to smooth out impedance irregularities of a power source or a load. When an attenuator is specifically used for this purpose, it is desirable that a simple means be available for calculating the terminal impedance of the attenuator when terminated at the other end by an impedance differing in value from the rated impedance of the attenuation network. While it is possible to compute the terminal impedance by the usual methods of circuit calculation, such a procedure presumes a knowledge of the resistance elements of the attenuator, and the method will be tedious, particularly for ladder networks. Another means based on four terminal network theory is available, and is presented in chart form for ease of computation. Two charts have been developed—one for use where the termination is resistive and the other for impedances having a large reactive component. The use of the resistive chart will be considered first, and the reactive diagram will be discussed in a subsequent article.

* *Acro Products Company, 5328-30 Baltimore Ave., Phila. 43, Pa.*

#### Use Of The Chart

The chart giving the relation between the terminal impedance and a resistive source or load impedance is a nomograph and is shown in *Fig.* 1. To use the chart proceed as follows:—

1. Divide the source or load impedance by the rated impedance of the attenuator.
2. Align a straight-edge between the above ratio as indicated on the scale at the right and the rated loss of the attenuator as given on the center scale.
3. Read the ratio of the terminal impedance to the rated attenuator impedance on the left scale.
4. If the ratio of source or load impedance to rated attenuator impedance is less than *1*, take the reciprocal and proceed as above. The quantity indicated on the left scale will then be the ratio of attenuator impedance to terminal impedance.

#### Application

It is of interest to consider a number of examples which will serve to illustrate some of the numerous applications of the nomograph. Assume that an amplifier with an output impedance of 600 ohms is to be matched into a 500-ohm line through a 600-ohm variable attenuator. The 500-ohm line impedance may readily be matched by bridging a 3000-ohm resistor across the output side of the attenuator. The load impedance presented to the attenuator then becomes 428 ohms. Let it also be assumed that it is desirable to restrict the impedance variation at the output terminals of the amplifier to 600 ohms ± 10 per cent. The problem is then to find the minimum attenuation that will make the input impedance of the attenuator 600 ohms minus 10 per cent. On the load side the ratio $Z_{K2}/R_L$ equals 1.17. Alignment on the chart with a straight-edge which intersects 1.10 on the opposite scale gives 2.25 db as the required attenuation.

Next, assume that an audio signal generator has an output impedance of 600 ohms ± 10 per cent, and for purposes of careful gain measurements on an amplifier, it is desirable to hold the impedance variation to ±2 per cent by means of an attenuator. The requisite attenuation is readily found to be 7 db.

The alignment chart may also be used to find the rating of an attenuator with illegible identification markings. This may be done by taking resistance measurements between either the input or output set of terminals with the opposite set first open and then shorted. Such a set of measurements may give for one attenuator values of 737 and 488 ohms, for example. The rated impedance is given by the square root of the product of these values and is equal to 600 ohms. The ratio $R_1/Z_{K1}$ with the output terminals open circuited is equal to 1.23. With a straight-edge between infinity on the left scale and 1.23 on the opposite scale, we obtain 10 db as the rated loss of the pad.

It should be noted that for the sake of generality the chart has been constructed for unequal attenuator image impedances. Since the result is given in ratio form involving the different image impedances, the procedure for attenuators of this type is identically the same as that outlined in the examples above.

The use of the chart is not restricted

[*Continued on page 34*]

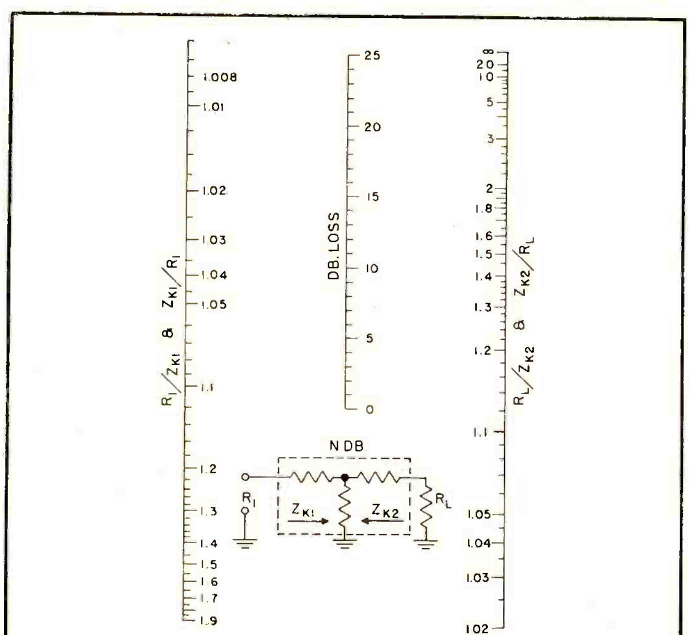
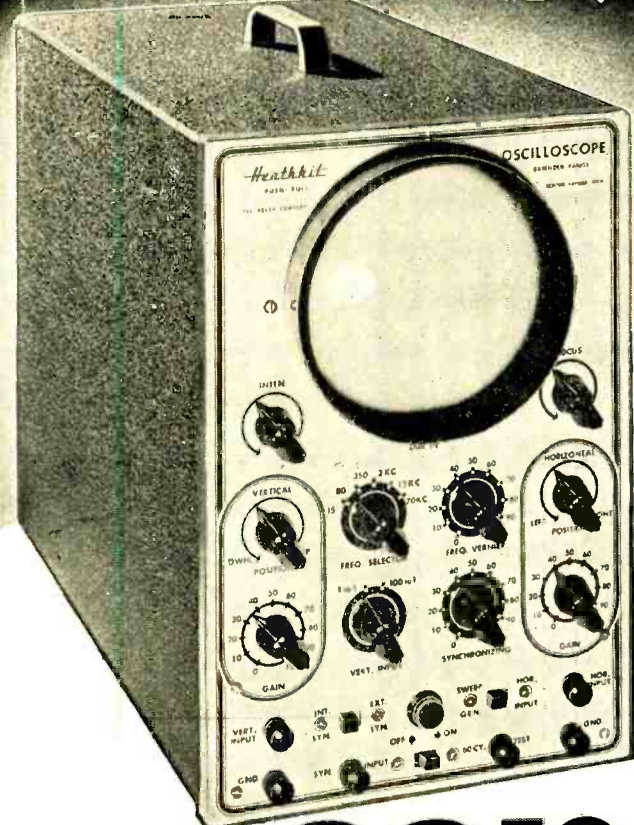



**Fig. 1. Nomograph for solution of attenuator problems.**

# *12 Improvements* IN NEW 1951

MODEL O-6 PUSH-PULL

# *Heathkit* OSCILLOSCOPE KIT

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- ★ New AC and DC push-pull amplifier.
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- ★ New intensity circuit gives greater brilliance.
- ★ Improved amplifiers for better response useful to 2 megacycles.
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- ★ New extended range sweep circuit 15 cycles to over 100,000 cycles.
- ★ Both vertical and horizontal amplifier use push-pull pentodes for maximum gain.

The new 1951 Heathkit Push-Pull Oscilloscope Kit is again the best buy. No other kit offers half the features — check them.

Measure either AC or DC on this new scope — the first oscilloscope under $100.00 with a DC amplifier

The vertical amplifier has frequency compensated step attenuator input into a cathode follower stage. The gain control is of the non frequency discriminating type — accurate response at any setting. A push-pull pentode stage feeds the C.R. tube. New type positioning control has wide range for observing any portion of the trace.

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The multivibrator type sweep generator has new frequency compensation for the high range it covers; 15 cycles to cover 100,000 cycles

The new model 0-6 Scope uses 10 tubes in all — several more than any other. Only Heathkit Scopes have all the features.

New husky heavy duty power transformer has 50% more laminations It runs cool and has the lowest possible magnetic field. A complete electrostatic shield covers primary and other necessary windings and has lead brought out for proper grounding.

The new filter condenser has separate filters for the vertical and horizontal screen grids and prevents interaction between them.

An improved intensity circuit provides almost double previous brilliance and better intensity modulation.

A new synchronization circuit allows the trace to be synchronized with either the positive or negative pulse, an important feature in observing the complex pulses encountered in television servicing.

The magnetic alloy shield supplied for the C.R. tube is of new design and uses a special metal developed by Allegheny Ludlum for such applications.

The Heathkit scope cabinet is of aluminum alloy for lightness of portability.

The kit is complete, all tubes, cabinet, transformer, controls, grid screen, tube shield, etc. The instruction manual has complete step-by-step assembly and pictorials of every section. Compare it with all others and you will buy a Heathkit. Model 0-6 Shipping Wt., 30 lbs.

## *New* INEXPENSIVE MODEL S-2 ELECTRONIC SWITCH KIT

Twice as much fun with your oscilloscope — observe two traces at once — see both the input and output traces of an amplifier, and amazingly you can control the size and position of each trace separately — superimpose them for comparison or separate for observation — no connections inside scope. All operation electronic, nothing mechanical — ideal for classroom demonstrations — checking for intermittents, etc. Distortion, phase shift and other defects show up instantly. Can be used with any type or make of oscilloscope. So inexpensive you can't afford to be without one.

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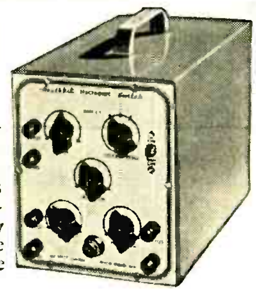

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# AUDIO engineering society

Containing the Activities and Papers of the Society, and published monthly as a part of AUDIO ENGINEERING Magazine

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# AES Standard Playback Curve

BASED ON THE PREMISE that the proper approach to the problem of equalizing disc recordings and transcriptions is to standardize on a *playback* curve and to let the recording engineers make their records however they see fit, knowing that they must sound properly balanced when played on this standard reproducing characteristic, the Audio Engineering Society announces the adoption of such a curve. This announcement follows action of the Board of Governors approving the report of the Society's Standards Committee consisting of: Gordon Edwards, chairman; S. E. Sorensen, vice chairman; James Bayless, Harry Bryant, and Russell Hanson, members of the Western Division; and Theodore Lindenberg, N. C. Pickering, A. A. Pulley, and Ralph Schlegel, members of the Eastern Division. Robert Liesenberg served as alternate to Mr. Sorensen.

The standard curve, shown in *Fig.* 1, is represented by the values in Table 1.

The decision to specify a standard playback response characteristic instead of a recording characteristic was deliberate on the part of the Standards Committee. This course was chosen because of the impossible task of achieving a universal recorded characteristic compatible with all individual recording conditions and systems.

Reference to the tabulation will indicate that all points on the curve are related to 1000 cps. This reference point has been used as a standard for many years, making it evident that the maintenance and calibration of equipment would be expedited by retention of this frequency as a reference point. Furthermore, the slope of the curve at this point is sufficiently flat so that an error of 10 per cent in frequency will produce a deficiency of not more than 0.5 db.

**TABLE 1**

| Frequency | db | Frequency | db |
|---|---|---|---|
| 30 | +22.5 | 1500 | − 1.5 |
| 40 | +20 | 2000 | − 2.2 |
| 50 | +18 | 2500 | − 3 |
| 70 | +15 | 3000 | − 4 |
| 100 | +12 | 4000 | − 5.5 |
| 150 | + 8.5 | 5000 | − 6.7 |
| 200 | + 6.5 | 6000 | − 8 |
| 300 | + 4.5 | 7000 | − 9 |
| 400 | + 3 | 8000 | −10 |
| 500 | + 2 | 9000 | −11 |
| 800 | + 0.5 | 10000 | −12 |
| | | 12000 | −13.5 |
| 1000 (ref.) | ±0 | 15000 | −15.5 |

Permissible tolerance ±2 db

The majority of engineers active in the recording field have felt for some time that the degree of high-frequency emphasis prescribed by the NAB transcription characteristic is excessive. The trend in modern microphones and amplifiers to a wider frequency range, approaching 15,000 cps, and the use of acoustically brighter studios have made this problem much more difficult. With this extended range, the acceleration of the reproducing stylus becomes a limiting factor. Consequently, it was deemed necessary to restrict the degree of high-frequency rise used in recording. This was accomplished by making the reproducing characteristic roll off only 12 db at 10,000 cps—approximately 3 db below the NAB specification—and continuing the response out to 15,000 cps. By doing this, the high-frequency situation has been alleviated somewhat. Since microphone and studio characteristics must be considered by the recording engineer, it is required that the sum of the electrical rise in the recording equipment and the acoustical rise in the microphone must not exceed the values shown by the reciprocal of the reproducing characteristic, unless it is intended to make the high end over-brilliant.

The low-frequency characteristic was chosen to fall somewhere in the middle of the numerous low-frequency curves now in use. It is felt that the turnover frequency is low enough to keep rumble down to reasonable levels, and high enough to avoid excessive amplitude and intermodulation at low frequencies. It will be noted that no "shelving" of the characteristic at low frequencies is recommended. Again, if the recording engineer desires for some reason to have a "bassy" sound, he can easily

[Continued on page 44]

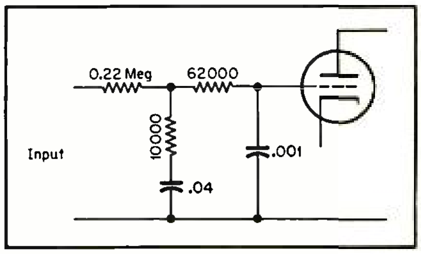


**Fig. 2. High impedance network to provide standard playback curve in grid circuit of amplifier stage.**

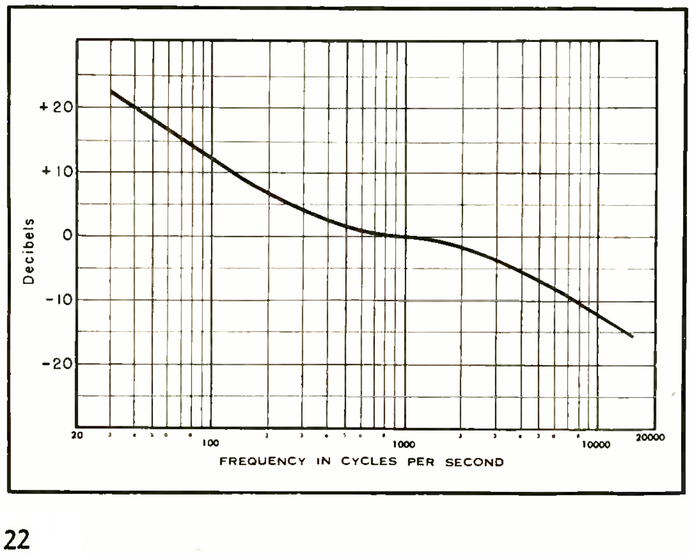


**Fig. 1. Newly adopted standard playback curve.**

# PRESTO SR-950's

# pay off for WFDR

**Chief Engineer BUD ARNOW praises PRESTO's performance... low maintenance after 1,000-reel test**

**WHEN NEW YORK'S STATION WFDR** went on the air last summer, they were faced with a major recording assignment: "taping" a Kaiser-Frazer sponsored news program with Joseph C. Harsch and Marquis Childs which was sent over-the-line from Washington. Not only did this show have to be recorded for delayed broadcast on WFDR, but the station was responsible for sending copies of the program, with specially dubbed commercials, to its sister stations in Detroit, Cleveland, Chattanooga and Los Angeles the same night.

Within half an hour of the time the show is recorded, commercials are added, additional copies are recorded and the tapes rushed to airport and railroad station for immediate shipment across the country. Additional flexibility and fast operation is provided by the coupling of four PRESTO SR-950's with a remote control system, allowing the operator to completely control the machines from his chair at the console.

More than 1,000 reels of tape have been used since WFDR installed its new PRESTOS. "The speed of such an operation and the need for dependable, high quality equipment were reasons for our selecting the PRESTO SR-950's," says Chief Engineer Bud Arnow. "After several months of rigorous use, we find the selection completely justified."

***WFDR's unique use of PRESTO equipment is further evidence that wherever fine recording is done . . . it's PRESTO two to one.***

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**wherever you go . . . there's PRESTO!**


EDWARD TATNALL CANBY*

## The Other Side of the Wall

THE SPREAD, these days, of various types of horn loaded speaker enclosure systems and the gradual shift from quadrangular to triangular shapes, for corners, is only part of an interesting trend now towards concern with audio sound after it leaves the actual transducer. Experiments with various departures from the usual plain box have been going on since the Beginning, but now the thing is out in the open and, commercially speaking, in the catalogues. People, and engineers, specifically, seem to be doing a lot of healthy wondering as to exactly what we intend to achieve as "perfect" reproduction. Concert Hall realism? That phrase is pretty much outdated now, for we know perfectly well that the monaural system isn't going to give a concert-seat effect nor ever can. What then?

Some years back, in more innocent days, I defined high fidelity as the greatest possible faithfulness to the *imagined* original (since, of course, we virtually never have the actual original at hand for an A-B test and hence must imagine it!)—and this factor of imagining, of mental image-creating, is now a major one in discussions of ideal reproduction and in tests looking towards better equipment design. What, specifically, should we be imagining as we listen to reproduced music?

#### Hole-in-the-Wall

Mr. P. G. A. H. Voigt's discussion of the "Hole-in-the-Wall" concept of listening (p. 40 of the October issue) strikes me as a most useful contribution, the kind of clearly reasoned envisioning of a mental concept that engineers provide in their "equivalent" circuits. The Voigt solution of the eternal difficulty in comparing concert-hall and home-living-room situations hits the nail on the head, I'd say—in that it takes into account very neatly both the binaural problem of concert hall directionality (liveness) and the added living-room reflections that we can't avoid in our own homes.

It works too. Just sit in front of a loudspeaker, eyes shut, and visualize what Voigt describes—a living room placed within a concert hall, with a single window through which one hears (from a *single* direction) both the direct musical beam and the reflected liveness—all of which is added to the reflections within the small room. Even the idea of a close-up soloist or announcer as standing right outside the window is one that clicks. With only an added suggestion on my part: there is in recording or broadcast both a Liveness balance—the *apparent distance* of various elements from the listener (solo and orchestra, say) and a Loudness balance, the simple volume level relationship between the same elements. The two balances do not always agree. Sometimes a very close-to singer or speaker is at a low volume level; often a distant-sounding soloist is nevertheless louder in actual volume than his nearer-sounding accompaniment. Volume and liveness balances are different. These might be classed as distortions of natural sound or, if you will, variants; in any case, Mr. Voigt's mental concept encompasses them beautifully.

I am sure that the Voigt solution of the problem of binaurality, to coin a word, should help all of us to figure out what we're trying to achieve or not to achieve. What is plainest of all is that the old concept of the orchestra as "right *in* your living room" just does not stand up. It must be, for best reproduction, a "virtual" image apparently *outside* your room, the sound coming in through an imagined hole, large or small. One must "see" right through the wall, or beyond the corner.

#### Multiple Reflection

One can produce, as I have in my own quite small room, an illusion of this kind by reflection, done irregularly so that the sound of the speaker is spread out over a wide apparent source—say eight or ten feet wide. I do it by beaming my speaker along the wall towards a corner, the sound reflecting in part from a piano nearby, part from a succession of surfaces—venetian blinds, steam radiator, panelled woodwork—so that the apparent source is spread out uniformly, centering in the corner. (Listeners can never find the speaker—an excellent sign of a good set-up.) Under this condition, one hears the orchestra or other performers spread out in space, *behind or beyond* the corner, the distance "beyond" depending, as

[*Continued on page 40*]

* *279 W. 4th St., New York 14, N. Y.*

# Pops

RUDO S. GLOBUS*

AFTER A FEW MONTHS of extensive treatment of the blacker side of the picture, we return this month to view and review the output of the pop factories for the recent past. If anybody has gotten the impression that new discs were not being pressed because this column failed to review them, *requiescat in pace*. Life is joyous and a plethora of 10- and 12-inch platters have been pouring into the neighborhood emporium. They have been heard and patly dispensed with by this ear as being not entirely worthy of space and comment. The few interesting items have been saved for an occasion such as this. We have the undoubted pleasure of being able to shower accolades and wheezy hails upon a few of the preeminent creatures to be found further along in this piece.

However, before throwing ourselves headfirst into the cauldron, a few words of caution. Secret and not so secret conferences with representatives of the leading manufacturers reveals the following sad information: the vinylite scare is real. We are now facing a situation similar to the shortages which plagued the record industry during the last war. All elements which go into record production are in a state of increasing scarcity. Metals, plastics, paper, etc., are all in short supply for recording purposes. As a result, the best and most obvious advice at the present involves careful checking of your equipment, including your diamond styli (if you use them), both for the sake of preservation of your present discs and the future playing of recorded music under decent conditions. Panic buying doesn't make sense . . . but the same scrupulous care that the average owner of a car bestows on his pet in times like these should be accorded to your reproducing equipment. It is also about time that we blasé ones take better care of our present collections. Replacements will be

[*Continued on page 26*]

* *960 Park Ave., New York 28, N. Y.*

# *BEATEN PATH*

***90%*** of the electronic manufacturers—from everywhere—who exhibited at the recent Audio Fair—with understandable pride in presenting their apparatus at its best—were observed to be using

## *Audax* POLYPHASE reproducers

What a striking tribute to this realistic performer which, when introduced but a few short months ago, was backed only by our own findings as to its overwhelming superiority! What a remarkable dramatization of the old adage about *customers beating a path to one's doorstep!*

Thousands of visitors came, saw and listened with astonishment to POLYPHASE's amazing *facsimile* realism. "Never before such EAR-QUALITY, such FAITHFUL reproduction!" . . . was the unanimous verdict.

Yes . . . and this must mean something to Y O U .

The unique technical story of WHY this sensational reproducer fairly revolutionizes listening, is set down in literature which is yours for the asking: b u t . . . ONLY YOU can decide what sounds best and most pleasing to your ears. Therefore . . . see it, HEAR it. and compare it with any reproducer at any price . . . then, you be the judge.

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*Available with the new Compass-pivoted Audax Arms as well as for Record Changers*

## POPS

[*from page 24*]

difficult to come by and the quality of discs to come cannot be guaranteed. A word to the wise is sufficient . . . keep your records clean and try if possible not to play them with the blunt end of a broken pencil.

In addition, it is heartily recommended that if you had been procrastinating in the purchase of discs to build up or complete your collection, act now! Prices, at least in the major cities, are still dirt cheap and there are innumerable mail-order houses which are offering spectacular specials. Prices will definitely go up on all categories in the near future. If you have any loose dough lying around the house that you don't need for feeding your face, clothing your body, paying your rent, buying bonds, or supplying friend spouse with her annual mink, pay attention to the facts of recording life.

### NEW RELEASES:

**Piano Moods** Ralph Sutton
**Columbia CL-6140**

If I have ever expressed bitterness with regard to the ineptness of our major companies to do well by jazz recording, I am now willing to go to the opposite extreme in a gleeful burst of enthusiasm for one of the really great "pop" recordings of our time. Before I completely blow my top, a few background words about this job.

Ralph Sutton is well known to the cognoscenti who habituate bistros such as Eddie Condon's in New York. They have long drowned their tears in tepid beer, for Sutton is one of the finest piano men of this generation who plays intermission sets under the worst possible conditions. After the band leaves the stand, Sutton arrives to face a din which would startle the most brazen high-pass filter. Nobody can hear him, and when you can, you are reduced to a level of nervous frustration which amounts to sheer madness. What could be heard revealed a piano man whose versatility, whose true artistry in the best of jazz traditions required recognition complete with a horseshoe garland. He has at last received his due. Columbia has made a recording of Mr. Sutton's pianism which on every possible level marks it as a great enterprise. Accompanied by the usual rhythm of bass and drums, Sutton does a job on "Ain't Misbehavin," "Tia Juana," "I Used to Love You" and "Muskrat Ramble" which bestows on both him, his percussion section, and Columbia Records the highest accolade possible for this column—a hearty stamp of the foot and a broad smile of the face. The liveness of this recording is breathtaking. The "in the same room" feeling is accompanied by the fact that the room is just the right size for the acoustic depth necessary for a job like this. Beautiful surfaces, marvelous balance, and a particularly accurate treatment of jazz piano sound results in a gem of a recording. Everything on the disc is magnificent, including a touching treatment of the late Fats Waller's "Jitterbug Waltz" and striking treatment of Fletcher Henderson's "Deep Henderson." A great piano man, magnanimously bestowed with a great recording job means emptying your pockets of all loose shekels and a fast dash to the nearest diskery.

**Benny Goodman** Carnegie Hall Jazz Concert
**Columbia SL-160**

If the year 1938 had any merits, they boiled down to the very great concert given by the top Goodman combination, augmented by practically every great man in the business. A weird story is now going the rounds that Benny recorded the whole concert, threw the acetates into a closet, and forgot about them. Then three years ago, Benny's daughter Rachel, wandering around through self-same closet, stumbled across the records, dragged them out, to Benny's surprise, and the above recording resulted. We deal with it in very simple terms . . . it must be owned by every man, woman and child who feels for these things. Whoever did the recording was a genius, considering how long ago 1938 really is. The job is so faithful that the results are superior to the original shellacs originating from the period. Musically, the two LP's are a treasure house. We need mention only a few of the wondrous things available. The great Bobby Hacket plays one of the greatest solos in his career in "I'm Coming Virginia." Sounding very much like Bix, but outplaying him on every score, the result makes the chops hang low. The Ellington solo greats, Cootie Williams and Johnny Hodges, make out of "Blue Revery" one of the memorable moments in jazz recording, and Basie's job on "Honeysuckle Rose" is nothing short of miraculous. But the two men who stand out with a distinction rarely found on records are Benny himself and the magnificent and percussively eloquent Gene Krupa. We needn't make much of Benny . . . there is enough of a concensus concerning his greatness to forbid further words. But Krupa, who is occasionally tossed off as merely a big name, sparks the whole concert. With a drive that never relaxes, with his typical "melodic" drumming, he teaches the one lesson that is never learned well enough . . . the contribution of the great drummer. Thank you Columbia records . . . and Merci Beaucoup, Rachel.

**Jimmie Noone** Apex Club Orchestra
**Brunswick BL 58006**

Brunswick has been doing a noble job of dubbing the classics in their catalogue. One of their more recent attempts involves the great recordings made of Jimmie Noone's Apex Club Orchestra in Chicago in the fatal year of 1928. The group features Jimmie Noone on clarinet; Joe Poston on alto sax; Earl "Father" Hines on piano; Buddy Scott on banjo; and Johnny Wells on drums. The whole group of recordings was made in two dates, with Lawson Buford, fabulous tuba man, added in the second. The recording job is extraordinary in every way, being superior in many respects to some of our modern attempts in the same direction. I know of very few recordings of jazz clarinet, specifically the difficult type job necessary to capture the quality of a stick man like Noone; which come off as well. The dubs are excellent, balance precise, surfaces excellent. The banjo and clarinet work on Apex Blues makes the blood course hot and fast. The treatment of "Sweet Lorraine" is for my money one of the greatest on records, with clarinet and sax working together and against each other in one of the most spontaneous and thrilling moments of greatness in jazz. Hines' work on piano is always great, but his job on "Monday Date" and the "Blues My Naughty Sweetie Gives to Me" is ultimate. Brunswick has also (wisely) made the set available on 78 (Album B-1006) for those who object to LP groupings. In either case, this is a worthy addition to any collection.

**The South** Jazz Volume 1

**Folkways Records**

Moe Asch, one of the finest people to adorn the record business, has unpretentiously gotten underway his jazz symposium. Two volumes (two LP's) are now available, but I am purposely separating them so that there will be no misunderstanding with reference to critical comments. Volume 1 is one of the most important things to appear in this field. Concerned particularly in clearly developing (and honestly, incidentally) the particular patterns of jazz origins, Volume 1 approaches the problem of the division between rural and urban origins wisely, with samples of each. Some of the bands have been recently recorded on the spot, others are careful selections from the category of "race" records. The notes are precise and to the point, the over-all recording is adequate, despite a few rough spots. The Omer Simeon Trio recording of "Blues for Lorenzo," featuring the great Creole clarinet of Omer Simeon with Pops Foster on bass and James P. Johnson on piano is a great highlight. The disc can be listened to either for education or for its music . . . that's up to you. It should be heard by anyone pretending an interest in jazz from a point of view other than the D. T. rhythms that accompany chronic alcoholism.

**The Blues** Jazz Volume 2

**Folkways Records**

Volume 2 in the Jazz series is not quite as pleasing as Volume 1. The dubs are poor and the surface of the LP disc itself is bad. Nor am I as happy with the general selection of material or with the accompanying program notes. Where Volume 1 retained an inner simplicity and lack of pretension, Volume 2 takes on the appearance of a patchwork quilt, with the negative aspect of confusing the issue in many cases. The selection of representative recordings of individual performers, such as Jelly Roll Morton, and Bessie Smith, is not of the best and Louis Armstrong is done a definite disfavor. There is nothing better available, however, so for the time being this will have to do.

**Muggsy Spaniers Ragtimers**

**Commodore FL 20,009**

This is an LP dub of some of the less distinguished Commodore singles. Featured are Muggsy, of course; Pee Wee Russell, clarinet; Ernie Caceres, baritone sax; Gene Schroeder, Dick Cary, piano; Sid Weiss, Bob Haggart, Bob Casey, bass; Eddie Condon, guitar; Joe Grauso, George Wettling, drums; Miff Mole, Lou McGarity, trombone. Recording is typically dead, and performance is characteristic, unfortunately, of this gloomy age. This is one of the most tired and apathetic readings of so-called Chicago Jazz on records. There is no drive, no interesting solo material, and a general lack of interest. The names above are, of course, all familiar. They are the greats revealing what happens in studio recording. All that's missing is the inevitable snore. Both the Jimmie Noone disc (reviewed above) and this one apply to so-called Chicago style. The difference is obvious within the first quarter of an inch . . . and so to sleep.

## NEW LITERATURE

● **Simpson Electric Company,** 5200 Kinzie St., Chicago 44, Ill. is distributing without charge an illustrated folder describing six of the Simpson instruments for FM and TV servicing. Included in the folder are sizes and weights, specifications, and prices.

● **Hoffman Radio Corp.,** 3761 South Hill St., Los Angeles 7, Calif. is publishing a 40-page booklet describing its facilities for the manufacture of military equipment. Issued primarily for government officials in the field of electronics, the booklet gives biographies of key executives, an overall picture of the six Hoffman plants, and a history of the company's wartime production.

● **Triad Transformer Manufacturing Co.,** 2254 Sepulveda Blvd., Los Angeles 64, Calif. is now releasing Catalog GP-51, an 8-page illustrated listing of the line of geophysical transformers known as "Geoformers". Introduced for the first time is a new group of miniaturized transformers said to perform all the functions of the items they replace although weigh but one-sixth and occupy but one-seventh the space of their larger counterparts.

● **British Information Services,** 30 Rockefeller Plaza, New York 20, N. Y. is offering for 40 cents a 55-page report on the subject, "Telecommunications and Equipment in Germany During the Period 1939–1945". This is an exceptionally fine technical review, and should be in the library of all engineers whose interest lies in the field of telecommunications.

● **Hudson Radio & Television Corp.,** 212 Fulton Street, New York 7, N. Y. is offering a free catalog of High-Fidelity sound equipment—containing complete descriptions of all the standard brand components required to assemble High Fidelity sound systems. All merchandise is available by mail or phone, or in person at the New York store.

● **RCA Victor Division** of Radio Corporation, Camden, N. J. is now distributing to tube and parts distributors the 1951 edition of the RCA Reference Book, a pocket directory of technical information on RCA tubes, electronic components, test equipment, batteries, and miniature lamps. Distribution of the book to dealers will be through tube and parts jobbers exclusively.

● **Precision Electronics, Inc.,** 641 Milwaukee Ave., Chicago 22, Ill. has available Catalog 6449, a complete listing of Precision beam-power amplifiers. All units are illustrated and thoroughly described. Power ratings of the various amplifiers range from eight to sixty watts.

● **Technology Instrument Corp.,** 1058 Main St., Waltham, Mass. has recently published its Laboratory Report No. 2, titled "Determination of the Q of Coils by Means of a Z-angle Meter and the Series Resistance Method." Included also is descriptive material covering certain items manufactured by the company. Copy will be mailed on request.

## SENIOR MUSICIAN'S AMPLIFIER

[*from page 14*]

It will be noted that inverse feedback is used, in two loops. The loop from the output transformer secondary to grids is used to wipe out just a trace of overshoot which appears on 10,000-cps square waves. The second loop, to the low ends of the input transformer secondaries, is used to lower the source impedance slightly and, as a by-product, to improve the IM distortion at lower power levels. Only 4 db feedback is used—including the effects of both loops—and there is absolutely no trace of oscillation in the combination of amplifiers. The source impedance on the 16-ohm output winding is 10 ohms, which is sufficient to give adequate damping to a good speaker.

The bias circuit for the 845's provides for balancing plate currents between the two tubes in addition to permitting a wide range of adjustment of bias voltage. The potentiometer $R_9$ adjusts the balance between the two tubes, while $R_{10}$ sets the average bias, serving as the self-bias resistor. Bias is set normally, under the operating conditions selected, at 85 volts for a plate supply of 1000 volts. This gives an effective plate voltage of 915, and results in minimum intermodulation distortion.

#### Analysis of Operating Conditions

The tubes are operated at a condition which is slightly in excess of normal rating in order to keep distortion as low as possible at the desired power output. Thus, with a 1000-volt supply and an effective plate voltage of 915, the plate current is 125 ma per tube, or a quiescent plate dissipation of 114 watts per tube. This is 14 per cent higher than the rated plate dissipation of the 845, but in view of the improved operation the excess was felt to be justified. Tests were made of the amplifier with 99 watts plate dissipation (900 volts plate, 100 volts bias, resulting in a current of 110 ma per tube) but the intermodulation distortion was approximately doubled. For example, at an output power of 38 watts, the IM distortion for 99-watt dissipation is 8.2 per cent, while for the 114-watt condition the IM distortion is 4.4 per cent. Increased tube failures, if any, will be a small price to pay for the lower distortion on records. Those who want to operate their tubes within the ratings may do so with the assurance that their amplifier will have no more distortion then most commercial amplifiers, and in all probability the distortion will be less. The 8.2 per cent IM at 38 watts in the 99-watt condition is the distortion rating of commercial high-quality amplifier manufacturers, Roys[1] states that IM distortion in excess of 10 per cent is evident to trained observers. when using test frequencies of 400 and 4000 cps. The 10-per cent IM point, using 40 and 2000 cps (a much more severe test) occurs in the 99-watt condition at about 45 watts output and in the 114-watt condition at 50 watts. Our own opinion is that the IM distortion in a recording amplifier should not be more than 2 per cent at operating levels in order that the distortion in the recordings be as low as possible. The 2-per cent IM occurs in the 114-watt operating condition at 25 watts output. Thus the limiting factor on quality in the recordings made with this amplifier is the cutting head.

#### Power Supply

The power supply for the Musician's Amplifier Senior resembles that of an amateur transmitter in that it is required to produce high voltage. USE EXTREME CARE WHEN WORKING ON THIS POWER SUPPLY. THE HIGH VOLTAGE PRESENT IS LETHAL. YOUR FIRST SHOCK MAY BE YOUR LAST, AND DEATH IS SO PERMANENT. These cautions may be redundant, but the builder must be made fully aware of the danger involved before attempting work with high-voltage units.

The 845 filaments are fed from two filament transformers so that the plate currents may be balanced. The rectifiers are type 866A mercury vapor tubes, and their filaments are supplied from a third transformer. The plate transformer furnishes a.c. voltages of 880 or 1175 each side of center tap. With choke input, the d.c. output voltage is 1000 at the current drain required. The plate leads are connected to the high-voltage tap, as shown on the schematic, *Fig. 4*. Separate power switches are used in filament and plate transformer primaries, and pilot lamps are arranged to indicate when the separate circuits are energized. In equipment of this type it is customary to delay the application of the plate voltage for 30 to 60 seconds after turning the filaments on in order for the amplifier and rectifier filaments to be thoroughly heated.

The filter is of the brute-force type, using 1500-volt oil-filled capacitors and two chokes. The latter are placed in the negative lead where the filtering is just as effective and there is less danger of breakdown to ground. The measured noise and hum level with both amplifiers connected normally and with an open

[1] "Recording and fine-groove technique," H. E. Roys; AUDIO ENGINEERING, Sept. 1950.

grid in the driver amplifier is −29 dbm, or 75 db below 40 watts output. No trouble was experienced with mercury vapor "hash" in the output, and no r.f. chokes were required in the rectifier circuit.

### Construction

Generally when one begins to build amplifiers of the power of this one, chassis-type construction is abandoned for the more efficient relay rack. For this unit, two sections are utilized, the amplifier proper being 8¾ in. high and the power supply 14 in. The total rack space occupied by the complete system—including the driver amplifier, the power amplifier, and the power supplies—is but 29¾ in. All equipment for a complete disc recording system may be placed on a single six-foot rack, with microphone inputs, preamplifiers, equalizers, mixers, and FM tuner, and a VU meter panel.

As will be seen from *Fig.* 1, the amplifier proper is quite simple in layout. Viewed from the rear, the output transformer is on the left, the input transformer on the right. The upper left terminal strip is the output connection, while the input terminal strip is at the upper right. The 845's are mounted in an inverted $3 \times 5 \times 7$ chassis, with a 6-prong male plug being used for the filament connections (3 leads for each tube because of the center tap). The plug at the right is for the high-voltage plate supply. The plate current balancing potentiometer $R_9$ and the bias resistor $R_{10}$ are mounted within the inverted chassis, although not visible in the photograph. Access to the balance control is through a hole in the front panel. It should be pointed out that accurate plate-current balance does not affect bass response as much as it does the hum and IM distortion. The feedback resistors are mounted on a strip attached to the input transformer.

Layout of the power supply is equally simple. A chassis $3 \times 7 \times 15$ is fastened to a 14-in. rack panel, as shown in *Fig.* 3. The plate transformer, two 845 filament transformers, and the filter capacitors are mounted on what is normally the top of the chassis, while the filter chokes and the filament transformer for the 866A's are mounted inside. The mounting of the rectifier tubes is so arranged as to leave space for the driver amplifier power supply. The two jacks shown are for measuring plate currents in the amplifier tubes.

The small junction box at the lower left of *Fig.* 3 mounts the cutter and speaker outputs, and a panel-mounted switch transfers the 40-watt output from the cutting head to a speaker, or terminates the output on the resistors shown along the base panel. All high-voltage terminals on both the plate and output transformers are covered by a Bakelite strip, and safety caps are used on the rectifier tubes. These safety precautions are essential.

**Performance**

The performance of the complete system indicates that the "big brother" is a worthy companion to the Musician's Amplifier. All tests were made using both amplifiers, and the frequency response is flat within 0.5 db from 20 to 35,000 cps. The amplifiers together will pass square waves with no ring, distortion, or roughness on the top up to a 10,000-cps fundamental. This means that the frequency response is reasonably flat and the phase shift is linear up to at least 200,000 cps. Furthermore, there is no transient oscillation. The absolute gain of both amplifiers is 84 db.

The IM distortion, using 40 and 2000 cps, is shown in *Fig.* 5. These values are based on power as read on the IM-Set

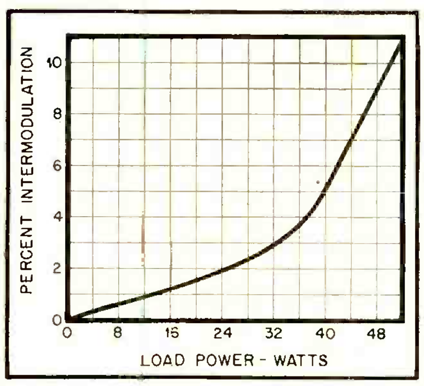



**Fig. 5. Intermodulation distortion curve for 50-watt amplifier, using frequencies of 40 and 2000 cps with a level difference of 12 db.**

meter, and not upon equivalent sine-wave power. It will be evident that at normal listening levels—say up to 2 watts—that the IM distortion is too low to measure. It is no more than 2 per cent up to 25 watts output, while at 40 watts the IM distortion is about 5 per cent. The 8-per cent point appears at about 47 watts, and distortion does not climb rapidly until about 60 watts.

While the Senior amplifier was intended for making disc recordings, the authors were pleased by its performance as a playback amplifier when playing recordings which had just been cut. Visitors to the Audio Fair confirmed those opinions, and many made mention of the "cleanness" of sound. This is the result of two factors: the tremendous reserve of power, and the low intermodulation distortion even at high power levels. *Crescendo* and *fortissimo* passages are handled with effortless ease. The user should be cautioned, however, not to turn up the gain unless the load is adequate to absorb the power. Ordinary speakers will not handle the full output of this amplifier.

**Amplifiers**

| | |
|---|---|
| $R_1, R_2$ | 15,000 ohms, 5 watts |
| $R_3, R_4, R_7$, $R_8$ | 10,000 ohms, 1 watt |
| $R_5, R_6$ | 30 ohms, 1 watt |
| $R_9$ | 200-ohm potentiometer, 4-watt Mallory M200P |
| $R_{10}$ | 500-ohm adjustable, 50 watts |
| $T_1$ | Input transformer, line to p-p grids, high level; Peerless K-281Q |
| $T_2$ | 80-watt output transformer, 4000-ohm pri., speaker impedances 2, 4, 8, or 16 ohms; Peerless S-275S |
| $V_1, V_2$ | 845's |

**Power Supply**

| | |
|---|---|
| $C_1, C_2, C_3$, $C_4$ | 5-μf, 1500-volt, oil filled |
| $E_1, E_2$ | 110-v pilot lights, with sockets and jewels |
| $L_1, L_2$ | 3-H, 225-ma chokes, Peerless C-315X or equivalent |
| $T_3$ | Plate transformer, 1180 v. each side of c.t., 300 ma; Peerless P-330K |
| $T_4$ | 2.5-v. 10-a. filament transformer; Peerless F-096X or equivalent |
| $T_5, T_6$ | 10-v. 5-a. filament transformer; Peerless F-140E or equivalent |
| $V_1, V_2$ | 866A's |

## ATTENUATOR TERMINAL IMPEDANCE

[from page 20]

to the 25 db maximum marking of the decibel scale. If a calculation is required for an attenuator of greater loss, the attenuator may be considered to be composed of several sections connected in tandem, each of loss less than 25 db. The impedance ration between each attenuator junction may then be computed by starting at the load and working back toward the input side.

### Appendix

The input impedance of any four terminal passive network, of which the attenuator is one example, is given by the following expression.[1]

$$Z_I = Z_{KI} \frac{Z_{K2} \sinh \theta + Z_L \cosh \theta}{Z_{K2} \cosh \theta + Z_L \sinh \theta} \quad (1)$$

Where $Z_I$ = the input impedance
$Z_L$ = the load impedance
$Z_{KI}$ = the input image impedance

[1] "Electric Circuits And Wave Filters," A. T. Starr, Equation 238.

$Z_{K2}$ = the output image impedance
$\theta$ = the attenuation constant plus j times the phase constant

For an attenuator operating within its rated frequency range the phase constant is zero, and $\theta$ is then the loss of the attenuator in nepers. This loss is equal to the decibel loss divided by 8.68.

Equation (*1*) may be transformed into the following form;

$$\frac{Z_1}{Z_{K1}} = \frac{Z_{K2}\,(e^{2\theta}-1)+Z_L\,(e^{2\theta}+1)}{Z_{K2}\,(e^{2\theta}+1)+Z_L\,(e^{2\theta}-1)} \qquad (2)$$

Solving for $e^{2\theta}$ gives;

$$e^{2\theta} = \frac{Z_L/Z_{K2}-1}{Z_L/Z_{K2}+1} \times \frac{Z_1/Z_{K1}+1}{Z_1/Z_{K1}-1} \qquad (3a)$$

$$e^{2\theta} = \frac{Z_{K2}/Z_L-1}{Z_{K2}/Z_L+1} \times \frac{Z_{K1}/Z_1+1}{Z_{K1}/Z_1-1} \qquad (3b)$$

Equation (*2*) may be solved in either form (*3a*) or (*3b*) and since these are identical except for a simple inversion of the impedance ratios, a single nomograph will provide a solution of both expressions. A significant result given by equation (*3*) is that the amount of impedance isolation depends only on the decibel loss of the attenuator and not upon any particular configuration of its resistance elements.

The nomograph is shown in *Fig.* 1. Since we are restricting the termination impedance to be essentially resistive, the other terminal impedance will also be resistive, and $R_L$ and $R_1$ may be written in place of $Z_L$ and $Z_1$.

## ERRATA

In the Audio Patents column, page 2 of the December issue, the letters *A* and *B* were omitted from the schematic of *Fig.* 1. *A* is the point at the lower end of the 1000-ohm cathode resistor of $V_1$, and *B* is at the cathode of $V_3$. To make the circuit adjustment, the lead connecting these two points is opened and $R_3$ in the cathode circuit of $V_2$ is adjusted to make points *A* and *B* at equal d.c. potentials.

The first paragraph of Mr. Johnson's article on page 18 should read "It is well known in audio circles that the human ear is very *in*sensitive to both low and high frequencies at reduced volume levels." The capacitor under $R_6$ on *Fig.* 5, page 41, should be .03 µf. The circled numbers on the pictorial schematic, *Fig.* 3, on page 18 refer to the following parts:

(1) IRC Type Q control, Q11–133
(2) IRC Multisection, M13–137
(3) IRC Multisection, M13–128
(4) 0.1 meg, ½-watt resistor
(5) 10,000 ohm, ½ watt resistor
(6) 82 µµf capacitor, Ceramicon
(7) .03 µf capacitor

# NEW PRODUCTS

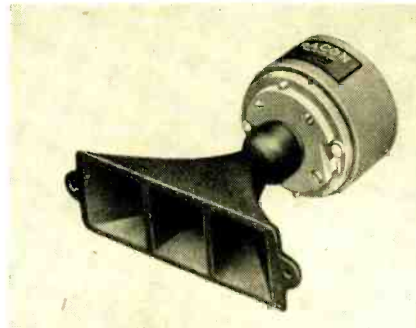
● **Remote Broadcast Amplifier.** Incorporating most of the qualities of studio equipment, the new Gates "Networker" portable broadcast amplifier has both standard a.c. and inbuilt-battery power supplies. In case of a.c. power failure, the battery system automatically takes

over. Also included in the unit is an audio oscillator to facilitate presetting of program levels. Separate p.a. connection is provided with panel volume control. As many as four microphones may be accommodated. Full specifications may be obtained from Gates Radio Company, Quincy, Ill.

● **Portable Receiver.** Model B-100 AM radio receiver offers a standard of circuit design and construction which is normally expected only of equipment considerably higher in price. It is the first complete radio to be included in the extensive line of Newcomb audio equipment. Among its features are a jack for

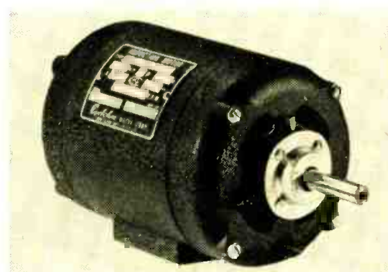
connection to external amplifiers or for use with headphones, 3-gang capacitor for tuning, 6-in. Alnico V speaker, and amplifier utilizing inverse feedback circuit with beam-power output. Tuning assembly avoids use of dial cords, with resultant ruggedness and freedom from trouble. Plywood cabinet is covered with washable two-tone leatherette. Model B-100 is now in production and may be ordered through representatives of the manufacturer, Newcomb Audio Products Co., 6824 Lexington Ave., Hollywood, Calif.

● **High-Frequency Speaker.** The need for a moderately-priced tweeter capable of handling high power is well met with Racon's new Model CHU-5. Providing clean and uniform response to 12,000 cps, with usable output well beyond 15,000 cps, the CHU-5 handles 25 watts of program material when used with a 12 or 15-in. cone speaker and proper dividing network. Packed with each unit is a 4-page pamphlet with wiring diagram to enable the purchaser to build his own



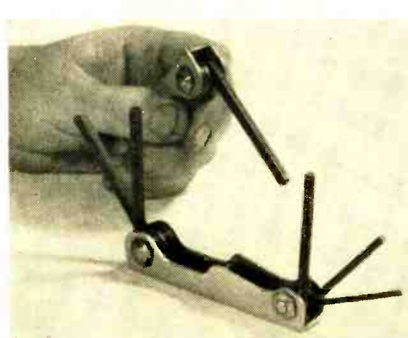
crossover network. Dimensions of the CHU-5 are 6½ × 3 × 6 in. Horn is made of cast aluminum and is flared for wide distribution pattern. Crossover frequency is 1500 cps. Full details of the entire Racon line may be obtained by writing Racon Electric Co., Inc., 52 E. 19th St., New York 3, N. Y.

● **Two-Speed Hysteresis Motor.** Designed primarily for use in tape recorder mechanisms, the new Model 2900 hystere-



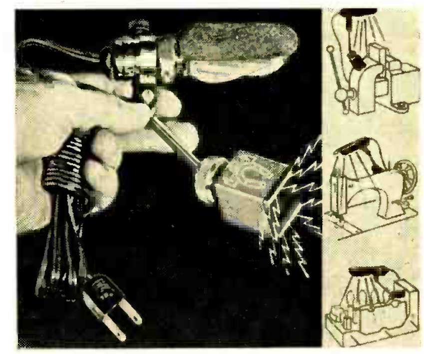
sis motor being manufactured by Howard Industries, Inc., Racine, Wis. is also available as a capacitor-type unit suited for a wide variety of industrial applications. Power ratings are 1/100 to 1/15 hp. Literature may be obtained by writing direct to the manufacturer.

● **Five-in-One Socket Head Tool.** Servicing of equipment which contains socket screws and bolts is greatly expedited by the "Smitty," a single tool which provides five of the most popular, standard-size socket-head wrenches. Individual



wrenches are made of tempered steel and can be ground down to compensate for wear. Also each wrench can be replaced as a unit, thus eliminating the need for buying a complete new tool. Manufactured by H. D. Hunter Co., Los Angeles, Calif.

● **Portable Lamp Unit.** The Miti-Mite consists of a permanent-magnet base to which is attached a small lamp by means of a ball-and-socket bracket assembly. In use the unit may be placed in any desired position on a ferrous surface, thus permitting adequate light to be directed



precisely where required while working on electronic equipment, in machine shops, or on home workshop devices. Manufacturer is Enco Manufacturing Co., 4522 W. Fullerton Ave., Chicago 39, Ill.

● **"Starmaker" Microphone.** Designed especially for television programming and said to be the "least visible" microphone ever developed, this new model is so slim you must look sharply to see it and so skillfully styled in shape and coloring that it is virtually lost in the average stage setting. The name "Starmaker"

signifies that instead of "stealing the show" the microphone permits the camera to concentrate on the performers.

The BK-4A microphone—the Starmaker—is suited for sound reinforcement and radio broadcast pickup, and has an output comparable to larger conventional studio microphones—110 microvolts per dyne per square centimeter—and an output impedance in accordance with RMA standards of 30, 150, and 250 ohms. It is non-directional and provides uniform frequency response between 50 and 15,000 cps. The effective output level at 1000 cps is -50 dbm, and special transformer design results in a low hum pickup level of -125 dbm. The unit has an over-all length of 12 in. and the greatest diameter is 1¼ in.

## MISMATCHING

[from page 15]

operating under normal living room conditions it is seldom that more than 2 watts have to be utilized with perhaps 6 watts allowed for unusual high level peaks. Thus it can be seen that only 50 per cent of the amplifier power will be utilized. Where this situation prevails, mismatches up to 200 per cent can be tolerated. Where ¾ of the amplifier output must be preserved for high-level operation, then it is permissable on many amplifiers to have 100 per cent variation in matching without affecting in any way the frequency range of the reproducing system.

However, this is on the assumption that the mismatch is upward, that is, the load impedance must be greater than the amplifier impedance. Mismatching upward preserves the optimum performance from the point of view of frequency range. Mismatching downward to a lower load impedance is not recommended since it may cause loss of low frequencies in addition to power. Low-frequency losses are due to loss of magnetization inductance when the output transformer is abnormally shunted down.

The type of output-stage regulation sought above is that wherein the output *power* tends to stay up in spite of load changes, as in *Fig.* 1, Curves A and B. This is of value in maintaining maximum high-frequency output because of the increased impedance of the voice coil at high frequencies. Constant power output permits maximum mismatching of load impedance, as shown in *Fig.* 2, Curves A and B. Such amplifiers have output which may be characterized as "poor regulation," or "high internal impedance." With such amplifiers it is wasted effort to attempt to achieve a precision match.

#### Constant Voltage Amplifiers

There are, however, some disadvantages in such "constant power" regulation which are manifest at the low-frequency resonant point of the loudspeaker. At resonance, the speaker impedance rises by two or three times its rated impedance. If the power remains constant at resonance as it does at other frequencies, the speaker will overshoot and produce exaggerated resonant boom.

Another type of regulation is that wherein the output *voltage* and not power, remains constant over a wide range of load impedance. Thus the power will drop as the impedance rises. The power into the load will fall proportionately with the ratio of mis-match. See Curve F, *Fig.* 1 or Curve C, *Fig.* 2.

It has been claimed that a speaker system which has overpronounced bass resonance and a poor transient characteristic may be improved by employing it with an amplifier where the *voltage* output is constant and independent of the load impedance. At the low-frequency resonance, the voice coil impedance rises greatly. If, however, the voltage from the amplifier remains constant for a given signal, then less power is delivered to the speaker at the resonant frequency, tending to restrict the extreme amplitude which causes boom. If the output voltage is sensitive to load changes as in a poorly regulated output stage, then the voltage will rise as the speaker impedance rises, thus contributing unnecessary watts to a condition which is already over-sensitized. Constant output voltage is achieved by incorporating large degrees of inverse feedback, and the use of efficient output transformers. The output impedance of the amplifier *acts* as if it were considerably lower than its *rated* impedance. This is known as a low internal impedance. The ratio between the rated impedance and the internal impedance establishes the damping factor of the amplifier. Many amplifiers today have a damping factor of 10 or more.

Resonance in a speaker is the point of maximum acoustic sensitivity and may frequently cause a peaked and distorted output.

If the regulation were such that the voltage rises with an increase in load impedance, then the cone might be overdriven at its resonant frequency, introducing undesirable distortion and hangover. Furthermore, amplifiers which have good voltage regulation are characterized by a low internal impedance. This acts as a sort of electrical brake, absorbing the counter e. m. f. which a cone generates when the signal terminates abruptly as in a transient impulse. Therefore, it may be said that well-regulated amplifiers with a good damping factor (a low internal impedance) will provide (*a*) reduction of the resonant effect and (*b*) improved transient response. This effect is greatest when the loudspeaker has a high conversion efficiency. With insensitive speakers, there is no improvement on the transient response. To realize the above advantages, a loudspeaker must further possess a flat or smooth response without sharp dips or peaks, and its cutoff at either end of the spectrum should be gradual rather than abrupt. This reduces phase-shift distortion, an illusive and debatable form of distortion not readily measurable, but which definitely contributes to poor transient response.[2]

On the other hand, the disadvantage of constant-voltage output lies in the fact that the full high-frequency capabilities of the loudspeaker may not show up. The voice coil impedance rises with frequency. At 10,000 cps it may be two to four times its value at 1000 cps. Thus, the power delivered from the regulated amplifier reduces with frequency and the speaker is under-driven. An increase up to 6 db at high frequencies may result by substituting an unregulated amplifier for a well-regulated one. Or, for a regulated amplifier, an increase in highs is possible by assuming a high load impedance and selecting a corresponding output tap.

While the constant-voltage type of amplifier appears to be the most sought after, it must be borne in mind that for applications where changes in load may occur frequently, the unregulated type of amplifier will prove more satisfactory. A study of the chart of *Fig.* 2 will reveal that a fairly large range of load impedances can be connected to this amplifier without reducing the power output too seriously. The amplifier used

[2] "Phase Shift in Loudspeakers," Ewaskio and Mawardi, *J. Acous. Soc. Am.*, July, 1950.

to develop this chart was a straightforward public address unit built some years ago and without inverse feedbacks. The output stage uses a pair of 6L6s and is rated at 20 watts. At low output levels, extremely large mismatch is permissible. Curve A, *Fig.* 2.

The so-called "rated" output impedance of an amplifier is not necessarily the "internal" output impedance. These may be wide apart, depending upon the damping factor of the output stage. This relationship between internal impedance and rated load impedance indicates the voltage regulation characteristic or damping factor of the amplifier. This is expressed as the number of db the output voltage will increase when the proper load impedance is removed and the output is left on open-circuit. Where precise and accurate information must be had as to permissable mismatch, the data on load characteristics of the amplifier must be obtained from the manufacturer.

The rated "load impedance" is that impedance into which the amplifier will deliver its maximum power for a given distortion. The "internal impedance" is the effective impedance of the output winding. Its value is considerably lower than the rated load impedance, and is established by the design and degenerative feedback system of the amplifier as well as the coupling efficiency of the output transformer. In true constant-voltage amplifiers, the power into the load will be proportional to the load impedance. Therefore, the power loss will be proportional to the mismatch ratio, and for full utilization of the amplifier capacity, a perfect match is required.

In large sound distribution systems using many speakers, loudspeakers are equipped with line-matching transformers which contain many taps. The purpose of these taps is to provide an intentional mismatch with particular speakers for the purpose of regulating volume. This is a common practice since volume reduction is obtained not by burning up output power into a pad, but by the simple method of not draining it from the amplifier. These mismatches are always effected upwards, that is, the transformer impedance is always greater than the impedance of the amplifier feed line. Thus, mismatches are used for a reduction of sound without distortion and there is negligible loss of quality or frequency range. This method of volume regulation requires the use of amplifiers of the constant voltage output type.

**Effect of Mismatching on Crossover Networks**

When a mismatch occurs on a crossover network, a shift in the crossover frequency is most likely to occur in addition to a loss of transfer power. If the mismatch is upward—that is, if the speaker impedance is larger than the impedance indicated on the network—the crossover frequency will be lower. Conversely, if the speaker impedance is lower than that for which the network is designed, then the crossover frequency is shifted to a higher value. In the case of networks, a reasonable mismatch is quite permissable since in effect a mismatch is constantly occuring in spite of the fact that a perfect match is assumed. This is because the voice coils have a rising characteristic with frequency. Actually, a so-called 600-cps crossover is never exactly a 600-cps crossover at all instants. It is varying up and down depending upon the voice coil impedance at any particular instant, which in turn depends upon the frequency content of the program at any given moment.

## RECORD REVUE

[*from page 24*]

with Mr. Voigt, on the liveness in the recording itself. I can assure you there is a far greater naturalness than the point-source speaker can ever give. Secondary (expected) results are a larger tolerance towards poor reproduction of various sorts, hence a greater usefulness to poor recordings of good music. (As one approaches the binaural situation, the ear's tolerance towards extremes both of distortion and of liveness increases. Natural binaural hearing has an enormous tolerance for these things. See this department, January 1950.) One amusing exception to improved naturalness occurred when I recorded a lady folk singer, close-to, and then played her back. The lady did *not* react well to being spread out over 10 feet of wall, and so we reversed the speaker to give a natural point source!

The ideal with this particular reflected set-up is a group of, say, five to ten instruments in a good, live small hall. With such a recording, the Canby version of the Voigt effect is quite exciting. The "hole" in my corner sounds not so much as a window as a pair of French doors, opening directly into the imagined concert hall. The sense of presence is astonishing, especially when there are small incidental noises, as of breathing, rustling music, creaking chairs. This is "hole-in-the-wall" at its best.

## NEW RECORDS

**Schumann, "Carnaval".**
Claudio Arrau, piano. **Decca LP DL 7502**

**Mozart, Clarinet Concerto, K. 622.**
Reginald Kell; Zimbler Sinfonietta. **Decca LP DL 7500 (10")**

**Hindemith, "The Four Temperaments".**
Lukas Foss, piano; Zimbler String Sinfonietta. **Decca LP DL 7501 (10")**

**Stravinsky, Duo Concertant; Copland, Violin Sonata.**
Joseph Fuchs, violin; Leo Smit, piano. **Decca LP DL 8503 (12")**

**Menotti. "The Consul"; complete recording.**
Original Cast. Marie Powers, Patricia Neway, etc. **Decca LP DX 101 (3 12")**

**Mozart, Six Violin Sonatas.**
Szymon Goldberg, Lili Kraus, piano. **Decca LP DX 103 (3 12")**

Here is a vivid cross-section of the new Decca (American Decca) Gold Label series, with which this company once more enters the ultra-classical field after parting company with London Decca, now known independently as "London." The titles are self-revealing—this is to be a real classical line rather than a semi-pops or mass-audience one. Decca's traditional interest in the stage will be taken care of. Domestic recordings, European, and re-issues of European catalogs—Parlophone-Odeon.

Technically? Not too happy a picture for us as wants uniformity and top quality wherever and whenever possible. There are all sorts of variations here. Decca would seem to follow RCA in most of these, with an apparent curve utterly unlike the Columbia one (and hence bound to cause disturbance among both average-machine owners and hi-fi users). But there doesn't seem to be much consistency here either.

To be specific, three of these are roughly similar; the Stravinsky–Copland disc, "Carnaval" and "The Consul" have weakish bass not unlike the RCA LP's, very little pre-emphasis of highs nor much that could be called clean and sharp at the top ("The Consul" is best in this respect). The violin sonata has a peaky low-high area to my ear, and not much above. I doubt if hi-fi enthusiasts will be using these as demonstration discs.

The Mozart Clarinet Concerto has a lovely sound acoustically and will delight musicians even though it has no highs at all that I can hear—in fact less brilliance than the old pre-war Victor recording of the same with Kell. Strangely, then, the Hindemith "Four Temperaments," same orchestra, is the one disc of all these that easily rates first-quality as to recording. Beautiful liveness, excellent highs and lows, good edge. (If you like Hindemith's "Mathis der Maler" try this.)

The Mozart Sonatas are re-issues of a celebrated pre-war series, the oldest dating before 1936. A wholly justifiable venture though Decca doesn't mention the recordings' age. They vary a bit; good piano, the violin somewhat distorted (as played wide-range), no highs above 5000 or so. It's hardly an engineers' recording—but remember: this has been a collectors' set for years, obtainable only as 14 separate shellacs at a fabulous price; now for much lower cost the breaks are gone, the whole is on three discs minus surface noise. Nothing lost and a lot gained. These remain today the "definite" performances, for most critics, of the Mozart sonata literature on discs.

**Verdi, Rigoletto (excerpts).** Berger, Merriman, Peerce, Warren, Tajo, etc. RCA Victor Orchestra, Chorale, Cellini.
**RCA Victor LP: LM 1104**

**Rossini, Cenerentola (Cinderella).** Abridged. Soloists, Orchestra, Chorus of Radio Italinana, Rossi. **Cetra Soria LP: 1208 (2)**

**Saint-Saëns, Samson and Delilah.** Soloists, Orchestra, Chorus of National Opera (France), Fourestier. **Columbia LP: SL 107 (3)**

**Offenbach Tales of Hoffman.** Soloists, Orchestra, Chorus of the Opera-Comique (France), Cluytens. **Columbia LP: SL 106 (3)**

**Beethoven, Fidelio.** Baümer, Sauerbaum, Hübner; Symphony Orchestra, Chorus of Mitteldeutche Rundfunk, Leipsic, Pflüger. **Oceanic LP: OCLP 301 (3)**

**R. Strauss, Elektra.** Soloists, Orchestra, Chorus of Maggio Musicale Fiorentino, Mitropoulos. **Cetra-Soria LP: 1209 (2)**

**Gilbert and Sullivan, The Gondoliers.** D'Oyly Carte Opera Company, New Promenade Orchestra, Godfrey.
**London LP: LLP 198/9 (2)**

**Menotti, The Consul.** Original Broadway Cast. Neway, Powers, etc.
**Decca LP: DX 101 (3)**

The above impressive listing of recorded opera on LP could extend right down several more columns and still be incomplete—and all this in a year or so! The column, not being particularly opera-minded, can't spend the thousands of words that alone could do justice to the tremendous efforts and the pleasures here indicated. Opera was hopelessly at a loss on 78 discs, even though valiant enterprises continued to result in the ten-ton albums that used to bring us big slices of the complete thing. LP revolutionizes the whole opera world and these are merely a few international indications of the extent to which opera LP has already progressed.

Details are impossible here. The Rigoletto excerpt disc is taken from RCA's complete LP recording, done outside of any opera company with a pick-up ensemble. Yet it is one of the very best operatic recordings to date, lively, well sung and well cast. Recording is excellent—big opera liveness, fine perspective with most voices at stage distance. Comparable to the earlier Carmen recording and others.

"Cinderella" must here represent dozens, literally, of new Italian recordings of out-of-the-way operas that otherwise we would never hear. Most are done with excellent recording, too—this one is tops in every way, quiet-surfaced, wide range, with good liveness and balance, though a trace thinnish. Lovely operatic froth. Samson and Delilah is heavyweight French, with all-French cast (as is proper). Not too good, I'd say, and the recording is metallic, as though copied from discs. The Offenbach, with similar forces, is superbly done, the essence of the best French music; recording is wonderful (trace of metallic quality at times) in its presence and naturalness. Highly recommended.

In the German line add to last month's Wagnerian Flying Dutchman, the Beethoven Fidelio—a first recording of a great work, complete with the intriguing spoken dialogue, ultra-hi-fi. A sincere, somewhat stodgy performance with rather wobbly singers, well acted and integrated throughout. The Strauss Elektra, done in Italy by Graeco-American Mitropoulos, is a whirlwind of musical shrieks and wails and murders and what-not, done with utmost intensity. Performance-recorded, but with minimum of irrelevant noise; orchestra is excellent but singers, wandering about the stage, vary in volume from loud to almost inaudible! Doesn't really seem to matter. Again, a good hi-fi recording, no doubt via tape.

Britain and America are represented here too. The G. & S. recordings are well known already among the fans. The new company generally can't quite match the old D'Oyly Carte of the earlier records, made 20-odd years back and still being played every day, but the greatly improved recording makes up for it, and there's nothing here bad enough to spoil the fun; the words—all-essential—are ultra-clear, the orchestra is lively. Menotti's The Consul, a stark, dramatic Broadway hit, comes through powerfully on records as did his The Medium. The Decca job isn't as clear in the vocal recording as was Columbia's The Medium; the voices tend to be rather close, the orchestra too distant for the important dramatic role it has. But these are bearable troubles.

Add to these a huge batch of Cetra Italian operas, familiar and unknown, more G. & S., Mozart's Impresario, Idomineo (two recordings!) and Seraglio, all of which I haven't got to yet (phew!), and you have an idea of opera LP fare. Terrific.

Opera boner of the year—according to 2nd hand reports. A major record company, announcing a coming recording of J. Strauss' Die Fledermaus (The Bat, renamed Rosalinda in New York performances) subtitled the work in its publicity barrage, "The Field Mouse"! Easy to guess how the dreadful thing happened. Somebody made like Canby-with-the-typewriter (unsci for music, Fielder for Fiedler, fulte for flute . . .) and typed out FELDERMAUS. Some bright little genius-assistant then made for the dictionary but fast, where FELD is listed as meaning PLAIN or FIELD. Hence—field mouse. Are their afces erd!

## AES Employment Register

POSITIONS OPEN and AVAILABLE PERSONNEL may be listed here at no charge to industry or to members of the Society. For insertion in this column, brief announcements should be in the hands of the Secretary, Audio Engineering Society, Box F, Oceanside, N. Y., before the fifth of the month preceding the date of issue.

★ **WANTED: ELECTRONIC ENGINEER,** degree, minimum three years audio circuit design and development, preferably for production. NYC area. Box 101.

★ **WANTED:** Recording Engineers, experience desired, with degree in Physics or Electrical Engineering, or with special qualifications. Please reply in full detail to Audio Company of America, 5520-22 Washington Ave., Houston 7, Texas.

● **RECORDING ENGINEER.** EE degree; experience in microgroove mastering, tape recording, studio work. Familiar with maintenance; worked with large variety of top-notch equipment. Presently employed by large NY recording organization. Age 24, married. Seeks responsible position with recording or broadcast studio in NY area. Box 102.

★ **TAPE and/or DISC RECORDER** and /or Maintenance Engineer. Salary open. New York City. Audio and Video Products Corp., 1680 Broadway, New York 19, N. Y.

★ **RADIO OPERATOR.** Duty aboard ships operated by Military Sea Transportation Service. Salary $4030 per annum, subsistence and quarters furnished while on duty. Voyages from New York to Europe and other parts of the world with durations of approximately 90 days. Duties involve control and operation of ship's radio equipment, including handling of all mesages. Must be able to handle minor repairs and maintenance, keep operating log, operate Ship Radar or other transmitting equipment, and perform certain clerical tasks. Minimum entrance requirement is possession of Radio Officer license issued by U. S. Coast Guard, although qualified applicants with 1st or 2nd Telegraph license will be assisted in obtaining USCG license. Applicant must pass examination on Radio Law, theory, and practice, and must have speed of 25 wpm or better; must be U. S. citizen, 18 to 55 inclusive, except for veteran preference eligibles; and must be physically capable of handling duties. To apply, obtain Form 57 at any 1st or 2nd class post office and file with Employment Branch, Industrial Relations Div., Military Sea Transportation Service, Atlantic, 58th St. and First Ave., Brooklyn 20, N. Y.

# CLASSIFIED

Rates: 10c per word per insertion for noncommercial advertisements; 25c 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.

**Equipment**

FOR SALE: Must sell my high-fidelity equipment: Hallicrafter SX61 year-old $155 (value $265), Amplifier Corporation of America ACA100DC, equipped for tuner, crystal, reluctance, mike; scratch eliminator, expander, etc., finest amplifier made, 30-watt; still factory guaranteed $115 (value over $200); 3378 special weighted turntable with Audax Polyphase, one-diamond, one-sapphire, $25 (value $65); Stephens 15-in. Co-spiral $25 (value $40), piecemeal or total value $565 for $282.50. Need cash. H. L. Williams, 1111 Calumet Avenue, Calumet, Mich.

Pickering S-140S Micro cartridge, played one hour, $9.00; GE RPX-046 broadcast cartridge with one .003" and two .001" sapphire styli, $8.50; M. J. Zirin, 21–74 34th Ave., L. I. C., New York.

FOR SALE: Bozak dual tweeter and 12-in woofer, new, in original cartons; with 4-mf high-pass filter. $45.00. Box CJ-1, AUDIO ENGINEERING.

FOR SALE: Amplifier Corporation of America 100GE, perfect, complete. Cost $212; sell $125. John Kersten, 820 Watson, Topeka, Kansas.

## PROFESSIONAL DIRECTORY



## DISTRIBUTED-SOURCE HORN

[from page 17]

essary, such as for a 500-cps DSH. Such a horn is intended to be used with a driver having an opening one inch in diameter. If the vertical dimension of the mouth of the horn were held to one inch in order to eliminate vertical expansion, the width of the horn would have been excessive. The greater vertical dimension causes this horn to be a little more directional in the vertical plane than the 750-cps horn. Therefore, the throat tapers gradually from 1 to 1¼ inches in the first five inches from the flange, and thereafter continues at a vertical dimension of 1¼ inches.

## AES PLAYBACK CURVE

[from page 22]

accomplish this by making his recording characteristic tip up at the low end; conversely, he can "thin out" the sound by the opposite procedure.

The shaping of this curve can be duplicated on a flat playback system with two sections of RC equalization, as shown in *Fig.* 2 which is one possible arrangement for use in an amplifier circuit. Both of the straight portions of the curve are slopes of 6 db per octave. The intersections of these slopes with the reference axis occur at 400 cps and at 2500 cps. At these points the response is 3 db away from the reference level. Within a tolerance of ±2 db it will be seen that all turnovers between 325 and 500 cps will fall in the area covered.

The adopted response curve (within its tolerances) is sufficiently parallel to the NAB response curve so that no problem will be encountered in the reproduction of NAB recording.

It is to be expected that the characteristic at the low-frequency end will stop rising at the 6 db/octave rate at some frequency determined by the range of the reproducing equipment. It is felt that first-class wide-range equipment will continue to 30 cps within the specified tolerance and then flatten off as rapidly as possible. Where equipment has a higher low-frequency cutoff, it is recommended that the reproducing characteristic follow the curve to its lower limit and then drop off as rapidly as possible.

On the high-frequency end, it is

recommended that the reproducing characteristic be followed to the desired upper frequency cutoff, above which point the response should drop off smoothly and rapidly. In wide-range equipment it is expected that the playback characteristic will follow the curve to 15,000 cps within the tolerance specified, and then drop off rapidly above this point.

### Typical Equalizing Networks

The equalizers of Fig. 3 are shown in order to facilitate the construction of these networks for use in professional installations. The Playback De-Emphasis Network is designed to give the proper roll-off characteristic in circuits of the impedances shown. If used with existing equalizers in playback circuits, the high-frequency response should be set on "flat" to obtain the proper curve.

The Recording Pre-Emphasis Network is designed for insertion in circuits of the indicated impedances ahead of the main recording amplifier. It is presumed that modifications will be made in the cutter network to obtain the desired low-frequency response. For information on the methods of adjusting these circuits, it is suggested that the engineer make inquiry from the cutter manufacturer.

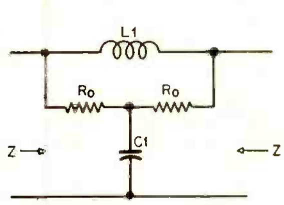
While most installations will already have some form of low-frequency equalizer for reproduction of existing types of records and transcriptions, it is possible that an entirely separate network will be required. The Playback Low-Frequency Boost Equalizer is designed to give a turnover frequency of 400 cps, with a total insertion loss (at 1000 cps) of 20 db. The half-loss point is 125 cps, and this equalizer will result in a slight decrease in response over the projected curve below about 70 cps. However, it falls within the limits down to 45 cps, and the decrease in response below that frequency may be an aid in reducing rumble.

All of these networks are designed to have constant impedance characteristics, and since they are symmetrical they may be used without regard to input or output connections. All networks shown are unbalanced, and usual transposition methods can be used to convert them to balanced networks if such are required in any particular installation.

### Conclusion

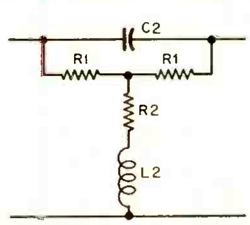
The new standard playback curve, if accepted by the Recording Industry, can achieve at long last a common platform for the reproduction of all recordings regardless of speed, groove dimensions, or manufacturer.

PLAYBACK DE-EMPHASIS NETWORK



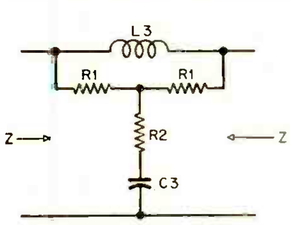

| Z (ohms) | L1 (mh) | C1 (μf) | Ro (ohms) |
|---|---|---|---|
| 150 | 9.55 | 0.408 | 150 |
| 250 | 15.9 | 0.255 | 250 |
| 500 | 31.8 | 0.127 | 500 |
| 600 | 38.2 | 0.102 | 600 |

RECORDING PRE-EMPHASIS NETWORK




| Z (ohms) | C2 (μf) | L2 (mh) | R1 (ohms) | R2 (ohms) |
|---|---|---|---|---|
| 150 | .0472 | 1.045 | 123 | 30 |
| 250 | .0284 | 1.74 | 204 | 50 |
| 500 | .0142 | 3.49 | 408 | 101 |
| 600 | .0118 | 4.19 | 491 | 121 |

PLAYBACK L-F BOOST EQUALIZER




| Z (ohms) | L3 (Hy) | C3 (μf) | R1 (ohms) | R2 (ohms) |
|---|---|---|---|---|
| 150 | 0.545 | 24.08 | 123 | 30 |
| 250 | 0.910 | 14.44 | 204 | 50 |
| 500 | 1.81 | 7.22 | 408 | 101 |
| 600 | 2.18 | 6.02 | 491 | 121 |

Fig. 3. Constant impedance networks suitable for line impedance indicated.

# RECEIVER BANDWIDTH

[*from page 19*]

the modulation consists of more than one frequency. He reports that the distortion is effectively intermodulation, being, for the case of two frequencies, a frequency modulation of the higher-frequency tone by the lower. This can reach surprisingly large amounts, and is especially distressing in that it is intermoduation distortion introduced by passive, linear circuits.

The problem is further complicated by the fact that where the intelligence is more complex than single-frequency tones (and it usually is) the bandwidth required may increase. Depending on the relative phases of the frequencies involved, the bandwidth may be increased or decreased compared to the bandwidth required to handle either tone separately, which means that in the design of an FM system we must make provision for an increase in the bandwidth.[5] (It is worthy of note that under conditions of complex modulation the FM spectrum may not be symmetrical, unlike the AM spectrum.) An indication of the amount of this increase in bandwidth is given to Corrington[6], who has investigated FM signal bandwidths down to sideband amplitudes of 0.1 per cent of the unmodulated carrier. With this precision, the bandwidth of an FM wave modulated by several tones will be approximately the sum of the bandwidths each tone would separately require.

For the usual program material (speech and music) the energy content above a fairly low frequency is approximately inversely proportional to frequency. This would tend to mitigate the bandwidth problem, since low modulation index will seldom coincide with maximum deviation. However, to improve the signal-to-noise ratio, pre-emphasis of frequencies above 2100 cps is introduced at the transmitter. This tends to maintain full deviation up to the highest frequencies transmitted. The de-emphasis network in the receiver does not alleviate the distortion problem, since the distortion has taken place *before detection,* and no operation in the audio system alone can reduce it. The problem is particularly serious in television receiver sound channels, since

[5] L. J. Giacoletto, "Generalized theory of multitone amplitude and frequency modulation," *Proc. I. R. E.,* v. 35, pp. 680–693; July, 1947.

[6] Murlan S. Corrington, "Variation of bandwidth with modulation index in frequency modulation," *Proc. I. R. E.,* v. 35, pp. 1013–1020; October, 1947.

the modulation index is 1.67 for 15 kc audio and 25 kc deviation.

Only two methods of attacking this question are available, other than altering transmission standards. One is to increase the bandwidth of the receiver. The other is effectively to do this by decreasing the bandwidth of the signal to be amplified in the i.f. section of the receiver, by feedback to the local oscillator. This method, which was first discussed by Chaffee[7], is further analyzed by Gladwin[4].

### Conclusions

Frequency modulation provides a method of improving signal-to-noise ratio by increasing bandwidth. Restricting the pre-detection bandwidth of the receiver used to detect these transmissions introduces distortion without significantly affecting the signal-to-noise ratio (at least for fluctuation noise), since in most systems this will be determined by the bandwidth of the (post-detection) final transducer (the loudspeaker, for audio transmissions). *Distortion introduced by restricted pre-detection bandwidth cannot be reduced by any post-detection operation.* (If there is 6 per cent intermodulation of a 11,-000-cps component before de-emphasis, after de-emphasis the intermodulation of the 11,000-cps tone will still be 6 per cent of its de-emphasized amplitude.) The choice of receiver bandwidth must therefore be the best compromise between the factors of adjacent-channel interference and distortion. In most areas, a bandwidth greater than one channel (200 kc) appears feasible. From the distortion standpoint, a bandwidth of 300 kc or more is desirable.

[7] J. G. Chaffee, "The application of negative feedback to frequency-modulation systems," *Bell Sys. Tech. Jour.*, v. 18, pp. 404–438; July, 1938.

Cruft Electronics Staff, "Electronic Circuits and Tubes," McGraw-Hill Book Co., New York, 1947; pp. 623–640.

F. E. Terman, "Radio Engineers' Handbook," McGraw-Hill Book Co., New York, 1943; pp. 578–582.

M.I.T. E. E. Staff, "Applied Electronics," John Wiley & Sons, New York, 1944; pp. 703–715.

Walter J. Frantz, "The transmission of a frequency-modulated wave through a network," *Proc. I. R. E.*, v. 34, pp. 114P–125P; March, 1946. *cf.* L. J. Giacoletto, "Network transmission of a frequency-modulated wave" (letter), *Proc. I. R. E.*, v. 35, pp. 1105–1106; October, 1947.

## New SUN Catalog

Copies of the new 100-page 1951 edition of "AUDIO EQUIPMENT, a Handbook for Music Lovers" may be had by writing or visiting Sun Radio and Electronics Co., 122–124 Duane St., New York 7, N. Y.

The new handbook contains a wealth of technical information on high fidelity, and listings, prices, and data on hundreds of components and sub-assemblies for home music systems or for p.a. use.

## ADVERTISING INDEX

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