AUDIO ENGINEERING

OCTOBER 1949

35c

THE AUDIO FAIR

See Page 26

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AUDIO ENGINEERING

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COVER

Proper manipulation of the microphone boom required for TV broadcasting operations presents a new responsibility to the audio technician whose past experience has been limited to aural broadcasting. The photo—a view in a CBS studio—will indicate the relatively complex, heavy construction of a TV mike boom as compared to the simple units used for sound broadcasting.

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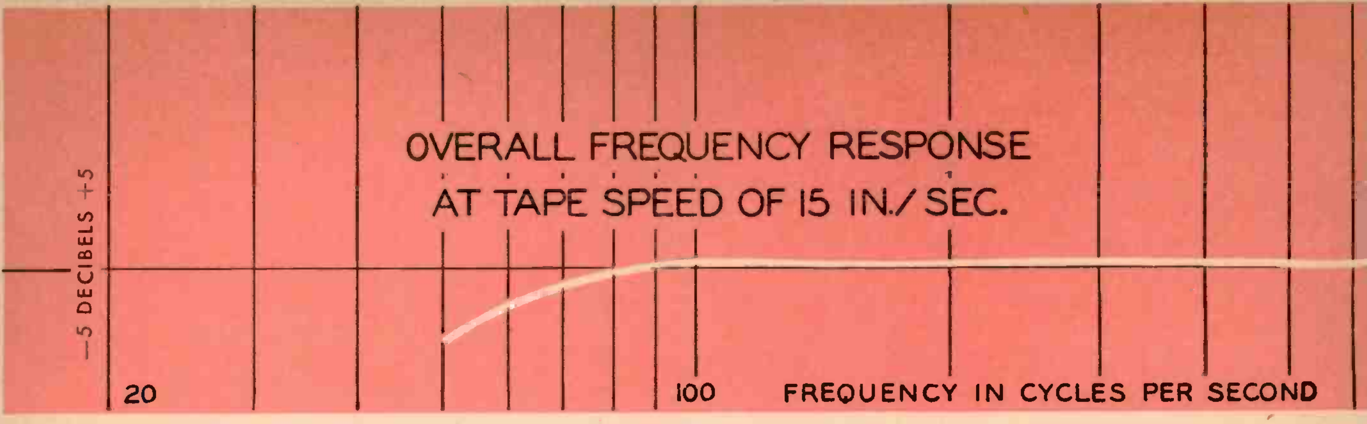
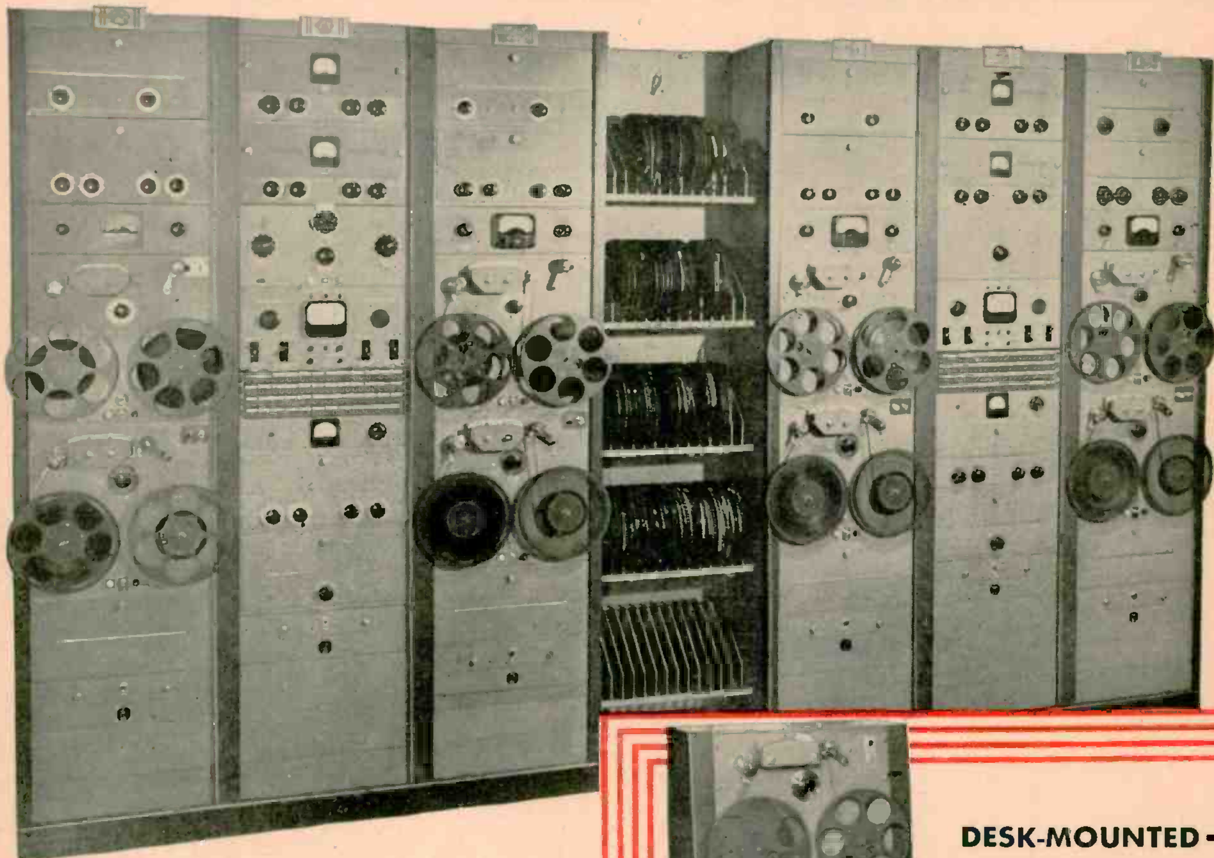


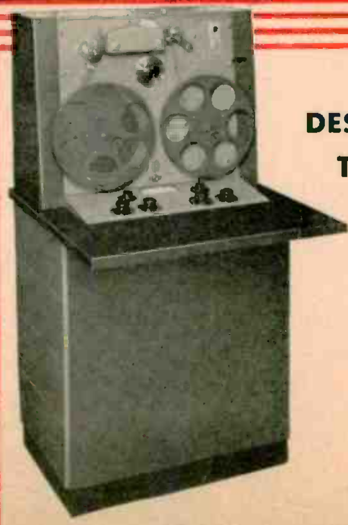
3 RCA PROFESSIONAL



Rack-mounted RCA Tape Recorders in action at NBC, Chicago

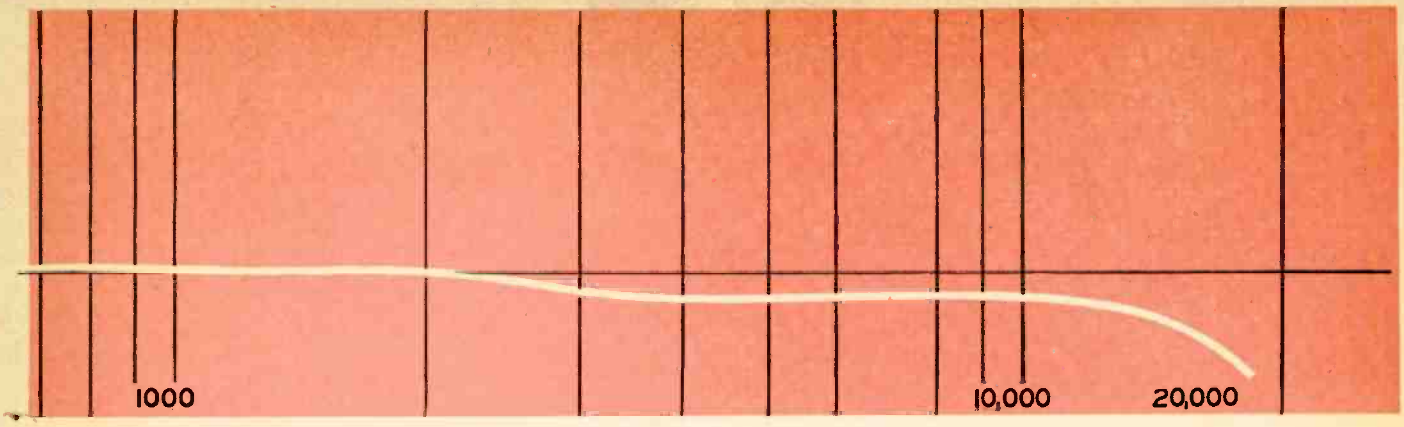
Rack-mounted RCA Tape Recorders (Type RT-5) are well-suited for control rooms and recording laboratories—lend themselves well to system layouts where more elaborate recording jobs are required. You load the tape and cue at the rack. You start the recorder by a switch at the control desk.

FREE—new booklet about RCA's revolutionary new Tape Recorder. Curves, illustrations—complete descriptions of recorder set-ups. Write Dept. 7J, RCA Engineering Products, Camden, New Jersey.



DESK-MOUNTED— Type RT-4A

The RCA Tape Recorder in desk-type console. Recorder and amplifier are "built-in" for maximum operating convenience. Plenty of desk-top space. Extra room below for additional amplifiers. A handsome and thoroughly dependable control-room recorder to install beside your studio consolette or turntables.



TAPE RECORDERS!

THREE OF THE finest heavy-duty tape recorders in broadcasting—at prices under any comparable type in the high-fidelity class!

Taking only three or four seconds to thread . . . and requiring no complex over-and-under threading or "doubling back" of the tape . . . RCA recorders are so simple to operate that anybody can run one. Vertical reel-mounting makes them easy to handle without bending or leaning over the instrument. Sturdy, two-sided reels reduce danger from unreeling the tape or snarling. There is only one driving motor—and only one 3-unit head, that plugs in and out without need for tools.

At the flip of a switch, you can run off high-fidelity recording or playback for 33 minutes—with response at 15 kc. Or 66 minutes of it with response at 7.5 kc, whichever you choose. Frequency compensation is automatic for either tape speed position. Tape tension is held so carefully that front-panel "speed-change" switching from *fast-forward* to *fast-reverse* is done instantly . . . without damage to the tape. Feather-weight tape tension also insures playback timing to ±0.2 per cent at both speeds (you can edit recordings precisely—with minimum tape stretch). Automatic tape "lift-off" eliminates head wear during rewinds. A separate recording and playback amplifier *enables you to monitor the tape and record programs simultaneously*—your assurance that important programs are actually on the tape.

Designed by men who live with the business, these RCA units meet the needs for a foolproof instrument capable of recording true-to-life shows in the field and in the control room. Frequency response is essentially flat from 30 to 15,000 cps—at a tape speed of 15 inches per second. Signal-to-noise ratio is 55 db on the console and rack models—and 50 db on the portable model. "Wow" and flutter is less than 0.2 per cent at 15 inches per second—and less than 0.3 per cent at 7½ inches per second. With the standard VU meter (large-size) you can read recording and output levels, plate currents, bias, and erase voltages —*directly*.

More than a hundred of the new RCA Professional Tape Recorders are already in commercial service. Ask any network, independent station, or transcription studio how they like them. Your RCA Broadcast Sales Engineer has the facts. Call him. Or write Dept. 7J, RCA Engineering Products, Camden, N. J.

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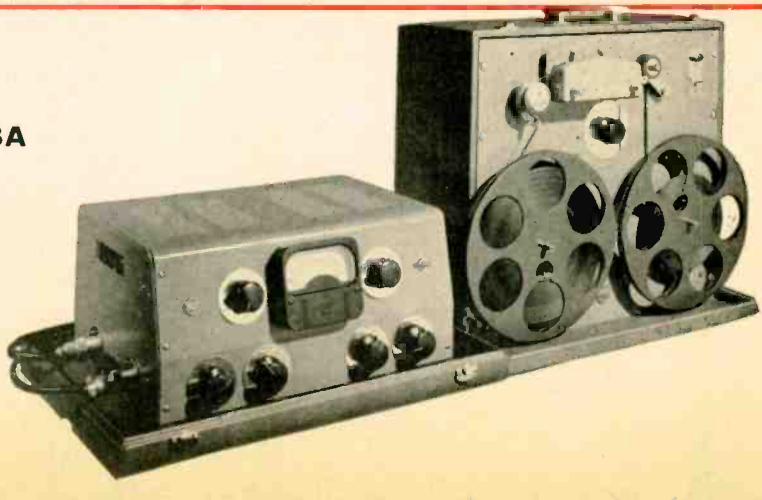
PORTABLE—Type RT-3A

The ideal recorder for high-quality "remotes," studios, or control rooms. The recorder is carried in one case. The amplifier is carried in another case. Amplifier input is arranged for standard microphone (cannon receptacle provided), or bridging of 600-ohm line (terminals). Playback amplifier is designed to feed standard 600-ohm lines and headphone jack.



EDITOR'S REPORT

FURNITURE CABINETS NEEDED

THE SOLUTION to any problem is usually simplified greatly by the complete statement of that problem. With the hope that this may be the case in this instance, it seems desirable that a few words be set down on behalf of the home experimenter—as we choose to call him—the audio hobbyist.

Such a hobbyist pursues what appears to be unattainable—since he is continually at it—and that is perfect reproduction. This "perfect reproduction" may differ appreciably from one installation to another, but who is to tell anyone just what he should consider perfection? One person may demand complete studio realism, while another may want "mellow" music. Let it suffice, though, that each person is entitled to judge whether or not his particular installation satisfies his desires. The steps toward this satisfaction—considering the equipment alone—are relatively straightforward. Components of practically all types, sizes, and styles may be had at the parts jobbers'. But when it comes to the cabinet to house this equipment, the road is not so easy.

Currently there are entirely too few furniture manufacturers who include cabinets in their lines which are suitable for housing a high-quality residence radio installation. If the hobbyist owns his own home, it is often quite simple to install the amplifier equipment in a basement or in an unused closet or under a stairway as suggested by a leading manufacturer of home music systems. The apartment dweller is confronted with many more difficulties. Even if he does have sufficient closets—a rarity in most apartments—they are likely to be full of clothes and boxes, as witness the hall closet made famous by Fibber and Molly.

The cost of having a custom cabinet made to order is usually prohibitive; the skills of the average individual do not usually include the type of craftsmanship necessary to construct suitable furniture cabinets which would be acceptable to the "interior decorator in charge." While most furniture manufacturers do make cabinets of various types, these are rarely adaptable to the requirements of residence radio systems. One radio components manufacturer provides a line of sectional cabinets which may be combined to make almost any desired arrangement, but these are all modern and may not fit into the decoration scheme.

What is needed, then, is a line consisting of about four cabinets in each of two designs—period and modern—that are styled to harmonize with standard furniture, and which will provide space for record changers or turntables, tuners, and amplifiers, and with at least one model large enough to include a tape or wire recorder. The addition of record storage space would be desirable in the larger models. These cabinets need not necessarily include space for speakers, for most serious hobbyists do not subscribe to the idea of having the speaker in the same cabinet with the remainder of the equipment. It is generally recognized that the volume required for good speaker performance must be of the order of six to ten cubic feet, and thus hardly suitable to be combined with another four to eight cubic feet of cabinet designed to hold the electronic equipment.

One of the reasons for the absence of suitable cabintery in existing lines is undoubtedly the fact that manufacturers have overlooked this market. It is firmly believed, however, that from five to ten thousand cabinets could be sold every year to music lovers and audio hobbyists who have been made aware of the advantages of specialized equipment in the search for optimum quality.

Many readers have already found a cabinet arrangement which answers their requirements completely; others are still groping. In an effort to get these two groups together, we would like to see photographs and simple sketches of satisfactory units. A number of the outstanding cabinet designs submitted will be described and shown in an early issue. May we have your ideas?

COLLEGE OF AUDIO ENGINEERING

Further proof of the growing recognition being given to the field of audio engineering as separate and distinct from other branches of electronics and radio is evident from the recent chartering by the State of California of the new University of Hollywood. The Hollywood Sound Institute, long outstanding as one of the better schools for professional training in our field, will be merged with the University, and will hereafter be known as the College of Audio Engineering. The University offers an eighteen-month major resident course in Sound and Audio Engineering, leading to the degree of Bachelor of Science in Audio Engineering. Other courses will include magnetic and film recording engineering, drama, music, radio, and television.

Dr. B. M. Klekner, president, and Howard M. Tremaine, vice president and educational director, are to be congratulated on their efforts toward the establishment of the new University, and our best wishes are extended to them.

AUDIANA

Elsewhere in this issue are a number of excerpts from your letters seconding the plea of Mr. Schwartz as presented in the Letters column of the September issue. The response was surprising, both as to the number of letters and the promptness with which they were forthcoming, and it appears that such a series of articles would be read with some interest. The first of the series is now being prepared, and is scheduled for the December issue.

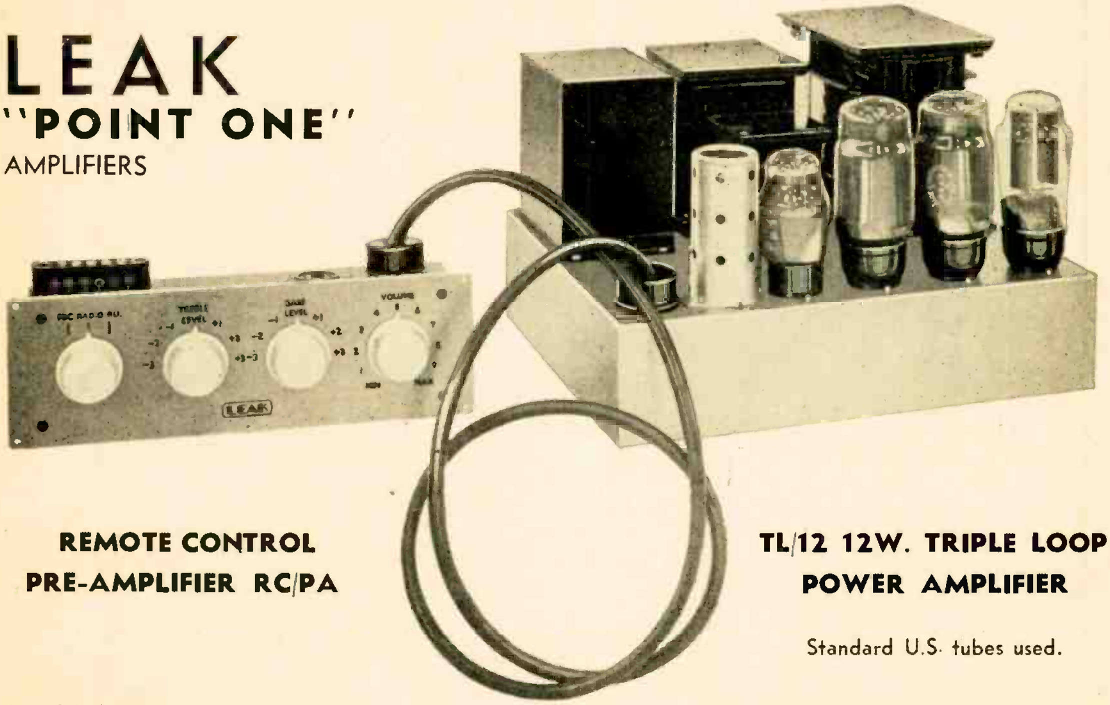
BRITAIN'S BEST AUDIO AMPLIFIER
DISTORTION : 0.1%

Investigate its quality of reproduction and workmanship at

ROOM 650, THE AUDIO FAIR

H. J. Leak M. Brit. I. R. E., will be in attendance to discuss technicalities and to settle distribution rights. He will be at The Hotel New Yorker from Oct.20—Nov.6.

LEAK
"POINT ONE"
AMPLIFIERS



REMOTE CONTROL PRE-AMPLIFIER RC/PA

An original feedback tone-control circuit.

No resonant circuits employed.

- Distortion: Less than 0.05%.
- Switching for Pick-up, Microphone and Radio, with automatic alteration of tone-control characteristics.
- High sensitivities. Will operate from any moving-coil, moving iron or crystal P.-U.; from any moving coil microphone; from any radio unit.
- Controls: Input Selector: Bass Gain and Loss; Treble Gain and Loss; Volume.
  Output Impedance: 0-30,000ω at 20 kc.p.s.

The unit will mount on motor-board through a cut-out of 10⅛ in. x 3⅛ in., or it can be bolted to the power amplifier, when, with a top cover, the whole assembly becomes portable.

For use only with LEAK amplifiers.

TL/12 12W. TRIPLE LOOP POWER AMPLIFIER

Standard U.S. tubes used.

A Leak triple loop feedback circuit, the main loop giving 26 db feedback over 3 stages and the output transformer.

- Push-pull triode output stage. 400 V. on anodes.
- No H.T. electrolytic smoothing or decoupling condensers.
- Impregnated transformers; tropically finished components.
- H.T. and L.T. supplies for pre-amp. and radio units.
- Distortion: at 1,000 c/s and 10 W. output, 0.1%: at 60 c/s and 10 W. output, 0.19%; at 40 c/s and 10 W. output 0.21%.
- Hum and Noise: —72 to —80 db on 10 W.
- Frequency response: ±0.1 db, 20 c/s-20 kc/s.
- Sensitivity: 160 mV.
- Damping Factor: 20. Input impedance: 1 Meg. Output impedances: 2ω; 7-9ω; 15-20ω; 28-36ω. Phase margin 20° ± 10°: Gain margin 10 db + 6 db.

25 W. model available.

The TL/12 Specification is bettered by check of the National Physical Laboratory (equivalent National Bureau of Standards) and their certificate will be on view.

Write for 16 page brochure "A".

We will be demonstrating with Leak Dynamic Pick Up & "550" Loudspeaker.

H. J. LEAK & CO. LTD. Westway Factory Estate, LONDON, W. 3.

— Letters —

Driver Figure-of-Merit

Sir:

Audio men who prefer the triode as a power output tube generally find the driver stage a bit of a problem because of the relatively high driving signal required by most low-mu power triodes. This is particularly true of the interesting 6AS7G.

In selecting a suitable driver, one might take a page out of the pulse amplifier man's notebook. Pulse men use a "figure of merit" to rate tubes for wide-band pulse-amplifier duty by comparing the product of the mutual conductance and the electrode capacitances. Similarly, the audio man might rate drivers according to a "driver figure of merit" by comparing the product of the grid-bias and amplification factor. Obviously, gain alone is of little consequence in a driver if the grid bias is low since the low permissible grid signal limits the plate signal output. On the other hand, a high grid bias will be nullified by too low a mu since again the plate output will be low.

On this basis, the old 27 looks surprisingly good with a "figure of merit" of 21 times 9. or 189. as compared to the 76 or 6P5 with 186.3, and to the 6SN7GT or 6J5 with 160. The old 6N7 has a very high figure of merit of 210. but its high mu of 35 means higher odd-order harmonics, and harsh intermodulation distortion. The 27 tends to be a bit non-linear at 250 volts on the plate and —21 volts on the grid.

For a time, the writer contemplated trying out the video pentodes 6AG7 and 6AC7 as triodes for driver duty. However, just recently one manufacturer has come out with a new 9-pin miniature twin-triode, the 5687, which appears to be the answer to the triode man's prayer. At 250 volts, it takes a grid bias of —12.5, and has an amplification factor of 16.5, giving it a driver figure of merit of 206.25. This is nearly as high as that of the rather high-mu 6N7.

By using two of these tubes in push-pull-parallel, one could get quite a walloping driver signal since conductance is doubled and plate loading can be cut down. This increases gain and provides better impedance matching looking into the power triode grid circuit. Of course, the electrode capacitances and Miller effect are more or less doubled, and circuit design must be carried out so as to hold down high frequency cutoff.

Admittedly, this simple method of rating driver tubes is a bit oversimplified, but is particularly effective where an "all-other-factors-are-the-same" condition exists. A table set up for various triodes shows a more less consistent decrease in grid bias with increase in amplification factor, indicating the general fact that medium-mu tubes are most effective as power-triode drivers, as a rule.

Ted Powell
5719 69th Lane,
Maspeth, N. Y.

LP Echoes

Sir:

. . . We have found that the most serious cause of echo in playing LP records is a worn reproducing stylus. This is probably due to a greater effect of the echo near the surface of the record where the grooves are closest, and the compliance of the medium is highest. In cases of severe needle wear, the shoulder formed on the tip may contact the "horns" which surround the adjacent groove.

Howard A. Chinn
Chief Audio-Video Engineer,

Schwartz's Responses

Sir:

Mr. Schwartz is definitely not alone in his wish for articles in good basic audio design. Please start such a series, and the sooner the better.

Kenneth A. Wahrenbrock,
1785 N. Hunter,
Stockton, California

Sir:

I heartily agree with Mr. Schwartz' plea. Such articles as commercial sound systems and the like that may be found in manufacturers' literature are a waste of space in your magazine.

Frank A. Peters,
Smithtown Branch,
L. I., N. Y.

Sir:

I approve heartily of the suggestion put forward by Mr. Schwartz. Most of us indicate by subscribing to this publication that we expect something on a higher plane than is found in the strictly popular magazines. At the same time, we are too busy to comb through a mountain of literature trying to arrive at best practices and so on.

Woodrow J. Radle,
Box 336,
Vandalia, Ohio

Sir:

Count me as seconding Mr. Schwartz' motion. . .

L. Jacobson
1535 Shattuck Ave.,
Berkeley 9, California

Sir:

Bravo for Mr. Schwartz' proposal. I approach audio purely from a music-lover's viewpoint, and must confess that I am partly baffled by a full 50 per cent of the articles—which however does not keep me from plowing through them all with no little pleasure or profit.

. . . The few of us benighted characters who can haltingly grope through a schematic would, once it was given us, find the series indispensable.

James H. Day
1201 E. Seneca Ave.,
McAlester, Okla.

Sir:

I read with enthusiasm Mr. Schwartz' letter. . . One suggestion: In planning the articles, have in mind their subsequent publication as a book.

A. D. Battey,
5757 Blackstone Ave.,
Chicago 37, Ill.

Sir:

Mr. Schwartz is not alone . . .

Such a series would help to allay a certain degree of disappointment which is inevitable on the arrival of an issue such as September, 1949.

Charles M. Waldo,
51 Jackson Road,
Wellesley Hills, Mass.

Sir:

I agree enthusiastically with the suggestion offered by Mr. Schwartz. Those of us interested as hobbyists and semi-professionally would welcome a series on fundamentals—design, placement, and practical suggestions on audio practices which are routine with the professional but are picked up the hard way by the hobbyist. Most of us have stumbled on these elements of audio engineering but at great cost of time and cash. Errors of "cut and try" could be somewhat eliminated for us. The cost of the output transformer I drilled a hole in the other day would buy another three-year subcription to A.E.

Name withheld
Seattle 5, Washington

Sir:

I agree substantially with the ideas of Mr. Schwartz. Here's hoping they will be carried out.

Donald J. Ketchum
Ketchum Sound Recording
Laboratory
South Pasadena, Calif.

[Continued on page 55]


music
comes to
life!

Audio Frequency Measurements

W. L. BLACK* and H. H. SCOTT**

Part I: Design, development, and maintenance all depend on the measuring procedures employed. The author discusses these methods thoroughly, and presents reasons for every step.

This paper was originally presented at the joint IRE-RMA Meeting at Syracuse, New York, on April 28, 1948 and is presented in its entirety in AUDIO ENGINEERING *by authorization of Radio Engineers.*

DURING THE LAST SEVERAL YEARS the Radio Manufacturers Association has given considerable attention to codifying minimum standards of performance for the major components of radio broadcasting systems. The engineering aspects of this subject have been considered by committees in the Transmitter Section of the Engineering Department of the Association.

Definitions and minimum standards for the audio facilities of a radio broadcasting system considered primarily as a complete electrical system have been issued as an RMA standard.[1] As defined in this standard, audio facilities comprise "all audio facilities from the input terminals of the microphone pre-amplifier to the input terminals of the main transmitter, excluding the studio-transmitter link which may be either wire line or radio. No pre-emphasis is included in the audio facilities."

Subsequently work was undertaken to outline methods of measurement of audio facilities. In this connection, it is necessary to specify conditions for testing to insure that measurements made at different times and on different apparatus will be comparable. Furthermore, it is desirable to indicate the instrumentation necessary for practical results. The measuring equipment should be such as to insure adequate and duplicable results in the light of the requirements of the standards involved, while at the same time avoiding the imposition of an undue burden on instrument manufacturers.

In the consideration of audio frequency measuring equipment it was early apparent that, while the subject is not new, there is a great dearth of correlated published material. In view of this situation, it is the purpose of this paper to summarize the technical background which is the basis for the RMA standardization activity, to indicate the philosophy leading to the formulation of the standards proposals as issued, and to outline possible pitfalls in making measurements on complex high-gain audio systems.

The measuring techniques which are discussed may be applied with equal validity to component parts of systems, such as an amplifier having a transmission gain or a network having a transmission loss, or to overall systems. However, emphasis is placed on system measurements because a complex high-gain system ordinarily presents more of a measurement problem than do system components.

As a practical matter, the important characteristics of audio systems for radio broadcasting which have been agreed upon for RMA standardization are: gain, frequency response (relative gain over a frequency range), single-frequency harmonic distortion, and noise (in the sense of noise being extraneous sound or corresponding electrical energy tending to interfere with the proper and easy perception of desired sounds or their equivalent electrical waves).

Gain Measurements

Gain for the determination of performance characteristics is measured between resistances equal to the rated source and load impedances. The term "insertion gain" may be defined[2] as the ratio, expressed in decibels, of the powers at a given frequency, which are delivered to that part of a transmission system beyond the point of insertion after and before the insertion of apparatus in the system. However, to take into account differences between source and load impedances, the Committee on Audio Facilities has defined insertion gain[1] as the ratio, expressed in db, of the power delivered to the load to the power which would be delivered to the same load if the amplifier or system were replaced by an ideal transformer which matches the load and source impedances.* For the purpose

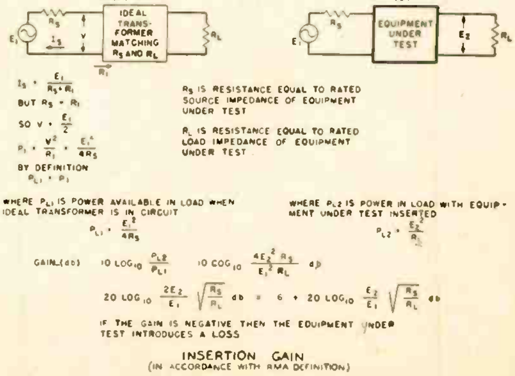
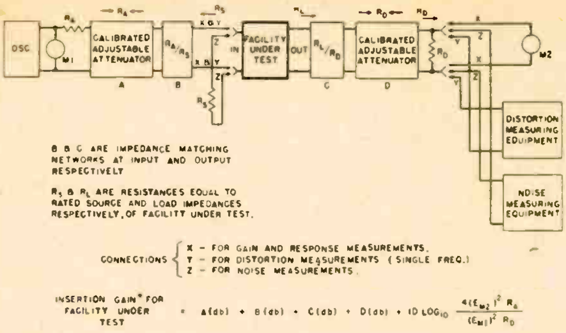


Figure 1

*This latter definition, based upon the power delivered to a resistance load by the system being measured and the optimum power transfer from the generator, is that generally implied in connection with amplifier gains (Ref. 3, pp. 48-50; ref. 4, pp. 226-227; ref. 5). However, it has not been uniquely named or defined in the literature. At the present time the term "transducer loss" and the cognate term "transducer gain" are understood to be under consideration. As they are being considered, both include the concept of an "ideal transducer" for the determination of reference power. The term "gain" in this paper is used in this latter sense.

*Bell Telephone Laboratories, Murray Hill, N. J.
**Herman Hosmer Scott, Inc., 385 Putnam Ave., Cambridge 39, Mass.

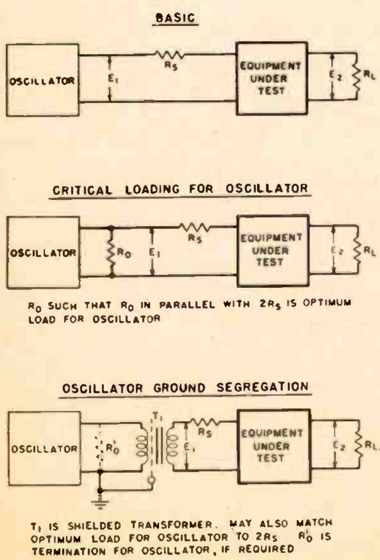


TYPICAL MEASURING SYSTEM FOR AUDIO FACILITIES

* AS DEFINED BY RMA COMMITTEE ON AUDIO FACILITIES

Figure 2

of measuring insertion gain (or loss) on this basis the arrangement shown in *Fig*. 1 is used. In this figure, *A* shows an ideal transformer matching the load impedance to the internal generator impedance. By definition such a transformer has no dissipation loss. Under this condition, the power in the load may be stated in terms of the equivalent internal resistance of a generator and the open circuit voltage delivered by that generator. In *B* the power dissipated in the same load after insertion of the equipment to be measured is defined in terms of the voltage across the load and the resistance of the load. Then by definition the gain is the ratio of the power in the load with the equipment under test in the circuit to the power delivered to the same load without the equipment under test.



OSCILLATOR CONNECTIONS

Figure 3

It is obvious that any further discussion of gain will refer with equal validity to frequency response, as the latter is relative gain over the specified frequency range. However, the determination of absolute gain requires more precise refinements in the measuring system than does the determination of relative gain (frequency response) as discussed in more detail later.

Measurements using resistance terminations for the measurement of the component parts of a system may not agree in total with the results of overall measurement of the system between resistances. Ordinarily the disagreement is, however, of relatively small magnitude when the interrelations of the impedances of the components have been considered in conjunction with the system design. For large variations from rated impedances, distortion of gain - versus - frequency characteristics may be sufficient to require consideration of the coupling factors[6] involved and may indicate corrective equalization.

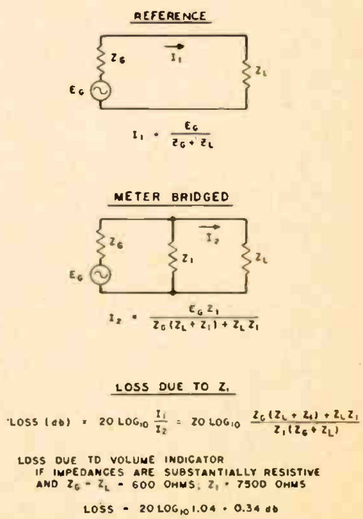
Practical Test Circuit

For practical tests, particularly where large amounts of gain or loss are being measured, the simple circuit of *Fig*. 1 is not adequate because of the limitations in the voltage ranges of the meters which may be available for indicating the input and output voltages. In order to obtain suitable voltage levels, calibrated attenuators are used in conjunction with the input and output meters. Since the attenuators may not always have the desired impedance for matching the equipment under test, impedance-matching networks or pads will be required in some instances. *Figure* 2 presents an essentially complete diagram showing all circuit elements which would ordinarily be required for audio-frequency measurements. In many cases several of the units may be combined in one physical instrument. Separate consideration of each of the various elements follows.

Oscillator

The source of power for gain testing is generally an audio frequency oscillator. This oscillator should cover the range of frequencies involved in the tests. Ordinarily absolute frequency accuracy and stability with time are not practical limitations. Thus absolute stability of the order of two per cent maximum, which is fairly readily achieved, is adequate. However, in the measurement of frequency selective devices such as filters and in the use of some types of distortion measuring instruments containing sharply tuned rejection circuits the accuracy of frequency may be a governing factor in accuracy of results. Another practical consideration is freedom from drift of output voltage with time and with variation in oscillator power supply voltage.

In addition, for gain measurements the spurious components, such as harmonic distortion and noise in the oscillator output, should not represent more than ten per cent rms of the output voltage. However, when distortion measurements are made, as discussed later, it is important that distortion and noise components in the oscillator output wave be appreciably below this value to avoid affecting the accuracy of the distortion measurement. Low distortion from the oscillator is also important if the equipment under test includes filters having sharp cut-off characteristics. It may be necessary to



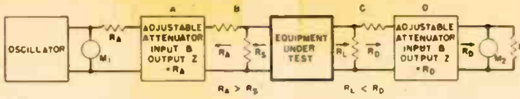
LOSS DUE TO BRIDGED METER

Figure 4

take special precautions to obtain satisfactorily low distortion from the oscillator. For example, with some oscillators the distortion is a function of output power. With such an oscillator the output level obviously should not be above that determined to be objectionable. Harmonic suppression filters may be necessary following the oscillator. Means for checking the oscillator distortion are described later.

Some oscillators may be critical as to load impedance, in which case it may be necessary to take special precautions in the output circuit, such as those shown in *Fig.* 3. Although this figure shows such load impedance correction as shunt resistance it is equally feasible to use a series resistance if the optimum load required for the oscillator is higher than that offered by the measuring circuit. The principal difficulty usually experienced with oscillators critical to load impedance is an increase in harmonic content with departure from optimum loading. It will often be necessary to include a transformer having an interwinding electrostatic shield between the oscillator output and the input of the testing circuit to control ground connections and parasitic coupling between the oscillator and the remainder of the testing system. This is discussed in more detail later.

In any event, with the input voltage to the test circuit measured at the location shown in *Fig.* 3, once the circuit at the output of the oscillator has been determined and the oscillator output voltage is stabilized, the output circuit does not affect the measurements of gain or of response as a constant output voltage is maintained, and the oscillator is then the equivalent of a zero internal impedance generator.



B AND C ARE MINIMUM LOSS "L" PADS MATCHING R_A TO R_S AND R_L TO R_D RESPECTIVELY

IF Z IS LARGER AND z IS SMALLER OF TWO IMPEDANCES BEING MATCHED BY EACH MATCHING PAD, THEN

$$\text{LOSS (db)} = 20 \log_{10}\left(\sqrt{\frac{Z}{z}} + \sqrt{\frac{Z-z}{z}}\right)$$

MATCHING PADS

Figure 6

Terminations and Meters

The desired objective of comparable results indicates the use of pure resistances for terminations. Such terminations include that for the output of the equipment under test as well as any used for input termination, including that used for equivalent generator internal impedance. If the impedance of a resistor used for such termination is within five percent of the desired resistance value over the frequency range from 0 to 50,000 cps, the inaccuracy of results due to such variation will be less than 0.01 decibel.

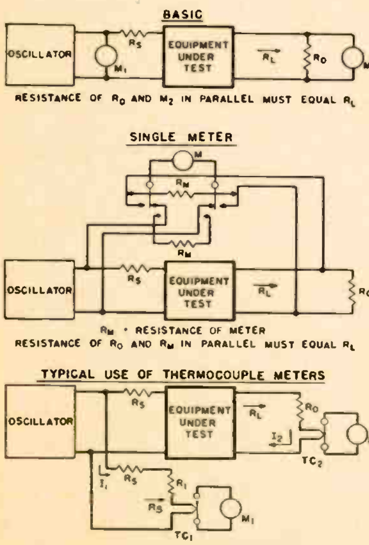
There are other factors regarding precision of terminating resistors which warrant consideration. These include the absolute value of output terminating resistors and the stability of such resistors with temperature, particularly when the output distortion of a power amplifier is being measured. Also included is the comparative accuracy of a pair of resistors when an arrangement such as *Fig.* 9 is employed.

The input voltmeter may be of the vacuum tube, rectifier, or thermocouple type, or may be a standard volume indicator. This meter may be rms. average or peak reading except as noted in specific instances later. The stability of this meter must be such that its readings are not influenced by extraneous factors, such as power supply to a vacuum tube.

If a rectifier meter is used, its possible introduction of extraneous modulation products, particularly when making distortion measurements, as well as its possible variation in impedance with change in input are limiting factors. The loss introduced in the transmission circuit by the ordinary meters of this type (of which the "standard volume indicator" is a special form) must be taken into account, particularly if the meter is alternately connected and disconnected during a test. This effect can be reduced to negligible practical proportions if a resistance equal to the impedance of the meter is substituted when the meter is disconnected. In the recommended good engineering practice section of the American Standards Association materal[7] on the "standard volume indicator" it is recommended that the value of its impedance be not less than 7500 ohms for use as a bridging instrument on a 600-ohm circuit. A volume indicator having such an impedance would introduce a 0.34 db loss as shown in *Fig.* 4, assuming all impedances are substantially resistive.

A thermocouple meter may be used provided it is appropriately connected to the circuit so that its internal resistance is taken into account. Suitable thermocouples will have a heater resistance of the order of 600 ohms or less for the sensitivity desired. Suitably calibrated thermocouple meters have good scale spread, practical freedom from frequency discrimination at audio frequencies, freedom from modulation, and adequate accuracy. The disadvantages are relatively slow speed of operation and danger of damage from excessive current.

In this general connection, the indication of a rectifier type meter, typified by one using a copper oxide rectifier, approximates the average value of a sine wave, while a thermocouple meter indicates the effective or rms value. However, if the former is cali-

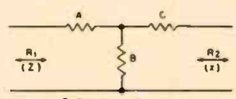


$R_1 + TC_1\text{(HEATER)} = R_S$ AND $R_O + TC_2\text{(HEATER)} = R_L$

$$\text{GAIN (db)} = 10 \log_{10} \frac{I_2^2 R_L}{I_1^2 R_S} \text{ db} = 20 \log_{10} \frac{I_2}{I_1} \sqrt{\frac{R_L}{R_S}}$$

ALTERNATIVE METER CONNECTIONS

Figure 5



IF $Z > z$ THEN $R_1 > R_2$

AND $X = \log_{10}^{-1} \frac{db}{20}$ = CURRENT OR VOLTAGE RATIO

WHERE db IS LOSS DUE TO PAD IN DECIBELS

THEN

GENERAL SOLUTION

$$A = \frac{R_1(X^2+1) - 2X\sqrt{R_1 R_2}}{X^2-1}$$

$$B = \frac{2X\sqrt{R_1 R_2}}{X^2-1}$$

$$C = \frac{R_2(X^2+1) - 2X\sqrt{R_1 R_2}}{X^2-1}$$

WHEN $R_1 = R_2 = R$

$$A = C = R\left(\frac{X-1}{X+1}\right)$$

$$B = 2R \frac{X}{X^2-1}$$

FOR $C = 0$ (MINIMUM LOSS PAD)

$$A = \sqrt{R_1(R_1 - R_2)}$$

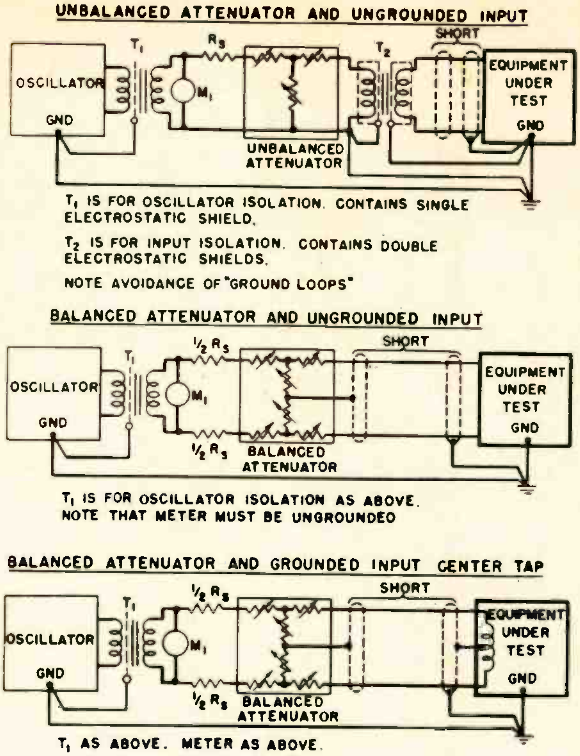
$$B = R_2\sqrt{\frac{R_1}{R_1 - R_2}}$$

FOR BALANCED PADS DIVIDE A AND C EACH BY 2 FOR VALUE FOR EACH SIDE OF CIRCUIT.

FOR CENTER TAP GROUND DIVIDE B BY 2 AND GROUND COMMOM POINT BETWEEN TWO HALVES

RESISTANCE PADS

Figure 7



BALANCE AND GROUNDING-INPUT CIRCUITS

Figure 8

brated in terms of rms values, no practical difficulty will be experienced on this score in making gain (and frequency response) measurements, even though one type is used at the input and the other type at the output, provided that the testing frequency has a sine wave form within the limits already discussed. In the determination of harmonic distortion, wave-form errors due to the type of meter used may limit the accuracy of measurement.[8]

The output meter may be similar to the input meter or may actually be the same meter alternately connected at the input and at the output. If the other components of the measuring system are so arranged that the input and output voltages are the same, the measurements are expedited with this arrangement, and errors due to absolute calibration of the meter and to its variation in indication with frequency are eliminated in making response measurements. However, convenient switching on this basis involves bringing wires from the input and the output of the system in close proximity and may cause undesirable coupling, particularly when a high-gain system is being measured. This may cause an error in absolute gain indication or an error changing with frequency during response measurements, or both. This procedure is, of course, impractical if the input and output of the equipment under test are not in approximately the same vicinity. For example, the input of the system being tested might be in a studio control booth and its output in a master control room.

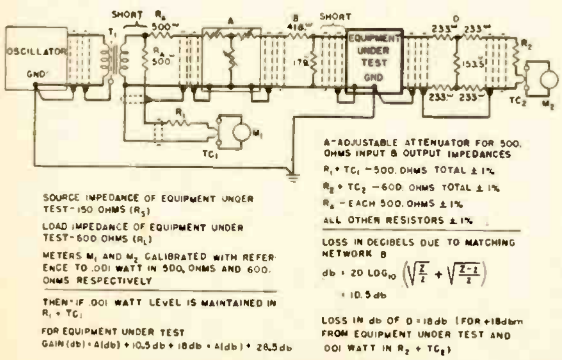
Any meter or meters used should have either flat frequency response for the range of frequencies involved in the measurements or must be calibrated for deviation with frequency to obtain accurate indication of absolute gain over the frequency range of interest. In addition, the instrument scale spread and pointer structure must be such that deviations are discernible on the instrument with changes in gain of the equipment under test to an accuracy corresponding to at least the order of accuracy desired for the value of absolute gain. Furthermore, the sensitivity of the output meter may require consideration in the case of loss measurements. Finally, the factors such as pivot friction and uniformity of magnetic field ordinarily affecting the accuracy of electrical instruments should be considered in conjunction with the absolute accuracy desired.

Figure 5 shows some possible variations in circuit arrangement for varying meter connections.

Adjustable Attenuators

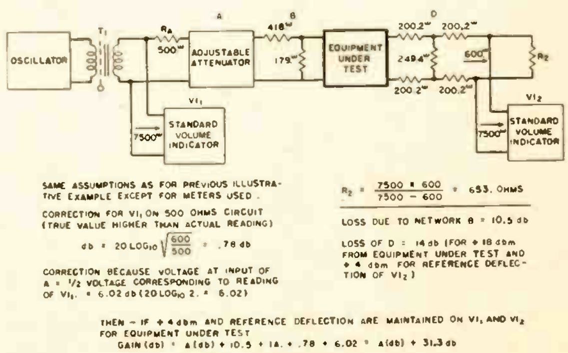
As a practical matter, greatest convenience of measurement is achieved if the meters used are held at constant readings and the variations in gain are determined by calibrated adjustable attenuators at the input and at the out-

(*Continued on page 38*)



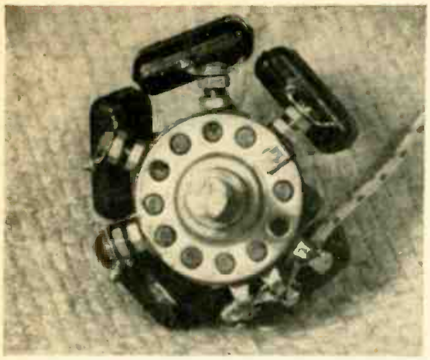
ILLUSTRATIVE EXAMPLE

Figure 9



ILLUSTRATIVE EXAMPLE USING STANDARD VOLUME INDICATORS

Figure 10



Construction Details of a Continuously Variable Loudness Control

J. W. TURNER*

The popularity of this type of control provides the incentive to construct a simpler form than the original.

Several months ago the writer constructed a loudness control according to the information set forth in David Bomberger's article in an earlier issue.[1] The improvement in balance at all levels, and particularly at average living room level and below, is just another one of those things which can only be appreciated through actual experience. No amount of description can replace one minute of listening to a system incorporating fully compensated control of this kind. Without exception, its excellence has been admitted by all who have heard it, and no one could fail to be impressed by its value after hearing the difference between a selection played at a low level using the loudness control and the same selection played at the same level but with the amplifier gain reduced by the usual methods.

After doffing the hat to Mr. Bomberger in the above fashion. it is necessary to point out that the control had one serious drawback to which the writer could not accustom himself. This lay in the fact that a switching arrangement was used, whereas nearly everyone is thoroughly accustomed to the smoothly variable nature of the standard volume control. The result of using a switch was a poor psychological situation in which it seemed that no matter which position of the eleven point switch was in use, another one might be better. It did not seem that a greater number of positions, as suggested by Winslow[2], was the right answer apart from the increased number of components. so some means of making the control continuously variable seemed indicated.

A survey of the catalogues failed to turn up a potentiometer which met the requirements with respect to number and location of taps, so it was decided to attempt the modification of a standard unit. An Ohmite 250K linear pot was chosen, chiefly because of the fact that the resistance element in this type is mechanically secure as compared to some types in which the carbon strip is fastened down only at the ends, permitting the strip to move

[*Continued on page 44*]

*440 *Rockaway St., Boonton, N. J.*

[1] "Loudness Control for Reproducing Systems" Audio Engineering, May 1948.

[2] "Full Range Loudness Control," Audio Engineering, Feb. 1949.

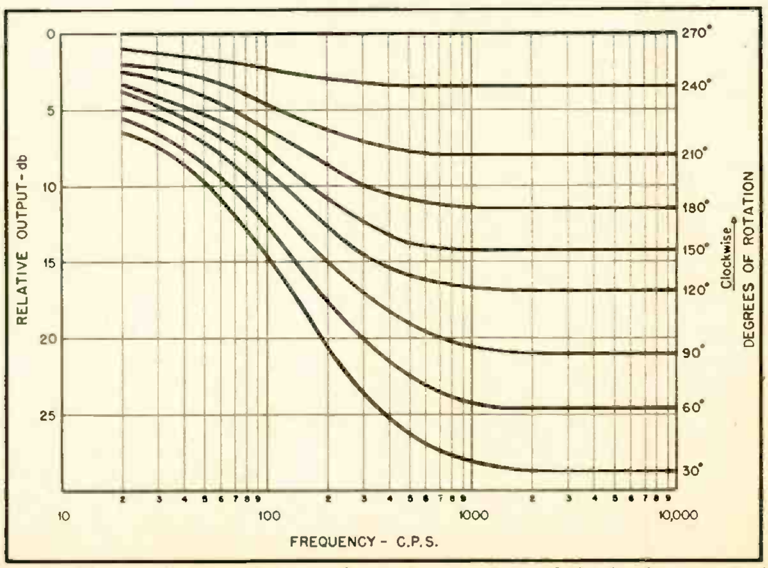


Fig. 1. Measured response curves for various settings of the loudness control.

Fig. 1. Ground loudspeaker with protective cover in place, and showing access plate which permits easy removal of driver unit for maintenance.

Ground Loudspeakers

DAVID SCOTT*

A unique loudspeaker arrangement which is ideally suited for airports or large athletic fields such as the one for which it was designed.

Designing a practical loudspeaker installation for use in a large outdoor arena has been a running problem for Czech engineers for a number of years. The unusual requirements which had to be met brought forth several different proposals and designs. However, none of these has been completely satisfactory until now.

The problem was a public address system for the Strahov stadium in Prague. This is one of the largest stadia in the world, the arena measuring 1000 by 650 feet, and the stands having a capacity of 280,000 spectators. It is used primarily for exhibitions of mass calisthenics and exercises in which up to 26,000 participants perform simultaneously. These are normally held at six-year intervals by the Sokol physical training organization which has been in existence in Czechoslovakia since 1862.

**Praha XVI, Zaverka 2460, Czechoslovakia*

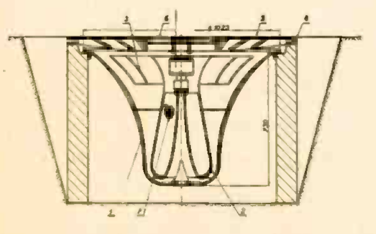


Fig. 2. Cross section of ground loudspeaker. Dimensions shown are in millimeters, with overall diameter of bell being 40 inches and depth of bell being 28.5 inches.

1 Bell
2 Horn center section ("bomb")
3 Deflectors
4 Ribbed cover support
5 Perforated main cover
6 Removable center section of main cover
7 Matching transformer

Since one of the features of these performances is synchronized movements of all the gymnasts, it is necessary that coordinating music reach each participant with a negligible delay. When loudspeakers were placed on the stands along one side of the field, the dimensions of the area are such that there was a time-lag of 0.6 seconds between the first and last rows of the performers. This resulted in a wave-like movement of the mass. Loudspeakers mounted along all four sides of the field would reduce this lag, but at the same time would introduce acoustical distortion.

For practical and aesthetic reasons loudspeakers could not be mounted on poles throughout the field, so experiments were made with loudspeakers placed in the ground. Early models of this type were either excessively complicated or were not waterproof or impervious to humidity, and therefore had to be removed and stored in a dry place between performances.

The most recently developed ground loudspeaker, described in this article, was first used during the Sokol exercises in 1948, and the results were satisfactory in every respect. The PM driver unit is completely waterproof, and during tests has been operated under water for as long as 24 hours with no harmful effects and with only a negligible change in its reproduction characteristics.

Fifty 15-watt loudspeakers are installed flush with the surface of the ground 115 feet apart in a regular pattern, so that no participant can be further than 80 feet from a speaker. The maximum time-lag is therefore .07 seconds. The construction of the steel grill covering each buried installation is capable of supporting a weight of 6.5 tons, permitting loaded sprinklers or other heavy vehicles to drive over them.

A cross-section drawing of a complete assembly is shown in *Fig. 2*. The concentric, exponential horn is composed of two sections, the bell (*1*) and center-section (*2*). The inside of the cross-section casting forms the neck of the horn, while its outside is the internal surface of the wide end and

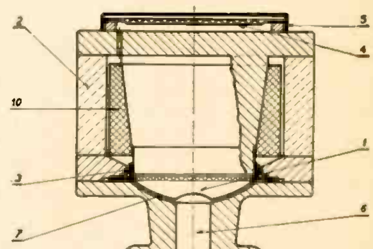


Fig. 3. Cross section of driver unit to show internal construction.

1 Plastic diaphragm
2 Alnico magnet
3 Voice coil
4 Compensation diaphragm
5 Protective cover
6 Throat
7 Pressure chamber
8 Contact ring
9 Internal threads for mounting and electrical contact

mouth. The small cone is part of the center-section, and acoustically covers the two-inch drainage hole in the base of the bell, but is undercut to permit water to flow underneath it.

The PM driver unit is screwed onto the throat of the center-section, as shown in *Fig.* 1, while its matching transformer (*7*) is mounted in the "dead area".

The circular deflectors (*3*) are held in position by wire supports, and the innermost section forms the inside surface of the horn mouth as well as acting as a dust cover for the PM unit. The ribbed cover-support (*4*) has additional deflecting fins which also strengthen it structurally. The perforated main cover (*5*) is bolted to the cover-support, but the cover center-section (*6*) can be removed easily to give access to the PM unit.

Fig. 4. Strahov stadium, Prague, viewed from the air. 17,000 men engaged in mass gymnastics before crowd of approximately 280,000 spectators in July 1948.

PM Driver Unit

Removal of the PM driver unit is accomplished as shown in *Fig.* 1. The dust-cover pulls off and the unit unscrews. In the cross-section drawing, *Fig.* 3, its construction may be seen in detail.

The flange on the plastic diaphragm (*1*) provides a water-tight seal, and the voice-coil (*3*) is placed in the air gap between the two poles of the concentric, Alnico V magnet. The voice-coil leads on the outer surface of the diaphragm pass through holes in the brass neck of the unit where they are connected to a small terminal strip and thence to the contact rings.

A wooden ring (*10*) is placed inside the magnet to make the sealed volume of air as small as possible so that the effect of temperature changes will be reduced to a minimum. The thin aluminum compensation diaphragm (*4*) with protective cover (*5*) on the top of the unit equalizes the internal and external pressure differences caused by heating and resultant expansion of the air. This type of construction completely seals the voice-coil and magnet.

The throat of the unit (*6*), with a diameter of 2 cm., and the pressure chamber (*7*), form an acoustic transformer. At the face of the throat is an insulated contact ring (*8*), while the internal threads of the mounting collar provide the second electrical contact. When the unit is screwed down tightly on the neck of the horn, perfect electrical and acoustical connections are automatically made. The contact surfaces of the horn are connected to the matching transformer, and from there wires are carried out through rubber grommets in the sides of the horn center-section and of the bell.

This type of ground loudspeaker was designed by Dr. Josef Merhaut and manufactured by the Tesla National Corporation, the center of the Czechoslovak electronics industry. In addition to tests of prolonged submersion in water, the PM driver unit has been subjected to extreme mechanical and electrical overloads. One test consisted of applying a low-frequency square-wave voltage of three times the normal rated input. This was maintained for a period of 72 hours without any noticeable harmful effects.

During the Sokol exhibitions last year torrential rains flooded the stadium on several occasions, yet the entire installation functioned quite unaffected. The success of these ground loudspeakers has prompted their use at airfields and other places requiring unobstructed movement and vision.

TECHNICAL DATA:

Area of the diaphragm: $A_d = 38.5$ cm^2

Moving mass of the diaphragm: 3.6 gms.

Throat of the horn: $A_o = 3.14$ cm^2

Radiation resistance of the diaphragm:

$c\rho \times A_o (A_d/A_o)^2 = 41.5 \times 3.14 \times 12.2^2$
$= 2 \times 10^4$ (cgs) (or g/sec^{-1})

Length of the horn: $L = 130$ cm.

Cross section of the horn is given by the equation:

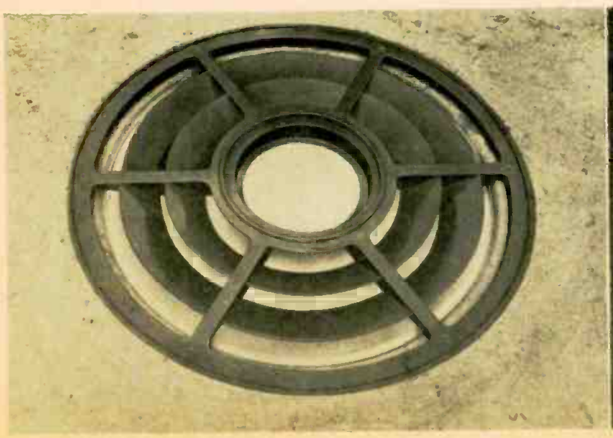
$A = A_o e^{\gamma x}$ where the exponent γ at the start is $= 0.0784$ cm^{-1} and changes continuously to the value of $\gamma = 0.046$ cm^{-1}.

Low-frequency cut-off: 200 cps

Rated input: 15 watts at a nominal voltage of 100 V_{eff}.

Saturation in the Alnico magnet gap: 17,000 gauss.

Fig. 5 (left). Perforated main cover removed to show ribbed support. Fig. 6 (right). Sound deflectors are visible when ribbed support is removed.



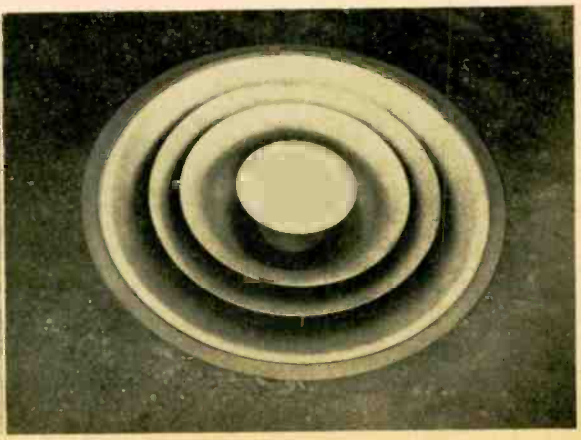


Fig. 1 (above), and Fig. 2 (below). Front and back views of new RCA 515S1 duo-cone loudspeaker.

New 15-Inch Duo–Cone Loudspeaker

HARRY F. OLSON* and JOHN PRESTON*
and
D. H. CUNNINGHAM**

Modifications made on the well-known LC1A result in a speaker which can be manufactured in mass quantities at lower cost.

THE ALMOST UNIVERSAL USE of the direct-radiator loudspeaker is due to its simplicity of construction and the relatively uniform response-vs-frequency characteristic. Uniform response over a moderate frequency band may be obtained with any simple direct-radiator speaker. However, reproduction over a wide frequency range is restricted by practical limitations. The portion of the speech-frequency range required for intelligibility falls in the mid-audio-frequency band. The range of the fundamental frequencies of most horn, reed, and string musical instruments also falls within this band. This is rather fortunate, because it is a simple task to build a direct-radiator dynamic speaker to cover this mid-frequency band. The two extreme ends of the audio-frequency band are the most difficult to reproduce with an efficiency comparable to that of the mid-frequency range. Inefficiency at the low frequencies is due primarily to low radiation resistance. Inefficiency at the high frequencies is due primarily to large mass reactance.

Volume range is another factor. An increase in volume and frequency ranges of a speaker multiplies the problems connected with obtaining low nonlinear distortion and broad directivity patterns. When the high-frequency range is increased, the directivity pattern becomes quite narrow, and some means must be devised for obtaining a broad directivity pattern. The problem of nonlinear distortion also is increased when the frequency range is increased. From the foregoing it is quite evident that there are many problems to be considered in the development and production of a high-quality wide-range speaker.

Wide-frequency-range, low distortion speakers are required for monitoring in radio and television broadcasting, phonograph and motion picture recording, high-quality sound systems, and custom sound-reproducing systems. The demand for a reasonably priced high-quality speaker by connoisseurs of high-quality reproduction is rapidly increasing. The direct-radiator speaker is particularly suited for these applications because the acoustical power required is relatively low and the space requirements comparatively small.

Some time ago a duo-cone speaker was developed, manufactured, and sold by RCA as the LC1A. It has now been

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

1 "Wide Range Loud Speaker Developments." H. F. Olson and J. Preston. *RCA Review*, Vol. VII, No. 2, June 1946.
2 Olson, *Elements of Acoustical Engineering*, 2nd Edition, D. Van Nostrand Company, New York, N. Y. 1947.

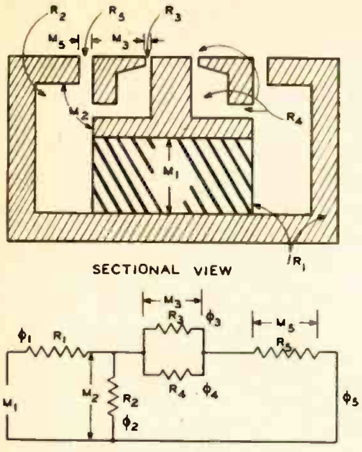


Fig. 3. Schematic sectional view and the magnetic network of the magnetic structure. M_1, the magnetomotive force developed by the permanent magnet. M_2, the magnetomotive force drop across the two air gaps. M_3, the magnetomotive force drop across the small air gap. M_5, the magnetomotive force drop across the large air gap. R_1, the reluctance of the iron. R_2, the reluctance of the leakage gap. R_3, the reluctance the small air gap. R_4, the reluctance of the added gap and leakage. R_5, the reluctance of the large gap. ϕ_1, the total flux. ϕ_2, the leakage flux. ϕ_3 the flux in the small gap. ϕ_4, the leakage flux and the flux through the added gap. ϕ_5, the flux in the large gap.

in the field for almost two years. The design principles embodied in this device have been found to be fundamentally sound and highly desirable. The LC1A duo-cone speaker[1,2] still remains the "de luxe" item, and particular pains are taken in its manufacture to maintain the high performance characteristics with no compromise in quality. The problem of incorporating the desirable features of the LC1A speaker into a simplified and lower-cost mechanism with certain compromises was considered and, as a result, a simplified version (Type 515S1) has been developed, designed, and commercialized. It is the purpose of this report to describe this speaker mechanism.

Magnetic Structure

In the duo-cone speaker Type 515S1 two separate cones driven by separate voice coils are used. Furthermore, the coaxial and congruent arrangement of the cones is maintained essentially the same as in the duo-cone LC1A. This type of vibrating system required two separate air gaps.

A fundamental study of two-air-gap magnetic structures was carried out. As a result, a magnetic bridge system with two air gaps supplied by a single magnet was developed. A schematic view and the magnetic network of this air gap are shown in *Fig.* 3. From a consideration of the magnetic network it can be seen that practically any ratio of flux densities in the two air gaps may be obtained by suitable selection of parameters. The magnitude of the flux density in the air gaps is governed by the magnetomotive force developed by the permanent magnet. The magnetic efficiency of this combination structure is higher than that of two separate magnetic structures in spite of the fact that the flux in the gap R_4 is lost. This higher magnetic efficiency is due to the smaller percentage of leakage in this structure as compared to that of two separate magnetic structures.

Vibrating System

A sectional view and the mechanical network of the vibrating system of the duo-cone speaker are shown in *Fig.* 4. The vibrating system consists of a large voice coil for the reproduction of the low-frequency range and a small cone driven by a small voice coil for the reproduction of the high-frequency range. The outside suspension of the

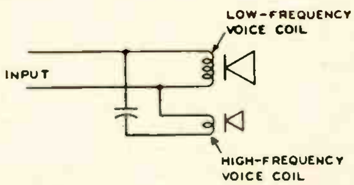


Fig. 6. The electrical crossover network of the duo-cone speaker.

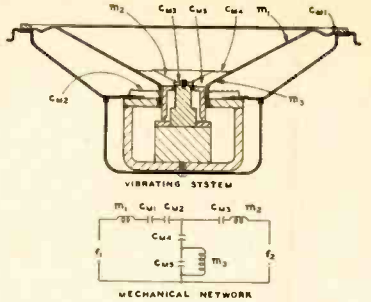
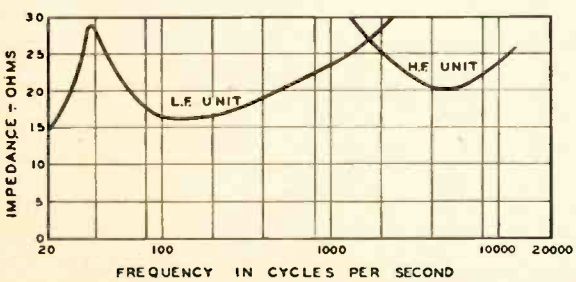


Fig. 4. Sectional view and mechanical network of the RCA 15-inch duo-cone speaker. In the mechanical network: f_1, the driving force in the low-frequency voice coil. m_1, the mass of the low-frequency cone and coil. C_{M1}, the compliance of the outer suspension system of the low-frequency cone. C_{M2}, the compliance of the centering suspension of the low-frequency cone. f_2, the driving force in the high-frequency voice coil. m_2, the mass of the high-frequency cone and coil. C_{M3}, the compliance of the centering suspension of the high-frequency cone. C_{M4}, the compliance of the outer suspension of the high-frequency cone. C_{M5}, the compliance of the cavity between the low-and high-frequency cones. m_3, the mass of air in the vent holes in the low-frequency cone.

small cone is fastened to the large cone. This construction eliminates the need for a "dishpan" or other outside support for the small cone. It also makes it possible to place the small cone very close to the large cone so that as far as acoustical radiation phenomena are concerned the two cones are congruent. In this construction, certain precautions must be taken to keep the vibrations of the large cone from being transmitted to the small cone. Referring to the mechanical network of *Fig.* 4, this objective can be attained by making the compliance C_{M3} of the center suspension of the small cone very small compared to the compliance C_{M4} of the outer suspension of the small cone. In general, in a speaker covering the high-frequency range it is desirable to make the effective compliance of the vibrating system of a high-frequency radiator small regardless of the manner in



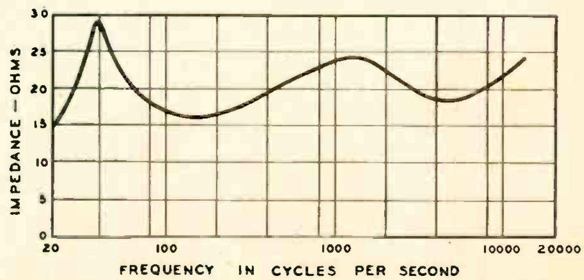


Fig. 5 (left). The electrical impedance-vs-frequency characteristics of the low- and high-frequency voice coils of the duo-cone speakers. Fig. 7 (right). The overall electrical impedance characteristic of the duo-cone speaker using the crossover network of Fig. 6.

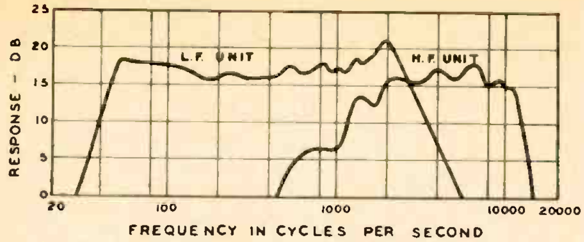


Fig. 9 (left). Response-vs-frequency characteristics of the high- and low-frequency units of the duo-cone speaker in the cabinet of Fig. 8 with the port closed.

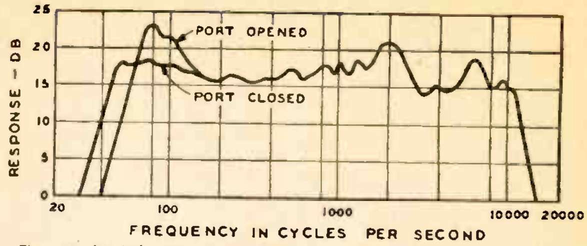


Fig. 10 (right). The overall response-vs-frequency characteristics of the duo-cone speaker in the cabinet of Fig. 8 with the port open and closed.

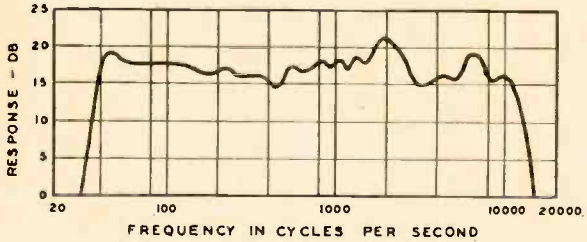


Fig. 11 (left). The overall response-vs-frequency characteristic using a flat baffle about 5 feet across.

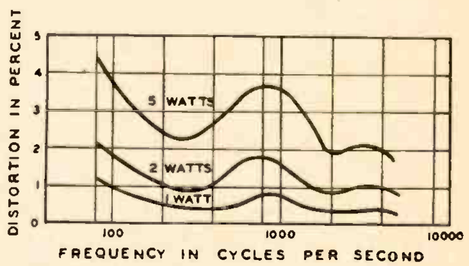


Fig. 13 (right). The total nonlinear distortion-vs-frequency characteristics of the duo-cone speaker for inputs of 1, 2, and 5 watts.

which it is used. In order to prevent coupling between the two cones through the compliance C_{M5}, it is necessary to vent the space behind the small cone. Under these conditions, the compliance C_{M5} of the cavity will be ineffective because the effective mass of the air in the vent holes shunts the compliance of the air cavity. If the cavity were not vented, the compliance C_{M5} would serve as a coupling means between the cones. By these expedients the motion transmitted to the small cone by the vibration of the large cone is negligible. The vibrating system of *Fig.* 4 retains the advantages of two separately driven, coaxial congruent cones.

Mechanical Design and Manufacturing Assembly

In any dynamic speaker, in order to assure good operation for a long life period under all conditions of humidity and temperature changes, it is important to have a good mechanical assembly of the moving parts relative to the stationary parts. The slightest interference with the movement of the voice coil and cone creates a noise disturbance too severe to be acceptable to the listener. This problem is greater on the duo-cone speaker because two sets of voice coils, cones, and air gaps must be properly aligned in their assembly. The solution to this problem was provided by designing the parts so as to give them full lateral freedom during assembly. This method allows the parts to be assembled accurately in a coaxial arrangement, which does not produce stresses resulting in off-center parts when the assembly fixtures are removed. The steel pole-piece members and the magnet are firmly bonded to one another and to the yoke with solder over their entire contacting areas. This type of junction is capable of resisting any movement due to shock or other disturbing forces. The magnet is made of Alnico V and weighs two pounds.

Ample clearances are provided between the voice coils and the pole-piece members to prevent any interference with the movement of the voice coils.

The cones, voice coils, and suspensions are all anchored to one another and to the metal speaker frame with cement. This cement is of a thermal-setting type especially developed for good adhesion to paper, metal, and cloth, and is resistant to loosening or deterioration caused by temperature, humidity, and aging.

Electrical Network

The cross-over network is an important consideration in a direct radiator speaker. In the design of a two-unit speaker in which there is a considerable path length between the two units, a cross-over network with relatively sharp cutoffs is required in order to prevent interference in the cross-over-frequency

[*Continued on page 46*]

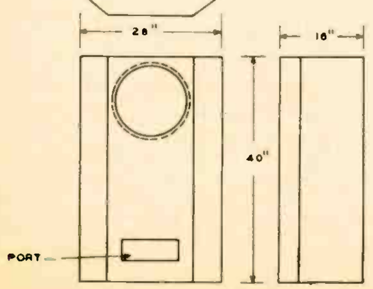
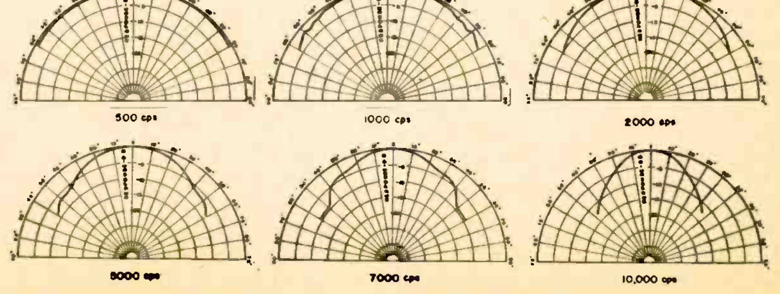


Fig. 8 (left). One type of cabinet which maye be used with the duo-cone speaker. Wood ¾" thick is used.

Fig. 12 (below). Directional characteristic of the duo-cone speaker at various frequencies.



Problems in Audio Engineering

L. S. GOODFRIEND*

In this concluding article, the author describes musical instruments and the human speech organs as sound generators.

As pointed out in the previous article, musical instruments and the organs of speech constitute a special group of sound generators. This article will discuss at length the manner in which various instruments produce musical sounds and will tabulate the more common musical instruments with their method of sound production and reinforcement or amplification.

Sounds generated by strings, reeds, or edges in air streams produce not only the fundamental and harmonics, but also generate inharmonic partials. These generators usually do not produce loud tones, but must have some form of amplification before they are clearly audible as instruments in a concert hall. The method by which this amplification takes place is usually the forced vibration of an air column, as in the case of reed and edge-tone instruments, or the forced vibration of a sounding board, as in the string instruments. In the first case the standing waves set up in an air column selectively reinforce the desired resonant frequency to which the column is tuned. In the case of the string instruments, the strings are coupled to an air chamber which has a particular resonant frequency, and to a sounding plate or membrane. In a piano there is a large wood sounding board which acts to couple the string to the air. This occurs because the string sets the sounding board in motion, and while the displacement of the board may be small, it moves a large volume of air. This is in contrast to instruments that require an air column resonator. For example, when resonance in the true sense (as shown by the simple mechanical system described last month) takes place in the string instruments, it causes a selective amplification which is greatest at one frequency. In the violin this is the so-called "wolf note," a loud unpleasant note, and one not easily controlled by the player. In the wind instruments and brasses additional coupling of the air column to the surrounding air is accomplished through the use of end bells which, like exponential horns on some types of loud speakers, couple the end of the pipe to the atmosphere with an action similar to a transformer coupling two lines of different impedance. The classification of the various types of instruments is shown in Table I.

It is not the purpose of this series to deal with the aesthetic and musical factors involved with bowing violins or tonguing wind instruments. The manner in which strings produce tones has been discussed earlier. A brief glance at the generation of tones by sharp edges placed in an air stream and by blown reeds, however, is in order.

Air Stream Generators

If a jet of air from a slit is aimed at a sharp edge, as in *Fig.* 1, the stream will divide and flow past the edge. As the air stream leaves the edge it forms little whirlpools, or vortices, alternately on each side of the edge. In other words, the stream tends to oscillate back and forth across the edge. The frequency at which these oscillations occur is generally within the range of audibility for most constructions, and is dependent on the velocity of air across the edge and on the distance from the slit to the edge. The tones produced by this method are not very loud and have a large number of overtones present. However, by placing the edge and slit at one end of a pipe whose fundamental is the same as the edge tone or one of the overtones, the fundamental will be reinforced and clearly heard. This is the method used to produce tones in the modern flue-pipe organ. The flute is also an edge-tone instrument, with the lips used as the slit, and the mouthpiece forming the edge.

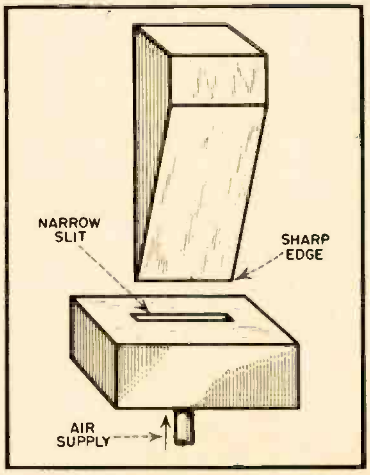


Fig. 1. Basic apparatus for producing edge tones. Narrow stream of air is "split" by sharp edge, which might be that of an organ pipe.

Reed instruments, on the other hand, depend on the motion of air about an obstacle. When we consider that sound consists of alternate compressions and rarefactions of the air, it is obvious that we can generate a sound wave by alternately turning a stream of air on and off. When a strip of metal or bamboo is placed at the end of a pipe, the reed will tend to vibrate at the frequency to which the pipe is tuned. When the reed and pipe are tuned to the same frequency, large amounts of power may be generated, and in the woodwind instruments this usually produces the squeaky sound associated with the playing of beginners.

Reed Instrument Construction

There are several types of reed structures used to produce sound in musical instruments. These are shown in *Fig.* 2. The clarinet and saxophone reeds operate against the opening of the mouthpiece, completely stopping the flow of air when it is against the opening. On instruments of the oboe family there are two reeds which vibrate against each other, alternately opening and closing. When they are open they form a tube through which the air passes. Other instruments that use this double reed construction are the English horn and the bassoon. The reeds on the instruments named are of the striking reed type as shown in (*A*) of *Fig.* 3; that is, they close the aperture through which the air passes by striking against an opening or against another reed. There is another type of

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

reed construction in which the reed stops the flow of air by moving back and forth through a slot in a plate as in (*B*) of *Fig.* 3, and as the reed passes through the plate it effectively cuts off the air. The brass instruments, including the trumpet, trombone, and French horn, are really reed instruments in which the player's mouth acts as a vibrating double reed, and the piping, of which the horn is made, acts as a resonator for the tones thus produced.

Although it might appear from the descriptions so far that each of the instruments described produces tones at the fundamental, this is not altogether true. In the brass instruments, in particular, the ratio of the width of the pipe to its length causes the second and higher harmonics to be resonated with greater ease than the fundamental, and it is only in the trombone that the fundamental is more prominent than the overtones. Pictures and charts of the structure of musical tones produced by the various instruments are so common in the contemporary literature that they will not be presented here.

Since it is possible to force a generator of edge or reed tones to generate sound having the pitch to which the resonating pipe is tuned, it is only necessary to change the length of the pipe to change the pitch. (The term pitch is used here because the tones produced by musical instruments are not simple, and do not have the characteristics of pure tones). In the woodwinds the length of the pipe is varied by opening and closing holes spaced along the length of the instrument. In the simpler instruments this is done by placing fingers over the holes, while in the more complex ones, the holes are covered by pads which are controlled through lever, key, and cam assemblies. In the brasses the length of the pipe can be changed through the use of valves which bypass the sound through longer or shorter lengths of pipe. One exception to this method is the slide trombone. In this case the length of the pipe itself is increased or decreased.

Two notable characteristics of woodwinds should be mentioned here. In the clarinet the bore of the pipe is straight, while in the oboe and saxophone it is conical. This difference causes the clarinet's harmonic structure to contain only the odd harmonics in its overtones, which is the structure normally associated with a closed pipe. The conical bore of the oboe permits it to produce even harmonics and an overtone structure that contains the complete series of harmonics. In addition to varying the pipe length, it is possible to overblow an edge or reed tone, causing some higher harmonics to become predominant. This also occurs in the brasses, and it is only through overblowing that the higher octaves may be produced in wood and brass wind instruments. If the reader would like to study this phenomenon without purchasing an instrument, it is only necessary to take a cola bottle and first blow the fundamental. Then, if the lips are pressed together to form a narrower slit, harder blowing should produce one or more of the overtones quite clearly, without the fundamental.

Percussion Instruments

The percussion instruments—drums, cymbals and xylophones—incorporate membranes, plates and bars. The mechanism of sound production of the

TABLE I

INSTRUMENT	GENERATOR	RESONATOR	CLASS
Piano	String	Sounding board	Percussion-string
Violin		Air chamber & plates	String
Violoncello		Air chamber, plates & floor	
Double Bass			
Harp			
Mandolin		Air chamber & plates	
Guitar		↓	
Banjo	↓	Air chamber & Membranes	↓
Flute	Edge tone, lips	Cylindrical bore pipe	Woodwind
Piccolo	used to form slit		
Clarinet	Striking reed	↓	
Saxophone	↓	Conical bore pipe	
Oboe	Double reed		
English horn			
Bassoon	↓	↓	↓
Trumpet	Lips	Cylindrical valved pipe	Brass
Cornet			
Bugle			
French horn		↓	
Trombone		Cylindrical pipe sliding section varies in length	
Tuba	↓	Valves	↓
Tympanum	Membrane	Air chamber	Percussion
Drums	↓	↓	
Xylophone	Bars	None	
Chimes	Bars (Hollow cylinders)	Air column	
Triangle	Rod	None	
Celesta	Plate		
Glockenspiel			
Cymbals			
Gong	↓		↓
Bell chimes	Bell	↓	Bell

first two types has been covered in an earlier article, and the relation of the bar to the string is analagous to the relation of the plate to the membrane. It is the use of the bar with which we shall concern ourselves here. If a series of bars are supported at the point where there is no motion in their standing wave pattern, and the bars are of increasing length, they may be struck in succession to produce a series of rising tones. It is possible to select a set of these bars having tones corresponding to the musical scale; thus a xylophone is the result if the bars are of wood, or a hollow chime, if the bars are hollow metal cylinders. The triangle and the tuning fork, are bent or split rods. The plate is used in the celesta, cymbal and gong.

Bells are often considered as special cases of plates and are extremely complex in theory. They are uesd musically as chimes, carillons and single bells.

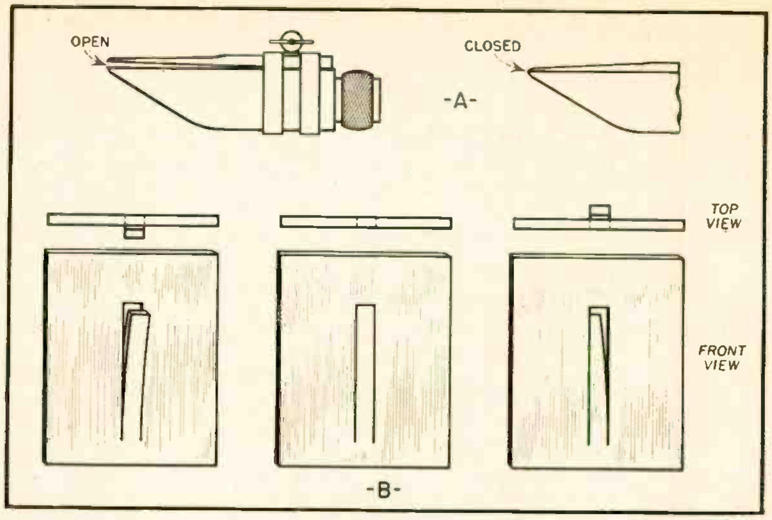


Fig. 3. (A) Side view of clarinet reed. (B) Metal reeds of the type employed in reed organs and harmonicas.

Speech

The study of speech has been the concern of three separate groups: teachers of speech and English, medical groups, and audio and acoustical engineers. Since better transmission of speech is the primary aim of a large group of the audio engineering profession, it is important to understand its production and characteristics. Speech is characterized by two distinct types of sound—buzz or hum tones, and the hiss sound. The vowels and their associated diphthongs, semi-vowels and transitionals, are of the buzz tone type; while the unvoiced fricative consonants, *f* and *s* are hiss sounds.

Buzz energy in the speech sounds is produced by a pair of muscularly controlled membranes in the larynx.

Fig. 2. Woodwind reeds differ in construction. The clarinet uses the single reed shown at the left, while the oboe and bassoon reeds at the right are actually two reeds placed back to back and wrapped at the stem to hold them in proper position.

These membranes interrupt the flow of air from the lungs at a periodic rate, and the tone thus produced is resonated in the mouth and nasal cavities. Hiss energy is produced by the flow of air through slits or past sharp edges in the oral cavity. Speech sounds are, in general, a combination of the two types of energy.

TABLE II

1. Pure Vowels (11)
   Long: ū (tool), ō (tone), ó (talk), a (far), ā (tape), ē (team).
   Short: u (took), o (ton), á (tap), e (ten), i (tip).
2. Diphthongs (4)
   ī, ou, oi, ew.
3. Transitionals (3)
   w, y, h.
4. Semi-vowels (5)
   l, r, m, n, ng.
5. Fricative Consonants (8)
   Voiced: v, z, th (then), zh (azure).
   Unvoiced: f, s, th (thin), sh.
6. Stop Consonants (8)
   Voiced: b, d, j, g.
   Unvoiced: p, t, ch, k.

The names used to tag particular combinations of sounds are the subject of a continual discussion among the various learned groups investigating speech phenomena. Table II shows an arrangement of speech sounds as worked out by Dr. Harvey Fletcher. The table is in order from buzz sounds to hiss sounds.

In contrast to musical instruments, which have hard walls and well defined smooth shapes, the oral and nasal cavities, which act to resonate speech sounds, have compliant, poorly defined, varying shapes. It is, therefore, the vocal cords that determine the frequency and not the resonator. These cords force air in the oral cavities into vibration, and by changing the manner in which energy is released through the mouth by movement of the lips and tongue we may combine the two forms of speech sounds to produce the full range of speech sounds or words. The similarity of the vocal cords to the reeds used in musical instruments should be apparent, and the overtone structures of each bears out the likeness. The sounds from reeds and vocal cords are in pulses which, since they are not purely sinusoidal, contain many harmonics and have distinctive qualities, depending on the phase and amplitude of their harmonics.

It is not difficult to see that all sound generators involve principles which are of a physical nature, and to recognize the importance of including physics as an element of the background for audio engineering. These same physical principles also form the basis for electronics and for architectural acoustics, which too many audio engineers consider as separate fields unrelated to the other fields of audio work.

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AUDIO engineering society

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

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

Convention Program

Thursday, Oct. 27th

1:30 to 2:30 p.m. Business Meeting—Installation of officers

2:30 to 5:00 p.m. Magnetic Recording Session

Chairman .... Dr. D. G. C. Hare

1. Operating Problems & Experiences .... R. H. Barnaby—NBC
2. Standards—Present Status .... R. M. Morris—ABC
3. Technical Problems of Standardization .... E. W. Franck—Audio Devices
4. Distortion Measurements .... G. L. Dimmick—RCA
5. Speed Regulation Problems .... P. Brubaker—Rangertone

Friday, October 28th

9:30 a.m. to 12 Noon Papers

1. Automatic Audio Gain Control & Limiting .... J. L. Hathaway—NBC
2. A New Development in Directional Microphones .... Dr. Harry F. Olson—RCA
3. Microphone Placement in AM & TV .... H. M. Gurin—NBC
4. Longitudinal Interference .... B. W. Augustadt—BTL
5. Control of Sound in the Theatre .... Dr. Harold Burris-Meyer
6. Logic in Relay Switching Circuits, with an Introduction to Boolean Algebra .... W. Keister—BTL

1:30 to 5:00 p.m. Papers

1. A New Coupling Circuit for Audio Amplifiers .... F. M. McIntosh
2. Standards—A General Discussion .... Cyril Ainsworth—ASA
3. Audio Techniques in TV Broadcasting .... S. Patremio—DuMont
4. Audio Consoles for TV .... R. W. Byloff—NBC
5. Sound Reinforcing System .... A. W. Schneider—Commercial Radio-Sound, Inc.

6:30 p.m. Audio Engineering Society Banquet
Presentation of awards—loudspeaker demonstrations.

Saturday, October 29th

9:30 to 12 Noon Audio Measurements Session

Chairman .... W. L. Black—BTL

1. The General Problem .... W. L. Black—BTL
2. Intermodulation .... Dr. Pederson—General Radio; E. Roys—RCA; J. K. Hilliard—Altec-Lansing; N. C. Pickering—Pickering Co.
3. Transient Methods ....
4. Operating Problems .... J. D. Colvin—ABC

THE FIRST annual convention of the Audio Engineering Society opens its first session at Hotel New Yorker (shown in the inset on the cover) at 1:30 p.m. on Thursday, October 27, 1949, with an anticipated attendance of a majority of the 800 members of the Society throughout the three-day meeting.

For a relatively young organization, an imposing array of technical sessions has been scheduled—rather more papers on audio than have heretofore been presented at all other conventions taking place within a year's time. To ensure the greatest interest in the technical sessions, the papers have been grouped to attract specialists in the audio field to specific mornings or afternoons where their particular interests lie.

The first session begins at 1:30 p.m. on Thursday with a Business Meeting of the national organization, at which time the newly elected officers will be installed. This will be followed by the Magnetic Recording Session under the chairmanship of Dr. D. G. C. Hare, and presenting papers covering operating, standardization, and measurements.

The Friday sessions will be devoted to a variety of papers, principally on equipment and operating techniques. These will be followed by the banquet to be held in the East Ballroom during the evening. Unique in professional society banquets, this one is limited to a minimum of speeches. The Society's annual awards will be presented at the banquet, however, and some enlightening entertainment is promised in the comparative loudspeaker demonstration.

The Saturday Morning session is devoted to Audio Measurements, under the chairmanship of W. L. Black, of Bell Telephone Laboratories. Considerable interest is being shown in the papers on Intermodulation, which are being presented by four different engineers, and which may lead to a more thorough understanding and standardization of this relatively new method of rating distortion.

All technical sessions of the Convention are open to members at no charge, while nonmembers may register for any or all sessions for a single nominal fee of $1.50.

The Audio Fair, being held simultaneously with the convention, consists of a number of exhibits arranged so that the manufacturers can demonstrate their products aurally as well as show them visually. The exhibits, which will cover practically the entire sixth floor of the Hotel New Yorker, will open at 11:00 a.m. on Thursday and remain open until 10:00 p.m. On Friday they will be open from 10:00 a.m. to 6:00 p.m., closing to permit members to attend the banquet. The exhibits will be open on Saturday from 10:00 a.m. to 4:00 p.m., at which time the Convention and The Audio Fair will come to a close.

Designed to give the exhibitor the opportunity of displaying his products in the manner in which they are designed to be shown—aurally—The Audio Fair will bring amplifiers, loudspeakers, phonograph pickups, microphones, turntables, measuring instruments, and accessories before the audio men in attendance, along with the latest developments in film, magnetic, and disc recorders and in equipment for broadcasting and TV as well as for the hobbyist. Anyone interested in any phase will find something to his particular liking.

The Audio Fair is open to both members and nonmembers alike, and there is no charge for admission.

PARTIAL LIST OF FAIR EXHIBITORS

Although last-minute requests are still coming in for exhibit space at The Audio Fair, the following exhibitors have already completed their plans for participation. As will be seen from a study of this list, most of the major manufacturers of sound and broadcast audio equipment will have their products on display, and all who attend will be able to hear as well as see the new developments in this field.

Altec Lansing Corp.
Ampex Electric Corp.
Audak Company
Audio and Video Products Corp.
Audio Development Company
Audio Devices, Inc.
Audio Facilities Corp.
Audio Instrument Company

Ballentine Laboratories, Inc.
Brociner Sound Laboratories
Brush Development Co.
Burlingame Associates

Frank L. Capps, Inc.
Clough-Brengle
Cook Laboratories

The Daven Co.
Allen B. DuMont Laboratories, Inc.

Electric Indicator Co.
Electronic Workshop, Inc.
Electro-Voice, Inc.

Fairchild Recording Equipment Corp.

General Electric Company
Gawlor-Knoop Co.

Hewlett-Packard Co.

James B. Lansing Sound, Ind.
H. J. Leak & Co., Ltd.
Livingston Electronic Corp.

Magnecord, Inc.
McIntosh Engineering Laboratories
J. A. Maurer, Inc.
Minnesota Electronic Corp.

Panoramic Radio Products, Inc.
Peerless Electrical Products Division
Permoflux Corporation
Pickering and Co., Inc.
Presto Recording Corp.
Prestoseal Manufacturing Corp.
Proctor Soundex Corp.

Racon Electric Co., Inc.
Radio Corporation of America
Rangertone, Inc.
Recogram Recorders Co.
Rek-O-Kut Company, Inc.

Sonar Radio Corporation
Somerset Laboratories, Inc.
Stancil-Hoffman Corp.
Stephens Manufacturing Corporation
Sun Radio & Electronics Co., Inc.

Tech Laboratories, Inc.
Tektronix, Inc.

University Loudspeakers, Inc.
U. S. Recording Co.

San Francisco Section Starts Audio Course

Audio engineers in the San Francisco area have begun a ten-lecture course on audio engineering which is being presented as a fall educational program by the Society Section. This series, which began Monday, September 26, is being held at the Redding School, Pine and Larkin Streets, San Francisco, at 8:00 p.m., and will continue on Monday evenings through December 12.

Nationally recognized authorities in the various fields covered have prepared subject matter which is being presented and interpreted by engineers active in the corresponding specialties with companies and educational institutions throughout the Bay area. The lecture series covers essentially the same subject matter as that of the New York section in its Spring Educational Series, and the original papers are the basis for this new series.

The Educational Committee of the San Francisco Section is composed of Walter T. Selsted, Pacific Broadcasting Co., chairman; Bob Hugh Smith, Dept. of Elec. Engrg., Univ. of California; Myron C. Stolaroff and Frank Lennert, Ampex Electric Corp.; Al Eisberg, KRON and KRON-TV; and Ross H. Snyder, KJBS and KJBS-FM.

Individual lectures or the entire series are open to members and non-members of the Society on payment of the established fees. Mr. Selsted, chairman, may be contacted at 363 Oakview, San Carlos, Calif.

Southern Michigan Section Starts Fall Season

The first program of the 1949-1950 season was held on Tuesday, September 20, at Kalamazoo, Michigan, with a paper on "Magnetic Tape Recording" presented by Mr. Tinkham, President of Magnecord, Inc., and Mr. Leroy W. Beier, of the Leroy W. Beier Co. In addition to the talk, the program offered a demonstration of a high-quality audio system consisting of the professional magnetic tape recorder manufactured by Magnecord, Inc., with an audio range of 30 to 15,000 cps; the new fifty-watt McIntosh amplifier; and the Stephens Coaxial two-way speaker and cabinet. This equipment is of broadcast quality, and does full justice to the program material used.

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, excellent knowledge of classical music. Available after 2 p.m. daily, all day Sat. and Sun. Box 97.
- **Audio Technician.** 12 yrs laboratory, mfg, and field experience. 1st phone, competent trouble-shooter and constructor with design background. Pleasing, effective personality. Desire responsible position with BC station or equipment manufacturer. Box 101.
- **Research and Development Engineer.** Ph. D., specialized in electronics, circuit design, electro-mechanical devices, acoustics, precision-mechanics, nuclear physics, equipment. Would like to be your consultant or part-time adviser. Box 102.
- **Electrical Engineer,** over 20 yrs electronic, acoustic, dynamic audio devices, systems. Accomplishments in development, design, manufacture, for commercial, marine, govt equipment. Exp. supervision, planning, estimating. Early radio background. Residence NY area. Box 103.
- **RCA Institute** graduate wishes position with audio company or recording studio. Box 104.

Student Chapter News

The first Student Chapter of the Audio Engineering Society at the RCA Institutes, Inc., N. Y., has completed a highly successful first semester. Active membership totals over fifty students, and interesting and informative programs have formed a major part of the monthly meeting. Such well-known men in the audio engineering field as Norman Pickering, and Clyde R. Keith have been guest speakers. An equally active program is planned for the coming school year.

Improved Audio Quality from Standard TV Receiver

C. G. McPROUD

A few simple modifications to the famous RCA 630TS will give better low- and high-frequency response with less distortion.

Audio quality in TV receivers has been the subject of several comments in these pages from time to time, but so far nothing constructive has been offered. In an endeavor to prove just how much of the poor quality which has been attributed to TV was due in fact to the receiver itself, some experiments were made and the final conclusions are that TV program transmission is considerably better than common receivers are able to reproduce.

This is reasonably understandable because in a high-priced item such as the average TV receiver, economies must be practiced to keep the selling price within reason. It has been, to date, far more important to provide a good picture than to provide good sound reproduction. To reduce costs, therefore, the audio channel is skimped in many receivers, although the picture quality has been held to high standards.

The factors which contribute to poor quality are obvious from a study of the circuit schematics. Considering one of the most popular receivers on the market — the RCA 630TS, either in original factory-built form or as a kit such as the Tech-Master—it will be observed that the audio channel consists of a high-mu triode with contact-potential bias as the first stage, and a pentode output stage without feedback. Add to this the use of an output transformer which has a ⅝ x ⅝-inch core and a small speaker with inadequate baffling, and it is no wonder that the quality is somewhat short of ideal. It will be noted from the schematic of the audio portion of this chassis (*Fig. 1*) that the coupling capacitors are smaller than optimum for good low-frequency response.

A few relatively simple changes will give this receiver a new voice—one which will compare with any good FM receiver—provided the output is fed to a larger speaker of recognized quality. These changes are not difficult to make, and aside from the physical aspects of mounting the output transformer, should be completed in an hour's time.

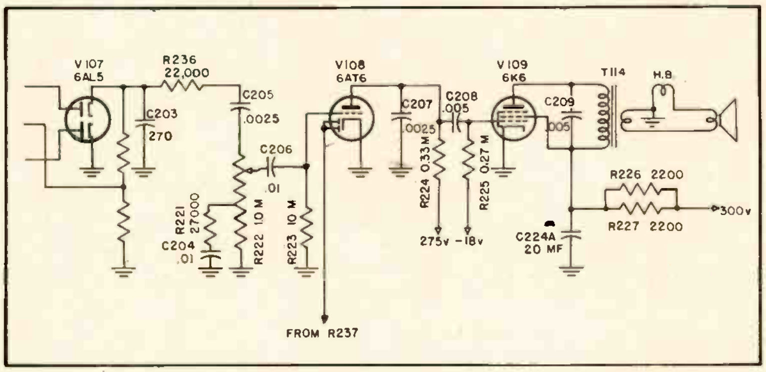

Fig. 1. Audio section schematic of RCA 630TS receiver chassis.

Recommended Changes

The most important change is the replacement of the output transformer. The new unit may be mounted on the chassis directly, or upon the speaker mounting bracket — the latter being somewhat simpler but restricting the size of the transformer used. Two different circuit arrangements have been used in the experimental changes, with comparable results from either method.

Referring again to *Fig. 1*, it will be noted that the output of the discriminator feeds the volume control through R_{236} and C_{205}. The capacitor C_{206} isolates the volume control from the grid of V_{108}, permitting the use of a 10-meg grid resistor across which the contact potential bias is developed. C_{207} in the plate circuit provides the de-emphasis, and the bias for V_{109} is obtained from the power supply. The output circuit is fairly conventional.

Using a pentode for the first audio stage so that feedback may be applied readily without overall loss of gain, it becomes necessary to obtain the de-emphasis by another means, since the capacitor C_{207} would be inside the feedback loop. This may be done by replacing R_{236} with a 56,000-ohm resistor, and connecting a 120-$\mu\mu$f capacitor C_1 from the junction of R_{236} and C_{205}. This gives a de-emphasis of 67 μsec, which appears to be adequate. Measured response of the audio system indicates a droop of 13 db at 10,000 cps, which is within 1 db of the nominal value. To improve the low-frequency response, C_{205} and C_{208} are both increased in value; C_{207} and C_{209} are eliminated. The arm of the volume control is connected directly to the grid of V_{108}, eliminating C_{206}. The circuit which formerly connected to the diodes of V_{108} is connected to ground through a 1N34 germanium crystal diode, thus maintaining the normal operating characteristics of the picture control circuit.

The bias required by the 6V6 in the output stage is somewhat less than that for the 6K6. Therefore, the two resistors R_3 and R_4 are employed in the grid circuit as a voltage divider, giving a bias of approximately 13 volts.

Physical Changes

Using a speaker separate from the chassis will eliminate the use of the present speaker field as a filter choke. A new choke coil having a resistance

Response ±2.5 db, 40 cps to 15 kc., Output –46 db.

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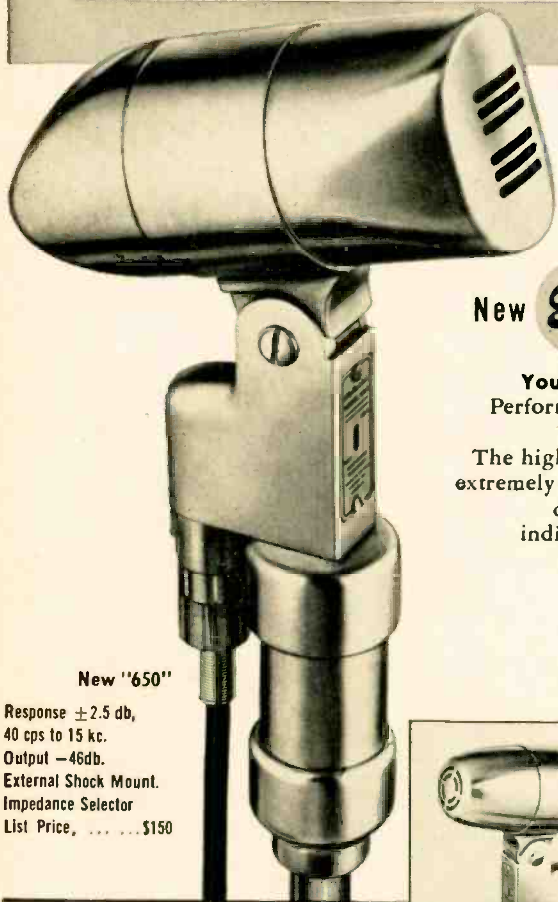

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Response ±2.5 db,
40 cps to 15 kc.
Output –46db.
External Shock Mount.
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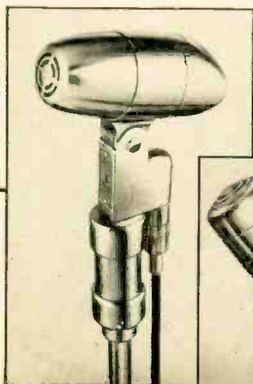
List Price, ... $150



New "645"

Response ±2.5 db,
40 cps to 15 kc.
Output –50 db.
External Shock Mount.
Impedance Selector.
List Price......... $100

The "635"

Response ±2.5 db,
60 cps to 13 kc.
Output –53 db.
Impedance Selector.
For Hand or Stand.
List Price.......... $60

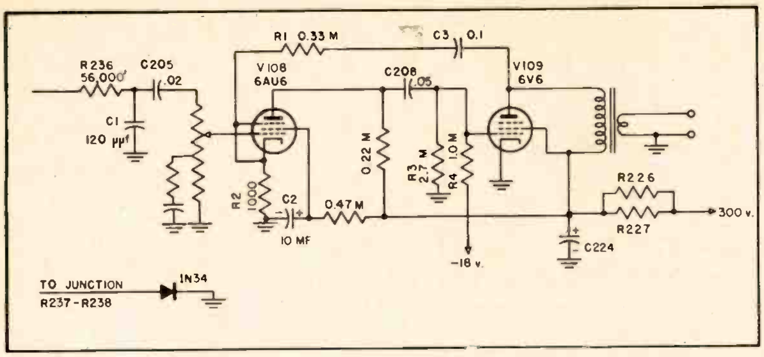


Fig. 2. Recommended changes, using feedback from plate of output stage.

of the order of 60 ohms should be mounted on the left apron of the chassis, approximately under the 1B3/8016 rectifier tube. The leads from this choke should be connected directly to the two terminals on the filter capacitor (C_{221} in the complete schematic) and permitting the removal of the leads to the tie point located adjacent to V_{109}. This leaves two connection points for the components in the feedback circuit used in *Fig.* 2, as well as for the additional filter capacitor C_2 in the screen circuit of V_{108}. All the connections should be removed from V_{108} except the leads to terminals 3 and 4. Connect a 1000-ohm resistor R_2 from terminal 7 to ground, and strap terminals 2 and 7 together. The plate and screen resistors should be connected to terminals 5 and 6 respectively, with the other end being connected to terminal 4 of V_{109}. An extra lead is run from the screen (terminal 6) to the tie point, and a 10-μf, 450-volt electrolytic capacitor C_2 is then connected between this lead and ground.

Using the circuit of *Fig.* 2, C_3 is connected from the plate of V_{109} to the remaining tie point, and the 0.33 meg resistor R_1 from this point to terminal 2 of V_{108}. The capacitor C_{208} is connected directly between the sockets, and the 2.7-meg resistor R_3 runs from terminal 5 of V_{109} to ground. The 1.0-meg resistor R_4 goes in place of the old R_{225} (0.27 meg).

The *Fig.* 3 arrangement is somewhat better when the output transformer is not of top quality, since the transformer is included in the feedback loop. It will require some care to make sure of selecting the correct polarity, however. Make a temporary ground connection to one side of the transformer secondary, and with a signal passing through the set, momentarily connect the feedback resistor R_5 to the other output lead. If the output is reduced, correct polarity is indicated and the connections may be made permanent. If not, reverse the connections to the transformer secondary. The values specified for the feedback resistor will give approximately 17 db of feedback, which will ensure a signal output of essentially the same value as in the original circuit.

The output transformers chosen for the two tests were both intended for a 5000-ohm plate load, and both had a number of output impedances. In one instance, a cased transformer was used, and it was mounted directly on the chassis with the terminals up. A shielded pair was used for the plate and B+ leads. To mount the transformer on the chassis in this fashion—assuming that the set is in finished form—the r-f unit must be removed. This is an operation which must be performed with care, and in general is not recommended. If the set is being assembled from a kit, the mounting of the transformer may be made before the r-f unit is installed, and a more workmanlike job is ensured. For the complete receiver, however, it is simpler and safer to mount the new transformer on the speaker bracket.

One additional change is recommended to provide more filtering for the output stage, desirable because of the improved low-frequency response. This involves removing the resistors R_{226} and R_{227} from their present connection to C_{220}, and reconnecting them to the lug marked with a square on C_{225}, directly below C_{224} when the chassis is in the normal position.

With these simple changes, the set is comparable to any good FM receiver with respect to quality of reproduction, and increased entertainment pleasure is sure to be had. The 630—already recognized as a reliable picture receiver—takes its place with the most expensive TV console. The 8TS30 is nearly identical, and has the filter choke already installed, since this chassis employed a PM speaker. Obviously, similar changes may be made on any table model TV receiver with the assurance that the inherent quality of FM transmission is there—and that an improved audio channel is all that is necessary.

Book Review

Radio Components Handbook. Cloth bound, 6 x 9, 211 pages. Technical Advertising Associates, Cheltenham, Pa. $2.50.

A new type of handbook which, while intended primarily for the radio receiver designer, is full of much useful data that should be familiar to anyone interested in radio and audio design. The general problems of commercial design are treated in a way not common to the usual engineering handbook, but with the point of view of the engineer working for a radio manufacturer. Thus the book does not provide the exact design procedure for circuits and equipment, but will serve to introduce the reader to another aspect of the radio field.

This handbook covers general design, transformers (both audio and power) r-f transformers, capacitors of various types, resistors, insulating materials, speakers, switches, and tubes and metallic rectifiers. Among the interesting treatments will be found the methods of choosing the correct component for a specific application, what specifications are important and why, how to design circuits for minimum cost, and numerous other design data.

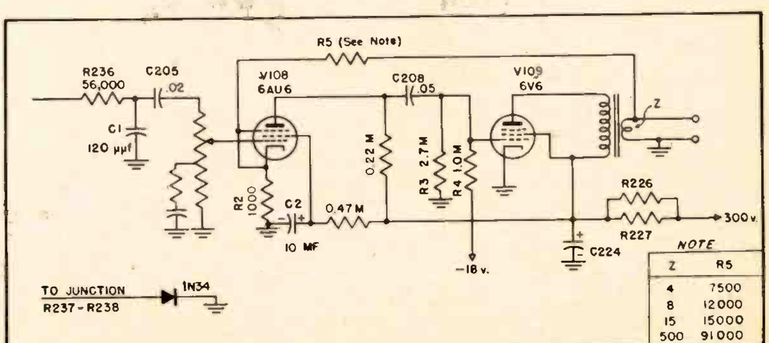
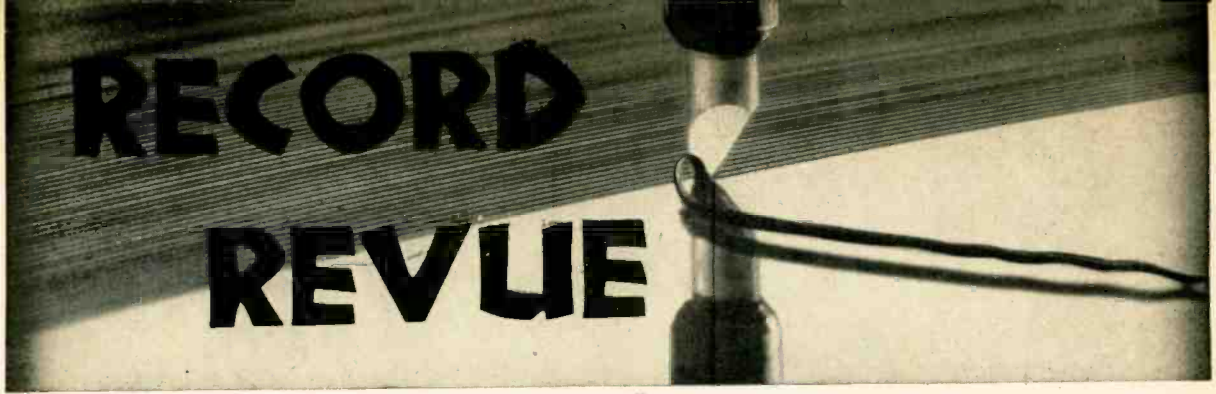


Fig. 3. Circuit used when it is desired to include the output transformer in the feedback loop.



EDWARD TATNALL CANBY*

Hindemith, Nobilissima Visione (St. Francis). 1937.
Philadelphia Orchestra, Ormandy.
Columbia MM 847 (3)
Hindemith, Symphonic Metamorphosis on Themes of Carl Maria von Weber. 1943.
Cleveland Orchestra, Szell.
(No 78-rpm album yet)
Both of above: Columbia LP: ML 4177

● This department has already spent a lot of space explaining why musicians use fancy names for simple things—perhaps it had better be admitted right now that one reason is simply that they *like* fancy names: i.e., they're only human. Witness the sage Mr. Hindemith, who has practically guaranteed a negative reaction to his two big orchestral works, above, by giving them such fabulous handles!

For, if you can get yourself past those forbidding monickers, you're likely to find a good deal of pleasure in listening to these works, if you are even the slighest bit attuned to music of Today, including, of course, jazz and what-not. The Nobilissima Visione, the Most Noble Vision, comes from the score of a ballet concerning St. Francis, and it is not unlike the quite popular "Mathis der Maler" ("Matthias the Painter") score of Hindemith, similarly put together in 1934 from the score of an opera. In "Mathis," now available in two different recordings and on All-Three Speeds, the final movement is the Temptation of St. Anthony, and here too is a similarity of theme, a different Saint. This is big, dignified music, dissonant but not noisy and harsh by any means; it has plenty of orchestral color and expression for the ear trained in Tchaikowsky and Brahms. Recording is up to the usual Philadelphia standard; the orchestra sounds huge and in that large sound a good deal is lost or blurred. Perhaps that's as it should be.

As to the Symphonic Metamorphosis on Themes of Carl Maria von Weber (Phew!), you are likely to find the surprise of the month, and perhaps the best All-Around Recording, too. Maybe Carl Maria was the most German of all early 19th century German Romantics. Maybe Hindemith did use his themes—and Hindemith, too, is noted for his Germanity, so to speak. The program notes on the record don't give you any other idea than the title itself—that here is a very German, very scholarly (or why so much Latin?) exposition and development, probaby full of fugues and what-not.

It is. The second movement (2nd cut) is a fugue—with a fine jazz theme in a very low-down trumpet, plus as snazzy a percussion section as you'll find in any local dive. It's *that* kind of fugue. It's that kind of piece, most of the way through, Weber or no Weber. American as all get-out.

My own private explanation for this is simple. Hindemith, in 1943, simply went American—after all, he was in this country and still is. The "Metamorphosis" title would seem to me to be an ingenious screen of pseudo-long-hairedness, behind which Mr. H. proceeded to show what he had learned about the U.S.A. and its music! This score is utterly unlike anything else I've ever heard of H., and if you think you know your Hindemith you had jolly well better try it out. Moreover, not only does it have a highly colorful orchestration of brass, percussion, everything a hi-fi fan likes, but the recording itself is out of this world, considerably better than that of the Philadelphia in the "Nobilissima Visione." And this is one of those quite rare LP's where almost everything is undistorted, only a few of the loudest squawks being on the fuzzy side. Try it.

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

Vaughan Williams, Symphony #6 in E minor.
New York Philharmonic, Stokowski.
Columbia MM 838 (4)

● While we're at it, here's another important contemporary piece that will be very easy listening for most. V.W. is England's elder statesman of music. He never was what you might call a "modernist" and his music today is conservative; but what counts in music is not radical or conservative tendencies (so many of us think that), but content. Music, we sometimes forget to remember, has laws of construction and logic that are as reasonable, when you get into them, as those of drama or the novel or the mystery story. The stuff has to fall together in a shape to be consistent; there must be no irrelevant material, however luscious and tempting it may be on its own, however descriptive or atmospheric or stirring. Vaughan Williams, while inclined towards the "Gone with the Wind" category in the way of size, writes good, consistent music. This symphony, conservative in tone, was written during the recent war, and the agony of emotion which it expresses is likely to hit you at once. Behind that agony, though, is the excellent craftsmanship that puts Vaughan Williams (that's his *last* name—his first is Ralph) in a class well above some of our other symphonists who also can muster a wicked orchestra and paint some pretty gory war scenes with it. There's no wise cracking in this music, little humor, no jazz at all. But some pretty fine stuff, of the serious sort.

Respighi, The Pines of Rome. 1924.
Cincinnati Symphony, Goosens.
RCA Victor DM, WDM 1309 (2)

● While the shouting continues over 33 vs. 45, don't overlook some good things in the way of music that may slip past you in the excitement—for example, this album from RCA. It is technically, I suppose, "contemporary" music but you won't think of it as that when you hear it. Respighi was, at least in 1924, a real old-fashioned neo-Impressionist (though he later had a change of heart and managed to write some pretty dissonant stuff before he died). The "Pines" is highly colored descriptive music, comparable to the better known "Fountains of Rome" in the same series of tone poems. Its biggest claim to notoriety, however, was and is the inclusion of the actual song of a live nightingale, recorded, as part of the score. Since the music dates from 1924 we can at this point wonder what the original nightingale on wax sounded like—probably there was a nice old-fashioned morning glory acoustic machine stuck in the middle of the orchestra! Judging from the scoring of the music at this famous passage, it must have been a pretty feeble sound—Respighi writes a kind of faint, shimmering background of strings and a pluck or two from the harp, against which a bullfrog or even a katydid would sound like thunder, let alone a nightingale! In this new recording the nightingale has quite obviously been refurbished. Sounds like a wide-range one to me. Might come straight from one of those tricky water whistles; or maybe from a clever vaudeville-style technician, one of those people who can imitate twenty birdcalls simultaneously. (After all, how about Baby Snooks?) But then, I'm no birdologist—ornithologist, if you will. Maybe it *is* a nightingale, mike-happy. Sounds good anyhow. The rest of the music makes a lot of fine noise, but it leaves me definitely bored.

Rimsky-Korsakov, "Antar" (Symphonic Suite).
The Cleveland Orchestra, Leinsdorf
Columbia LP: ML 2044 (1 10")

● This is music for those who have been playing that LP of the "Scheherezade" Suite until it's worn out. Same type of stuff, with the special difference that this is unfamiliar, whereas "Scheherezade" is hardly that. The recording, on LP, is good but, on my equipment at least, it tends to that buzziness in the loud parts which is so often found in the Columbia product as played on magnetic pickups, wide-range. Nevertheless, an interesting comparison, musically and technically, with the earlier disc. (Incidentally, I have met the man who made the recording—Scheherezade just mentioned—with the barking dog in the final measures of side 2. It *was* a dog. He even knows what dog. But that's about all I could get out of him. Hush-hush. It was a French poodle, that much I did get.)

Mozart, Symphony #35 ("Haffner").
Pittsburgh Symphony, Reiner.
Columbia MM 836 (3)
LP: ML 4156 (½)

● The most often heard version of this

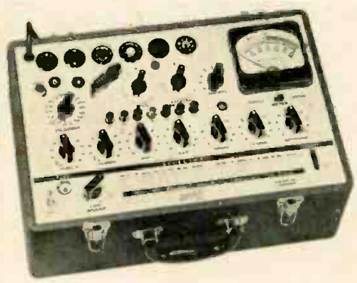
[*Continued on page 49*]

NEW PRODUCTS

• **Tube testing** is a necessity for any user of vacuum tubes, and for both laboratory and service applications the recognized optimum test method is that of the dynamic mutual conductance of the tubes operated under test voltages approximating those encountered in normal use. A new lightweight portable tester, Model 600, is offered by Hickok under the classification of "technicians" model. This instrument, with self-contained power supply, provides direct reading mutual conductance measurements with ranges of 3000, 6000, and 15,000 micromhos. For complete information, write H. D. Johnson, The Hickok Electrical Instrument Co., 10617 Dupont Ave., Cleveland 8, Ohio.

• **Sound effects consoles** are usually the results of a combination of apparatus which is added from time to time as the occasion arises. Not so the unit recently announced by Gray Research and Development Co., Inc., 16 Arbor Street, Hartford 1, Conn. This console is a complete instrument with all the necessary features already added.

The new Type 352C unit is especially useful for television work, since the sound effects engineer is playing an increasingly more important role, and his equipment must be extremely versatile. Three turntables, each continuously variable from 10 to 130 rpm, are mounted on the console, with four tone arms so arranged that the two center arms may be used on either of the two adjacent tables. Each arm is equipped with a "grain-of-wheat" lamp to permit exact placement of the exposed stylus. Necessary amplifiers, filters, equalizers, and controls are mounted in an easily accessible position, the amplifiers being of the plug-in-type for easy replacement and maintenance. A transparent script rack does not obstruct a view to the stage, and a roll top protects the unit from dust and from dial-twiddlers. Complete information and block schematics may be obtained from the manufacturer.



Hickok Electrical Instr. Co.

Gray Research and Dev. Co.

• **Magnetic recording,** like every other new art, brings with it the need for a number of accessories. Among them are splicers, and a simple unit for making the desirable diagonal butt joint is now available from Magnecessories, Box 6960, Washington 20, D. C. This unit was designed especially for the amateur, but is also satisfactory for the professional where the simplest possible device is desired. It is provided with mounting holes to permit attachment to the recorder near the tape channel.

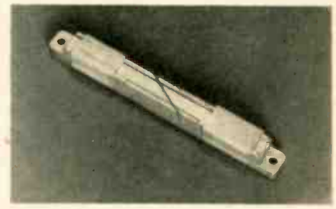
Also available from the same source is a solution called Visi-Mag, which will deposit finely divided iron on magnetic recording tapes to make the recording visible for checking alignment of heads and for determining defects in head-to-tape contact.

• **Small parts storage** is somewhat of a nuisance to the hobbyist or the occasional constructor, because he is not usually equipped to handle parts of the type employed in radio work—resistors, capacitors, machine screws, lock washers, nuts, soldering lugs, and many others too numerous to mention. Bulletin 520, available from Andrew Technical Service, 4747 N. Damen Avenue, Chicago 25, Ill., describes two different sizes of trays, both 11⅜" in length and 2¾" deep, with widths of 2" and 3¾" respectively, which may be combined in a number of forms to provide adequate storage for small parts. These trays are constructed of transparent Polystyrene, with molded index-card slot and a finger pull at the front of each. Four removable partitions make it possible to adjust the trays for parts of varying sizes, and the height and width of the trays is such that they stack in standard metal shelving used in industrial plants.

• **A "Dynaural" system,** based upon the famous H. H. Scott Dynamic Noise Suppressor, has recently been introduced as a device in which the band-width is automatically and continuously adjusted to conform to the requirements of the music, thus combining maximum fidelity with minimum noise level. The first unit available is the Type 111-A Dynaural Converter, intended for use with standard amplifiers, phonographs, and combinations, and offered at the lowest price in history for a dynamic noise suppressor.

Operating up to a maximum frequency of 14,000 cps, the device minimizes needle scratch as well as the pops and crackles on plastic records and the rumble from turntable motors. Connections are made quite simply, and a single remote control may be mounted on the panel of the phonograph or on the radio panel, as desired. Further information may be obtained from Hermon Hosmer Scott, Inc., 385 Putnam Ave., Cambridge 39, Mass.

• **Static will again become** an annoyance to record enthusiasts with the winter months. A new product introduced by Walco Products, Inc., 60 Franklin St., East Orange, N. J., is a liquid which, when applied to



Magnecessories

Andrew Technical Service

Herman Hosmer Scott, Inc.

record surfaces, creates a condition in the record which causes it to discharge any inherent static electricity so that it will no longer attract dust particles. Walco Static Eliminator is applied by spreading a few drops on a soft cloth which is then rubbed over the surface of both sides of a record. Then a follow-up rub with a dry cloth will further spread out an invisible, microscopically thin film (of a thickness of one to 10 molecules) over the entire record surface, which is then immune to static electricity, so that dust may be brushed off easily. Records may be played from 50 to 100 times before another application of the Eliminator is required.

Samples are available from the manufacturer when requested on the letterhead of broadcast stations and large commercial users of phonograph records.

• **Synthetic rubber** — neoprene — is now being used for Sealnuts, a combination mounting and sealing device for toggle switches and control shafts, with the result that greater flexibility is obtained at low temperatures, and greater resistance is offered to sunlight, weathering, and other aging factors.

These devices are used extensively on military, naval, and commercial equipment

[*Continued on page 51*]

New Polyphase Reproducer System *

Incorporating principles which provide a simple and logical solution of today's problem of high quality reproduction of different types of records and transcriptions—at incredibly low cost.

DESIRE FOR MUSIC springs from the pleasure it can afford. However, one could hardly expect much pleasure from a record that can be played only after changing and shifting of apparatus, back and forth.

To enjoy today's discs (micro, 78 rpm. etc.) requires a single pickup unit capable of delivering such quality performance as would be delivered by two or more separate high grade magnetic reproducers—each designed expressly for a given type of recording.

The new AUDAX Reproducer,—presented herewith,—*will do just that.*

This new AUDAX is perhaps the most important and revolutionary advance since the advent of the electronic pickup itself,—back in 1926. Yet,—remember,—its cost to you is *less than the cost of ordinary pickups.*

Your admiration will be aroused when you see and hear the way this remarkable instrument works.

You will know,—this new AUDAX performs important functions that no other unit does.

You will know,—this new AUDAX is the very type of instrument you so long wanted, but thought impossible of development.

You will know,—this new AUDAX constitutes the complete answer to your reproducer problem.

You will know,—this is the logical instrument for YOU—whether you play one type or several types of discs.

When you learn that, with all its unprecedented accomplishments, this new AUDAX costs less than ordinary pickups,—you too will say:

"Yes, this is IT!"

Wide range performance with any type disc • Point pressure about 7 grams • Genuine sapphire styli (or diamonds if desired), replaceable individually by the user himself • Output about 30. m.v. • High or low impedance • Needle radiation very, very low • Ear quality *par excellence*

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Also available for Radio Stations:—

This is the answer for which you waited so long. This remarkable reproducer —one single unit—will play ALL your discs—superbly!

There is no substitute for experience. When you are buying a motor car, washing machine or refrigerator, almost instinctively you evaluate the experience of the manufacturer behind the product. Has he the all-important KNOW-HOW to justify your implicit confidence? In no other field is this KNOW-HOW more important than in the field of Electronic Sound Apparatus, where AUDAX has set the pace for more than twenty-five years.

* Pats. Pend.

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AUDAK COMPANY

500 Fifth Avenue **New York 18, N. Y.**

"Creators of Fine Electro-Acoustical Apparatus Since 1915"

Techni-Briefs

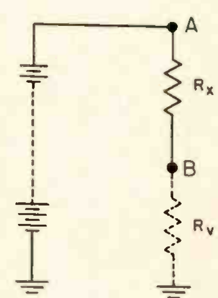
Measuring High-Resistance Values

UNTIL RECENTLY, the average audio engineer has not had much contact with resistors of the order of more than ten megohms in the general run of his work. However, with the re-entrance of the condenser microphone and the attendant high input resistance of that device, resistors of the order of 100 megohms are finding their way into the audio facilities of the up-to-date sound installation.

Then too, ambitious scientists are branching into nuclear work, if not as a vocation, at least as an avocation. Here the needed resistors are best expressed as a higher power of tens of megohms, and it is not unusual to find resistor values of 5 x 10^{11} ohms in such installations.

A suitable method of measuring these components with a degree of accuracy of better than ±5 per cent is needed, and is indeed simple to accomplish by the method to be described. All that is necessary is a source of comparatively high voltage and a vacuum-tube voltmeter, such as the RCA VoltOhmyst, Model 195-A, or its equivalent. A word of caution should be inserted here—this is a decidedly dangerous procedure, and is to be undertaken only with due caution, commensurate with the high voltages employed. Such a system can produce a lethal shock, if not treated with proper caution and respect.

Figure 1 shows the general procedure for making the tests. E_b represents a source of high-voltage direct



current, a suitable value for which can be chosen from the suggested values in Table I for the approximate value of the resistor under test. R_x is the unknown resistor, and R_v is the input resistance of the particular v-t voltmeter, including both the resistance of the probe and that of the instrument itself as a lumped figure.

TABLE I

Resistance to be measured	Power Supply Voltage
100 megohms	100 volts
10,000 "	500 "
50,000 "	2,000 "
100,000 "	5,000 "
500,000 "	10,000 "

Proceed as follows: Measure the

voltage of the power supply at point A, taking the necessary precaution to use a sufficiently large probe resistor so as not to exceed the rating of the voltmeter. Then measure the voltage at point B—that is, with the unknown resistor in series with the present probe. Then, calling the two voltages E_a and E_b respectively, the value of the unknown resistance R_x is given by the formula

$$R_x = \frac{E_a - E_b}{E_b} R_v$$

where R_x and R_v are both expressed in megohms.

In the absence of a high-resistance probe for making measurements of the high voltages required for these tests, it is not too difficult to make such a needed adjunct to a v-t voltmeter. A probe suitable for adapting the RCA 195-A to measure with a full-scale value of 5000 volts needs only a 41-megohm resistor, which may be had to an accuracy of ±1 per cent, which is more accurate than that claimed for the instrument itself.

The formula used to determine the resistance required for a high-voltage probe can be expressed as follows:

$$R_p = (N - 1)\ R_v + r_p$$

where R_p = the resistance of the new probe;
N = the number of times the maximum voltage range is to be increased;
R_v = the input resistance of the v-t voltmeter including the normal probe; and
r_p = the resistance of the normal probe supplied with the instrument.

All resistance values are expressed in megohms.

With these simple directions, it will not prove difficult for the most uninitiated to measure the highest useable resistance. The same technique can be used, of course, to measure insulation resistance of cables, winding-to-winding and core-to-winding resistance of transformers, and for similar high-resistance measurements. Such measurements can be considered to be better than ±5 per cent, since they do not depend on the accuracy of the v-t voltmeter itself because the readings are purely comparative and are made by the same instrument and usually on the same scale. It is necessary that the readings be taken with reasonable accuracy, and that the power source is at least that indicated in the Table I.

Llewellyn Bates Keim
Consulting Radio Physicist
20 E. 74th Street
New York 21, N. Y.

AUDIO FREQUENCY MEASUREMENTS

[*from page 16*]

put of the equipment under test as shown in *Fig* 2. This method has several advantages. The meter scale range, absolute sensitivity, and possible variation in accuracy with indication are not factors in the choice of meters used. Possible observational errors due to the use of meter-range switches are eliminated. The amount of calculation to obtain the desired result from observed readings is minimized. Further, this arrangement has the merit that known input and output levels over a wide range of values can readily be provided. This is of particular practical importance if the same testing equipment is to be used to measure a wide range of gains and losses and various power levels.

The increments of attenuation available and the accuracy of their calibration together with the scale sensitivity and accuracy of the meters used governs the accuracy with which absolute gain can be determined. Response (relative gain) measurements require absolute accuracy so that relative gains are indicated within the desired limits of precision. A total measuring error of ±0.2 db from all causes is the order of precision required for frequency response (relative gain) measurements on equipment for broadcasting transmission. This limit includes frequency response errors in the attenuators. These may ordinarily be avoided by careful attenuator design. Failing this, recourse to calibration is possible. In some instances, particularly in attenuator network arms of low resistance values, contact resistance in switches may introduce errors. Careful design and proper maintenance of the switches will minimize this difficulty. The adjustable attenuators should preferably be mounted in a shielded enclosure. This precaution minimizes the possibility of errors due to parasitic capacitances to external surroundings, which become increasingly troublesome with increasing frequency.

Impedance Matching Networks

The calibrated adjustable attenuators will have fixed input impedances determined during design. If the impedances from and into which it is desired to measure the equipment under test are other than those of the attenuators, it is necessary to add impedance matching networks. These ordinarily can be fixed pads. The addition of such pads to the testing circuit is shown in *Fig*. 6. The determination of the values of such pads is well covered in extant literature.[9,10] However, *Fig.* 7 is included to summarize information for determining such pads as well as "equality impedance" fixed pads, which may be useful to supplement the adjustable attenuators. It should be noted that the "zero resistance" arm of the minimum loss matching pad is always toward the smaller of the two terminating impedances and that there is only one possible value of loss for such pads if both input and output are matched.

The power handling capacity of the resistors used in pads may also require consideration on occasion. For example, when measurements are made on an amplifier for a high-powered sound system, an output pad might well be used to reduce the power to normal measuring level, and the difference between the power out of the amplifier and that in the meter circuit would be dissipated in the pad.

Ordinarily one per cent accuracy will be adequate for the values of the resistors used for pads. However, the required accuracy (or alternative calibration of actual loss) will be governed by the accuracy desired in absolute gain indication. In addition, freedom from change of attenuation with frequency or calibration for such change of loss is also a necessary consideration.

In connection with the use of both adjustable attenuators and fixed pads, whether for impedance matching or to supplement limited range adjustable attenuators, it should be noted that Thevinin's Theory may be applied to reduce the input and the output networks to the equivalent of a generator in series with a resistance.

Balance and Grounding

For measured results comparable to actual performance conditions, the equipment under test should be grounded in the same way for measurement as it is in actual use. In particular, the grounding or freedom from grounding of the input or output or both should be maintained. Among the practical problems which this introduces are, first, the balance of attenuators (both fixed and adjustable), and second, the control of oscillator grounding.

The attenuators, including those for impedance matching, should be of the unbalanced type for connection to a grounded circuit and of the balanced type for connection to circuits intended for ungrounded operation or with a "center-tap" ground. When using an unbalanced measuring circuit one side should always be grounded. The term "ground" is used here as meaning that zero potential plane is used for reference. The impedance to ground for all points on the grounded side should be as low as possible, the interconnecting leads should be as short as possible, and no series resistors included in the ground circuit. For example, the generalized pads of *Fig.* 7 should have their series resistors in the ungrounded side of the circuit. A properly balanced attenuator requires both resistance balance between the two sides of the attenuator and capacitance balance to ground on the two sides. The latter is ordinarily provided by the proper design of the calibrated adjustable attenuator switches. A ground at the center point of the shunt resistance element of the attenuator is usually necessary to insure balance in actual use. Tests to determine the adequacy of the balance (assuming freedom from parasitic coupling) may be made by reversing the connections either to the input or to the output of the attenuator in question and observing whether the output is affected due to such reversal, particularly at the higher audio frequencies. An alternative arrangement to the use of balanced attenuators is the use of an electrostatically shielded and balanced transformer between the attenuators and the equipment under test as shown in *Fig.* 8. This necessitates taking into account the loss introduced by such a coil, or coils, and the possible change in loss with frequency-response measurements.

One practical check of the stability of the measuring circuit is to make a known change in the output level from the oscillator with a corresponding change in the input attenuator setting. For example a 10-db increase in test signal level and a 10-db increase in the input attenuator should result in the same input level to the equipment under test and consequently no change in observed output level. This check should preferably be made at a frequency in the higher range of the frequencies to be used for testing.

The oscillator output circuit may be grounded, or even though not grounded may have sufficient capacitance to ground to introduce errors (the usual practical case). Therefore, this circuit must also be considered in conjunction with the input ground. This condition can often be provided for by the use of an electrostatically shielded transformer at the oscillator output as shown in *Fig.* 3. As the reference input voltage is measured beyond this coil, its frequency-response characteristic does not affect frequency-response measurements. However, it should be borne in mind that such a coil may contribute undue harmonic distortion unless it is chosen to handle the desired oscillator output power adequately. This is of particular importance in making single-frequency harmonic measurements. The efficacy of an electrostatically shielded transformer is a function of the reduction of effective interwinding capacitance brought about by the shield, which is a function of the transformer design. Effective interwinding capacitance of the order of 15 to 20 μμf is feasible with such a coil having a single electrostatic shield and capable of operating at approximately ten milliwatts power level. This is ordinarily adequate. However, a coil having an electrically separate electrostatic shield around each of the two windings may have an effective interwinding capacitance of less than 4 μμf.

In addition to the transmission circuit grounds, the shields ordinarily required on the interconnecting wiring must be grounded. Such leads, particularly those at the input of the equipmet under test, should be as short as possible. In grounding these shields precautions should be taken to make the grounding leads as short as possible and to avoid ground loops. Each shield should be connected at one end only and so grounded that a "radial ground" system results.* This is illustrated in *Figs*. 8 and 9.

Bridging Gain

A special condition of gain measurement occurs when it is desired to determine bridging gain which has been defined previously as "the ratio, expressed in db, of the power delivered tc the bridging amplifier load to the power in the load across which the input of the amplifier is bridged." For this measurement the output of the input attenuator is terminated by a resistance equal to the reference load, and the input of the equipment under test is connected in parallel with this load. Equipment intended for bridging operation will ordinarily have an input impedance which is high relative to that of the circuit on which it is bridged. However, it will still be necessary to take into account the reduction in power in the reference load due to the bridged input for accurate results. Otherwise, the measurement technique does not differ from that previously discussed.

A specific arrangement for measuring the insertion gain and frequency response of a hypothetical system is shown in *Fig*. 9. For purposes of illustration, it is assumed that the measurements are to be made at a constant output power level of 18 db above .001 watt, the input is grounded on one side and the output operates into an ungrounded circuit. It is further assumed

*While such a ground system will ordinarily be adequate, in certain cases other arrangements may be better as determined by trial or by analysis of the particular case.

that a single 500-ohm adjustable "T" attenuator is available and that thermocouple meters are to be used. The necessary fixed pad values are shown in this figure.

In connection with the meters in this figure, it should be noted that when both are indicating .001 watt no meter correction need be added. Further, both can be held to this indication, provided the oscillator output level adjustment is sufficiently fine, the steps on the adjustable attenuator are of the same order of magnitude as the desired gain indication, and the output power is to be held constant. If the input level were to be held constant for the frequency-response measurement, the setting of the adjustable attenuator and the reading of M_1 would be held constant at the reference frequency, for example, 100 cps. Then, as no output adjustable attenuator is available, the variation of gain with frequency could be indicated on M_2. If the power reading on this meter at reference is termed P_R and is .001 watt, the correction in decibels is obtained for other frequencies by observing the power indicated by M_2 and determining the number of decibels corresponding to that indication referred to P_R. If this power is greater than P_R, then the number of decibels difference must be added to the gain determined for the reference frequency, or, if less, subtracted. It is probable that greater accuracy of indication can be obtained by reading small variations on the thermocouple meter scale than by the use of 0.1-db steps on attenuators.

In this same connection, if the desired input level is equivalent to —50 dbm (2.45 millivolts, rms, in series with 150 ohms), this level is achieved in the illustrative example with .001 watt indicated by M_1 and 39.5 db in the adjustable attenuator. This 39.5 db plus the 10.5 db of the matching network provides the desired equivalent of —50 db referred to .001 watt.

For further illustration, there is shown in *Fig.* 10 an arrangement using standard volume indicators as the input and output meters. This figure also indicates the necessary corrections because of the use of such meters. In particular it should be noted that the resistance of the output volume indicator in parallel with the terminating resistor must be taken into account for proper output termination.

The illustrative examples of both *Figs.* 9 and 10 are essentially similar to the general basic circuit of *Fig.* 2. However, it will be noted that the arrangement of the input meter circuit of *Fig.* 9 is such that the same input voltage appears across the input terminals of the input adjustable attenuator as that indicated by M_1, thus avoiding the 6 db correction required in the case in *Fig.* 10. With the arrangement of *Fig.* 9 the relative values of the series input resistances are, of course, factors in the accuracy of measurement.

(To be concluded)

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Selenium Rectifier Booklet

A booklet just made available describes Westinghouse selenium rectifiers for power supplies and electronic circuits, with efficiency curves for both the standard (type M) and the high-voltage (Type H) cells together with discussions of efficiency, aging, life, back leakage, and forward and reverse resistance. Life characteristics are plotted graphically for both types of cells under various overload conditions and for high ambient temperatures. Also included are formulas for calculating rectifier performance, cell ratings for a wide range of applications, and a tabular presentation of schematic diagrams.

For a copy of this booklet, write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

LOUDNESS CONTROL

[from page 17]

in a vertical direction as the shaft is rotated. There are undoubtedly other controls which could be used, but this type seems nearly ideal.

Construction

The installation of the extra taps was accomplished in the following manner: The cover was removed from the control and an ohmmeter connected between the center and one side of the pot. The control was then rotated to give readings of 50K, 100K, 150K, and 200K. At each of these settings a scratch mark was placed adjacent to the rotor contact, beginning at the edge of the resistance element and extending to the outer edge of the bakelite. Holes are drilled and tapped for 2-56 screws into the edge of the bakelite opposite each of these marks. The drilling and tapping must be done carefully because of the brittle nature of the material, which tends to crumble.

Next, four lugs are installed, the sketch in *Fig.* 2 showing how this was done. Other variations will occur to the individual, but this method proved to be satisfactory.

The major problem, that of making a good electrical contact to the resistance element at the proper intervals, was considered from many angles, including pressure contact, etc., but was solved in simple fashion by making use of conductive paint. In the writer's case this was an air-drying silver paint, but there are no doubt many other possible materials, notably aqua-dag. In any case, the material is applied with a fine pen to the edge of the resistance element at each of the pre-

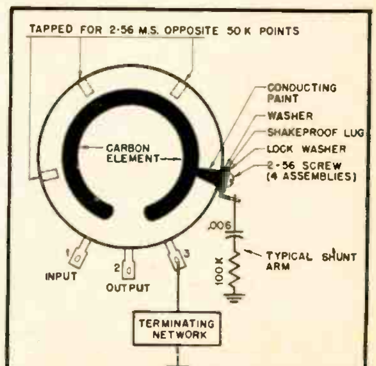


Fig. 2. Physical modifications to standard type of volume control to convert to loudness-control operation.

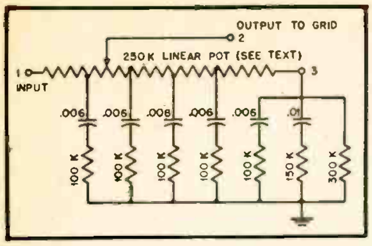


Fig. 3. Electrical circuit of continuous loudness control.

viously located 50K-ohm points, care being taken not to encroach upon the area of contact of the rotor. The paint is carried out over the edge of the bakelite and to the tap, being applied liberally once away from the resistance element.

Once the paint has dried the shunt arms may be added, either directly upon the control, as was done in this case, or externally upon a terminal board.

The schematic of the complete control is shown in *Fig.* 3. Two other points should be considered: first, the fact that in removing the original dust cover in the type of pot we have also removed the stop, making 360 deg. rotation possible, which is highly undesirable because rotating the shaft too far in the direction of minimum gain will bring the control to the point of maximum gain in a very abrupt manner; and second, the fact that it would be wise to enclose the unit in a shield to prevent the collection of dust on the exposed resistance element, as well as to reduce the possibility of hum pickup.

The first problem can be solved in a variety of ways; the use of pins or a block placed on the panel in such a way as to prohibit the travel of a pointer-type knob beyond the proper limits seems perhaps the simplest method and the one which was used in the present case.

As for shielding, a 2½ in. diameter shield can was cut down to the length of 2¼ in. and a ⅜ in. hole was drilled in the center of the closed end. The control was then mounted inside the can with the shaft protruding through the hole, the input, output and ground leads having first been attached. A cover for the open end of the shield can was made from a flat piece of aluminum and attached to the shield by means of screw lugs riveted to the can. Holes are provided in the cover for bringing out the leads.

Response

It will be noted that although these controls have a nominal effective rotation of approximately 310 deg., curves are shown only from 30 deg. to 270 deg., an effective rotation of only 240 deg. This is accounted for by the fact that linear potentiometers, though specified as such, actually have a slow rate of change of resistance at both ends of their range. The unit for which curves are shown was ineffectual over a range of about 30 deg. at each end.

The maximum control range of only 30 db, as indicated by the response curve of *Fig.* 1, may be deemed insufficient by some, but has been found to be adequate. This type of control has radically changed the writer's listening habits so that it is no longer considered necessary to shake the house. With the control set at the position of minimum output, the amplifier gain was adjusted to give a level in the room which might be described as "conversational background". The output at the maximum setting of the control is then more than adequate for normal listening.

The entire construction of the unit described required little more than an hour of working time. The improvement from the standpoint of operation has had the effect of greatly enhancing the value of the loudness control in the ear of this listener, whose hat is now permanently off to Mr. Bomberger.

DUO-CONE LOUDSPEAKER

[*from page 22*]

range. Since the large cone is effectively a continuation of the small cone, the cross-over between the low- and high-frequency cones in the duo-cone speaker need not be confined to a narrow frequency band, because the two cones vibrate as a single cone in this region. Thus it is possible to use a very simple cross-over network. The electrical impedance-vs-frequency characteristics of the low- and high-frequency voice coils are shown in *Fig.* 5. It can be seen that the electrical impedance of the low-frequency unit increases rapidly above 1000 cps. As a consequence, it is not necessary to use an inductance in series with the low-frequency coil to reduce the current in this coil in the high-frequency region. The only external element required for the cross-over network is a capacitor in series with the high-frequency unit which limits the current through the high-frequency unit at the low frequencies. The voice-coil circuits and cross-over networks are shown in *Fig.* 6. The electrical impedance-vs-frequency characteristic with the crossover network and normal operation of the mechanism is shown in *Fig.* 7. The cross-over frequency in this system extends well over an octave. However, as pointed out, this spread is not objectionable, because in the overlap region the two cones vibrate as a single unit.

Cabinets

For most applications the direct-radiator speaker is housed in some type of cabinet. One design of cabinet which has been found to be suitable for the duo-cone speaker is shown in *Fig.* 8. The speaker mechanism is designed to be flush-mounted on the front face of the cabinet. The cabinet is completely lined with one-inch Ozite. This lining absorbs standing-wave systems and reduces the amplitude of the fundamental resonance. The cabinet is equipped with a port which may be used to accentuate the low-frequency response if this type of response-vs-frequency characteristic is desired. The cabinet dimensions for the duo-cone mechanism are not critical. Satisfactory operation can be obtained with any well-designed cabinet having a cubical content of approximately 5 to 7 cubic feet. The mechanism may also be used in a flat baffle.

The measured response-vs-frequency characteristics of the duo-cone speaker mechanism mounted in the cabinet of *Fig.* 8 are shown in *Figs.* 9 and 10. These characteristcs show the effect of the port opening in the cabinet upon the low-frequency response. The response with the port closed is relatively uniform from 50 to 11,000 cps. These characteristics also show that the response is uniform in the overlap frequency range of the low- and high-frequency units.

The response-vs-frequency characteristic of the duo-cone speaker mechanism mounted in a flat baffle is shown in *Fig.* 11.

Directional Characteristics

The directional patterns of a high-quality speaker should be substantially independent of frequency over a broad angle. The directional characteristics of a cone speaker are a function of the frequency. At the low frequencies, where the dimensions are small compared to the wavelength, the system is nondirectional. When the dimensions of the cone become comparable to the wavelength, the system becomes directional. At higher frequencies, the directional pattern becomes progressively sharper with increase in frequency. A uniform pattern may be obtained by decreasing the size of the radiator with frequency. This decrease is approximated by the use of two cones—a large cone for the low-frequency range and a small cone for the high-frequency range. The directional pattern of a cone is also a function of the cone angle because of the finite velocity of sound transmission in the cone. When the angle of the cone is increased, the directional patterns become broader at the higher frequencies. Relatively wide-angle cones were used in the duo-cone speaker in order to obtain broad directional patterns in the high-frequency range.

The directional characteristics of the duo-cone speaker for the frequencies 500, 1000, 2000, 5000, 7000, and 10,000 cps are shown in *Fig.* 12. A consideration of these characteristics shows that a broad directivity pattern is maintained over the entire response range.

Nonlinear Distortion

The nonlinear distortion-vs-frequency characteristic depicts the spurious harmonics which are generated by a loudspeaker. There are many possible sources of distortion in a direct radiator dynamic speaker. A few of the most common sources of distortion are: the suspension system, lack of rigidity in the cone, inhomogeneity of the air-gap flux, and inadequate flux density in the air gap. The expedients for reducing or eliminating these distortions have been considered at length in the literature and will not be repeated here. Every effort was made to develop a system in which these distortions would be as low as possible without adding unduly to the complexity of construction, the sensitivity, or the cost. The total distortion-vs-frequency characteristics of the duo-cone speaker for inputs of 1, 2, and 5 watts are shown in *Fig.* 13. The average input to this speaker for a level of 75 db in the average living room is about 0.1 watt. The distortion under these conditions is negligible. Even at an input of 5 watts the distortion is quite low.

ERRATUM

Through an error arising somewhere between manuscript and final printing, the name of the Principal of Archbishop Stepinac High School was shown incorrectly in the caption of Fig. 5, page 13, of the September issue. Father Joseph C. Krug has been Principal of the school since its opening.

RECORD REVUE

[from page 32]

symphony is that recorded before the war by the great Sir Thomas. Beecham has a special way with Mozart, and his big rep among Mozart fans has plenty of basis, notably the wonderful accuracy of phrasing and of detail on which he always insists. But there are those who wonder sometimes just how far Sir T. can carry certain Mozartean eccentricities and maintain his hold on the cognoscenti. The Beecham "Haffner" (it is Columbia MM 399) is characteristic—a beautifully precise and finished performance. Yet a single hearing of this new Reiner edition is enough to show how different the same music can sound, and it would seem to me, legitimately so. There is no one interpretation of a work like this. There are aspects of it, things in it that may be overlooked, or put in their place, brought out, even exaggerated. An interpretation is the sum total of hundreds of such considerations. Speaking generally (for this can be no essay on Mozart), the Beecham version makes the symphony a beauty but a rather amiable affair, without much in the way of tension. It pauses, almost, to polish off every entrancing detail; there is humor and ease in it. The Reiner version, strikingly different, is tense, serious, taut. The music has drive, as that of the G minor symphony, number 40. It is almost harsh. And hearing it thus, one realizes that these tensities *are* in the music, to be brought out or to be smoothed down, according to conductorial taste. So are the glittering and precise beauties that Beecham brings out. And who can say what Mozart's own conception of the balance of these forces might have been?

Beethoven, "Triple" Concerto in C, Opus 56. John Corigliano, violin; Leonard Rose, cello; Walter Hendl, piano; New York Philharmonic, Bruno Walter.

Columbia MM 842 (4)
LP: ML 2059 (1 10")

● Here is an epochal record, because it is one more in the dual series of definitive recordings this conductor has been making for Columbia, the Beethoven and the Mahler series; also because here is a recording of a big, important Beethoven piece that would be well known to all of us were it not for its unorthodox form—a concerto with not one but three soloists. In these days our concert planners prefer to let well enough alone and stick to the single-solo concertos. Three is definitely a crowd! Thus the "Triple" is virtually never heard and more the pity. It takes a man like Walter to put it through and, better, to make his three soloists perform as a team so perfectly that one hears no concatenation of rival virtuosi striving against the common rival, the orchestra, but instead a unified and smooth-flowing exposition of pure Beethoven. That's something.

Recording balance is unusually clever—this was a knotty problem, to set up three differing soloists so as to register all of them clearly, yet keep them in balance with a full orchestra. The trick was one of liveness. The soloists are close-to, much closer than the orchestra, but *not* louder, an ingenious mike trick that is used more and more these days as engineers realize that mere volume counts for almost nothing, perspective and apparent distance everything. For those interested in problems of separation of this sort (and they crop up in popular music all the time), this recording is a good one for study. The LP edition that I heard is not, I'm sorry to say, as perfect as the last Walter Beethoven, the First Symphony, which is about the finest LP I've ever heard, musically as well as technically. Here we have the same slight buzzings in the loudest passages that seem to be plaguing me lately in so many LPs. You can quickly eliminate the distortion with a cut-off at 8000—but this is torture to a hardened hi-fi man!

Don Cossack Concert.
Don Cossack Chorus, Serge Jaroff.
Columbia MM 844 (4)

● The Don Cossacks go on and on, and presumably get older and older. Though I haven't all of the past recordings with me to prove it, I have a feeling they also get throatier and throatier, with a bigger tremolo content each album. Nevertheless, this is still very fine singing—in fact there is no competition at all to it in the Russian music sphere. Main trouble nowadays (and for some time back) with the Dons is that a good percentage of their ingenious choral arrangements is so much hogwash. Were it not for those fabulous Cossackian tones, the swells and the dyings-away, the high falsettos and the sub-basement basses, the sense of utterly controlled hysteria—were it not for the legitimate spell of the chorus itself and its extraordinary technique, the stuff would show up for what it is, cheap salon music. By far the best of the album is in the true religious music, here by Tchaikowsky himself, written in the great 19th century Russian tradition.

Superb recording, better than ever. (Or maybe I have better equipment now than I did for the last album!)

Meyerbeer, Coronation March; Chabrier, Joyous March.
Minneapolis Symphony, Mitropoulos
Columbia 3-201 (1 7")
19013-D (1 10")

● For the summer's dizziest, try this one, in the 7-inch size or its ten-inch 78 counterpart. The two marches are quite respectable, or have been until now—in this superduper high fidelity recording under the great Greek conductor's hypnotic touch they are turned into hysterical rat races. Nobody on earth could march at such a tempo, nor with such explosive assistance! Gives just a wee bit that familiar effect you've heard when a 33-rpm record is played 78—but this time it's bona fide. Rather fun to listen to, though, and as a *tour de force* of orchestral playing it can't be matched. Nor is any other conductor likely to try.

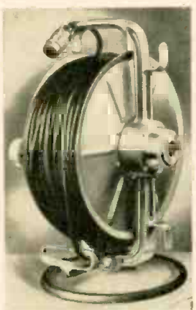
Mr. Canby's column is shortened this month due to illness which has prevented him from preparing his usual entertaining discussion of some aspect of music or musical reproduction. His comments will be resumed with the November issue. Ed.

NEW PRODUCTS

[*from page 34*]

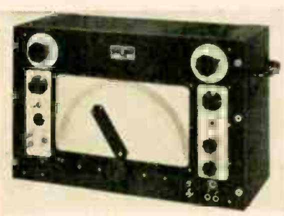
to prevent dirt, water, or gas from entering panels around switches and control shafts. There are also numerous applications for the Sealnut in portable and emergency equipment which is subjected to exposure.

Sealnuts are a product of Radio Frequency Laboratories, Inc., Boonton, N. J., from which may be obtained complete information as to size and styles.



• **Reeling and handling** of portable cables is a difficult operation unless the user is provided with an efficient reel mechanism designed just for the particular application. Any type of reel will hold a cable, but it is inconvenient if it is necessary to unwind the entire reel just to get at the plugs at the start end. With the inside end of the cord terminated by a plug to which access may be had from the outside of the reel, it is only necessary to unroll the required amount of cable and connect a jumper to the plug on the side of the reel. In addition to saving time, this method is also saving of wear on the cable itself, since only that part which is in use is exposed. Thus cables should last almost indefinitely.

Such a reel has recently been introduced by Industrial Electrical Works, Omaha 2, Nebr., and prices and further information may be obtained from them.



• **Sweep frequency generators** are rare in the audio field, but unquestionably they are useful items where a number of measurements must be made on equipment, particularly in the development stage. Routine maintenance of equipment is also simplified by the use of instruments of this type.

The Automatic Audio Sweep Generator recently announced by Clough Brengle Co., 6014 Broadway, Chicago 40, Ill., covers a continuous range from 25 to 32,000 cps, and the sweep may be adjusted to any spread from 500 to 10,000 cps within that range or the instrument may be operated manually. Distortion is held to less than 0.5 per cent, and the sweep calibration is linear. The repetition rate may be adjusted over the range from 2 to 10 sweeps per second. Complete construction and operational data is given in Bulletin 14A, available from the manufacturer.

• **Stylus Pressure Gages** are important to the engineer and experimenter alike to make sure that a phonograph pickup is operating under optimum conditions. Quite a number have been brought out during the last decade, but none has been so useful to the audio man as that recently offered by Livingston Electronic Corp., Livingston, N. J. This device is molded plastic, and contains a unique spring indicator which provides two scale spreads without any adjustments or manual operations. The entire scale covers a distance of about one inch, with half of that amount covering the range from 0 to 10 grams, while the remaining half of the scale covers the range from 10 to 30 grams, the two most useful ranges for phonograph pickup work.

• **Loudspeakers** — always an interesting subject among audio engineers — are appearing in a variety of new types, one of the more recent being the Integral Space Transducer. This unit incorporates some unique features which provide excellent distribution of sound throughout the room as a result of the internal construction of the corner unit, which combines horn loading with a multiplicity of features which make for an attractive speaker for home use. Further information on the unit may be obtained from Audio Research Laboratories, 5531 John Avenue, Superior, Wis.

• **Noise generation** is considerably simplified by the use of a new miniature noise generating diode recently made available by Sylvania Electric Products, Inc., 500 Fifth Ave.. New York 18. This tube, type 5722, is designed for standard laboratory noise measurement, and is operated with 150 volts on the plate and with filament voltages ranging from 2.0 to 5.5 volts, depending on the desired plate current or noise output. In intermittent service, the maximum plate dissipation is five watts, and the noise spectrum extends up to 500 megacycles/second.

• **The Corner Horn principle,** now widely accepted as highly efficient, is utilized in a new model of the Brociner-Klipsch Dual-Horn Reproducer which is now offered in attractively styled cabinets for use in the home, both period and modern. The new models feature improved performance. Driver units of higher efficiency afford cleaner reproduction of the extreme bass, a better balance in the middle range, and exceptionally smooth and flat frequency response to 15,000 cps. The basic features of the original Klipsch system are retained, and fundamental tones from 30 to 15,000 cps are reproduced cleanly and distributed throughout the listening area with uniformity. Horn loading permits bass reproduction without hangover, resulting in remarkable definition, and individual bass instruments are clearly recognized because there is no resonant frequency to be excited by all notes in its vicinity.

Details of the new models may be obtained from Brociner Electronics Laboratory, 1546 Second Ave., New York 28, N. Y.

NEW LITERATURE

• **Co-axial Transmission Lines.** What amounts to a complete reference library on co-axial transmission lines is available to broadcast and TV engineers, and to others in high-frequency electronic fields from Andrew Corporation, 363 E. 75th St., Chicago 19, Ill. This material is essentially a catalog, but contains many reprints of magazine articles on this subject.

• **Sun Mailer.** The Sun Radio Monthly Mailer, designed to bring news, descriptions, and prices of new or unusual items available from this distributor. Free to anyone in the industrial electronics field. Write on your letterhead—Sun Radio & Electronics Co. Inc., 122 Duane St., New York, 7, N. Y.

• **New jobber catalog**—with 196 pages of "everything in radio and electronics"—is offered free by Allied Radio Corp., 833 W. Jackson Blvd., Chicago, Ill.

• **Tube data book,** the seventh edition of this useful manual, has just been brought out by Sylvania Electric Products, Inc., Emporium, Pa. Includes data on 637 types of receiving tubes, together with characteristic curves of types in common use, resistance-coupled amplifier data, interchangeable tube charts, dictionary of terms, and instruction on the use of characteristic curves. Available from jobbers at a nominal charge.

• **High-speed rectangular** coordinate recorder is described in a brochure available from Airborne Instruments Laboratory, Inc., Mineola, N. Y. This instrument plots voltage or the log of voltage as a function of time or of the displacement angle of a measured element.

• **Die-less duplicating** is described fully in a 40-page catalog just published by manufacturers of Di-Acro equipment, O'Neil-Irwin Mfg., Lake City, Minn.

• **Television Components** Replacement Guide is the title of the third edition of a useful 4-page reference available from Standard Transformer Corporation, 3580 Elston Ave., Chicago 18, Ill. Ask for bulletin DD338B.

• **Varnished Insulation**—extremely important to the electrical engineering industry—is the subject of an interesting booklet just published by the Varnished Fabric and Paper Section of the National Electrical Manufacturers Association. The book covers the nature, purpose, origin, development, and use of varnished insulations. A copy may be obtained free from the NEMA, 155 E. 44th St., New York 17, N. Y.

LETTERS

[*from page 10*]

Sir:

I read Mr. Schwartz' letter with much interest. I would like to add my name to the list of your readers also interested in such a series.

Paul M. Kersten, M. D.
826 Watson Ave.,
Topeka, Kansas

Sir:

I am in complete accord . . .

Not only is the available literature quite widely scattered, but the treatment varies from too elementary a presentation to one which is highly theoretical. Such a series can very well cover the "great in-between" and be a boon to the technically minded layman and audio hobbyist.

George W. Sioles,
36 E. Montauk Highway,
Lindenhurst, N. Y.

. . . Exactly expresses my need . . . a boon to those of us who are not *bona fide* audio men from way back . . . There must be others like myself who would appreciate articles, not "written down" in the accepted sense, but perhaps couched in more elementary terms—projects which could be attempted with reasonable assurance of ultimate success without necessity of investing in expensive test apparatus . . . Chalk up one vote—would fill the great gaps in my own as well as in many others' audio educations. . . and on and on.

(Your response has been remarkable, and it also shows what we have not been giving our readers. The series requested by Mr. Schwartz will be inaugurated with the December issue. Ed.)

Address Changes . . .

Subscribers to AUDIO ENGINEERING should notify our Circulation Dept. at least 3 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 cannot duplicate copies of AUDIO ENGINEERING sent to your old residence. Old and new addresses MUST be given.

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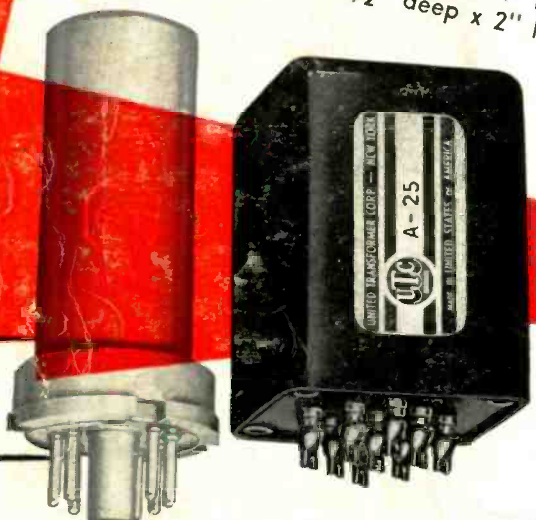

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A-12	Low impedance mike, pickup, or multiple line to push pull grids	50, 125/150, 200/250, 333, 500/600 ohms	80,000 ohms overall in two sections	30-20,000	15.00
A-18	Single plate to two grids Split primary	8,000 to 15,000 ohms	80,000 ohms overall, 2.3:1 turn ratio overall	30-20,000	14.00
A-19	Single plate to two grids 8 MA unbalanced D.C.	15,000 ohms	80,000 ohms overall, 2.3:1 turn ratio overall	50-20,000	18.00
A-24	Single plate to multiple line	8,000 to 15,000 ohms	50, 125/150, 200/250, 333, 500/600 ohms	30-20,000	15.00
A-25	Single plate to multiple line 8 MA unbalanced D.C.	8,000 to 15,000 ohms	50, 125/150, 200/250, 333, 500/600 ohms	50-12,000	14.00
A-26	Push pull low level plates to multiple line	8,000 to 15,000 ohms each side	50, 125/150, 200/250, 333, 500/600 ohms	50-20,000	15.00
A-30	Audio choke, 300 henrys @ 2 MA 6000 ohms D.C., 75 henrys @ 4 MA 1500 ohms D.C., inductance with no D.C. 450 henrys				10.00

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