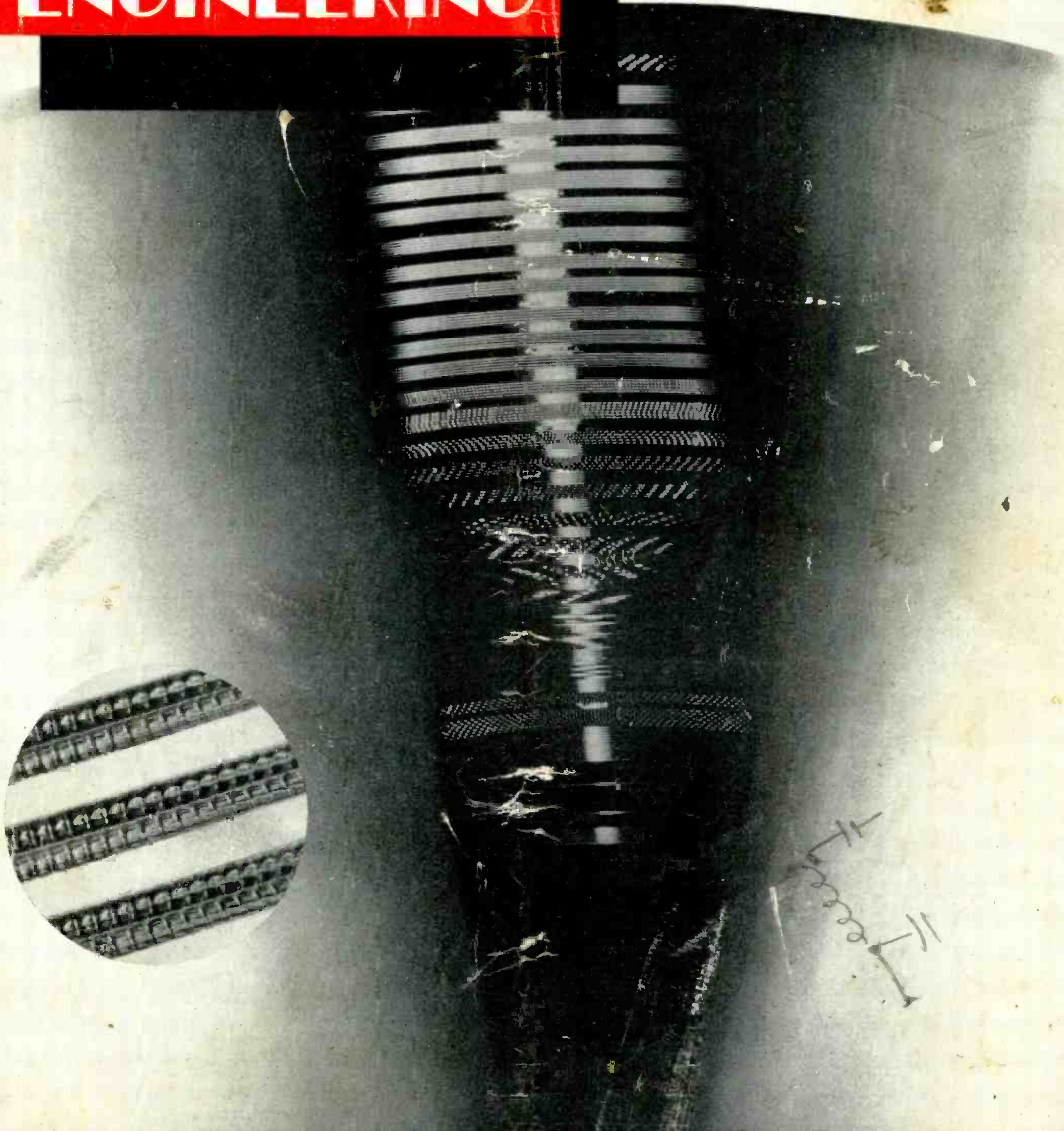
AUDIO ENGINEERING

SEPTEMBER
1949
Conlon
35c



Published by RADIO MAGAZINES, INC.

DON'T LET THE SUMMER'S HUMIDITY HAUNT YOU THIS FALL!

Left-over moisture is no problem when you record on humidity-resistant audiodiscs*

The worst of the summer months have passed — but the humidity lingers on. And its after-effects may actually be felt far into the fall and winter. For an ordinary lacquer recording disc absorbs moisture much more readily than it will give it up. And "left-over moisture," absorbed during the summer, can spoil many a recording months after the humidity has fallen below the danger point. So why risk "grey rings" and high noise level, when you can be sure of faultless recording with *humidity-resistant* Audiodiscs?

In Audiodiscs, the moisture problem has been solved *permanently* by the addition of a special moisture resisting agent — without any change in the basic lacquer formulation. As this development was perfected in 1947, we have had plenty of field experience to back up our own laboratory tests. During the summers of 1948 and 1949, for example, none of our customers has reported any humidity trouble.

So — for truly fine recording and reproduction all year around — be sure to ask your dealer for Audiodiscs!

TAPE RECORDISTS — Send for your Free Samples of the NEW audiotape*

Now, after 2½ years of research and development, Audio Devices offers you a complete line of highest quality magnetic recording tape — designed for *matched performance* in any tape recorder.

Two different types of paper-base Audiotape are now available — one with a high coercive-force black oxide, and the other with a medium coercive-force red oxide. This choice of characteristics enables you to select the tape that best matches the bias of your machine — for maximum quality of recording and reproduction.

Plastic-base Audiotape, with the same choice of oxides, will be available shortly.

We'd like you to test this new Audiotape, in your own machine. The coupon at the left, or a request on your company letterhead, will bring you a 200-foot sample of each type without cost or obligation.

AUDIO DEVICES, INC.
444 Madison Ave., New York 22, N. Y.

Gentlemen:

Please send me, free of charge, two, 200-foot samples of paper-base Audiotape — one with high coercive-force oxide, and the other with medium coercive-force oxide.

NAME __________

COMPANY __________

ADDRESS __________

CITY __________ STATE __________

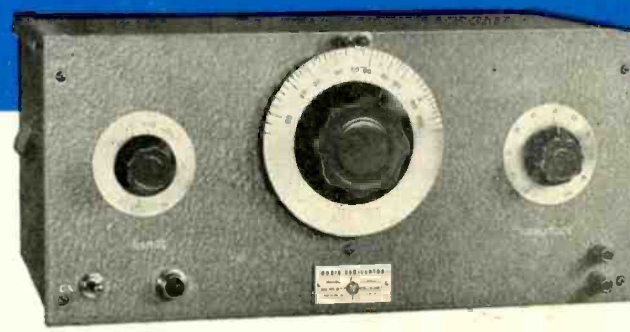
THEY SPEAK FOR THEMSELVES

*Trade Mark

AUDIO DEVICES, INC.
444 MADISON AVE., NEW YORK 22, N. Y.
Export Dept.: ROCKE INTERNATIONAL, 13 East 40th St., New York 16, N. Y.

Audiodiscs are manufactured in the U. S. A. under exclusive license from PYRAL, S. A. R. L., Paris

hp OSCILLATORS GIVE YOU PRECISE TEST VOLTAGES from ½ cps to 10 mc!



–*hp*– MODEL 200C

From ½ cps to 10 mc, there's an –*hp*– resistance tuned oscillator engineered to your exact need. Ten precision oscillators in all, including a portable unit that operates from batteries. Each has the familiar –*hp*– advantages of high stability, constant output, wide frequency range, low distortion and no zero set during operation. –*hp*– precision oscillators are used by radio stations, manufacturers, research laboratories and scientists throughout the world.

SPECIFICATIONS OF –*hp*– OSCILLATORS

INSTRUMENT	FREQ. RANGE	OUTPUT	DISTORTION	FREQ. RESPONSE	PRICE
–hp– 200A	35 cps to 35 kc	1 watt/22.5v	Less than 1%	± 1 db to 15 kc	$120.00
–hp– 200B	20 cps to 20 kc	1 watt/22.5v	Less than 1%	± 1 db to 15 kc	120.00
–hp– 200C	20 cps to 200 kc	100 mw/10v	Less than 1% to 20 kc	± 1 db to 150 kc	150.00
–hp– 200D	7 cps to 70 kc	100 mw/10v	Less than 1% 10 cps to 70 kc	± 1 db throughout range	175.00
–hp– 200H	60 cps to 600 kc	10 mw/1v	Less than 3%	± 1 db, 60 cps to 600 kc	350.00
–hp– 200I	6 cps to 6 kc	100 mw/10v	Less than 1% above 10 cps	± 1 db, 6 to 6000 cps	225.00
–hp– 201B	20 cps to 20 kc	3 w/42.5v	Less than ½ % (1 watt output)	± 1 db throughout range	250.00
–hp– 202B	½ cps to 50 kc	100 mw/10v	Less than 1% 1 to 1000 cps	± 1 db, 10 to 50,000 cps	350.00
–hp– 202D	2 cps to 70 kc	100 mw/10v	Less than 2% 10 cps to 70 kc	± 1 db, 7 cps to 70 kc	275.00
–hp– 204A (Battery Op d.)	2 cps to 20 kc	2.5 mw/5v	Less than 1%	± 1 db throughout range	175.00
–hp– 650A	10 cps to 10 mc	15 mw/3v	Less than 1% 100 cps to 100 kc	± 1 db throughout range	475.00

For complete details on any –hp– instrument, write direct to factory or contact the –hp– technical representative nearest you.

HEWLETT-PACKARD CO.
1640L Page Mill Road, Palo Alto, California
Export Agents: Frazar & Hansen, Ltd.
301 Clay Street • San Francisco, Calif., U. S. A.

ANOTHER -*hp*- SERVICE

Person-to-Person Help With Your Measuring Problems

Almost anywhere in America, –*hp*– field representatives can give you personal help with your measuring problems. They have complete data on –*hp*– instruments, their performance, servicing and adaptability. Call the nearest –*hp*– field representative whenever, wherever you need help with a measuring problem.

BOSTON, MASSACHUSETTS
Burlingame Associates
270 Commonwealth Ave.
KEnmore 6-8100

CHICAGO 6, ILLINOIS
Alfred Crossley & Associates
549 W. Randolph St.
State 7444

CLEVELAND 12, OHIO
M. P. Odell
1748 Northfield Avenue
Potomac 6960

DALLAS 5, TEXAS
Earl W. Lipscomb
4433 Stanford Street
Logan 6-5097

DENVER 10, COLORADO
Ronald G. Bowen
1896 So. Humboldt Street
Spruce 9368

FORT MYERS, FLORIDA
Arthur Lynch and Associates
P. O. Box 466
Fort Myers 1269M

HIGH POINT, NORTH CAROLINA
Bivins & Caldwell
Room 807, Security Bank Building
Phone 3672

LOS ANGELES 46, CALIFORNIA
Norman B. Neely Enterprises
7422 Melrose Avenue
Whitney 1147

NEW YORK 7, NEW YORK
Burlingame Associates
11 Park Place
Digby 9-1240

SAN FRANCISCO 3, CALIFORNIA
Norman B. Neely Enterprises
954 Howard Street
Douglas 2-2609

TORONTO 1, CANADA
Atlas Radio Corporation, Ltd.
560 King Street West
Waverley 4761

WASHINGTON 9, D. C.
Burlingame Associates
2017 S. Street N. W.
Decatur 8111

***hp* laboratory instruments**
FOR SPEED AND ACCURACY

Listen for the words "Transcribed by AMPEX" after the great shows in radio

Here's why.....

the new series 300

AMPEX

MAGNETIC TAPE RECORDER
answers industry need!

Designed by engineers who had your engineering needs in mind!

Portable model

Console Model 300* $1,573.75
Portable Model 300 $1,594.41
Rack Mounted $1,491.75

*Meter panel extra

F. O. B. Factory, San Carlos, Calif.

★ ***Original program quality preserved***

Use of independent reproduction facilities allows instantaneous monitoring and makes possible the most stringent comparisons between recordings and originals.

★ ***Tape and playback noise non-existant***

Use of special record and bias circuits has eliminated tape noise.* Extreme care has been exercised to eliminate hum pick-up.

★ ***Editing made easy***

With Ampex editing is almost instantaneous. Single letters have been actually cut off the end of words. Scissors and scotch tape are all the tools needed.

★ ***You can depend on Ampex***

Read what Frank Marx, Vice President in charge of Engineering, American Broadcasting Company, says: "For the past two years A.B.C. has successfully used magnetic tape for rebroadcast purposes... A.B.C. recorded on AMPEX in Chicago...17 hours per day. For 2618 hours of playback time, the air time lost was less than 3 minutes: a truly remarkable record."

SPECIFICATIONS

FREQUENCY RESPONSE:
At 15" ± 2 db. 50—15,000 cycles
At 7.5" ± 2 db. 50— 7,500 cycles

***SIGNAL-TO-NOISE RATIO**: The overall unweighted system noise is 70 db. below tape saturation, and over 60 db. below 3% total harmonic distortion at 400 cycles.

STARTING TIME: Instantaneous. (When starting in the Normal Play mode of operation, the tape is up to full speed in less than .1 second.)

FLUTTER AND WOW: At 15 inches per second, well under 0.1% r.m.s., measuring all flutter components from 0 to 300 cycles, using a tone of 3000 cycles. At 7.5 inches, under .2%.

Manufactured by Ampex Electric Corporation, San Carlos, Calif.

DISTRIBUTED BY

BING CROSBY ENTERPRISES
9028 Sunset Blvd., Hollywood 46, Calif.

AUDIO & VIDEO PRODUCTS CORPORATION
1650 Broadway, New York, New York

GRAYBAR ELECTRIC CO. INC.
420 Lexington Ave., New York 17, N. Y.

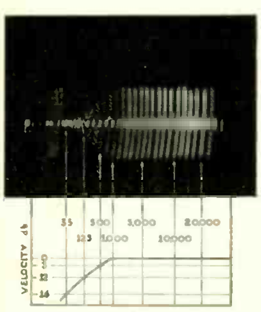
AUDIO ENGINEERING

Successor to RADIO

MEMBER AUDIT BUREAU OF CIRCULATIONS

Established 1917 — SEPTEMBER, 1949 — Vol. 33, No. 9

CONTENTS



COVER

Light pattern of new Cook Laboratories frequency test record, showing flat recording characteristic up to 20 kc. Frequency bands are shown on the curve at left. Insert is a photomicrograph of the 20-kc grooves.

AUDIO ENGINEERING (title registered U. S. Pat. Off.) is published monthly at New York, N. Y., by Radio Magazines, Inc., D. S. Potts, President; Lawrence LeKashman, Vice Pres. Executive and Editorial Offices at 342 Madison Avenue, New York 17, N. Y. Subscription rates—United States, U. S. Possessions and Canada, $3.00 for 1 year, $5.00 for 2 years; elsewhere $4.00 per year. Single copies 35c. Printed in U. S. A.

Entered as Second Class Matter July 29, 1948 at the Post Office, New York, N. Y., under the Act of March 3, 1879.

EDITOR'S REPORT

TV AUDIO PERSPECTIVE

THE CONVERSION of television receivers to high fidelity standards entails a number of considerations which were not immediately apparent when the original idea came to mind. Chief among these are the relation between the size of the performers' images and the audio level at which the sound is reproduced. Even with a high quality amplifier and speaker system, with the naturally fine quality resulting from a correctly designed and aligned FM channel, it is apt to be noted that when the sound is reproduced at what is a normal level for radio programs the overall perspective seems to suffer slightly.

It does not seem quite realistic for a baritone who appears to be from four to six inches in height to fill a living room with a volume of sound which might be expected from the singer himself, if he were present. Yet in a purely aural program, this discrepancy does not exist, and either singer or orchestra may reasonably be reproduced at concert hall volume. This effect is more and more noticeable with the smaller direct view tubes, and will undoubtedly be an unconscious factor in upgrading the buyer of a replacement TV set to one with a larger screen. With the 10- and 12-inch tubes being electrically interchangeable, one manufacturer has already discontinued production of sets using the smaller size, and the increased picture size is now obtainable for only a slight increase in cost. Manufacturing economies due to mass production will naturally lower the cost of the 16-inch tube and the additional equipment required to operate it properly, so that it will become the most popular size for home receivers, particularly in the console models.

Another difficulty presently noticed is the increase in studio noises that becomes perceptible when the audio bandwidth is increased. The continuous movement of technicians, cameras, microphone booms, and other paraphernalia incident to the production of a TV program necessarily creates some noise, mainly in the low-frequency range. Consequently, improved low end response of the receiver audio system and loudspeaker tends to increase the effect of this noise. The condition is not serious, and even now the better programs are reasonably free of disturbances of this nature. However, it is true that larger and better-baffled speakers do make such noises more noticeable. Greater experience in the production of programs will minimize this trouble.

Television sound is improving perceptibly—almost week by week—and program production is making great strides. To reproduce the sound in the home with a maximum of realism, it is becoming more and more obvious that high-quality audio channels are desirable—including the speaker. The addition of two tweeter horns or small cone speakers at the upper corners of the picture area will help the illusion that the sound is coming from the screen, especially when the large speaker is somewhat removed from the picture tube, as it is in many consoles and combinations. While this would increase the cost somewhat—necessitating the additional speakers and some means of dividing the frequency spectrum to keep lows off the high-frequency speakers—it would improve the illusion appreciably.

COMING ATTRACTIONS

We are especially fortunate in being able to offer an important paper by W. L. Black and H. H. Scott on the subject of "Audio Frequency Measurements." This paper will run in two parts, the first appearing in the October issue. Mr. Black of Bell Telephone Laboratories, and Mr. Scott whose work on the Dynamic Noise Suppressor is well known, collaborated on this paper, which was originally presented at the joint IRE-RMA Spring Meeting in 1948. The subjects covered include the measurement of gain, frequency response, single-frequency harmonic distortion, and noise. The treatment is considered authoritative, and should become a permanent reference in the audio field.

Also in the October issue is scheduled an article on the conversion of one of the more popular TV receiver chassis to give improved audio quality. The changes are relatively simple, and are desirable if larger speakers are to be used with the existing chassis. This model, the RCA 630TS, was sold in tremendous quantities, as a complete receiver, and a nearly identical unit is still extremely popular in kit form as supplied by a number of sources.

CONVENTION TIME

With the beginning of the fall season, it appears that conventions are with us again. Most important to the audio field is the first annual convention meeting of the Audio Engineering Society, coupled with The Audio Fair, of which more elsewhere in this issue. This convention takes place in New York City on October 27, 28, and 29.

The "Greatest Show in Amateur Radio" also comes to New York this fall, with the ARRL Hudson Division Convention being scheduled at the Ninth Regiment Armory for October 7, 8, and 9.

HIGH FIDELITY MUSIC FANS WILL LOVE PICKERING'S LATEST CONTRIBUTION TO RECORD PLAYING PLEASURE . . .

. . . available for the first time, a perfect set-up for playing 33⅓, 45 and 78 rpm records—with absolutely faithful reproduction—the true concert quality originally recorded

PICKERING DEVELOPS ADAPTER CLIP FOR NEW WEBSTER-CHICAGO RECORD PLAYER PERMITTING PLUG-IN USE OF PICKERING CARTRIDGES

NOW **discriminating listeners of recorded music can have, at a moment's notice, high fidelity music with all the realism and brilliance as originally recorded. By plugging in the particular Pickering Cartridge for the type of record to be played—a gold Pickering Cartridge for standard records, a silver cartridge for microgroove records . . . the Webster-Chicago Player is ready to give concert quality music . . . and frequencies from 30 to 15,000 cycles are reproduced without discrimination and without distortion.**

This is the Webster-Chicago changer arm with a Pickering pick-up cartridge plugged in . . . and ready to produce concert quality music.

- **GOLD-FINISHED PICKERING CARTRIDGES, models 120 and R-150 ARE FOR STANDARD RECORDS**
- **SILVER-FINISHED PICKERING CARTRIDGES, model 140, ARE FOR MICROGROOVE RECORDS**

Buy them as a set . . . be ready to play either microgroove or standard records . . . have the particularly required Pickering Cartridge at hand to give you the optimum in listening pleasure . . . remember, Pickering Gold-Finished Cartridges are for standard records . . . and . . . Pickering Silver-finished Cartridges are for microgroove records. All Pickering Cartridges are available with either a diamond or sapphire stylus. Pickering diamond styli will outwear the finest sapphire styli ten to one.

PICKERING CARTRIDGES AND AUDIO EQUIPMENT ARE AVAILABLE THROUGH LEADING JOBBERS AND DISTRIBUTORS EVERYWHERE.

Pickering & Company Inc. Oceanside, New York

Book Reviews

Radio and Television Mathematics, by Zernhard Fischer, Vice-President in Charge of the Training Division at the American Television Laboratories, Hollywood, Calif. The Macmillan Company, New York. $6.00

A practical handbook which consists essentially of nearly 400 problems typical of those encountered in simpler design work on radio, television, and audio equipment. The author has selected one problem of practically every type of calculation and carried it through each step to its solution, making the process thoroughly understandable. These problems cover the field from basic circuit components to the more specialized elements in television and electronic control apparatus.

The discussion of the use of the j-operator is particularly clear, and should prove valuable to the beginner in radio mathematics, although its presentation is thorough and is couched in terms which—while readily understandable—are completely accurate. The formulas required for the various problems are grouped in one section so that they may be referred to easily after the instructional portion of the book has been studied, and the section of extra problems for practice provides the reader with sufficient exercise to familiarize him with the methods of solution.

Elements of Sound Recording, by John G. Frayne and Halley Wolfe, Electrical Research Products Division, Western Electric Company. 686 pages. John Wiley & Sons, Inc., New York. $8.50.

This book is somewhat remindful of the earlier "Motion Picture Sound Engineering" which was produced by the Academy of Motion Picture Arts and Sciences in 1934, and which has since been the standard reference work in film recording and the equipment used in making sound pictures. However, "Elements of Sound Recording" is completely up to date, and should definitely be in the library of anyone involved in any phase of recording.

The authors start with a discussion of the nature of sound, and continue with basic chapters on electrical, mechanical, and acoustical circuits with a clear presentation of the analogy as a means to the solution of problems arising in the study of mechanical elements. Tubes, audio amplifiers, network theory, attenuators, filters, and equalizers are given short descriptive treatments which are suitable for reference use.

Although "Elements of Sound Recording" has a strong leaning toward film recording—with some eighteen chapters devoted to this subject—it is still valuable to both disc and magnetic recordists because the principles underlying all types of recording are essentially similar. The book is important as a general text, and will be of continuing use as a reference work.

— Letters —

Hobbyist's Plea

Sir:

While it appears that your magazine fills the bill for the professional engineer, it also goes a great way toward satisfying the needs of the purely amateur builder who builds either for the fun of it, or who starts by attempting to get quality he cannot buy easily and still ends up building forever for the fun of it. This area—inadequately covered by the other radio monthlies where perhaps it more properly belongs—could be covered by AUDIO ENGINEERING without detracting from its maturity.

I would like to see a through-going set of closely knit articles elaborating the basic fundamentals of audio design and application written for the technically minded layman. Most important, the relevant problems should be considered individually over time in a strictly logical fashion.

Without denying the great value of many separate articles which have appeared from time to time, I would still argue for a step-by-step, highly co-ordinated presentation of these topics which must be considered in the design and physical layout of a modern, high-quality set of audio components. That such a program would involve repeating ground already covered in one issue or another is justified to my mind.

Concretely, here is my suggestion. Set aside the last article each month with a series of topics to run the gamut of "audiana". Then repeat the cycle in a more advanced way, with more formulas, more details. If perfectly serious, it would hardly hurt the feelings of your best equipped reader; indeed, it may help others come that much closer to his standards.

This is just the sketchiest of ideas. A year or so of such articles would provide a base for further expansion, a reference for more technical specialized articles, and a centralized set of fundamental notes for future review. Is there any *one* place where the relevant information is systematically collated? There are, of course, many excellent engineering design texts, and many discussions of practical considerations. But not in one, nor even in just a few places.

M. H. Schwartz
810 Avenue C,
Bayonne, N. J.

(Note: If Mr. Schwartz is not alone in this idea, we would be in favor of following his outline, which accompanied the letter, and which would be an excellent guide. Ed.)

Pleases Hobbyist

Sir:

Your magazine arrived on August 9 at 4 p.m., and before 8 p.m. I had built the Tubeless Hi-Fi Tuner described. I had been looking for a good tuner for some time, and fortunately was able to get the required coils here in Canada.

I am well pleased with the tuner, although it separates two local stations—1010 and 1050 kc—with difficulty. However, the other three come in fine.

Sinclair Hemingway
189 Millwood Rd.
Toronto, Canada

Magnetic Materials

The Arnold Engineering Company offers to the trade a complete line of Magnetic Materials

PERMANENT MAGNET MATERIALS

- Cast Magnets, Alnico I, II, III, IV, V, VI, XII, X-900
- Sintered Magnets, Alnico II, IV, V, VI, X-900, Remalloy*
- Vicalloy*
- Remalloy* (Comol)
- Cunico
- Cunife
- Cast Cobalt Magnet Steel

HIGH PERMEABILITY MATERIALS

- Deltamax Toroidal Cores
- Supermalloy* Toroidal Cores
- Powdered Molybdenum Permalloy* Toroidal Cores
- Permendur*

*Manufactured under licensing arrangements with WESTERN ELECTRIC COMPANY

Write for information relating to any of these Magnetic Materials

THE ARNOLD ENGINEERING COMPANY

SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION

147 EAST ONTARIO STREET, CHICAGO 11, ILLINOIS

Modern School Sound System

ARTHUR W. SCHNEIDER*

Archbishop Stepinac High School. Eggers and Higgins, Architects; George A. Fuller Co., General Contractors.

Recent educational advances practically demand the availability of flexible, high-quality, public-address facilities. The system installed in the new Archbishop Stepinac High School fulfills these requirements with outstanding success.

RECENTLY DEDICATED in the city of White Plains, in Westchester County, New York, is perhaps the most beautiful and most efficient High School built in this country to date. This school for boys was named after Archbishop Stepinac of worldwide fame, and is dedicated to the advancement and education of boys throughout the world. In its planning every advantage was taken of up-to-date materials, functions, and equipment.

The sound equipment was supplied by the Commercial Radio-Sound Corporation, whose engineers designed a modern, all-inclusive sound system. It is the purpose of this article to describe the functions, design, and installation of the entire system.

Figure 1 shows the overall block schematic of the system. It will be noted that there are actually many separate systems, each an operating unit of apparatus in itself but which, together with the main control rack, constitute a complete integrated and flexible system capable of facile operation from the master control station located near the Principal's office. These systems are basically as follows:

1. Two-channel main classroom system
2. Auditorium system
3. Gymnasium system
4. Cafeteria system
5. Studio classroom system

Studio Classroom System

The studio classroom system, as shown on the block diagram and in the photograph of *Fig.* 2 with Father Hargrave at the controls, is a 30-watt amplifier providing two studio inputs, talkback, and facilities for amplifying the signals from an AM/FM radio receiver. Located in the control room is a small metal cabinet containing the tuner and power supply. This tuner is used for feeding programs into the studio classroom, and can also be used for feeding an auxiliary program to the main rack.

Monitoring facilities are provided which, together with the talkback facilities, permit complete control by the instructor of "mock" and "real" broadcasts. It is also to be noted that it is possible to feed the program originating in the studio from this unit to the main system. Magnetic recording facilities have been provided for instructional uses, as well as for recording talks of visiting dignitaries so they may be played back at a later time through this or any of the other systems, or through all of them simultaneously.

Cafeteria System

The cafeteria system is a 30-watt amplifier with one input brought out to a microphone station. This system is used for locally originated programs from a portable phonograph turntable or for use by the instructor in charge of the cafeteria. The equipment is located in a metal cabinet with flush trim, the appearance of the complete unit being shown in *Fig.* 3.

Eight speakers, located in the side walls of the cafeteria, give adequate distribution of all programs without an excessive level in any part of the room.

Gymnasium System

The gymnasium system is rather unique in view of the fact that it makes use of a multiple-speaker installation because the problem of illusion is not a serious one, and because the system is used mainly for instructional purposes. However, since it is contemplated that one of the principal uses of this

Fig. 2. Father Hargrave at the controls of the studio-classroom amplifier, which approximates all the functions of a normal broadcast mixing console.

*General Manager, Commercial Radio-Sound Corp., 570 Lexington Ave., New York.

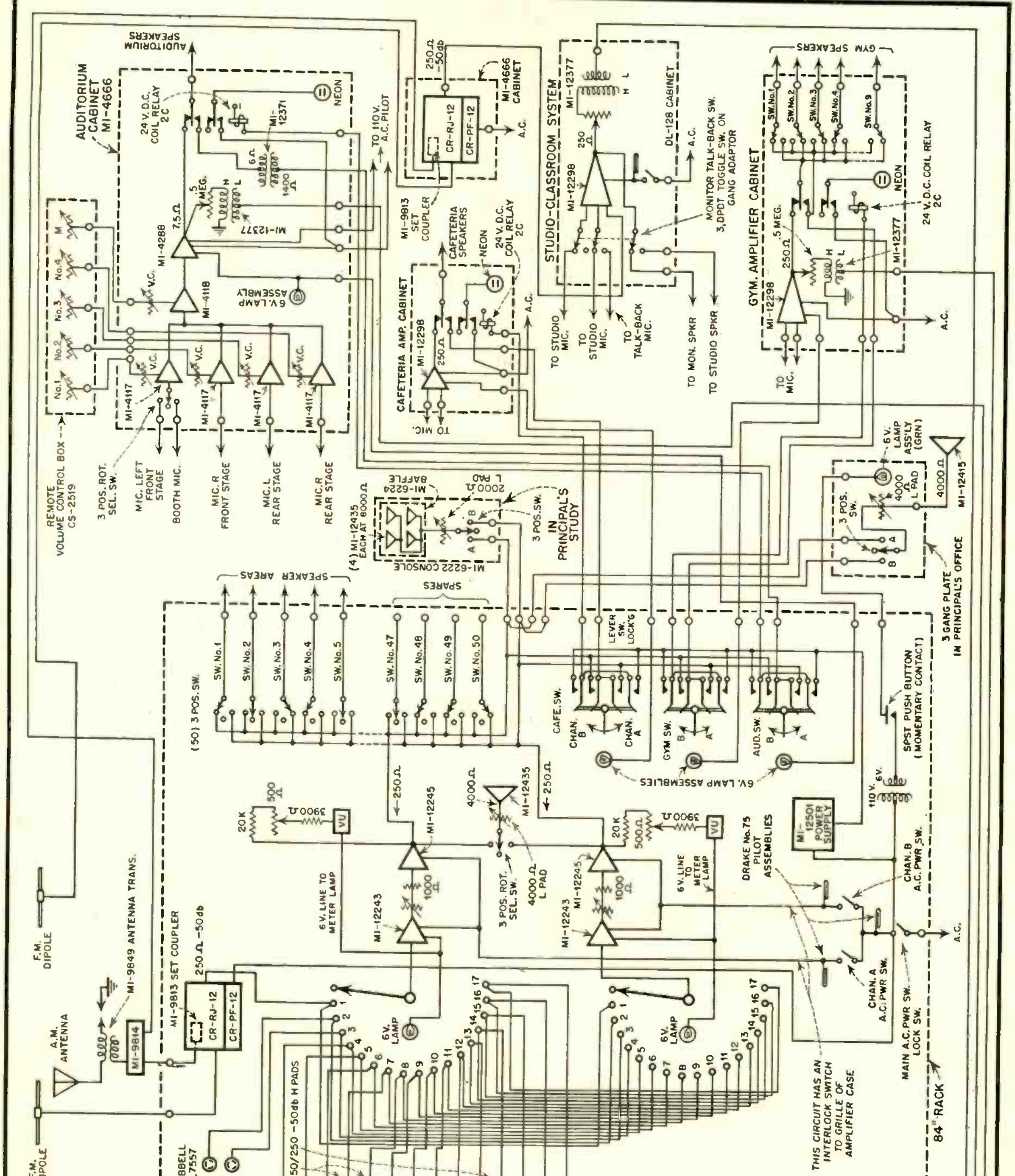


Fig. 1. Block schematic of the entire High School sound system.

system will be in connection with meetings, banquets, athletic exhibitions, and so on, a multiple installation was decided on, employing twelve loudspeakers flush in the ceiling and arranged on nine circuits. When tested, this system proved to be completely satisfactory. It is possible to place the microphone on any side of the room, using with it appropriately located speakers selected by the nine switches shown in *Fig.* 4, so as to provide for many varieties of banquets or other setups. It is also possible to cut off the central speakers should the gymnasium be used for wrestling bouts, prize fights, or other exhibitions. It is to be noted from the block diagram that master control can feed the speakers with any desired program, or that a program originating in the gymnasium may be fed to the main control for redistribution.

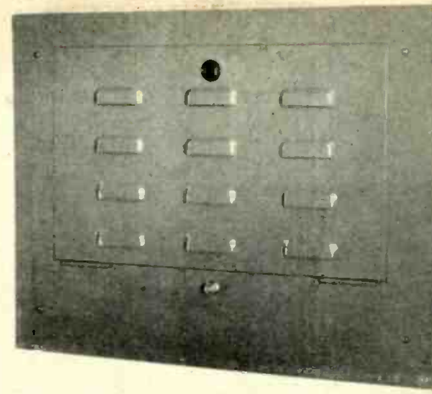


Fig. 3 (right). Cafeteria system amplifier housing, closed. Fig. 4 (left). Cafeteria system amplifier, showing various input controls as well as speaker selecting switches.

Auditorium System

The auditorium system employs a four-input amplifier permitting control of each microphone circuit independently either from the amplifier location in the projection booth or from a remote control station located in a locked box in the rear of the Auditorium. This four-unit mixer-and-master is the RCA MI-4273 type, feeding a MI-4288 power amplifier.

This amplifier, together with four microphone receptacles located on the stage, feeds two MI-1469-1425 multicellular units located behind decorative grilles in the center of the proscenium arch. As with the other systems, it is possible for master control to feed the speakers with any desired program, or it may pick up the locally originating program and feed it to the other systems.

Master Control

This is a rack type of construction selected for its flexibility of operation, ease of installation and servicing, and lower fabrication cost. The rack is shown in *Fig.* 5. Located in the top panel is a six-inch MI-12435 accordion-edged cone speaker together with a three-position selector switch on the left and a monitoring volume control on the right. The next panel has the AM-FM radio tuner, and below it is the input selector system. Each of the selector switches is an 18-position, two-circuit, non-shorting switch, especially designed for this application, and can connect any one of the program sources to either of the two channels. These sources are: rack input receptacles 1 and 2, the Principal's microphone, music room, band room, auditorium system, gymnasium system, Chapel microphones 1 and 2, studio classroom system, and separate direct microphone circuits from the auditorium, gymnasium, and cafeteria. It is to be noted that these last three microphone circuits were put in as an emergency measure in case any one of the three systems involved should fail. For example, if the amplifier in the cafeteria should fail, it is possible to plug the microphone into an outlet in the cafeteria which connects directly to the main rack, and set the selector switch on the main rack to cafeteria input. With the cafeteria output switch set to the same channel, it is possible to continue with programs in the cafeteria just as easily as with the local system. In this manner, a main amplifier is used to provide program from and to the cafeteria. Similarly, direct microphone circuits can be used in the auditorium and the gymnasium.

The next panel on the rack is the voltage-amplifier, VU-meter, and gain-control panel. This includes two Daven step-by-step attenuators and two illuminated VU meters. Behind the panel are the two preamplifiers whose internal controls are used to equalize the gain of each channel. Below this panel is the classroom distribution switch panel with fifty special three-position selector switches. The three telephone-type key switches shown below are used to control the distribution of programs to the cafeteria, gymnasium, and auditorium. Pilot lights over these switches indicate that the local systems are in use, and are energized by the 6-volt filament circuit brought back from each of the local amplifiers. The lower portion of the cabinet is taken up with two 70-watt MI-12245 power amplifiers, together with the necessary terminal strips for connecting the rack to all external circuits. Three power switches

Fig. 5. Main amplifier rack assembly—master control—with the author (left) and Father King, school Principal.

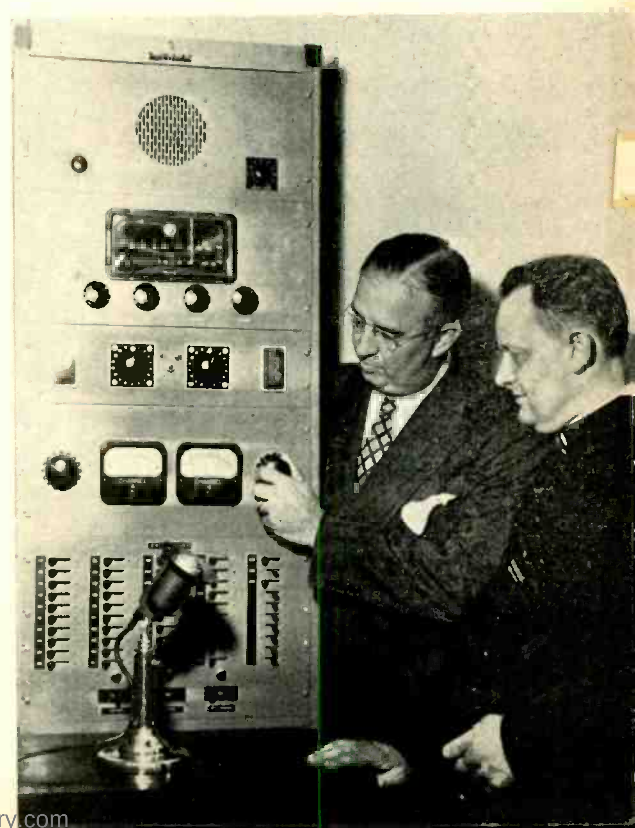


Fig. 6. Cardinal Spellman addressing assembled guests at the dedication ceremonies, with two system microphones at right and left. Radio station microphones are in front.

are provided—a main key-operated switch and two auxiliary switches which are used to energize the two channels. The type of equipment selected was chosen with the service aspect in view. The voltage amplifiers are of the plug-in type, and the 70-watt power amplifiers are serviced from the rear—the hinged chassis permitting complete accessibility without disturbing the amplifier. The 24-volt plug-in power supply is used to energize relays in the auditorium, cafeteria, and gymnasium systems. These relays are those that cut off the local program and permit the program from the rack to come through and bypass the local amplifiers. The separate loudspeaker control provided in the Principal's office permits manual selection of either Channel A or Channel B program, as well as control of volume. The pilot light located on this panel is controlled by a button located on the input selector panel, and the operator at master control can signal to the Principal when the circuit is complete for him to address selected groups.

The antenna system supplied is a rather unique one. On a single mast approximately fifteen feet above the roof level there are two 300-ohm FM dipoles, each of which feeds into a special antenna coupling transformer. The 300-ohm balanced antenna line is transposed into a 50-ohm unbalanced coaxial line. RG-58/U cable is used to carry FM signals from the antennas to each of the two receivers, where a similar transformer is used to transpose the signal back to a 300-ohm balanced circuit. Inasmuch as the antenna runs have to be in conduit and the FM signals are low in level, this type of transmission circuit was decided on.

For AM signals, a 60-foot flat top antenna approximately fifteen feet above the roof is used. It is coupled into an antenna transformer to transpose the signal to a 70-ohm balanced circuit. This is fed into a distribution transformer at the first receiver and the output of this distribution transformer

[Continued on page 39]

Test Record List

FREQUENCY RECORDS and other types of records designed for various testing purposes are indispensable to the audio engineer for checking pickups, equalization, and overall performance of a disc reproducing system. They are practically the only measuring device which will include the performance of the pickup, and may be said to be as useful as a gain set or a volume indicator in other branches of audio work.

A number of test records are available commercially—doubtless there are many more which may be obtained from various sources from time to time—but those listed below are standard items, and are readily obtainable. Their uses include the checking the mechanical performance of record changers as well as the most common tests on frequency performance of pickups, equalizers, and amplifiers, and in making various acoustical measurements. Unfortunately, no manufacturer lists a complete "warble-frequency" record for loudspeaker testing over a wide range of frequencies, although a few such records are in existence, and may be found by diligent search.

At the time of compilation, this list is believed to be complete for lateral phonograph records and transcriptions, as far as possible comprising those records which are regularly in stock. The audio engineer or experimenter may well want several of them on hand to be able to make complete checks of his equipment.

RCA VICTOR

12-5-5 (Old No. 84522A) 12-inch, 78 rpm. Shellac, DF with 12-5-7 on reverse. Glide frequency record, 10,000 to 30 cps. Crossover, 500 cps. 1.5 db below CV portion. Essentially CV above 800 cps, with 3-4 db dip at approximately 8,000 cps. Buzzer signals at 10, 9, 8, 5, 4, 2, and 1 kc, and at 500, 200, 100, and 50 cps.

12-5-7 (Old No. 84522B) Reverse side of 12-5-5. Two modulated bands: at 78 rpm, 2300 and 1000 cps for 1:00 and 2:15 min. respectively; at 33⅓ rpm, 1000 and 400 cps for 2:26 and 5:15 min. Frequencies are held constant to within 0.2 per cent instantaneous.

12-5-9 12-inch, 78 rpm. Shellac, DF, same on both sides. Four bands, each one minute. (1) Unmodulated; (2) 400 cps at 5.9 cm/sec; (3) 1000 cps at 9.6 cm/sec; (4) Unmodulated. Frequencies held constant to within 0.2 per cent instantaneous.

12-5-11 12-inch, 78 rpm. Shellac, DF, same on both sides. Test record to check operation of changers. Contains a landing area with no lead-in spiral, at least one unmodulated normal pitch groove at the outside, and a steep blank spiral into a normal pitch groove at the inside which joins a lead-out and eccentric groove.

12-5-13 10-inch, 78 rpm. Shellac, DF, same on both sides. Same as 12-5-11, except for checking operation with 10-inch records.

12-5-15 12-inch, 78 rpm. Unfilled Vinyl, DF, same on both sides. Four warble frequency bands of thirty seconds each, with sweep rate of approximately 5.5 cps. Frequencies are: 500-2500 cps; 750-1250 cps; 1250 to 1750 cps; 1800-2600 cps.

12-5-17 10-inch, 78 rpm. Shellac, DF, same on both sides. Same as 12-5-15 except that each band is seven seconds in length.

12-5-19 (T-2484-1) 12-inch, 78 rpm, Unfilled Vinyl, SF. Frequency bands, CV above 800 cps; turnover 500 cps, with level at 500 cps 1.5 db below normal level of approximately 8.6 cm/sec. Bands: ten seconds each, 10, 9, 8, 7, 6, 5, 4, 3, 2, and 1 kc, 800, 500, 300, 200, 100, and 50 cps; 1000 cps down 2 db from normal, and 10 kc band at inside of record.

12-5-21 (T-2913) 12-inch, 78 rpm. Unfilled Vinyl, DF, with 12-5-23 on reverse. For test-

[Continued on page 40]

New Developments in Logarithmic Amplifiers

C. J. LeBEL*

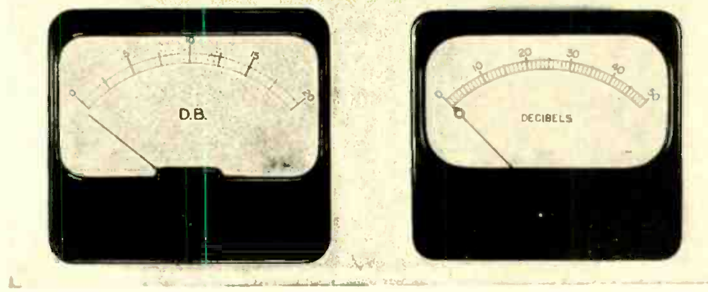


Fig. 1. Meter scales which result from logarithmic amplifier and linear vacuum tube voltmeter.

A description of a novel method of converting an audio signal to an output voltage which is proportional to sound level.

In a logarithmic amplifier the output voltage is equal to the logarithm of the input voltage, independent of frequency or input voltage. The logarithmic effect may be secured in the amplifier stage itself, or in the interstage coupling circuit. While the definition applies to both a.c. and d.c. amplifiers, basic fields of usefulness seem to lie chiefly in the former.

We can think of a logarithmic amplifier as a device with an output in db for a normal linear (voltage) input. Applied as a converter between any linear-scale indicating or recording device and a source of voltage, it enables an ordinary v-t voltmeter or oscillograph to read db on a linear scale.

A good example of this lies in the measurement of acoustical reverberation time. A studio or auditorium is filled with steady sound, the tone is shut off, and the sound decay is measured. Reverberation time is defined as the time for the sound intensity to drop 60 db. As a practical fact, it is recognized that only the first 30 or 40 db of decay are important, and that any echoes, slap, or other non-uniformities during this interval are very significant. A decay curve, which has very pronounced irregularities in this most prominent portion, is likely to prove characteristic of studios which are bad sounding or difficult to use properly. While 100 db per second recording speed will care for the basic sound decay, a much higher speed is necessary to reproduce the fine structure—perhaps 1000 db per second. Direct writing oscillographs are available that will follow a 200-cps sine wave fairly well; combined with a 50 db logarithmic element, they make possible recording at 5000 db per second with ample margin of safety. High-speed level recorders heretofore generally used have had a nominal writing speed of not over 600 db per second. Being servo systems, and using tapped potentiometers for the logarithmic effect, some question may be raised whether their true *following* speed was not considerably under 600 db per second.

By using a sufficiently slow sweep rate, a cathode ray tube with a P-7 slow decay phosphor, and a timing circuit to control the loudspeaker, it is possible to examine reverberation characteristics on a cathode ray oscilloscope.

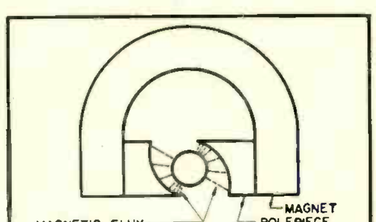


Fig. 2. Magnetic structure of meter with shaped pole pieces.

Observing and recording program levels form other applications of logarithmic indications. The standard VU meter will indicate maximum level very well, but it shows nothing about the lower levels to which many programs drop much of the time. The new technique provides a volume indicator with 50 db range—one which will indicate minimum as well as maximum levels. It is not suggested that a 50 db meter be used for peak indication, but rather that it supplement the VU meter at lower levels. The same logarithmic unit may be used to feed a recording oscillograph (via a suitable amplifier) for an accurate permanent chart of program levels. For training purposes a chart record of this type should be invaluable.

A similar application is that of measuring or recording any phenomenon which is varying over too wide a range to be handled properly by an unaided linear-scale device. Continuous measurement or recording of noise without frequent use of a range-changing switch calls for a scale range of 30 to 50 db, which can be provided most easily by a log element. If multichannel recording is necessary, such as in machine noise analysis with quarter-octave band filters, an arrangement of this sort will provide high-speed recording at less than a third the cost of, and at a tenth the size and weight of a whole group of high-speed level recorders.

Securing the Logarithmic Effect

A wide variety of means is available for securing a logarithmic characteristic. The earliest and virtually the only method repeatedly mentioned in the literature is the use of variable bias on the grid of a variable-mu tube, a species of a-v-c circuit. Perhaps the best work on this type of circuit was done by F. V. Hunt in a paper published in the 30's. He fed the amplified signal back to the grid through a rectifier. For a wide db range he used several tubes and rectifiers, with one taking over as the previous tube reached cutoff. By virtue of careful selection of tubes and individual circuit adjustments to fit the tubes a wide range of levels could be covered. On the other

**Audio Instrument Co., 1947 Broadway, New York 23, N. Y.*

hand, the accuracy of result depended entirely on tube characteristics, so that a change in tubes had to be accompanied by considerable testing and adjusting.

Another method of *indicating* in db is to feed the amplified and rectified signal to a d'Arsonval meter movement whose distribution of magnetic flux in the air gap is non-uniform, as shown in *Fig.* 2. this can be achieved by using especially shaped pole pieces, a method employed in several v-t voltmeters. The scale law can be followed exactly, but a 20 db range seems to be the maximum obtainable. This construction has been used for indicating meters, but not for recording meters, due to practical difficulties. A meter movement of this type is satisfactory for steady signals, but not for transients such as reverberation, speech, music, or noise, because the damping factor changes with meter reading. At the lower part of the scale, the movement is overdamped and very sluggish; at the upper part of the scale the damping is insufficient and the pointer will overshoot badly. On program material a reading taken at the top of the scale will fail to check one taken with another multiplier setting at the bottom of the meter scale by as much as five to ten db, a good indication of the possible error.

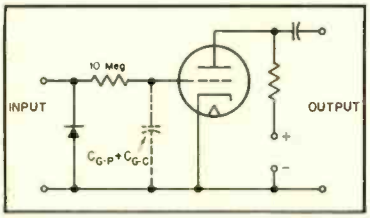


Fig. 3. Circuit using Maxwellian distribution of emission velocity for logarithmic amplification.

Another method that crops up periodically, involves the use of the Maxwellian energy distribution of vacuum tube electron emission. A resistance of ten megohms is placed in series with the control grid (*Fig.* 3) and the input signal of the logarithmic tube is rectified so that the grid is driven only positive. Considerable effort was spent on this old idea, only to abandon it finally for these reasons:

1. The linearity of the logarithmic relation is only approximate; the curvature is enough to require a special meter scale.

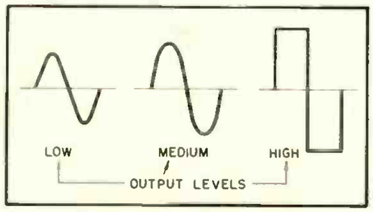


Fig. 4. Output waveform of logarithmic circuit at various output voltages with sine wave input.

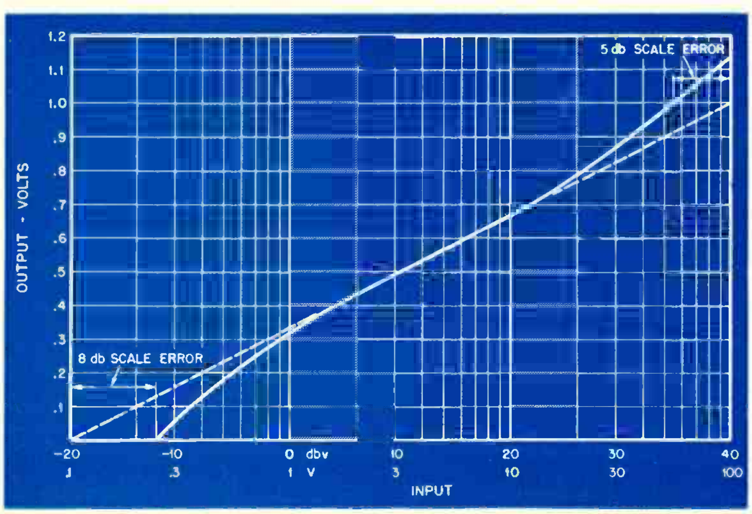
2. To achieve this slightly curved relation over even a moderately wide db range calls for the use of a very large grid resistance—of the order of ten megohms—and hence about three hundred volts driving voltage. To secure this undistorted output from an amplifier stage takes rather special design or high plate voltage.

3. The high grid resistance combines with the grid capacitance of the tube to form a low-pass network which greatly attenuates the higher frequencies. For example, an attenuation of 3 db is reached at only 1000 cps, and it increases rapidly above that frequency. If this happens in the indicating vacuum tube voltmeter, it is not serious; but if we try to use such log circuit to feed an external a.c. oscillograph-amplifier, the attenuation is excessive.

4. The input-output curve changes rapidly with small changes in tube heater voltage, and careful stabilizing is necessary.

On these grounds it was felt necessary to abandon the method, and look for another.

Fig. 5. Error produced by slight curvature in logarithmic relation.



Logarithmic Materials

The preferred method is to use a material whose resistivity varies inversely with the current through it. The preferred relation is $E = K \log I$, where E is the voltage drop across the material, I is the current through it, and k is a constant which depends on the dimensions of the material and its specific resistance at a given current.

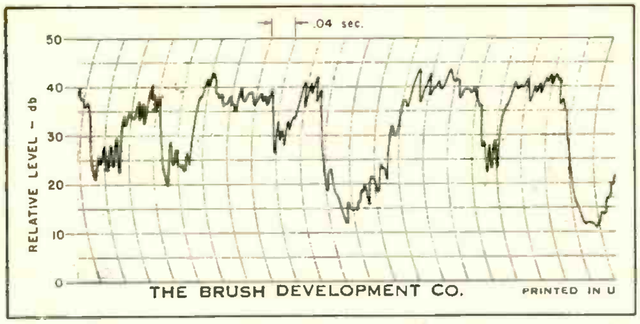
Since d.c. amplifiers are a nuisance, it is highly desirable that the material be usable in small cross-section, so that the shunt capacitance will not be high enough to prevent its use on a.c. if desired. Incidentally, any logarithmic material distorts the waveform, for it takes the logarithm of the input voltage instantaneously throughout the voltage cycle. The distortion varies with input; at low input the wave appears semicircular, as shown in *Fig.* 4, whereas at high input the wave becomes practically square.

When we come to study materials, we find that many semi-conductors have logarithmic characteristics, with great differences in the range over which they exhibit the effect accurately. In the worst materials the log range will barely cover 10 db; in the best it will extend over 50 to 70 db. Some varieties of copper oxide and silicon carbide show interesting properties in this respect.

It is desirable to adjust the circuit characteristics so that the log relation is followed perfectly. A slightly curved characteristic (*Fig.* 5) will require a hand drawn meter scale, or result in an error of as much as 5 db if a linear scale meter is used.

Operating Conditions

When using a perfectly logarithmic material, the relation $E = K \log I$ requires that the circuit be such that the current is not significantly affected by the varying resistance of the material. A series resistor must be used, with a value which is high compared to the resistance of the log material at the minimum working voltage. If



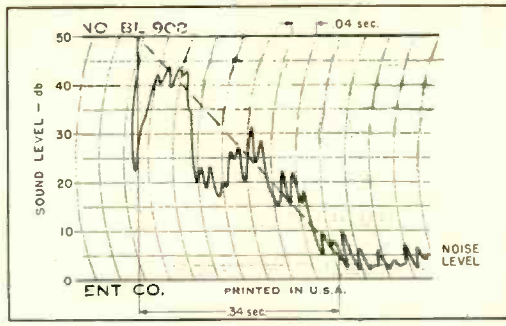


Fig. 6 (left). Oscillogram of radio program, showing ease of observing range of levels covered. Fig. 7 (right). Acoustical decay curve, with dotted line showing mean slope of sound level from maximum to noise. Time indicated (.34 sec) represents drop of 40 db, but reverberation time is based on drop of 60 db. Thus, reverberation time is 0.51 sec.

carried too far, this leads to extremely high circuit loss, and a series resistance which is so high that stray capacitance has some effect at the higher frequencies.

Rather than use excessive series resistance, the characteristic may be linearized at small inputs by applying suitable bias. The bias voltage should be accurately stabilized, for too much bias is as bad as too little.

Using the Logarithmic Effect

In using a logarithmic circuit a number of problems must be overcome to retain the accuracy of the relation. These revolve around the input amplifier, the output circuit, the meter circuit, and use with external oscillographs.

Any amplifier used between the voltage to be measured and the logarithmic circuit must be extremely linear in its input-output voltage relation over the complete working voltage range, or the overall log-law conformance is injured. When we ask instrument linearity of an amplifier circuit over a 40 or 50 db range, we call for rather high grade design. It is simply not possible to take *any* amplifier off the shelf, and expect it to fulfill the linearity requirement; an amplifier of instrument quality is called for. Commercially, this practically compels combining log circuit and input amplifier in a single unit.

If an external circuit is to be fed from the output of the log circuit, an isolating amplifier must be used to avoid shunting the log output with a load and injuring its accuracy. This amplifier must be linear over the full voltage range, or the log accuracy is destroyed. More difficult yet, it must be done over a wide frequency range, for the output of the log circuit is a square wave. If the fundamental frequency is 15 kc, then the output amplifier should be good up to 100 or 150 kc.

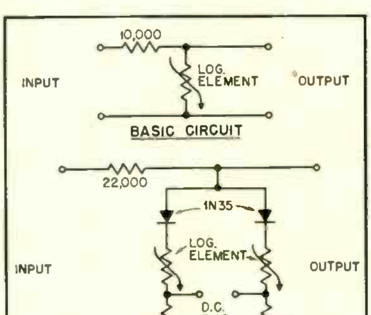
Finally, the voltmeter which measures the output of the log circuit must be of the vacuum-tube type, to avoid loading, and must be of wide frequency range to retain accuracy as the waveform changes with level.

The wide range of system levels to be handled imposes strict requirements on circuit noise. For example, a logarithmic meter designed for a 50 db range, and with a full scale sensitivity of one-tenth of a volt, reads a voltage of 70 db below one volt, or approximately —68 dbm in a 600-ohm circuit, at the lowest part of the scale. This will show up poor filtering or unremoved line fluctuation in very strong fashion. Again, we find it expedient to build input amplifier and log circuit as a unit.

Use with Oscilloscopes and Oscillographs

In view of the wide frequency range and instantaneous action of a properly designed log circuit it may be desirable to feed its output into an indicator with faster response than that of even a good volume-indicator meter. Since the log circuit output amplifier delivers a.c., it may be fed into a standard cathode-ray oscillograph to read instantaneous peaks visually, or to be photographed on a moving film.

Fig. 8 Bias circuit for logarithmic element.



If the material is not varying at so rapid a rate that a cathode ray oscillograph is necessary to follow the variation, the much more convenient direct writing oscillograph is available. At least a half dozen manufacturers can supply these units, which can follow a sine wave of up to 100 or 200 cps with good fidelity. They can therefore follow a signal variation within .01 seconds with ease, and write the result directly on a paper chart. If program level is to be followed, the signal may be rectified and applied to the oscillograph galvanometer. The same method may be used when recording acoustical reverberation curves. The recording speed can be reduced by shunting a capacitor across the galvanometer coil if it is desired to match the speed of a VU meter for program recording or similar purposes. *Figures* 6 and 7 show examples of log amplifier applications with two types of measured sound levels.

There is an intermediate class of recording where the speed of the direct-writer is too low, and the speed of the cathode ray tube is not necessary. For such work photographic recording oscillographs of the Duddell type are made by a number of manufacturers, recording up to 10 kc, on film or paper of any length from a few inches to hundreds of feet.

Both direct-writer and Duddell type oscillograph are inherently fairly linear, and a logarithmic circuit is necessary to enable them to record any phenomenon varying over a wide range of amplitude. Incidentally, the same log action will protect the oscillograph or indicating meter from violent overloads, for when a strong signal has passed through the log circuit, the galvanometer sees not the overload, but the logarithm of it. Thus a ten-fold signal overload becomes a two-fold ratio at the output of the log circuit, and a hundred-fold signal overload becomes

[*Continued on page 45*]

Problems in Audio Engineering

LEWIS S. GOODFRIEND*

Part V. A study of sound generators.

Any study of sound must necessarily include a study of the principles involved in the generation of sound whether from an original source, or as a reproduction by means of some form of electro-acoustical transducer, such as a loudspeaker. In the previous article, considerable space was devoted to the wave equation and to its derivation, and before continuing further it is desirable to derive the simplified equation for the intensity of a sound wave as an illustration of the mathematical methods used. The general form of the equation for intensity is

$$I = \frac{2\pi^2 \rho_s c^3 a^2}{\lambda^2}.$$

Multiplying the numerator and denominator by c/c—which is equivalent to multiplying by 1—gives

$$I = \frac{2\pi^2 \rho_s c^3 a^2}{\lambda^2} \times \frac{c}{c} = \frac{2\pi^2 \rho_s c^4 a^2}{\lambda^2 c}$$

Then, by substituting $P_s\gamma/\rho_s$ for c^2 in the numerator,

$$I = \frac{2\pi^2 \rho_s P_s^2 \gamma^2 a^2}{\lambda^2 c \rho_s^2}$$

The terms may now be rearranged, giving

$$I = \left[\frac{P_s^2 \gamma^2 2\pi^2 a^2}{\lambda^2} \right] \frac{1}{\rho_s c}$$

The part in the brackets is equal to the effective sound pressure P. We now have a simplified form of the equation for intensity expressed in terms of two constants for the medium—density and wave velocity—and the effective sound pressure

$$I = \frac{P}{\rho_s c}$$

Returning now to the radiation from a plane piston in an infinite wall, let us compare the radiation pattern for the piston to that for an ideal point source. It will then be possible to examine the pattern for the loudspeaker. While the radiation from a plane circular piston in a wall is almost identical with that from a point source, actually there are several differences in the respective radiation patterns. However, these differences are small at long distances from the piston and at low frequencies, as shown in *Fig.* 1. If the wavelength of the sound being radiated is less than four times the diameter of the piston, the pattern narrows down and the intensity along the axis perpendicular to the center of the piston is much greater than at an angle off to one side. For the case of the loudspeaker it will be noted that the curve shown in *Fig.* 2 is similar, with the loss at 90° being about double that for the piston of the same diameter. This is the result of a conical surface radiator in the loudspeaker and the fact that the cone is not absolutely rigid. However, in working problems in sound distribution it is not illogical to assume that the loudspeaker will behave as a plane piston, and for a rough estimate of the distribution at low frequencies, the point source treatment may be used. The computation of the high frequency case is not simple, and the published curves for the distribution of sound from pistons are of great value here. In order to overcome the normal concentration of sound along the axis at high frequencies,

*Rangertone, Inc., 73 Winthrop St., Newark 4, N. J.

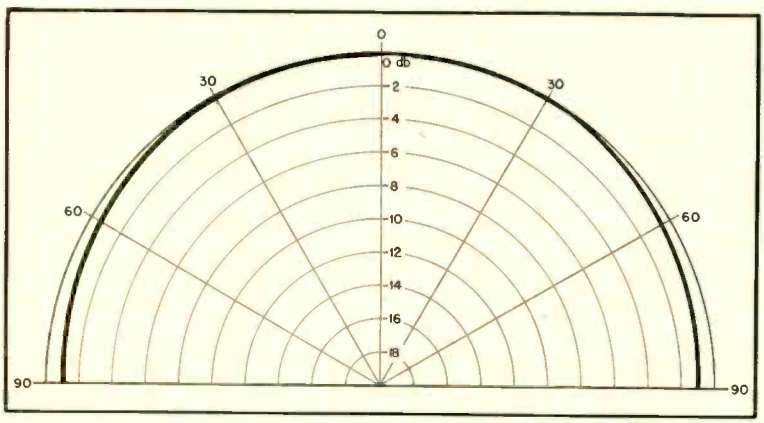


Fig. 1 (above). Polar pressure radiation pattern for a plane circular piston in an infinite wall. The piston is small compared to a wavelength and the pressure was measured at a long distance from the piston.

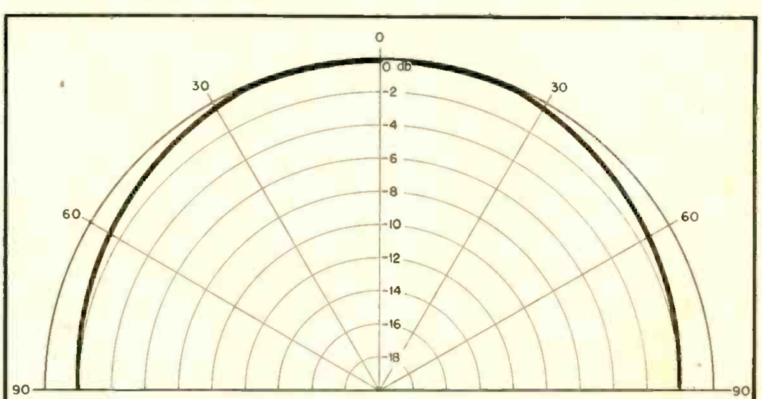


Fig. 2 (right). Polar pressure radiation for a loudspeaker in an infinite baffle. The diameter of the speaker is small compared to a wavelength.

audio engineers use multicellular horns or directing vanes which help to distribute the energy more evenly. In addition it is known that a good low-frequency unit is seldom efficient as a high-frequency reproducer. Therefore, a separate high frequency horn designed to have a high efficiency and good distribution pattern is not a whim of the manufacturer or the theoretician, but the logical solution to two problems.

Acoustical Dipole

If there are two point sources of sound spaced by an infinitesimal distance and radiating 180° out of phase, we have what is known as a dipole or doublet source of sound. For purposes of analysis it is also possible to use a small spherical source, but instead of pulsating, as in the case of the point source, the sphere oscillates back and forth. The radiation from a dipole is not uniform in all directions, but is maximum along the axis through the two points or on the axis along which the oscillating sphere moves, *Fig.* 3.

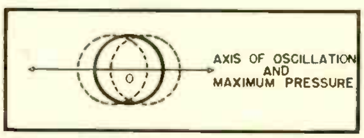


Fig. 3. The oscillating sphere moves transversely along the axis, which is also the axis of maximum pressure.

This is the case of the loudspeaker when not in a baffle of any kind. The equations for the radiation from the point source and the dipole differ in one important respect. Radiation from a point source varies directly with the square of the frequency, and that from the dipole varies as the fourth power of the frequency. This means that the low-frequency response of a loudspeaker outside of a baffle drops much more rapidly than that of a speaker in a baffle.

The phenomenon associated with a point source can also be associated with a loudspeaker in an infinite baffle or a wall. However, if the speaker is in a finite square, flat baffle there will be some frequency at which the wavelength of sound is long enough so that the sound diffracted around the edges of the baffle travels one wavelength before reaching the front of the cone. At this frequency, destructive interference (cancellation) will result. Below this frequency the system acts in a manner similar to a dipole source, while above, it will act in a manner similar to a point source. Further information on this subject will be found in the references. Although there are other types of sound sources, they will not be dealt with here, as they enter into audio only in the design of special instruments.

Mechanical Vibration and Sound Generators

Having examined the various forms of radiation most common in the audio field, let us turn our attention to the generation of sound waves by considering the application of some perturbing force to strings, pipes and plates. It shall be assumed that the reader is familiar with some of the fundamentals of physics or will consult a physics text. The generation of harmonic oscillations may be studied by taking an ideal, frictionless case of the simplest mechanical vibrating system, a spring and a weight, *Fig.* 4. The spring is fastened at one end to a wall, at the other end to a ball which rolls on a perfect bearing. It is found from physics that if the weight is pushed toward the wall and then released it will oscillate back and forth, and the frequency of oscillation is dependent only on the mass of the weight and the stiffness or compliance of the spring. (Stiffness k is the reciprocal of compliance C.) The equation for frequency is

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

where k = stiffness in dynes per cm.
m = mass in grams.

This frequency is called the natural frequency of vibration of the system, and as defined by the Proposed American Standard is "a frequency of free oscillation." In other words, the natural frequency is the frequency of vibration of any system which is excited by a small perturbing force which is then removed. For the practical case of a plucked string the natural frequency may be the fundamental or any harmonic, the fundamental being expressed as

$$f = \frac{1}{2l}\sqrt{\frac{T}{m}}$$

where f = fundamental resonant frequency in cps.
l = length of the string between supports in cm.
T = tension along the string in dynes.
m = mass per unit length in grams.

If a sinusoidal driving force is now applied to either the string system or the weight-spring system at the resonant frequency and in phase, standing waves are set up in the system. Actually the term "standing wave" comes from the case of a wave that is transmitted down a string, pipe or bar, and is reflected so as to reinforce the next wave coming from the transmitting end. When standing waves are set up in a vibrating system the amplitude of the vibrations is likely to increase, being limited by either the resistance forces within the system or the amplitude at which the system will destroy itself.

When the string is excited at some frequency other than the fundamental it will produce the fundamental and the harmonically related overtones up to and including the exciting frequency, and some of the higher overtones. In musical instruments it is phases and relative intensities of these overtones, in addition to the sound box amplifier, that greatly affect the quality or timbre of the instrument. Without any sort of sound box the note from the string would be almost inaudible.

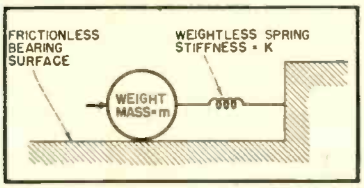


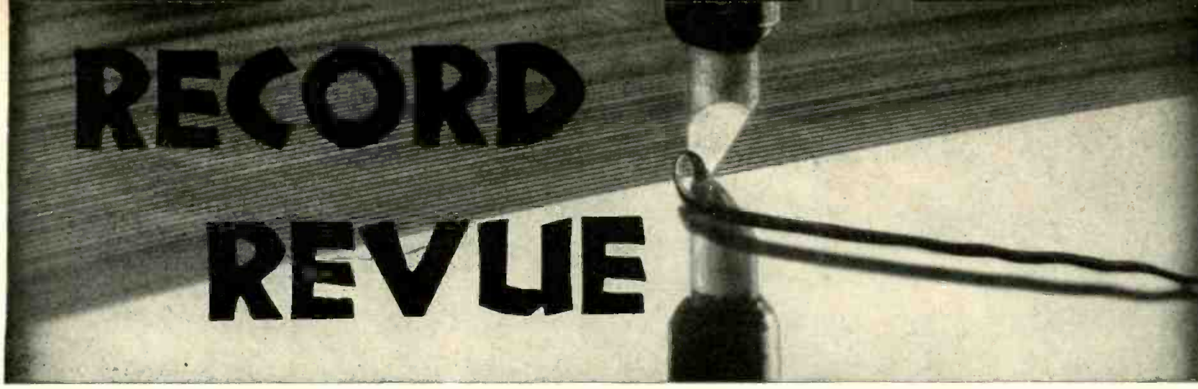
Fig. 4. The ideal, frictionless, case of a weight and a spring fastened to a rigid wall.

Air Column Generator

The next generator to be examined is the air column. Fundamentally the air column is not a sound generator, but a resonator for the sound made by a vibrating reed, double reed, or edge tone. Organ pipes, clarinets, trumpets and trombones are a few of the instruments that use this method to produce amplification of the sound generated by one of the three methods named. The usual example—the organ pipe—will be discussed here. When a sound wave travels the length of a tube which is terminated by a closed end, it is reflected back to the other end of the tube. If the wavelength of the sound is equal to four times the length of the tube (the tube is then said to be a quarter-wavelength long) the wave will be reflected back to the transmitting end in the correct phase to reinforce the original wave and we have the case of a standing wave in a tube. It is also possible to have a standing wave in the tube for any wavelength whose frequency is an odd multiple of the fundamental frequency.

In the case of the pipe with the far end open, standing waves will exist at a frequency whose wavelength is twice the length of the pipe or at any multiple of this frequency. Therefore it may be stated that the tone produced by a closed pipe will contain only the odd harmonics of the fundamental while the tone of an open pipe will contain all the harmonics.

[*Continued on page 46*]



EDWARD TATNALL CANBY*

MY HONORED FATHER, who is a great story teller (the kind of story that grows about 27 per cent at each telling) accidentally got me started on a bit of random speculation, which will be elaborated herewith. His story was about the nice old gentleman who was a bit harder of hearing than he quite realized. He was finally persuaded to acquire one of those new streamlined hearing aids. It worked too, and he found himself catching things he hadn't for years. Didn't like the gadget too much, though. "Trouble is," he said, "I come up to meet these nice young women and all I keep hearing is their tummies rumbling."

The more humorless among us may want to question that on strictly scientific grounds—but the fact is that hearing aids are bound to give a slightly distorted ear-view of the wearer's surroundings. Not only the usual forms of electronic distortion, if any, or amplitude distortion (unnatural volume, as the hearer receives it in the brain; or perhaps a sound inadequately compensated for the peculiar curve of the ailing ear—cf. AUDIO ENGINEERING, *July* 1949) but—and this is my point of departure—a hearing aid is a monaural device. That constitutes the most enormous distortion of normal hearing that I can imagine.

Now I haven't consulted anybody about this little idea and so if perhaps the hearing aid industry has long since gone into the problem, my immediate apologies. I am sure that the rest of us, in any case, have seldom if ever thought of it. And I have yet to lay eyes or ears upon a dual hearing aid, which is what I'm wondering about. A two-channel, two-miked, two-eared device that would give a good approximation of binaural, i.e. normal, hearing.

Ever since, in casually wondering about binaural problems in the recording of music, I hooked up a hand mike through an amplifier to one of those huge, padded earphone sets (surplus from Army tanks), then walked about my quarters, making ordinary noises like footsteps, tapping things, rattling china, the mike acting as my ear, I've been having monaural nightmares. The shock of this "monaural" hearing (actually, both ears were hearing, but both heard exactly the same sounds) substituted directly for the binaural, was hardly believable. As has been pointed out here before, the most immediate apparent effect of the substitution of monaural for binaural hearing is an enormous increase of liveness. (Hence the dead radio studio, to compensate.) An ordinary apartment kitchen in operation—with water running, pots and pans clanking slightly and the like—sounds with this set-up as though it were operating in one corner of an all-tile indoor swimming pool! Tap two pot handles together and the echoes resound—this in a room that a moment before had seemed perfectly "normal" to your two ears. Dangle yourself and mike out the window, on a busy city street, and you hear the most astonishingly cavernous sound, as though your home opened directly into Mammoth Cave, somehow equipped with busses and trolley cars. A few moments with this experiment, which I advise all recording enthusiasts to try, will teach more of the difference between monaural and binaural sound than a month of Sunday reading.

Unfortunately, I still have my hearing. It was reasonably normal, at least, at the 1939 World's Fair testing station. I haven't tried a hearing aid. Don't actually know how it sounds, to the deaf. Any sound is a lot better than no sound. But even so, I can now imagine some of the effects that the deaf may have to get used to, monaurally! I can see that deafness in only one ear might be compensated for, so that the two ears were again working in a reasonably normal manner, so to speak. I can also see that a binaural effect would be out if one ear were entirely gone.

Since I am speculating high, I'll by-pass the slight matter of convenience—of having to wear a button in each ear—with the philosophical reflection that after all you can only look at one side of a person at a time. Might look a bit silly, I admit, to be found equipped on both sides. People no doubt would ask you whether one was for hearing to the right and one to the left, and why not one on the forehead for straight ahead. It would be like wearing socks of different colors or a wrist watch on each arm. People might stare. But with all this, *if a binaural aid worked*, if it gave better hearing, I'm betting some brave souls would try it, and memorize a convenient spiel to explain a hundred times a day what "monaural" means.

My speculation, entirely untested, is that a binaural aid, with two complete channels, each adjusted and compensated to match its particular ear, a common, locked-together volume control that would maintain the loudness relation between the two (*loudness*, not intensity) might give an extraordinarily satisfactory sound compared with any known monaural aid, working by itself. Details would be quite tricky and, no doubt, results would vary greatly with the type of deafness, as already noted. Still . . . what say?

Another point that, indirectly, led me to all of this is the great difficulty with any other type of binaural sound set-up, the necessity for separation of the two sound channels so that each goes only to one ear and there are no leaks to the other ear. The only satisfactory way of doing this in any sort of reproduction is to use earphones. A system where open speakers are set up at some point away from you is bound to introduce a very large leakage, both ears hearing a good slice of both channels, the listener then quite literally not knowing his left from his right. Worse, there are problems of phasing, since the out-of-phase arrival of sounds in the two ears has a vital part in binaural hearing. With earphones all of this is taken care of. Sounds arrive electrically at the ear itself and the phasing of the two microphone sources is preserved. The phones themselves insure separation of the two channels.

But who wants to wear earphones these days to listen to music or to watch a movie? That's going back to the first juke box, the "phonograph parlours" of the 1890's, with its dozens of snaky tubes, held to the ear. Barring some form of stereophonic sound, there is no 100 per cent solution that I can see to the problem of separation of channels except the dual 'phone—and thus what is a disadvantage for binaural reproduction becomes a fine advantage in the hearing aid, which can hardly do other than separate the two channels, exactly as desired. It's a natural.

It is to be noted that I have not so far mentioned the usual feature of any discussion of binaural hearing, the perception of direction. It is easy to think that the gain in this respect with binaural over monaural hearing is the most important noticeable factor. I assure you it is not. And particularly with the hearing aid. Unless you are blind as well as deaf, you will seldom be bothered by any acute failure of direction sense with a hearing aid, I'd guess. The tie-up between eye and ear is so sensitive and quick that binocular vision plus monaural hearing is plenty adequate. (Perhaps a one-eyed person with a monaural hearing system might get pretty balled up—but this begins, somehow, to remind me of the famous New England cows with the legs on one side shorter than on the other so they could stick to the hillsides. Traffic of course, always moved to the right.) No, direction perception is a secondary matter as one consciously compares one-eared and two-eared hearing. True, the physical basis of all that happens is in the last analysis a matter of direction perception. But *as we hear the sound*, the conscious effect of mon-

[*Continued on page 36*]

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

AUDIO engineering society

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

Audio Engineering Society, Box F, Oceanside, N. Y.

OFFICERS
C. J. LeBel, President
C. A. Rackey........Executive Vice-Pres.
John T. Mullin.........Western Vice-Pres.
Norman C. Pickering...........Secretary
Ralph A. Schlegel...................Treasurer

CONVENTION HIGHLIGHTS

A program of considerable interest is being planned for the technical sessions of The Audio Fair, which will be sponsored by the Society for presentation at the Hotel New Yorker in New York October 27, 28, and 29.

Highlighting the many papers to be given will be a session on magnetic recording which will consider the experience which has been gained during recent years in the relatively new recording medium. Authorities in the field will discuss several phases of the art with particular stress on problems which have been encountered and applications to which magnetic recording has been successfully adapted.

The present status of magnetic recording standards will be reviewed, particularly as regards interchangeability and uniformity of performance, to be followed by a summary of present standards. In another paper, the effect of the lack of adherence to standards already set up and resultant problems will be aired.

Speed regulation in magnetic recording will be discussed from the standpoints of both timing and flutter, or average and instantaneous speed. The type of drives now in use and projected are to be considered.

In addition to rounding out the program with a presentation of methods of duplicating magnetic tapes, other papers on new magnetic developments are planned.

At another session a symposium on audio testing methods is to be held, with both equipments and methods of operation to be described. Among the factors to be discussed by a panel of experts will be frequency characteristics and harmonics, intermodulation and cross-modulation measurements, and methods of measuring transient response means of pulses and square waves.

The exhibits of manufacturers at The Audio Fair promise to cover the entire field of audio equipment, with the roster resembling a listing of the major manufacturers.

Audio Fair Stresses Sight and Sound Demonstrations

No exhibit of audio equipment can be complete without giving the visitors an opportunity of *hearing* the equipment, in addition to that of seeing it and observing its operation. For this reason, The Audio Fair was conceived as a solution to this need, and the method of presenting the exhibits has been lauded by both manufacturers and engineers alike.

Departing completely from the more usual form of exhibit which consists of many booths in an auditorium, The Audio Fair is to be held on a single floor of the Hotel New Yorker, with exhibitors having separate rooms in which to show and demonstrate their equipment. The entire sixth floor of the hotel is to be devoted to the exhibits, and those attending will actually be able to hear the equipment being shown.

Banquet Features Loudspeaker Comparisons

The principal feature of the banquet of the Society, to be held on the evening of October 28, during the convention, is a comparative demonstration of loudspeakers presented in true "A-B" fashion. Using high-quality magnetic tape with live recorded programs involving classical and popular orchestral, piano, vocal, and speech sections, and using the same amplifier equipment throughout for each test, the speakers on exhibition will be demonstrated one by one for the edification of those who attend the banquet.

Each person attending will be given a card on which the various loudspeakers will be listed by an identifying letter. This card will provide columns for each type of program material, and the listener may score the performance as the speakers are demonstrated. Following the tests, the listeners will be informed as to which speakers are designated by the letters, thus giving the listener an opportunity to arrive at his own opinion in an unbiased manner. Since the demonstration is solely for the entertainment of the listeners, the score cards will not be collected. Consequently the test cannot be considered a sampling of listener preferences.

The banquet will also feature the installation of newly elected officers, who will begin officially their 1949-50 year of duties in the Society.

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 AES Editor before the tenth of the month preceding the date of issue. Address replies to AES Editor, Audio Engineering, 342 Madison Ave., New York 17, N. Y.

- **Technical Public Relations man,** with wide experience in publicity, brochure production, press relations, etc., especially in audio work. College graduate, 30, married, presently employed. Will consider part-time employment. Box 91.
- **Audio Engineer,** with manufacturing, design, development experience in disc, film, and magnetic recording and reproduction and in sales engineering for recording equipment desires to change present position, held 10 years. Age 33, married, university graduate in engineering. Prefer New York area, but willing to travel. Box 92.
- **Audio Engineer,** BSEE 1936. Section head at govt lab; 8 years applied research, analysis, and development in electronics, electro-acoustics, sound recording and reproduction. Desire position in private industry in audio or electronics, northeast preferred. Age 33, married. Box 93.
- **Music Engineer.** Grad. RCA Institutes; MA in Music (Harvard). Excellent background in audio and music. Seeking position requiring coordination of technical and musical considerations. Highest references. Available Sept. 6. Box 94.
- **Engineering Student Graduate.** Trained in audio amplifier and circuit design. Interested in audio-video amplifier and test equipment design. Box 95.
- **Engineering Trainee.** RCA Institutes graduate, Age 25. Recording, amplifier, and transducer interests. Machine shop experience. Box 96.
- **Recording Engineer.** 10 years exp. recording, maintenance, disc and tape. Good mixer, available after 2 p.m. daily, all day Saturday or Sunday. Box 97.

Lateral Feedback Disc Recorder

G. R. YENZER*

How proper use of feedback improves lateral-type recorders.

THE VERTICAL-TYPE FEEDBACK RECORDER introduced in the electrical transcription field about 1938[1] made possible vertical recordings of wider frequency range with reduced distortion and provided a higher degree of uniformity among recorders. This paper describes the W.E. 2A Lateral Recorder, developed around the same general feedback principles as the corresponding vertical feedback cutter.

Although the principles involved are the same for both types, the lateral development presented an entirely new set of problems. For example, in the vertical unit the generated forces are chiefly compressive and tensional and are transmitted from the driving coil to the stylus by means of a thin cone, while in the lateral recorder the member which connects the drive coil to the stylus is subject to forces in shear, and as a result it was found necessary to increase its thickness thirty-fold in order to eliminate spurious vibrations. As will be seen later, it is imperative that the vibrations which are produced by the generated forces be constrained to the mode for which they are intended.

The requirements for an ideal recorder include not only uniform response and low distortion through the audible frequency range, but also the ability to maintain its performance for long periods of time despite temperature and humidity variations and regardless of whether the recording medium is the softest wax or the most resistant lacquer. It can be demonstrated that proper application of the feedback principle to a recorder element will achieve these objectives.

*Bell Telephone Laboratories, Inc., Murray Hill, N. J.

[1]Recent Developments in Hill and Dale Recorders, by C. F. Wiebusch and L. Vieth. *SMPE Journal*, Jan., 1938.

Theory

Assume the recorder element to consist of a vertical member attached to a fixed support by a reed hinge and carrying a recording stylus at its free end (*Figure* 1). The element can be vibrated by means of an attached driving coil as in the dynamic-type loudspeaker. Motion of the element induces a voltage in a second (feedback) coil which is proportional to the velocity of the motion, as in a moving-coil reproducer. The recorder is connected to an amplifier system as shown, the object being to move the cutting stylus with a vibrational velocity V whose wave shape is an exact replica of the wave shape of a signal voltage E.

A general expression for the relation between stylus velocity and signal voltage in an electromechanical feedback recorder system has been previously developed.[1] It is desirable to repeat its derivation here, with the terminology applied specifically to the lateral unit. Let

E = signal voltage
E_2 = output voltage of A-circuit amplifier
V = stylus velocity (inches per second)
E_3 = voltage generated by the feedback coil
E_4 = voltage output of the B-circuit amplifier
$E_1 = E + E_4$ = voltage input to A circuit amplifier (1)

All of the above are complex quantities. Let

$$A = \frac{E_2}{E_1} \times \frac{V}{E_2} = \frac{V}{E_1} \quad (2)$$

and

$$B = \frac{E_3}{V} \times \frac{E_4}{E_3} = \frac{E_4}{V} \quad (3)$$

where E_2/E_1 and E_4/E_3 are the voltage gains of the A-circuit amplifier and the B-circuit amplifier, respectively, and V/E_2 and E_3/V are respectively the electromechanical transducer conversion factors of the drive coil and the feedback coil. Therefore,

$$AB = \frac{E_4}{E_1} \quad (4)$$

The product AB thus defines the transmission around the loop formed by the A-circuit amplifier, recorder, and B-circuit amplifier. Substituting the value of E_4 from this equation in (1), we find

$$E_1 = E \frac{1}{1-AB} \quad (5)$$

which, with equation (2), gives

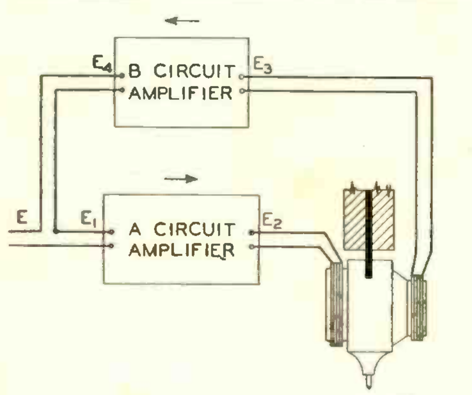
$$V = E_1 A = E \frac{A}{1-AB} \quad (6)$$

Equation (6) thus determines the behavior of the system (stylus velocity vs. frequency and phase shift vs. frequency) when A and B are known. In particular, when AB is large compared to unity, the condition usually present in the recorder, equation (6) becomes

$$V = \frac{1}{-B} E \quad (AB \gg 1) \quad (7)$$

which indicates that under this condition the velocity depends only on the signal input E and the factor $1/B$ which can be made very nearly constant.

[Equation (3) shows B to consist of two factors E_3/V and E_4/E_3. For the former to remain constant and independent of the amplitude and frequency of signal voltage E, the feedback coil must meet three conditions: It must be rigidly coupled to the stylus; it must vibrate in a uniform magnetic field; and it must be unaffected by the magnetic field set up by currents in the drive coil. The other factor to be maintained constant, E_4/E_3, represents the



$$E_1 = E + E_4 \quad (1)$$

$$A = \frac{E_2}{E_1} \times \frac{V}{E_2} = \frac{V}{E_1} \quad (2)$$

$$B = \frac{E_3}{V} \times \frac{E_4}{E_3} = \frac{E_4}{V} \quad (3)$$

$$AB = \frac{E_4}{E_1} \quad (4)$$

$$E_1 = E \frac{1}{1-AB} \quad (5)$$

$$V = E_1 A = E \frac{A}{1-AB} \quad (6)$$

$$V = \frac{1}{-B} E \quad (AB \gg 1) \quad (7)$$

$$V = E \frac{A}{1-AB} + \frac{n}{1-AB} + \frac{d}{1-AB} \quad (8)$$

Fig. 1. Electromechanical feedback system.

voltage gain of an amplifier working at low level and presents no problem. It should be noted that these factors, which are responsible for the benefits accruing to the use of feedback, when once embodied in a physical recorder are inherently stable, and consequently the performance of the system should remain fixed over long periods of time.]

If equation (6) is rewritten to include noise and distortion products as well as signal, it becomes

$$V = E\frac{A}{1-AB} + \frac{n}{1-AB} + \frac{d}{1-AB} \quad (8)$$

where n and d are the noise and distortion, respectively, introduced in the amplifier and recorder without feedback. Hence, when AB is large compared to unity, a considerable reduction in noise and distortion is effected. Other forces acting upon the stylus during recording (such as those produced by the turbulent air of suction and blowing equipment and reaction forces due to the mass, stiffness and resistance of the recording medium) may be considered as noise or distortion, and their effect is reduced in like manner when AB is large.

Unfortunately, these benefits are obtained only with precision in design and manufacture. Examination of equation (6) reveals that if at any frequency the quantity AB becomes equal to $1 + j0$, the denominator becomes zero and the system will sing or oscillate. Nyquist[2] shows that for stability a polar plot of $|AB| \angle \theta$ and its conjugate from zero to infinite frequency must not enclose the point $1 \angle 0$. Bode[3] estimates that for each 10 db of feedback in the useful range one octave must be added to the actual range which must be explored and controlled to insure stability. He aptly describes the limitation as tantalizing—"In typical designs the AB characteristic is always satisfactory except for one little point. When the engineer changes the circuit to correct that point, however, difficulties appear somewhere else, and so on *ad infinitum*. The solution is always just around the corner." This frustration is magnified when a mechanical element possessing both mass and stiffness is added to Bode's circuit. A moment's reflection will prove that this is true, for only at the frequency for which the mass reactance is equal to the stiffness reactance will the driving force be in phase with the stylus velocity. As the frequency is reduced, the stiffness reactance increases and the phase between driving force and velocity approaches -90°

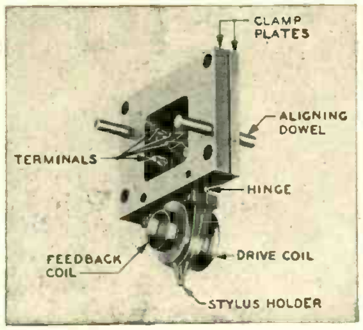


Fig. 2. View of vibrating member.

Similarly, as the frequency is increased above resonance the mass reactance predominates and the phase between driving force and velocity approaches +90°. Introduction of the mechanical element has therefore augmented the original phase shift by 180°.

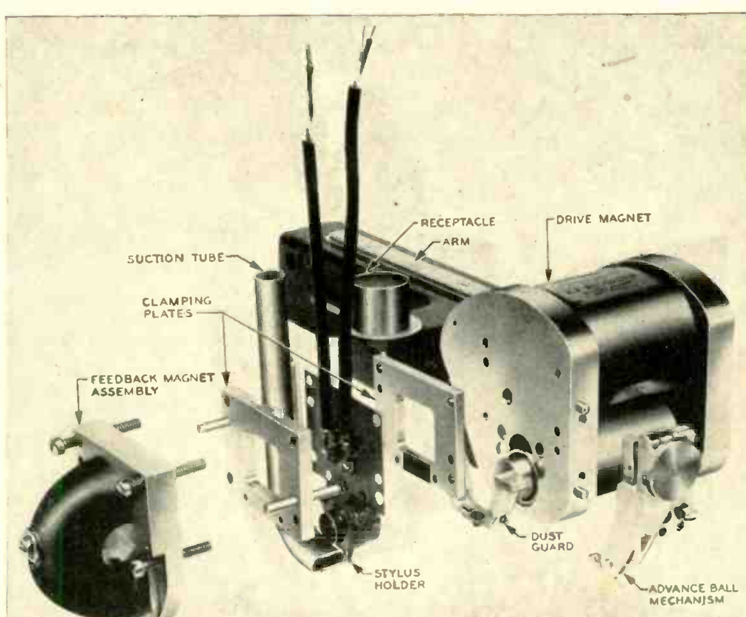
Actually, this simple recorder element, which for convenience has been assumed to be rotating about its hinge in the plane of the paper (*Fig.* 1), will undoubtedly change its mode of vibration as the frequency is increased, and this change will further modify the phase shift. Additional trouble is likely, therefore, when all parts of the element no longer vibrate in unison or when at "one little point" in the frequency spectrum the element vibrates in either or both of the planes perpendicular to the plane of the paper, to say nothing of rotating about each of the mutually perpendicular axes. Vibrations in six distinct modes (some of which may be intercoupled) are possible, several are probable, and all affect $AB \angle \theta$.

Description

The vibrating member as finally evolved is shown in *Figure* 2. It consists of a precision casting of magnesium to which the drive coil and the feedback coil are permanently attached. At the bottom is a cylindrical cavity into which the stylus shank can be cemented and at the top is a flat spring or hinge of beryllium copper. This spring is tightly clamped between carefully lapped plates of non-magnetic stainless steel which in addition to their clamping function provide facilities for terminating the coil leads. Breakage of leads is no longer a problem since they are supported throughout their entire length on a compliant plastic apron securely cemented to the moving element. When the vibrating member is attached to the magnetic assemblies, the voice currents resulting from a voltage impressed on the drive coil produce forces which swing the member about its hinge. Due to this motion a voltage proportional to the stylus velocity is generated in the feedback coil.

Figure 3 is an exploded view of the recorder showing the assembly in greater detail. Both magnets are covered by plastic jackets to prevent accidental contact with magnetic objects which would otherwise cause the formation of secondary poles with resultant loss in flux. Precisely located dowels automatically align the gaps

Fig. 3. Exploded view of the recorder showing the assembly in detail.



[2]H. Nyquist, Regeneration Theory. *Bell Syst. Tech. J.*, Jan., 1932.
[3]H. W. Bode, Relations between Attenuation and Phase in Feedback Amplifier Design. *Bell Syst. Tech. J.*, July, 1940.

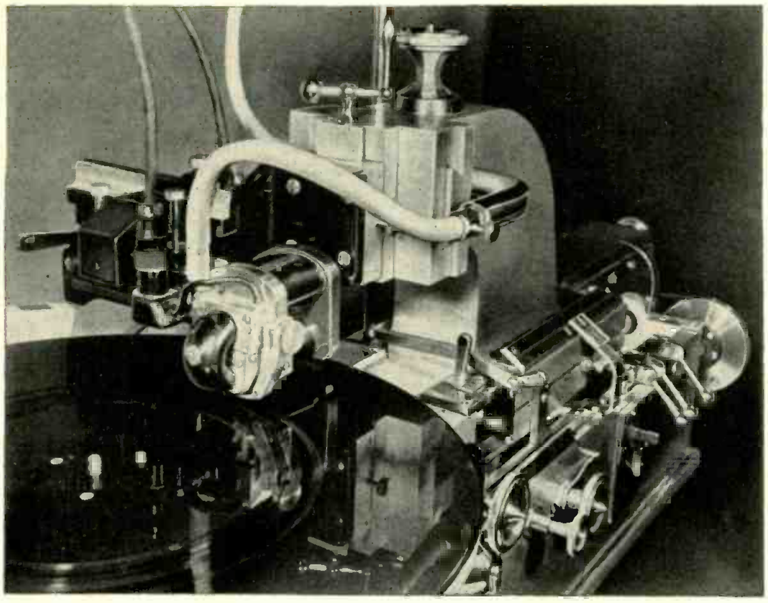


Fig. 4. Western Electric 2A recorder attached to a Scully recording lathe.

of the two magnetic assemblies with the coils of the moving element, insuring adequate and permanent clearance for the vibrating parts. Precision manufacture allows complete interchangeability of components with elimination of trouble generally associated with centering moving parts in a restricted space. After these parts have been assembled, the vibrating element is further protected against dust and magnetic particles by a transparent plastic closure assembly at the base of which is attached a flexible neoprene insert and through which the stylus holder protrudes.

The advance-ball mechanism (*Fig.* 3) is composed of two accurately machined precision castings. The assembly can be quickly positioned for either increasing or decreasing spiral. Adjustment of the depth of cut can be exactly controlled by means of a smoothly running thumb screw which can be locked in position if desired. Either a sapphire ball or a felt pad can be accommodated.

The suction tube extends above the head to allow attachment of a suction hose. It is generously proportioned and so located that it will remove wax or lacquer shavings without danger of fouling.

Figure 4 shows the recorder in operating position. Although the recorder weighs 4-3/4 pounds, the weight on the lathe is no greater than for the feedback vertical recorder, since in the new unit the usual balancing weight is replaced by an adjustable counterspring. The mass and spring values have been carefully chosen to avoid mechanical resonances when recording at either 33-1/3 or 78 rpm.

The recorder is connected to its associated amplifier by means of a cord, nominally 8 feet long, composed of two twisted pairs each individually shielded and with a different lay of the pairs to reduce electrical coupling between them to a minimum. Experimentally, substitution of a 20 foot length of cord showed no detectable deterioration in performance. Conductors, shielding, twist, fillers and braid covering have been chosen to produce a cable as flexible as is consistent with the requirements. The cord terminates in a plug in which the contacts have been sized and gauged to provide adequate contact pressure without requiring excessive pull-out force.

The amplifier with which the cutter must be used is a W. E. 115 type having a two-stage, push-pull, 15-watt, internal-feedback amplifier in the A circuit and a single push-pull stage of adjustable gain in the B circuit of *Figure* 1.

Measured Results

Frequency Distortion. Stylus velocity can be determined in several ways. Methods whereby it is calculated from observed values of amplitude and frequency are satisfactory only at low frequencies where the amplitudes are relatively large and can be measured by means of a microscope with calibrated eye-piece. Another method, that of measuring a recorded signal by means of a calibrated reproducer, is satisfactory provided care is taken to correct for all effects introduced by the reproducer itself. The optical method of Buchman-Meyer (the so-called Christmas-tree pattern) is quite popular and the results are dependable for most purposes. However, unless rather exacting precautions are taken, the pattern appears fuzzy and striated as the frequency is increased beyond 10,000 cps and therefore becomes difficult to interpret. Another method for determining stylus velocity is applicable only to the feedback cutter. The voltage E_3 generated in the feedback coil is proportional to the velocity of the coil. If the parts joining the stylus holder to the feedback coil are sufficiently rigid to prevent any relative motion, and no electrical coupling exists between the drive coil and feedback coil, voltage E_3 is also a true indication of the stylus velocity, V.

In *Fig. 5*, curves *A* and *B*, the stylus velocity was measured by the feedback coil voltage method, and in curve C the stylus velocity was determined by the Buchman-Meyer optical method.

For the feedback condition a signal voltage E of 0.5 volts applied to the input terminals produces a stylus velocity V of approximately 1" per second maximum velocity and the feedback coil voltage E_3 measures approximately 0.018 volts. The difference between curve B and curve C, starting at 7,000 cps and increasing with frequency, is the result of relative motion between stylus point and feedback coil in this frequency range caused by multiple bending of the hinge, and is responsible for the sharp dip and recovery in response in the neighborhood of 11,000 cps. One remedy has been found to be the addition of mass so distributed that the new percussive center causes no reaction at the hinge. On the other hand, to drive this increased mass would require more current and so reduce the margin against burnout and amplifier overload. The dip and recovery in response in the neighborhood of 11,000 cps has been completely eliminated in experimental models by a generous application of damping material, but the use of sizable damping pads is undesirable for several reasons: necessity for rigid shop control to insure uniformity in results, effect of temperature change, aging over long periods of time, etc. It was decided to forego the use of such "swamping" resistance and, as a result, all mechanical damping is omitted for the useful frequency band. A non-critical damping member reduces a peak in the response at approximately 40,000 cycles. This reduction decreases the phase shift by an amount which is small in itself but which provides added phase margin stability to permit recorders and amplifiers to be interchanged at will. The response at frequencies between 16,000 cps and 20,000 cps is not under the direct control of feedback action but remains fairly smooth; several sharp dips of the order of 10-15 db occur for frequencies between 20,000 cps and 40,000 cps, and definite cutoff occurs in the neighborhood of 50,000 cps, beyond which the response is more than 25 db down.

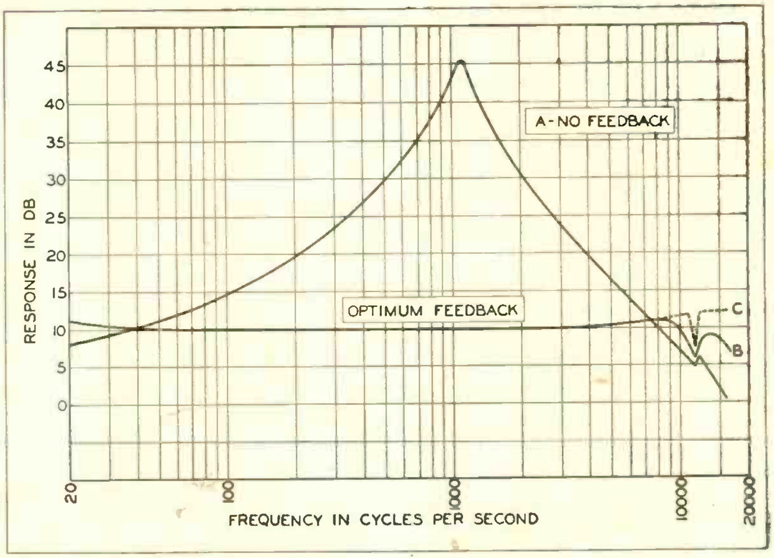


Fig. 5. Frequency response of feedback recorder.

Physical Limitations

As the recording art is practiced today, the recorded level of the low frequencies will be limited by the *amplitude* of stylus motion in order to prevent cutting into adjacent grooves, the level of medium frequencies will be limited by the *velocity* of the stylus so as to prevent the heel of the recording stylus from touching the groove wall, and the level of the high frequencies will be limited by the *acceleration* of the stylus to prevent the radius of curvature of the groove from becoming less than that of the reproducing stylus. The amplitude limitation depends upon the unmodulated groove width and the groove pitch, while the velocity and acceleration limitations are functions of the linear groove speed. *Figure* 6 shows the maximum level that can be recorded within these limitations for a pitch of 88 grooves per inch with the width of cut equal to the land between grooves, a linear groove speed of 25 inches per second (approximately 6-inch diameter at 78 rpm), and a minimum radius of curvature of .002 inch in the recorded groove. The power required of the 115• type amplifier in order to produce this maximum level recording is also shown in *Figure* 6. As a matter of fact, in actual recording the maximum level is usually made considerably lower than that shown because of tracing distortion of the reproducer.

It should be understood that the velocity curve of *Figure* 6 is not recommended as a recording characteristic but only a limit beyond which a recorder should not be required to perform. To arrive at a recording characteristic the limit curve would be modified by the energy distribution curve of the material to be recorded and by a factor which would take into account the manner in which distortion becomes more or less disagreeable with various frequency and energy combinations. This is usually determined by experience in the recording studios and is not properly a consideration in recorder design.

Occasionally, in a preliminary recording of a selection, the distributions of frequency and energy are such that the record, although of average loudness, will possess less than the usual tracing distortion. Because competition is keen among the recording companies to produce the loudest records consistent with distortion which their experience shows to be tolerable, it is common practice to make the final recording of such a selection at a higher level to effect a gain in the signal-to-noise ratio at the expense of increasing tracing distortion. For this reason, the recorder should be capable of meeting the more demanding velocity requirements of *Figure* 6 rather than the less stringent ones which result from a consideration of tracing distortion alone.

It may be argued that the maximum level curve of *Figure* 6 should be based on a linear groove speed of 20 inches per second (approximately 5-inch diameter at 78 rpm) since this speed more nearly represents the condition at the innermost grooves of most records. If this argument is accepted the margin of reserve power increases by a factor of 2.4, or 3.9 db.

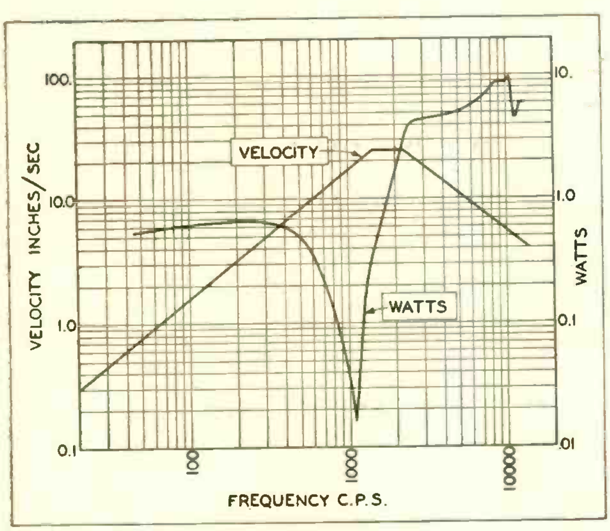


Fig. 6. Physical limitations of a recording system and power required to drive the feedback cutter.

Amplitude Distortion

The realization of a flat response curve fulfills but one requirement of an ideal recorder. Increasing importance is being attached in the audio engineering fields to amplitude distortion and intermodulation distortion. Harmonic and intermodulation measurements on disc recorders are seldom, if ever, published. For this reason, few recording men know whether a criterion of a good recorder is 5%, 10% or 20% inherent distortion. One reason for this lack of information is the difficulty of performing the measurements, the customary procedure being to cut a test record and measure the distortion generated in a reproducer when the

RECORDER USED	LOW FREQUENCY COMPONENT FREQ	AMPLITUDE	VELOCITY	HIGH FREQUENCY COMPONENT FREQ.	VELOCITY	% INTERMODULATION DISTORTION MEASURED IN OUTPUT OF W. E. 9B REPRODUCER
2A	40	.0025"	0.63"/SEC	2000	0.16"/SEC	1.0
	60	"	0.94	"	0.24	1.0
	100	"	1.57	"	0.39	1.0
W.E. D90946	40	.0025	0.63	2000	0.16	9.5
	60	"	0.94	"	0.24	9.2
	100	"	1.57	"	0.39	9.0
CONTEMPORARY	40	.0025	0.63	2000	0.16	52.0
	60	"	0.94	"	0.24	53.0
	100	"	1.57	"	0.39	52.0

MEASURED INTERMODULATION DISTORTION

TABLE I. Intermodulation measured with the aid of a reproducer.

record is played back. The measured distortion necessarily includes that of the reproducer, and if the linear velocity of the recorded groove is not sufficiently great, added distortion due to the finite size of the reproducer point (tracing distortion). Measurement of harmonic distortion is particularly difficult with a sharply tuned wave analyzer unless the turn-table has negligible wow or flutter. On the other hand, intermodulation measurements of the two-frequency modulated carrier method[4] in which the sum of the intermodulation products is indicated on a meter are not greatly affected by small changes in turn-table speed. For this reason the intermodulation method is becoming increasingly popular for measuring distortion in disc recorders. Apparatus suitable for performing these measurements is available in commercial form.[5] Table 1 shows intermodulation distortion measured in the output of a Western Electric 9B reproducer when reproducing records cut by a 2A recorder, a W.E. balanced-armature, rubber-line recorder, and another commercially available recorder (also of the balanced-armature type.) In each recording the velocity levels were so chosen that the low-frequency component fully modulated the groove of an 88 grooves per inch record in which the width of cut equaled the "land" between grooves. The velocity of the high-frequency component was then adjusted to be ¼ (—12 db) that of the low frequency. The same cutting stylus (.002" radius, 87° included angle) was used successively in each recorder. The linear velocity of each record was sufficiently large to eliminate tracing distortion in the reproducer output. It was found necessary to employ a moving-coil-type reproducer in order that the distortion introduced by the reproducer would not mask that generated in the recorder. In fairness to the third recorder, it should be mentioned that when the input was reduced 6 db the intermodulation distortion decreased to the more reasonable values of 21%, 24%, and 23%, which is probably comparable to 6% on a harmonic basis.

The limitations in measuring technique due to the inclusion of a reproducer and varying turn-table speed are eliminated by the feedback cutter provided the feedback coil voltage E_3 is a true replica of the stylus velocity V. For then the feedback coil may be considered as an ideal reproducer following the contour of the recorded wave even as the stylus is engraving it. Obviously, distortion products measured in the output E_3 of this reproducer are independent of variations in turn-table speed and contain no tracing distortion. Table II is a tabulation of intermodulation distortion products in a 2A recorder measured by this means. For each measurement in Part A the intensity of the low frequency was adjusted to produce full groove modulation as in Table I. The results of this test compare quite closely with those of the preceding method if allowance is made for the rather small distortion contributed by the reproducer in obtaining the data of Table I. Part B shows the intermodulation distortion produced by fixed frequencies at several intensities. The intermodulation test presented in Table II was repeated using 7,000 cps and then 12,000 cps in place of 2,000 cps, with almost identical results.

Effect of Record Material on Recorder Response

The use of voltage readings E_3 to measure stylus velocity and distortion also makes it possible to compare the behavior of the cutter when recording "in air" to that when recording in the most resistant lacquer medium. It is important in all types of disc recorders that this difference in behavior be made

[Continued on page 44]

MEASURED INTERMODULATION DISTORTION

A

LOW FREQUENCY COMPONENT FREQ.	AMPLITUDE	VELOCITY	HIGH FREQUENCY COMPONENT FREQ.	VELOCITY	INTERMODULATION DISTORTION PERCENT
40	.0025"	.63"/SEC.	2000	.16"/SEC	0.61
60	"	.94 *	"	.24 *	0.62 *
100	"	1.57	"	.39	0.61

B

*WITH THE ABOVE VELOCITY VALUES OF 60~ AND 2000~ AS A REFERENCE, THEIR LEVEL TO THE RECORDER WAS VARIED IN 2 DB STEPS:

INPUT TO RECORDER	INTERMODULATION (%)
-6 DB	.47
-4	.49
-2	.55
0	.62
+2	.83
+4	1.14
+6 (60~ SINGLE AMPLITUDE = .005")	1.70

TABLE II. Intermodulation measured by output voltage of the feedback coil.

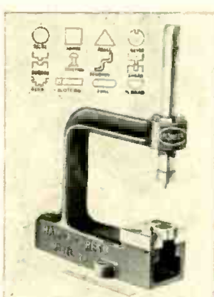
[4] Analysis and Measurement of Distortion in Variable Density Recording, by J. G. Frayne and R. R. Scoville. *SMPE Journal*, June, 1939.

[5] An Improved Intermodulation Measuring System, by G. W. Read and R. R. Scoville. *SMPE Journal*, February, 1948.

NEW PRODUCTS

• **Pioneer Ham-R-Press.** Added to its already popular line of screw-type punches, including the new square and keyed models, the Pioneer Broach Co., Dept. RA, 1424 S. Main St., Los Angeles 15, Calif. has introduced what appears to be the cleverest innovation to date in tools for the small shop or home constructor. It consists of a frame made of strong nickel alloy designed to hold a movable ram on which may be affixed a variety of punches which mate with dies seated in an opening on the work table. The punching operation is then completed by a hammer blow on the ram. A centering point eliminates the need for drilling of the chassis before punching the desired openings, and dies are available for round holes from ⅛ to 1½ in., and square and oval holes from ⅜ to ⅞ in. Practically any desired shape can be obtained by making combination cuts. The Ham-R-Press is available with throat depths of 5, 7½, 12, and 24 in. allowing for practically any size of chassis. Riveting, slotting, notching, and staking tools are listed in the literature available from the manufacturer.

• **Toroid inductors** in the miniature class are available custom wound to any specified inductance value over the range from 1 mh to 25 h, with no extra charge, from The Hycor Company, 7116 Laurel Canyon Blvd., North Hollywood, Calif. These inductors are particularly useful in audio filters requiring high values of "Q" and are wound on molybdenum-permalloy dust cores. The toroid form of construction reduces the external field almost to zero, and it is possible to stack a number of these coils together without interaction, as well as to use them without particular regard to the proximity of power supply components. Specifications of these coils are supplied in technical bulletin A-5.



Pioneer Broach Co.

The Hycor Co.

• **Pre-fluxed Ribbon Solder.** Imagine making a perfectly satisfactory soldered joint with only a match for heating! With the new DeLuxe Ribbon Solder this is now possible, making it simple to solder wires at places where it is impossible or inconvenient to carry a soldering iron. To use, a piece of ribbon solder, ¼ in. or less, is wrapped around a wire splice, and the joint heated with a match. For larger wires, it is desirable to use a candle or a cigarette lighter in order to maintain heat for a sufficient time. DeLuxe Ribbon Solder may also be used on sheet metal or heavier parts, although more heat will be required, usually provided in the form of a torch. Information: Proved Products Mfg. Co., Drawer 1190, San Fernando, California.

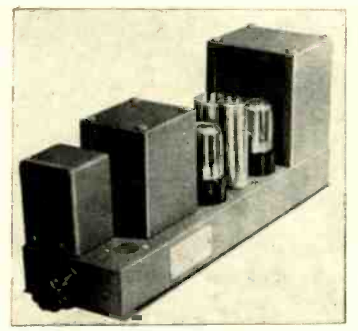
• **New Speaker Line.** Permoflux Corporation, 4900 W. Grand Ave., Chicago, Ill. announces a new line of high-fidelity speakers, ranging from 6 to 15 in. in the standard line, and with two sizes—12½ and 15½ in. —in the Coronet line. These speakers are low-distortion, wide-range single direct radiators, covering the range from 40 to 12,000 cps. A new edge damping compound lowers the resonant frequency and provides increased flexibility with a resulting increase in power handling capacity at low distortion. Further information may be obtained from the manufacturer.

Proved Products Mfg. Co.

Permoflux Corp.

• **RCA Service Co.,** Inc., Return Apparatus Control, Bldg. 8-2, Camden, N. J. announces a fast repair plan for RCA Microphones and transcription pickups which enables the shipping of a repaired microphone within four days from receipt, and only two days for pickups. Also available is a service for the repair and calibration of all types of RCA test and measuring equipment. This service should be a boon to radio stations and other users of this equipment, since the time usually consumed in a repair job greatly exceeded these short periods.

• **Audio Development Company,** 2833 13th Avenue South, Minneapolis, Minn. now offers a new series of high-fidelity eight-watt amplifiers suitable for radio and TV broadcasters and for other locations where reliable service must be maintained. Known as the Type 71 series, these amplifiers are available with different input and output impedances, and have a gain of 50 db when used with matching input, or of 38 db when used with bridging input. Frequency response is held to within 0.5 db over the range from 50 to 12,000 cps, with a nominal distortion of not more than 2 per cent over the same range. The built-in power supply is constructed with components having low external fields, and no special precautions need be observed if the amplifiers are mounted near other equipment.



Audio Development Co.

A. J. F. Industries

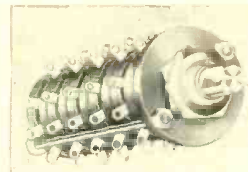
• **An induction Pickup coil** which may be used for a number of audio applications is the latest product of A.J.F. Industries, Inc., 858 Monroe St., Brooklyn 21, N. Y. This coil which has a d.c. resistance of over 2000 ohms, makes it possible to locate and measure small electrical impulses, to pick up a radio program to feed to a p.a. system by placing the coil near an audio or output transformer of a small receiver, or to reproduce a two-way telephone conversation through a speaker system without making any connections to the telephone circuits.

Another use for the coil is in exploration of hum fields, such as those which surround phonograph motors or the transformers and chokes of a power supply. By connecting the coil to an amplifier, the amount of hum pickup may be measured by an output meter, or fed to a speaker for aural analysis of frequency and intensity.

NEW PRODUCTS

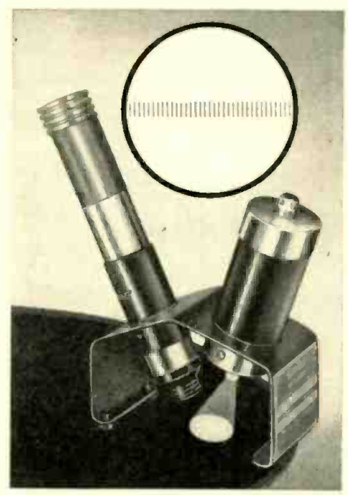
[*from page 28*]

• **Many applications for amplifier** construction involve the use of tap switches, and in some instances space is at a premium. Grayhill, Chicago switch manufacturer, supplies a small rotary tap switch, Series 5000, which has just recently been made available as a multi-deck unit with a maximum of 10 contacts on each deck, and with continuous



rotation. With less than ten contacts, stops are employed, and rotation is no longer continuous. Any reasonable number of decks may be addded, with each requiring an increase in length of only 13/16 in. In spite of its small size, the switches may be had in either shorting or non-shorting types. Information and specifications may be requested from Grayhill, 4524 West Madison St., Chicago 24, Ill.

• **Recording Microscope.** Successful study of the results of disc recording usually necessitates a good microscope, but they have been rather expensive until recently, when the new Model 231 was introduced by Clarkstan Corporation, 11927 W. Pico Blvd., Los Angeles 34, Calif. Containing a built-in



illuminator, and with a calibrated reticle and adjustment for powers of 20x and 40x, this instrument was designed expressly for use with recorders. The reticle is calibrated in either 2- or 4-mil gradations, depending on the power used, and has the unique feature of having an eye point 1 in. above the eyepiece, thus facilitating its use by those who wear glasses.

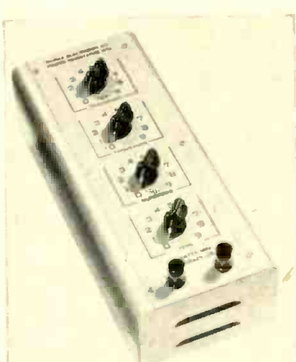
• **Plug-in subminiature amplifiers** are now available in units with voltage amplifications of 10, 100, and 1000, all in similar forms and small enough for most applications. Amplification is substantially flat from 20 cps to well above the audio range, and the tubes and components are completely sealed in compound to provide resistance to humidity and to mechanical shock. These units all contain three subminiature tubes, with the cathode follower output and the input being connected directly to the grid

of the first cascade amplifier. Further information may be obtained from The Walkirt Company, 5808 Marilyn Ave., Culver City, California.

• **The Electronic Workshop, Inc.**, 351 Bleecker St., New York 14, N. Y. is now marketing its control unit, Model C-3, long used as an integral part of custom systems. The unit includes a continuously variable volume, bass, and treble controls, with the tone control settings providing a complete

range from a 16-db boost to a 20-db cut in both bass and treble. The unit is designed to work from a 50,000-ohm source into a 1-megohm load, and has a total insertion loss of 20 db. Available with or without switch, the unit is supplied with an attractive etched plate 7½" x 2½". The housing is 1½" deep, and will fit into a 2-inch chassis.

• **Decade resistance boxes** are a necessity in many types of audio measurement, and the unit recently offered by Marma Electronic Co., 1632 N. Halsted St., Chicago 14, Ill. is particularly useful because of its power handling ability. The Model 10 resistance box will dissipate a minimum of



10 watts, and a maximum of 30 watts, depending upon the setting, and covers the range from 10 to 99,990 ohms in 10-ohm steps, all with an accuracy of 2 per cent. Resistors are wirewound using Advance wire, and they are insulated from the metal case in which they are mounted. This device should find considerable use in laboratory work, as well as by experimenters and equipment development engineers.

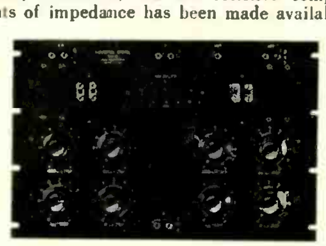
• **High-Fidelity Tape Recorder.** With a response within ±2 db from 50 to 10,000 cps at a tape speed of 7½ in. per sec., the new Audiograph tape recorder employs both constant current output and pre-emphasis equalization, and permits head replacement without variation in response. Housed in two carrying cases with a total weight of 80 lbs.,

this unit incorporates more flexibility than most in its price range. Among its outstanding features are: plug-in equalizers to permit future changes; two microphone inputs with impedance-change switches; and separate recording, line, monitoring, and playback amplifiers. Full information can be obtained from the Audiograph Co., 1410 El Camino Real, San Carlos, Calif.

• **Decade Inductors.** One of the difficulties confronting the development engineer in audio work has long been the high cost of decade inductors. Using high-Q toroid coils, the new units offered by The Hycor

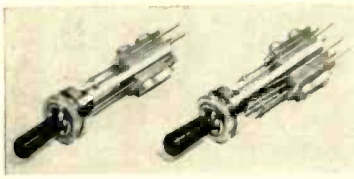
Company, 7116 Laurel Canyon Blvd., North Hollywood, Calif. cover the range from 1 mh to 10 h in four decades, all with accuracy of 2 per cent. Bulletin D obtainable by writing the manufacturer, contains full information.

• **Laboratory Bridge.** A new universal bridge for measurement of inductance, capacitance, resistance, and the resistive components of impedance has been made available



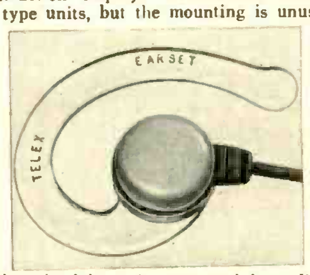
by Freed Transformer Co., 1718-36 Weirfield St., Brooklyn 27, N. Y. This instrument, Model 1150, has a frequency range from 20 to 20,000 cps, and is guaranteed to 1 per cent accuracy. It is arranged to be used in most of the conventional bridge configurations.

● **Lever Switch.** A new key-type switch requiring only a single hole for mounting has been announced by Switchcraft, Inc., 1328 N. Halsted St., Chicago 22, Ill. Known as the LEV-R switch, this unit is especially



adaptable to all types of low-power switching where good contact is essential. Contacts of silver, rated at 3 amperes, 120 volts a.c. are standard, with palladium contacts being available for such uses as low-level communication circuits. These switches are stocked by most leading radio parts jobbers.

● **The Telex Earset,** weighing only one-half ounce, is the latest product of Telex, Inc., Telex Park, Minneapolis 1, Minn. The construction employs conventional hearing-aid type units, but the mounting is unusual



in that the 'phone is supported by a lightweight plastic frame, thus eliminating headband and pressure on the user's ear. Available with either high- or low-impedance units, the Telex Earset offers comfortable listening level with an input of 0.3 milliwatts.

● **Quick disconnect cable couplings** designed for all-weather and submarine applications will be of interest to users of electrical and sound equipment in places where there is a possibility of the connections being immersed. These connectors have withstood tests with external pressure conditions

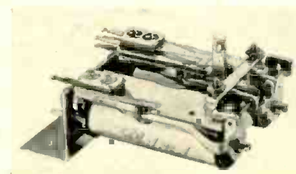
equivalent to 1150 feet of water, and with no leakage or seepage. The quick-disconnect feature is convenient—only a quarter turn of the shell is required to make or break the coupling,—and no tools are necessary. Plugs are made with a wide variety of inserts of the standard Army-Navy type, and the shells are made in bronze, aluminum alloy, or stainless steel. For further details, write to Roylyn Inc., 718 W. Wilson Ave., Glendale 3, Calif.

● **The Soundmaster** is one of the newer entries into the field of lower priced tape recorders. This model has a continuous playing time of one hour with a net frequency response on playback from 80 to 5000 cps,

±3 db, and is equipped with a tone control in addition to the conventional operating controls. The erasure is by means of graduated permanent magnetic field, and a neon lamp is used as a volume indicator. The unit

is self-contained, and provides for phono, radio, or microphone inputs, and for output to an external speaker, although a 6½" PM speaker is built in. Information: Pelco Industries, 629 2nd Ave., N. Y. 16.

• **Phil-trol Relays** are made in such a variety of types that they are capable of filling almost every requirement for low-power switching. One of the latest is the interlocking type shown. When the lock-up relay coil is energized, the switching contacts are



actuated, and a mechanical latch holds the relay in the operated position, even after the control circuit is opened. When the second relay is energized, the action of its armature releases the latch, restoring the circuit to the non-operated position. A complete catalog of relay types is available from Phillips Control Corp., 612 N. Michigan Ave., Chicago 11, Ill.

• **Pre-recorded Tapes.** Apparently the first to announce the availability of commercial recordings on magnetic tape, Amplifier Corp. of America has contracted with representatives of Vox and Polydor, prominent European recording studios, for exclusive rights to their libraries, which feature internationally famous orchestras and solo artists. The first catalog is now available, listing the selections and performing artists copied onto ¼-in. tape for reproduction at the secondary standard speed of 7½ in. sec., and may be obtained by writing direct to the Recording Division, Amplifier Corp. of America, 398-4 Broadway, New York 7, N. Y.

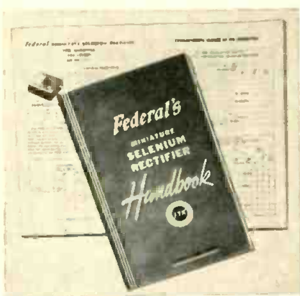
• **An amplifierless PA system** is the newest product of University Loudspeakers, Inc., 80 S. Kensico Ave., White Plains, N.Y. Known as the Powrmike, this device consists of the microphone of special design, and an efficient horn speaker. The only power source required is 6 volts, d.c., which may be supplied by a "hot shot" battery or by a storage battery when used in mobile work. The output is approximately 1.5 watts over the voice spectrum and the Powrmike cannot be overloaded, nor does it have any "hiss" characteristic. While the system is not intended as a substitute for a conventional Pa system, it has exceptional value for reinforcing speech without the need for bulky amplifier systems.

NEW LITERATURE

• **Thordarson transformers,** Catalog 400H, listing the entire line of transformers, chokes, and audio components, available from Thordarson Electric Mfg. Division, Maguire Industries, Inc., 500 W. Huron St., Chicago 10, Ill.

• **Aerovox capacitors,** together with the C-R bridge, L-C Checker, and interference Filter Selector. This six-page folder lists Duranite Molded paper tubulars, several types of electrolytics, oil-filled tubulars, mica capacitors, and other components. Ask for Form SC-549, Aerovox Corporation, New Bedford, Mass.

Federal Miniature Selenium Rectifier Handbook, a 48-page aid to engineer's manufacturers, and other users, describes basic theory of selenium rectifiers and carries



through to the design details and applications of 23 types. Available (25¢) from jobbers or from Federal Telephone and Radio Corporation, 900 Passaic Ave., East Newark, N. J.

The new Yeoman line of transformers is described fully in the latest catalog issued by Audio Development Company, 2833 13th Ave. South, Minneapolis, Minn. This line incorporates the high standards of performance of the Quality Plus series, but the use of open frame construction and the elimination of terminal boards reduces the cost of manufacture, resulting in lower prices.

Electronic and electrical components which are needed for quality construction are described fully in Catalog #300 which may be obtained from Cambridge Thermionic Corporation, 445 Concord Ave., Cambridge, 38, Mass. The products listed include terminal lugs and boards, swagers, hardware, insulated terminals, and a series of coils and chokes, as well as unwound forms for special applications.

• **Microphones.** Bulletin 154, illustrating and describing the new Model 911 Crystal and Model 611 Dynamic Microphones; and Bulletin 104, with concise information and list prices on the entire line of microphones and accessories. Electro-Voice, Inc., Buchanan, Mich.

• **Soldering Guns.** Descriptive catalog bulletin covering the Weller Soldering Gun line, which includes four models for every soldering requirement. Weller Manufacturing Co., 808 Packer St., Easton, Pa.

• **Preferred Tubes.** A new issue of the RCA Preferred Tube Types List, Form PTL-501A, has been brought out with revisions to keep abreast of advances in the electronic field. Commercial Engineering, RCA Tube Department, Harrison, N. J.

• **Transformers.** Complete catalog of new equipment transformers for audio and power applications is available from Chicago Transformer Division, 3501 Addison St., Chicago 16, Ill.

RECORD REVUE

[*from page 20*]

aural sound is the first great increase of liveness and secondly, (we hear effects, not causes) a very great increase in confusion, a decrease in the ability to sort out sounds.

If the change in liveness is the first thing to be noticed, the increase in confusion with the monaural system is surely the most vital point. Hearing aids with one channel (the other ear being too deaf to help) bring a tremendously confused sound to the wearer when things get at all complicated. A hearing aid at a tea party must be an instrument of torture for the wearer—no wonder he so often leans towards you, or thrusts his mike in your face—*not to get more volume*, but to achieve greater separation between your voice and the surrounding confusion! If you normal-hearing engineers want to see for yourselves, try my microphone and earphone experiment in the middle of a crowd of talking people—then be sorry for the monaurally deaf! And the tragedy of it is, as I see it, that probably not one in a hundred thousand hearing aid wearers knows why there is such confusion. Most probably blame it either on the machine, which is not to blame. Or much worse, on themselves. It's bad enough to have to wear such a gadget but to find yourself at sea and confused in spite of it is pretty hard. Must be slipping, such an unfortunate soul is likely to think. My nerves are shot . . . . everything seems to echo and reverberate and I can't tell one voice from another. Bad. What's the matter with me? Mister, you need another ear.

This being a record column, maybe we'd better end on that subject for the record. It is hardly necessary at this point to mention the tremendous importance of these same effects, in reverse, when music is recorded. We have found highly ingenious ways to fool the ear into accepting an utterly artificial, multi-mike monaural sound as a good faked binaural one. Good enough. But somebody, every day, turns up with the odd notion that reproduction from records is supposed to be like the original sound. When that person is a recording engineer, things go haywire and fast. When he is a listener, perhaps the consequences are less—but there are a lot of listeners to add together and the net quantity of confusion as to how reproduced music should ideally sound is terrifying. No monaural sound will ever be like a binaural one, nor will we have exact reproduction until someone figures a way to feed two ears at once and separately without tying wires to each.

Final word: what does a monaural hearing aid user hear when he listens to monaurally recorded music? Perfect reproduction of course— the same that a color-blind man with one eye would see in a black-and-white movie.

Recent Recordings

Liszt, Six Grand Etudes after Paganini.
Concert Hall LP CHC 10
Robert Goldsand, Pianist.

Villa Lobos, Quartet #6 (Quartetto Brasieiro)
Concert Hall LP CHC 19
Stuyvesant Quartet.

Beethoven, "Spring" Sonata for violin & piano.
Concert Hall LP CHC 17
Joseph Bernstein, Ella Goldstein.

• The LP record, a bit surprisingly, has turned out to be the salvation of the small company in the classical field—at least most of 'em are making like salvation. LP processing is reasonably available now, some through Columbia, a good deal elsewhere; packaging and shipping costs are greatly lowered, a vital matter with small companies. And sales must be good, judging from what's appearing. A good many small company LP recordings don't even get around to appearing on 78 at all. Concert Hall so far has issued only unlimited edition LP's, as above; an interesting arrangement is that whereby this company has taken over rights to recordings made by other companies—especially interesting since the International Records items to date, including the Liszt Etudes and the Villa Lobos Quartet above, are better sounding than almost anything of Concert Hall's own! Indeed, they are about the finest jobs of their type I've heard anywhere, with wide range, low distortion, a beautiful liveness, a cross between Mercury (domestic) and English Decca ffrr. All of these LP's seem more stable, less finicky in the playing than many a Columbia LP. Part of the reason, I'd guess, is wider groove spacing, somewhat shorter play; another aspect is considerably less pre-emphasis of the highs—these running more or less like their 78-rpm counterparts, not far from flat as my ear judges it. Surprising the difference between optimum control settings for these and the average Columbia LP.

The Liszt piano is a gorgeous, big, sonorous sound, not unlike the best of RCA Victor's Horowitz-type recording. The Villa Lobos quartet is similar, a big, resonant sound with ultra clear details. The Beethoven, recorded by Concert Hall, is quite different, with dullish highs (they are present), rather close and dry acoustics. Not bad, though, for the music. Surface noise is fairly noticeable in all of these, partly due to lack of Columbia's pre-emphasis.

Mendelssohn, Octet for Strings, Opus 20.
Polydor-Vox LP PLP 6510
Pro Musica Chamber Group.

Schumann, Trio #1 in D Minor, Opus 63.
Polydor-Vox LP PLP 2030
Trio de Trieste (violin, cello, piano).

Mozart, Piano Concerto #15 in B flat, K. 450.
Vox LP VLP 6580
Andor Foldes; Lamoureux Orch., Bigot.

Vivaldi, Gloria Mass for solos, chorus, orch.
Polydor-Vox LP PLP 6610
S. Zanolli, sopr. A. Giordano, mezzo. Choral Academy of Lecco. Orch. of Teatro Nuovo, Milan, cond. Perdollo.

• Here is a batch from another sudden convert to LP—Vox has for the moment virtually deserted the 78 field. These are typical of this company, which now farms out its recording here and there over the face of Europe. Vox's music has always been extremely interesting, its recording technique and pressing highly variable, according to the "farm" of the moment! The tendency is towards excellent acoustics, fine balance, only fair recording; or irregular recording with some wonderful sounds, marred by defects such as sudden blasting peaks.

These LP's vary most astonishingly in these respects. The Mendelssohn Octet and the Mozart, from France, are similar—rather dead, with weak highs, only fair presence, but excellent musical balance some distortion towards ends of original 78 sides. For some inexplicable reason the Mozart 78 sides have not been patched in the LP and there are several old-fashioned breaks while the records "change"! Moreover, the grooves are wide pitch, only six 78 sides to the entire LP. (But, after all, Mozart didn't write any more.) No records, these for a hi-fi enthusiast, but remember, there's music on them and it's perfectly audible, hi-fi or no. People will like them.

The Vivaldi Gloria Mass comes from Italy. Musically it is extremely interesting to anyone who goes for such works as the Bach Mass, the Handel Messiah, Mozart Requiem, etc., since this work and indeed anything for chorus by Vivaldi has been unheard of in these parts. It's a brilliant piece, easy to catch onto, almost juicy in the Italian manner. The performance is so-so, with a lot of throaty Italian singing, Listerine style; but the singers like the music and that helps no end. And as to the recording—most interesting technically! With a 5000-cps cut-off (the usual plush home console machine) it sounds perfectly swell. With an 8000 cut-off it still sounds extremely good, with more brilliance, a few slight buzzinesses. But—open 'er up to 10,000 and the most excruciating distortion shrieks at you! It's razor-edge, just the kind of thing that drives the anti-hi-fi listener mad. A rather unusual example of excessive distortion limited almost entirely to the extreme upper frequencies. (Note—if you play this with 5000-cps cut-off, cut down on the low end too, for balance. With attenuation of the lows, the music sounds surprisingly good.)

As for Schumann, there's no indication where this big, diffuse, highly Romantic piece was recorded; it's quite unlike any of the above Vox imports. Here the bass is tremendous, the highs rather spineless, so that the piano bass and the cello, for once, actually drown out the violin! Might be in part the mike set-up. A large bass attenuation will change this remarkably; the cello suddenly gets back where it belongs and the violin comes forth. It's a nice piece and the sound is big and full, if again nothing for the hi-fi fan to rave over.

Vivaldi, Concerto Grosso in D minor, Op 3, #11.

Mercury LP MG 10002

Mozart, Divertimento in D major, K. 251. Dumbarton Oaks Chamber Orchestra, Schneider.

- This is a reissue, by still a third company in the LP field, of a recording issued last year on 78, originally recorded on 16-inch, 33-rpm discs. This is one of the short series of domestic-made jobs done for Keynote, then absorbed by the Mercury label; technique was one-mike, with Fairchild cutters, giving beautifully clear, wide-range sound. The LP version seems as good as the 78 was, especially since the 78's had rather bad surface noise to mess up the higher tones.

There seems to be little doubt, incidentally, that LP records re-recorded from tape or 16-inch originals are consistently better than those copied from 78-rpm masters. Those companies, like Mercury, fortunate enough to have either of these types of original are in a fine position for LP's. Tape originals will doubtless soon supersede the still omnipresent 78 recordings now being made in Europe—the Vox series, for instance, and the British Columbias, copied not too successfully here as LP's. Big question? What will the forthcoming English LP's from Decca (London) sound like—copied from 78's?

Tchaikowsky, Overture "1812," Opus 20.
a) Mercury LP MG 15000 (1/2 10")
b) Capitol 78 EBL 8022 (2)
Amsterdam Concertgebouw Orchestra, Mengelberg.

• Here's a fine kettle of fish! These two are, to the best of my knowledge and ear, taken from the *same* original German recording. Capitol, some months back, announced a suit against Mercury for infringement of rights to German recordings, and this is an illustration of what gives. No word, to date, of the results; in any case what seems to have happened is that Mercury, on the other side of the Iron Curtain, got rights to the Czech Ultraphon catalogues—which included many German recordings via previous exchange arrangements. (The whole of Europe has been networked for decades with such arrangements and the Nazi period followed by the war and the Liberation, plus the present East-West split and the assorted MG control, has made an incredible stew of the whole business.) Capitol, going in from this side of the Curtain, via Germany itself and the U.S., got direct rights to the German records at the source! The astonishing thing is that the recording was made in Holland (presumably), no doubt through still another inter-country arrangement, probably invalidated by now.

Be that as it may, the recording of the "1812" is typically wide-range, with the sharp, rather tinny brass and strings we now are getting to know in these older Telefunken jobs. Not quite distortion-free compared to newest wide-range recording, but still quite amazing. Capitol's version is, I'd say, somewhat filtered, to smooth things out a bit. Mercury's sounds more like a straight re-recording, with more in the high end, but not as smooth. Otherwise, granting the difficulty of directly comparing an LP and a 78, the two are neck and neck.

Imagine the confusion when, this fall, Capitol brings this out on 45 *and* as an LP!

Strauss-Chasins, Waltz-Fantasy, ("Music of Johann Strauss").
Mercury LP MG 10005
Abram Chasins and Constance Keene, pianos.

• Slightly misleading title here. This is two-piano music that is about 50 per cent Strauss, the rest Chasins. Themes are from Strauss, but the harmony is a special sophisticated dinner music sort, quite unlike the original Strauss, far more elaborate, and the "continuity" is entirely Chasins, moving from one idea to another in pot-pourri style somewhat like a Gilbert and Sullivan operetta overture. An ingenious job, I'll admit, and not at all bad listening, though Johann most assuredly wouldn't know what to make of it. The piano playing is terrific, the arrangement for the two pianos extremely skillful. (One number is a similar fantasy on themes from "Carmen" by Bizet. Fine background music, too.

The recording is spacious, the two pianos a bit in the background, avoiding thus a lot of "ping". Funny how much better two-piano recording sounds than one-piano. This is evidently domestic Mercury, not European. It's as good piano as has been done here.

HIGH SCHOOL SOUND SYSTEM

[*from page 14*]

feeds the two radio receivers through coupling transformers. This type of transmission for AM signal was chosen because the balanced transmission circuit provides an efficient method of coupling unaffected by noise pickup.

Located over the clock in each of the classrooms is an accordion-edge speaker mounted in a flush baffle. The size of back box was designed to provide an acoustic volume suited to this mechanism to provide the best overall response.

As a side light to the technical aspects of the equipment, it is interesting to know that practically all the facilities of the system were used on the day of dedication at which time His Eminence Cardinal Spellman, together with other dignitaries of the Church, educational and political worlds, dedicated this school.

In order to cover this large number of people gathered in front of the school for the dedication ceremonies, two multi-cellular speakers were installed on the parapet and were fed from one of the nearby classroom circuits. During the dedication of the Chapel, the voice of the Cardinal and the choir were picked up over the microphone inputs indicated on the block diagram as Chapel Mike #1 and Chapel Mike #2. This program was distributed through the selector system to the outdoor speakers, the classrooms along the first floor, the gymnasium, and the auditorium.

This description of one type of elaborate system is offered to show how a specific requirement for sound service may be fulfilled by designing into the system all of the necessary facilities for flexibility and complete coverage. While systems of this magnitude are encountered rarely, the same principles obtain in smaller layouts, and those facilities which are not required may simply be omitted. The system described is functioning to the satisfaction of the Principal and staff, and is proof that time spent in the original design and installation is more than repaid by the performance and convenience of the finished product.

TEST RECORDS

[*from page 14*]

ing record changers; consists of three modulated bands of 936 cps tone for "wow" check. Inside eccentric groove is equal to largest known to be used on a Victor record.

12-5-23 (T-2914) Reverse side of 12-5-21. Modulated bands joined by spirals to indicate limits of standard records. Modulation is at 400 cps at level of approximately 5.9 cm/sec., and spirals provide checks for 10- and 12-inch records, and center eccentric is standard.

12-5-25 12-inch, 33⅓ rpm. Unfilled Vinyl, SF. Frequency bands: 400 and 4000 for intermodulation test purposes, followed by frequencies of 12, 11, 10, 9, 8, 7, 6, 5, 4, 3, 2, and 1 kc, and 700, 400, 300, 200, 100, 70, 50, and 30 cps. Crossover frequency 500 cps, with CV portion above crossover held to ±0, —1.5 db to 10 kc, and —3 and —2.5 db at 11 and 12 kc respectively.

12-5-29 7-inch, 45 rpm. Unfilled Vinyl, DF, with 12-5-31 on reverse. Consists of 20-sec. band of 1000 cps at 4.4 cm/sec, unmodulated section, 1:30 min. of 400 cps at 2.6 cm/sec, unmodulated section, and 20 sec. of 1000 cps at 4.4 cm/sec. Last music groove for check of record changer operation has diameter of 4.250 in.

12-5-31 Reverse side of 12-5-29. Frequency bands of 1000 cps, 10, 9, 8, 7, 6, 5, 4, 3, 2, and 1 kc, 700, 400, 300, 200, 100, and 50 cps, followed by another band of 1000 cps. Crossover frequency, 500 cps. Levels shown on curve of *Fig.* 1.

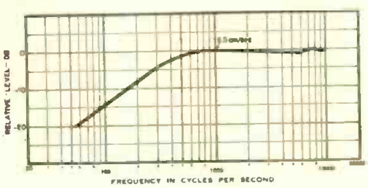


Fig. 1

RCA-Victor Test and Technical Purpose records may be obtained by ordering from
Custom Record Sales Section,
RCA-VICTOR DIVISION,
155 E. 24th St.,
New York 10, N. Y.

COLUMBIA

10004M 12-inch, 78 rpm. Shellac. Frequency bands of 1000 cps, 10, 9, 8, 7, 6, 5, 4, 3, and 2 kc 1500, 1000, 800, 500, 300, 200, 150, 100, 70, and 50 cps. Crossover frequency, 800 cps. Frequencies announced.

10003M 12-inch, 78 rpm. Shellac. Same frequency bands as 10004M, but with crossover frequency of 300 cps.

YTNY-170-4 16-inch, 33⅓ rpm. Same frequency bands as 10004M, but with crossover frequency of 500 cps. (Standard groove dimensions for transcriptions.)

RD-103 12-inch, 33⅓ rpm, LP Microgroove. Frequency bands of 10, 9, 8, 7, 6, 5, 4, 3, and 2 kc; 1500, 1000, 800, 500, 400, 300, 200, 150, 100, 70, 50, and 30 cps. Levels as shown at (A) in *Fig.* 2. This record is essentially flat over constant-velocity portion, with crossover at 500 cps.

RD 130A 12-inch, 33⅓ rpm, LP Microgroove. Frequency bands same as RD 103, except levels arranged so as to reproduce ±2 db of "flat" on correctly equalized LP reproducing system. Levels as shown at (B) in *Fig.* 2.

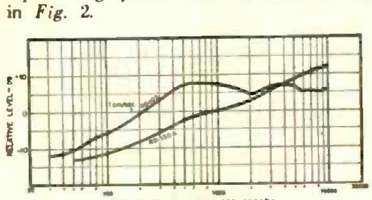


Fig. 2

XERD 281 12-inch, 33⅓ rpm, LP Microgroove. Gliding tone frequency record, from 10 kc to 50 cps; marking tones at 10, 8, 5, 4, 3, 2, and 1 kc, and at 500, 400, 200, 150, 100, 70 and 50 cps. Levels are approximately same as on RD 103.

Columbia Test Records may be obtained from any local Columbia distributor, or from Columbia Records, Inc., 799 Seventh Ave., New York 19, N. Y.

LONDON GRAMOPHONE

Album No. LA 32, consisting of three 12-inch records pressed on a mixture having a shellac content of not less than 22 per cent, which results in a surface hardness essential for long life. This is the same material on which London Decca records are pressed, and surface noise is held to a minimum.

T—4996 (A) Glide-tone record, covering the frequency range from 14,000 to 3000 cps, with a break at every 1000-cps point. Levels are shown on *Fig.* 3, and are in accordance with recording curve employed on Decca "ffrr" records.

T—4996 (B) Reverse of above. Glide tone record, ranging from 3000 to 10 cps, with breaks at 2000, 1000, 400, 250, and 100, cps. Levels are as shown on *Fig.* 3.

T—4997 (A) and (B) Glide-tone record, same on both sides, covering the frequency range of 14,000 to 10 cps, with breaks at every 1000-cps point, and at 400, 250, 100, and 50 cps. Level is constant from 14,000 to 400 cps, with levels below 400 cps same as on T-4996. (*Fig.* 3).

T—4998 (A) Frequency bands of 14, 13, 12, 11, 10, 9, 8, 7, 6, and 5 kc at constant level.

T—4998 (B) Reverse of above. Frequency bands of 4000, 3000, 2000, 1000, 400, 250, 100, 55, and 30 cps, with levels as shown by the dotted curve of *Fig.* 3.

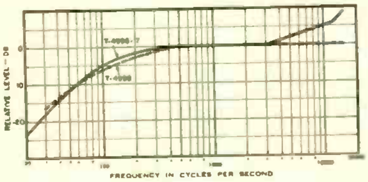


Fig. 3

Album also includes stroboscope disc for both 78 and 33⅓ rpm for power frequencies of 50 and 60 cps.

CLARKSTAN

1000A 12-inch, 78 rpm. Vinylite, SF. Sweep frequency record for oscillographic observation of equipment response. Range—70 to 10,000 cps, flat within ±1 db. Sweep repetition rate, 20 per second. Crossover 500 cps.

1000D 12-inch, 78 rpm. Vinylite, SF. Sweep frequency record similar to above, but covering range from 5000 to 15,000 cps, flat within ±1 db, for observation of response in high-frequency ranges. Sweep repetition rate, 20 per second.

100A 16-inch, 33⅓ rpm. Vinylite, SF. Sweep frequency record similar to above, but covering range from 60 to 10,000 cps, and recorded with NAB characteristic. Sweep repetition rate, 20 per second.

All three above records have synchronizing pulses at beginning of each sweep, and with marker pulses at 1, 3, 5, 7, and 10 kc. Clarkstan frequency records may be obtained from most radio jobbers, or from Trionic Co. of America, 11927 West Pico Blvd., Los Angeles 34, California.

STANDARD RADIO

Frequency Test Record, 16-inch, 33⅓ rpm. Vinylite, SF. Frequency bands of 1000 cps, 10, 9, 8, 7, 6, 5, 4, 3, and 2 kc, 1500, 1000, 800, 500, 400, 300, 200, 150, 100, 70, 50, and 1000 cps. Crossover at 500 cps, with constant velocity recording above this frequency. intended for use by broadcast stations, recording studios, and professional users, and groove dimensions are standard for transcriptions. Obtainable from Standard Radio, Inc., 1 E. 54th St., New York 22, or 140 N. LaBrea, Hollywood 36, California.

COOK

Series 10, 10-inch, 78 rpm. Plastic. DF. Side A: Frequency bands with voice announcements. CV above 500 cps with 3 db knee at crossover. Velocity of stylus is 9 cm/sec, ±1 db. 1000 cps, 20, 17, 15, 12, 10, 9, 8, 7, 6, 5, 4, 3, and 2 kc, 1500, 1000, 700, 500, 350, 250, 125, 62.5, 40, and 35 cps, followed by 1000 cps band.

Side B: Band 1 (for 33-1/3 rpm): LP spot check with standard LP preemphasis—100, 1000, 3000, 6000, and 10,000 cps. Band 2: 100 and 7000 cps intermodulation test, with 7000 cps 12 db lower than 100 cps, on flat basis. No preemphasis. Band 3: Slow sweep frequencies, from 1000 cps to 35 cps, with 350-cps crossover.

Both sides are cut with V-tip stylus, permitting use with either 1- or 3-mil reproducer. Cook Laboratories, 139 Gordon St., Floral Park, N. Y.

DISC RECORDER

[from page 26]

as small as possible to insure that the frequency response of the cutter will not vary with discs of differing hardness nor change as the diameter or depth of cut of the recorded groove changes. The expanded scale of *Figure* 7 shows the stylus velocity of the 2A recorder in cellulose nitrate relative to that in air as measured by readings of feedback voltage E_3. This relationship was found to be independent of the linear groove speed.

Perhaps one of the most important yet least appreciated factors in recorder performance is its response to a suddenly applied impulse, or its transient response. Speech contains many transients, and in music many instruments are more readily identified by their characteristic transient attack than by their harmonic content. It is important, therefore, that these transients should undergo as little change as possible in the recording process. In general this requires a wide frequency band of uniform response and a phase shift which is linear with frequency throughout the band, not only to prevent degradation of the components of the transient itself, but also to insure that individual elements of the recorder do not vibrate independently at their own natural frequencies when subjected to this form of shock excitation and so introduce extraneous frequencies which help mask the original impulse. The transient response of the feedback cutter system was studied by observing the oscilloscope tracing of voltage E_3 while the stylus was recording a square wave of 400-cps repetition rate. The record was then played back with the reproducer output connected to the scope. Both patterns showed steep sides and fairly sharp corners, indicating satisfactory high- and low-frequency response with linear phase relationship. Superposed on the horizontal top of the patterns was a transient wave of approximately 11,000 cps with a small initial amplitude and having a decrement sufficient to reduce the amplitude of the wave train to substantially zero in 1/1600 second (¼ cycle of the 400 -cps repetition rate). It seems reasonable to assume that such a transient will not seriously affect an otherwise high-quality recording.

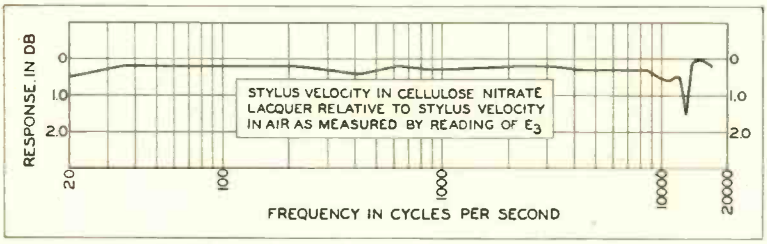


Fig. 7. Effect of record material on recorder response.

That the behavior of the recorder would be satisfactory when subjected to a sudden impulse or transient could have been predicted by a consideration of data taken under steady-state conditions. *Figure* 5 shows the response to be flat over a wide frequency band. The phase shift corresponding to the no-feedback-condition curve can be calculated and then modified according to equation 6 (feedback results in improved phase linearity as well as improved response). Phase calculated in this manner checks quite accurately with measured results over the frequency band where feedback is controlling and indicates a favorable condition for transient response.

Conclusion

The data presented above on frequency response, reserve power, intermodulation distortion. effect of varying record material, phase and transient response attest to the benefits of properly controlled feedback in a disc recorder; benefits which are permanent and independent of temperature and humidity variations as well as the deterioration of damping members.

It has also been demonstrated that the recorder possesses another inherent advantage—the ability to permit rapid evaluation of response and distortion while in actual use by examination of the feedback voltage, E_3. This can be a valuable tool with which to investigate and correlate recording parameters as well as facilitate routine checking of the complete recording channel.

It is hoped that the recorder will be instrumental in establishing new standards in the disc recording field.

Logarithmic Amplifiers

[from page 17]

only a four-fold increase at the output. These are within the capacities of most oscillographs.

Circuits

Some of the circuits are new enough to warrant discussion, and some are well known to the art. The means of applying bias to the log element is perhaps the most important. The log element alone may be used in a simple circuit, at the expense of some curvature of the log characteristic at low input levels. If we apply bias, it has to be d.c. To ensure the right polarity of bias for the right signal polarity, it is necessary to use two matched log elements appropriately biased, with the inputs to the two elements through oppositely phased rectifiers as shown in *Fig.* 8. The outputs of the elements are paralleled through the rectifier resistances (which are low by comparison). The bias voltage should be set very carefully for best results, then stabilized.

The most convenient output circuit, with a log element which gives a large enough output voltage, is a cathode follower. The one shown in *Fig.* 9 has an output impedance of 1000 ohms, low enough to feed a shielded cable without attenuation of high frequencies. Lower impedance may be secured if necessary by raising the transconductance of the tube.

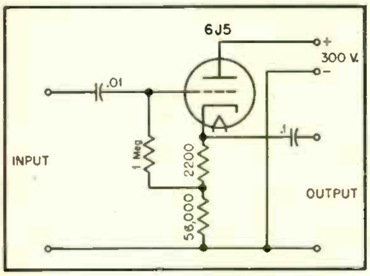


Fig. 9. Cathode follower output stage.

The input amplifier which drives the

log element is a standard instrument amplifier, with heavy negative feedback for stability, and an exceptionally well filtered power supply.

Precautions

It might be well to emphasize some basic precautions. They have been given before, but they will bear repeating.

The slightest degree of nonlinearity in the amplifiers is cumulative, and can result only in a non-linear scale. Worse than that, every time a tube is changed, the scale law will change—an unbearable situation. To avoid this, check the amplifiers carefully for nonlinearity, with a gain set and a v-t voltmeter. The possession of a good logarithmic material is only a part of the design problem, for one must retain the linear-log relation in the rest of the circuit after achieving it in the log element.

Finally, the log element should be so proportioned that the maximum output voltage is of the order of a volt. Too small an output will require more amplification in the vacuum tube voltmeter and in the output circuit, amplification which will handle a 15000 cps square wave without distortion. This is costly and unnecessary, for the log output can be made as much as a volt without trouble.

It is believed that the stable logarithmic system, perhaps combined with an oscillograph, has very interesting possibilities in audio instrumentation.

PROBLEMS IN AUDIO

[*from page 19*]

If the source of the sound which the pipe amplifies or resonates, contains numerous other frequencies, but none that are harmonically related, then only the one frequency will be amplified. This is the case with the organ. In either the reed or the flue-pipe organ, the tones produced by the reed or edge contain numerous tones, some that are harmonically related and others that are not. However, because the pipe is a selective device it will deliver a fairly pure harmonically related series of tones.

The final two cases of sound generators that will be considered in this article are the circular membrane and the circular plate. There have been numerous analyses made of plate and membranes of various shapes. However, they are extremely complex and result in a series of equations for each case which express the frequency of the fundamental and the series of overtones for the different modes of vibration of the plate and the membrane.

Basically, if a stretched circular membrane is struck in the center, a two dimensional wave will be gener-

ADDRESS CHANGES...

Subscribers to AUDIO ENGINEERING should notify our Circulation Dept. at least 5 weeks in advance regarding any change in address. The Post Office Dept. does not forward magazines sent to a wrong address unless you pay additional postage. We can not duplicate copies sent to your old residence. Old and new addresses MUST be given.

AUDIO ENGINEERING
RADIO MAGAZINES, Inc.
342 MADISON AVENUE
New York 17, N. Y.

ated and the air in front of the membrane will be set in motion thus causing a spherical wave to be generated in the air. This is the situation that occurs when a drum is struck. However the form of the enclosure of the drum also affects the modes of vibration thus determining the overtone structure. The frequency spectrum of the stretched circular membrane may be expressed by the general equation.

$$f = \frac{C}{R}\sqrt{\frac{T}{m}}$$

where C = a constant determined by the overtone to be found and the mode of vibration.
R = radius of membrane in cm.
T = tension on membrane in dynes per cm.
m = mass in grams per square cm. of area.

In the references, the book by Dr. H. F. Olson contains an excellent list of the numerical values of the constant C.

For the clamped circular plate which appears in audio work as the diaphragm of the carbon microphone, the telephone receiver, and certain types of loudspeakers, the derivation and the resulting equations of its fundamental frequency and overtones are even more complex than those for the membrane. The general form of the equation is

$$f = \frac{Ct}{R^2}\sqrt{\frac{M}{\rho\,(1-\sigma^2)}}$$

where C = constant determined by the overtone to be found and the mode of vibration.
R = radius of the plate between clamps in cm.
ρ = density of the plate in grams per $cm.^3$
M = Young's modulus of elasticity in dynes per $cm.^2$
σ = Poisson's ratio.
t = thickness of plate in cm.

Again the reader is referred to Dr. Olson's book for the values of the constants.

Having discussed the general background of sound generators, two special cases will be left for the next and concluding article. These are the generation of speech sounds and the generation of sound by musical instruments.

Reading List

Acoustics.—Wood, Alexander, *Interscience Publishers, Inc.*, New York, N. Y., 1941.

Elements of Acoustical Engineering.—Olson, Harry F., *D. Van Nostrand Company, Inc.*, New York, N. Y., 1947.

Theory of Sound.—Lord Rayleigh (John William Strutt) *Dover Publications*, New York, N. Y., 1945.

Vibration and Sound.—Morse, Philip M., *McGraw-Hill Book Company, Inc.*, New York, N. Y., 1948.

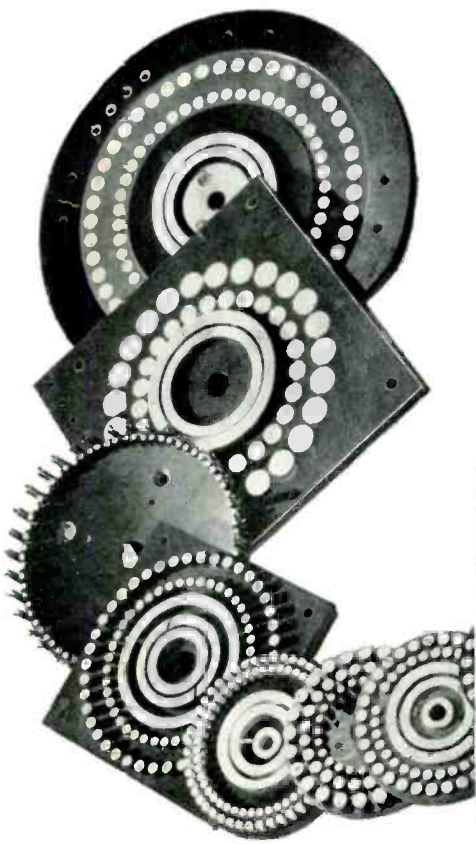
ADVERTISING INDEX

. . . FOR THOSE TOUGH "*Switching*" PROBLEMS TRY DAVEN!

WRITE FOR YOUR COPY OF OUR NEW SWITCH BULLETIN

Whether you use switches for industrial applications, communications or laboratory work a Daven-constructed unit will give maximum performance. Many years of engineering experience and skilled workmanship have been combined to make a truly superior switch.

Daven switches are the rotary selector type—outstanding in design and capable of withstanding the most critical tests. They are preferred by engineers who want the best.



Some outstanding features are

- Low and uniform contact resistance.
- Minimum thermal noise.
- High resistance to leakage.
- Trouble-free operation and long life.
- Roller-type positive detent action.
- Depth of unit not increased by addition of detent.

A full line of standard switches are available. Listed below are a few of the popular types.

Type	Operation	Maximum No of Positions (per pole)	Maximum Poles Per Deck	Deck Diameter Size
C1A	make before break	31	1	1¾"
C2B	break before make	15	1	1¾"
C7A	make before break	11	2	1¾"
C8B	break before make	5	2	1¾"
D1A	make before break	47	1	2¼"
D7A	make before break	14	4	2¼"
D9A	make before break	9	5	2¼"
D10B	break before make	5	5	2¼"
E3A	make before break	47	2	2¾"
E4B	break before make	23	2	2¾"
E7A	make before break	23	4	2¾"
E8B	break before make	12	4	2¾"
F2B	break before make	30	1	3"

Single deck switches are round. Multi-deck switches are square.

DAVEN can adapt a standard switch for your special requirements.

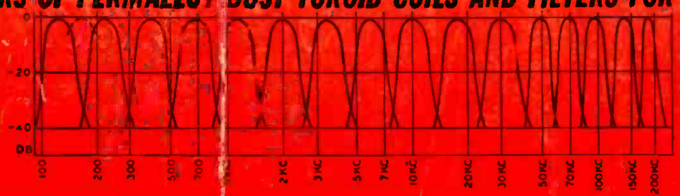
Our engineers will be glad to offer suggestions on *your* problems.

Send your detailed information to Department A-6.

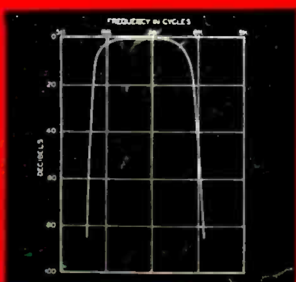
THE DAVEN CO.
191 CENTRAL AVENUE
NEWARK 4, NEW JERSEY

FILTER SPECIALISTS

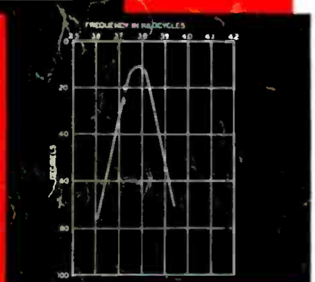
PRODUCERS OF PERMALLOY DUST TOROID COILS AND FILTERS FOR OVER A DECADE



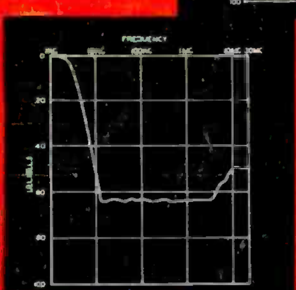
FOR FILTERS



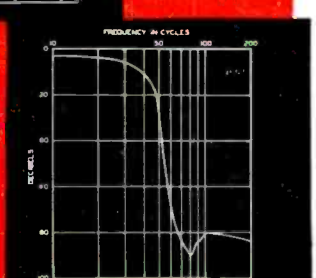
BROAD BAND
SHARP CUTOFF
FILTER



NARROW BAND
SHARP CUTOFF
FILTER



ATTENUATES
10KC TO 30
MEGACYCLES



LOW FREQUENCY
— LOW PASS
FILTER

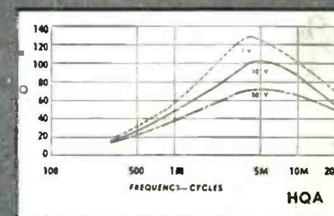
HQA, C, D
$1\frac{13}{16}$" Dia. x $1\frac{5}{16}$" High.

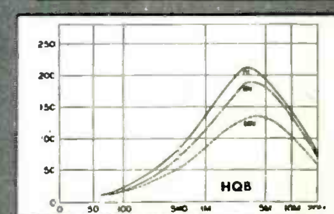
HQB
2⅝" L. x 1⅝" W. x 2½" H.

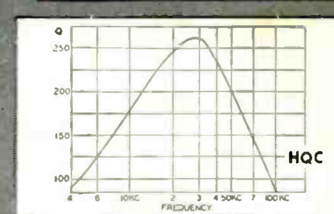
UNCASED TOROIDS

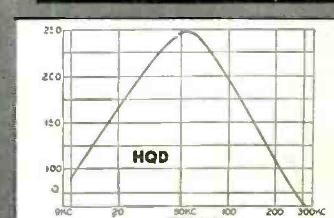
VIC
1⅜" L. x 1¼" W. x 1½" H.

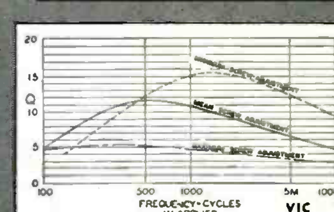
FOR HIGH Q COILS











SUB-OUNCER TOROID FILTERS

Filters employing SUB-OUNCER toroids and special condensers represent the optimum in miniaturized filter performance. The band pass filter shown weighs 6 ounces.

write for catalog PS-409

United Transformer Co.

150 VARICK STREET NEW YORK 13, N. Y.
EXPORT DIVISION: 13 EAST 40th STREET, NEW YORK 16, N. Y. CABLES: "ARLAB"