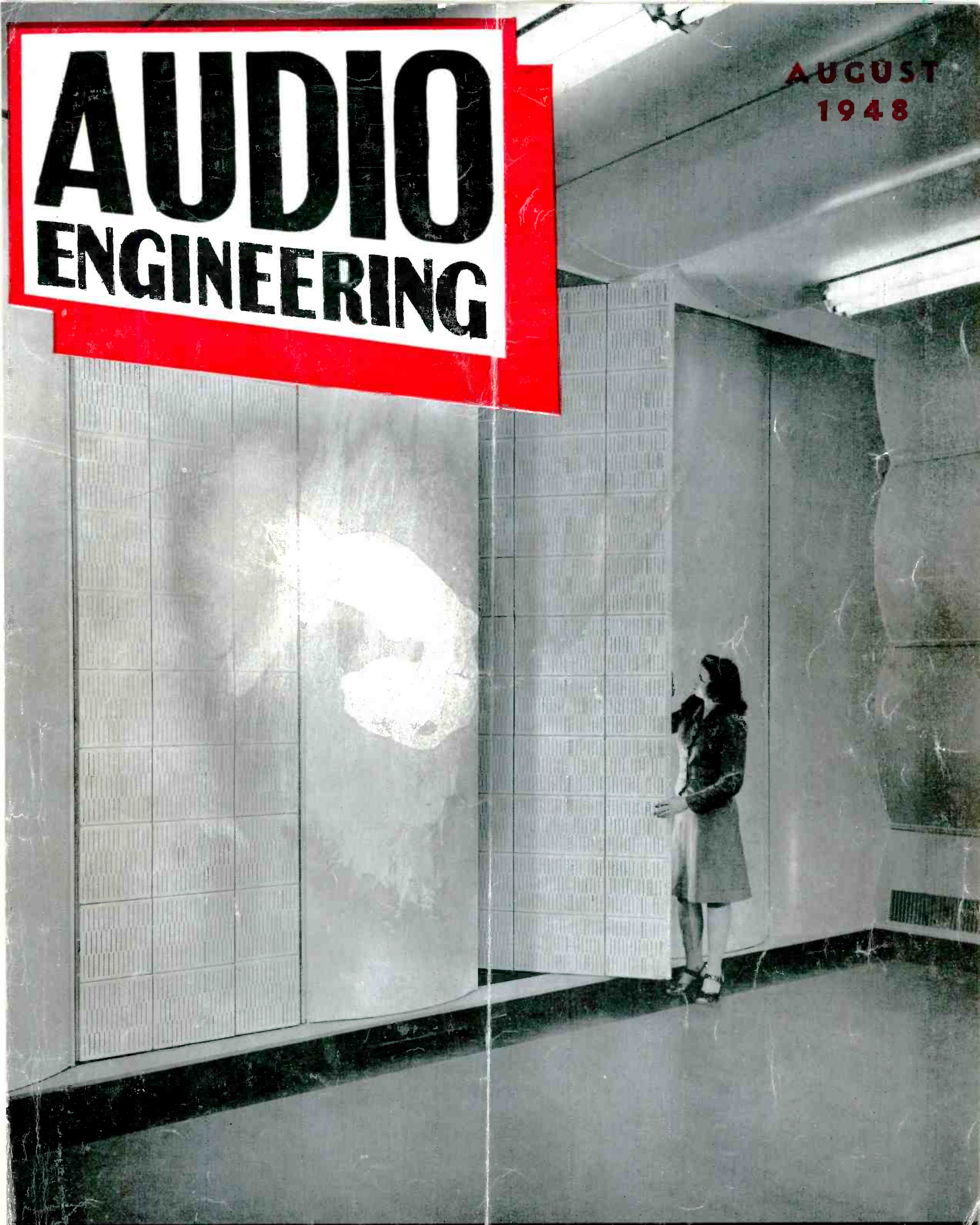
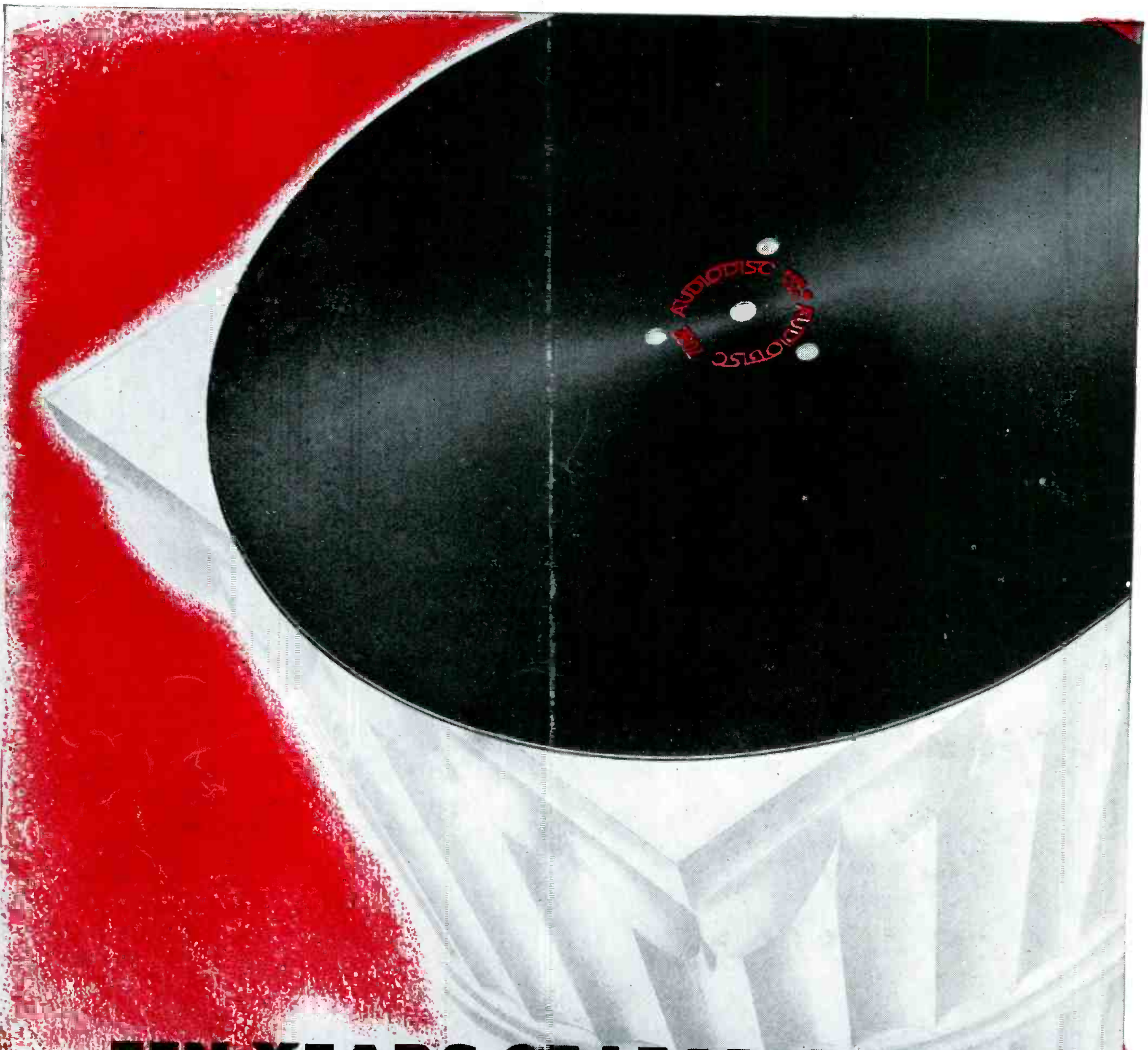
AUDIO ENGINEERING

AUGUST 1948



THE JOURNAL FOR SOUND ENGINEERS



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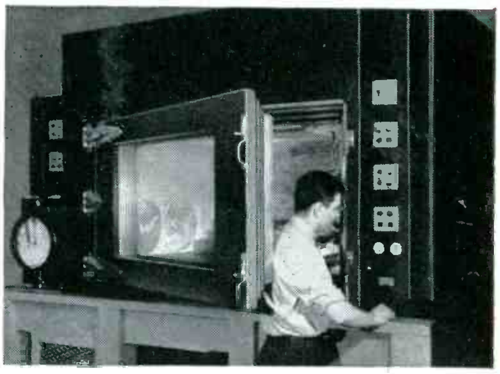
PRECISION IN PRODUCTION

Many people realize and take advantage of the fact that "the tough ones go to UTC." Many of these "tough ones," while requiring laboratory precision, are actually production in quantity. To take care of such special requirements, the UTC Laboratories have a special section which develops and produces production test equipment of laboratory accuracy. The few illustrations below indicate some of these tests as applied to a group of units used by one of our customers in one production item of equipment:

The component being checked here is a dual saturable reactor where the test and adjusting conditions necessitate uniformity of the complete *slope* of the saturation curve. The precision of this equipment permits measuring five widely separated points on the saturation curve with saturating DC controllable to .5% and inductance to .5%.

Servomechanisms and similar apparatus depend, to a considerable degree, on phase angle operation. The transformer adjusted in this operation requires an accuracy of .05 degrees phase angle calibration under the resonant condition of application. With wide change in voltage and temperature range from −40 to +85 degrees C., the phase angle deviation cannot exceed .2 degree. To effect this type of stability, specific temperature cycling and aging methods have been developed so that permanent stability is effected.

This test position involves two practical problems in a precision inductor. The unit shown is adjusted to an inductance accuracy of .3%, with precise (high) Q limits. It is then oriented in its case, using a test setup which simulates the actual final equipment so that minimum inductive coupling will result when installed in the final equipment.



The hermetic sealing of transformers involves considerable precision in manufacturing processes and materials. To assure consistent performance, continuous sampling of production is run through fully automatic temperature and humidity cycling apparatus. It is this type of continual production check that brings the bulk of hermetic sealed transformers to UTC.

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AUDIO ENGINEERING

Successor to RADIO

Established 1917 | AUGUST, 1948 | Vol. 32, No. 8

CONTENTS

COVER

Acoustic treatment of one of the studios at KSL, Salt Lake City, Utah.

AUDIO ENGINEERING (title registered U. S. Pat. Off.) is published monthly at New York, N.Y., by Radio Magazines, Inc., J. H. Potts, President; S. R. Cowan, Sec'y-Treas. Executive and Editorial Offices at 342 Madison Avenue, New York 17, N. Y. Subscription rates—United States, U. S. Possessions and Canada, $3.00 for 1 year, $5.00 for 2 years; elsewhere $4.00 per year. Single copies 35c. Printed in U. S. A. Entered as Second Class Matter at the Post Office, New York, N. Y., under the Act of March 3, 1879.

— Letters —

More On "Toward a New Audio"

Sir:

Isn't it time I made some reply to the numerous comments resulting from my letter "Toward A New Audio" in the April issue? I have received some 30 letters to say nothing of phone calls and personal visits. I particularly enjoyed reading the letter of Samuel Weissman in the June issue. This was written with much charm, and the mellowness of the letter indicated that Mr. Weissman perhaps felt I wrote with tongue in cheek.

Mr. Weissman considers it presumptous that I should suggest a reinterpretation of the composition as intended by the composer. What was behind the propositions in my letter was that the listener to a perfectly linear reproducing system in no way hears the composition as the composer intended. And this I shall explain shortly:

If high-fidelity reproduction could recreate music as the composer intended, the whole art of reproduction would surely have attained an ultimate point of development. But, unfortunately, this is not possible. I do not believe there is a single reproducing system in the world where the listener may hear a composition as the composer intended and annotated his script. Music in its reproduced form reaches the listener only after much artistic and physical intervention, so much so that absolute identity to the original as conceived by the composer is impossible. By this is meant that in addition to the notations of the composer on the score:

1. An arranger may have a hand.
2. A conductor or band leader intervenes.
3. Individual interpretation by each member of the orchestra.
4. The acoustics of the concert hall.
5. Temperature variation at time of performance affecting pitch of instruments.
6. The quality of the transmission or recording system.
7. The placement of the microphone at the pick-up source.
8. The engineer at the monitoring controls.
9. The limitations in dynamic range of transmission.
10. The limitations of the reproducing equipment.

So who can say what the original should have been? After all this, who can deny the listener his part in the rendition? Radio music is therefore so much conditioned by the mechanics that make it possible, that I plead for one more link, that of final listener satisfaction......final coupling to the

[*Continued on page* 8]

IMPROVED NULL DETECTOR

for a-c Impedance Bridges

SENSITIVE • RUGGED • CONVENIENT TO OPERATE

THE G-R Type 707-A Null Detector is designed for use as a visual null indicator for balancing bridges, and for other null-detector measurements at power-line and audio frequencies. It contains a one-inch cathode-ray tube in a non-inductive degenerative amplifier circuit, with tuning and phashing networks and sweep and sensitivity controls. As a null detector on any a-c impedance bridge its advantages over other types of detectors are numerous and include:

1—Operation in noisy locations

2—Not affected by strong magnetic fields

3—May be used at frequencies up to 2 kilocycles, and higher as an untuned amplifier

4—Separately indicates balance of the resistive and reactive components

5—Makes possible precise balancing of either component with only moderate close balance of the other

6—Precise measurement of the steady component can be made while the other varies erratically

7—Shows immediately any drift of either or both components

8—Provides positive indication of the direction of off-balance for either component, as selected

9—Can be calibrated to show the degree of unbalance

10—Can be used at all times at maximum sensitivity even with the bridge far off-balance

11—Supplies instantaneous response

12—Will withstand any overload caused by marked off-balance, and is instantaneous in recovery

The input impedance of the detector is one megohm. Its sensitivity is 150 microvolts at 60 cycles and 200 to 300 microvolts at 1,000 cycles. Its selectivity is 40 db against the second harmonic. Plug-in units (sold separately) tune the amplifier to any operating frequency between 20 and 2,000 cycles with a continuous tuning range of plus-minus 5% for each unit. For operation at any frequency below 400 cycles a phasing unit (sold separately) is required.

TYPE 707-A CATHODE-RAY NULL DETECTOR . . . $285.00

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EDITOR'S REPORT

MAKING CRYSTALS AMPLIFY

● LAST MONTH we had just put our issue peacefully to bed when Bell Labs announced the Transistor, a germanium crystal amplifier/oscillator which we consider one of the most important developments in this field during the past decade. Those of us who have played around with crystal detectors have often wondered if some means of making them oscillate or amplify would ever be discovered. And many of us did a little unsuccessful experimenting on our own hook. But not until Drs. John Bardeen and Walter Brattain of Bell Labs learned the secret. could anyone do the trick.

In view of the importance of this new development, it behooved your editor to publish as quickly as possible technical data on this device. We could break it into the July issue by pulling out our editorial and a column of letters, but we found that Bell Labs wouldn't release any data on the theory of operation, and very little on the design of the device. But with such technical details as they did supply, Winston Wells got busy in his laboratory and built the unit described last month, working night and day over the long Fourth-of-July weekend. He produced a unit which had somewhat greater power output than the Transistor, at decreased gain. Above all, he worked out a theory of operation, and plotted characteristic curves, which will guide others who wish to experiment along these lines. Thus, we are able to present to you information on this new development that can be obtained nowhere else at the present time.

In the current issue, S. Young White has taken over the continuation of this series of articles on the germanium crystal amplifier, with practical working models and construction details in this issue. Because of the minute spacing (.002 to .005 inch) between the crystal contacts, much of White's work had to be done under a medium-power microscope. A jeweler's loupe wasn't quite strong enough.

Future articles on this device will deal with its applications. There are many jobs which it can do better than electron tubes, others where it is far inferior. It consumes power in its input circuit, which has low impedance (100 to 1000 ohms) at all frequencies, and its output power is normally of the order of 35 milliwatts, at impedances of the order of 10,000 to 15,000 ohms. There are enormous variations in impedances between units, which indicates that one of the first steps in the commercial development of the new device will be careful control of the amount and distribution of impurities in the raw germanium crystal, as well as in the spacing of the contacts, etc. But the field is wide open for the experimenter, as well as for research workers in communications and nuclear physics.

NAVY NEEDS ENGINEERS

● WE have just received a letter from the Chief of the employment operations division of the Navy Department requesting that we bring to the attention of our readers information regarding position vacancies in Washington. Engineers and scientists in practically all fields are needed, as well as mathematicians and physicists. Salaries range up to $10,330 per annum. Applications should be made on Standard Form 57, available at any first or second-class Post Office, and should be mailed to Code 612, Room 1213, Main Navy Building, 17th and Constitution Ave., Washington, D. C.

WITH OUR AUTHORS

● A complete series of articles on the design and applications of acoustical test equipment will start soon. Had lunch with J. A. Maurer, sound-on-film authority, who is also preparing a number of articles, on his specialty. Now that the tone-warning device for telephone recording has been approved, E. W. Savage will continue his series on telephone recording. W. W. Wetzel of Minnesota Mining has three interesting stories on magnetic recording, including a special method of making duplicates from recording tape. McProud is working on an extraordinary preamplifier, to be built into a mike, using the new germanium crystal amplifier units. —*J. H. P.*

— Letters —

[from page 4]

peculiar esthetic urge and capabilities of that listener.

That a home listener should select his own frequency intensity is as natural as his request when attending a concert, that he ask for a seat in front of the tympani or the viol section. Consider how haphazard are the listening circumstances of the concert-goer, because each area in the hall has its own acoustics; where the time difference between him and either end of the stage may be an appreciable time difference; where certain weak solo instruments may be practically inaudible during pianissimo passages; and where acoustic phase interference may exist because of differences in path length relative to the listener and two identical instruments. Surely, the radio or phonograph owner has the inalienable right to say, "I'm going to listen to my music in any darn way I please." This is not a crude, uncultured attitude. It is actually recognition of radio's inadequacy. It is an unconscious desire to play a greater esthetic part in the program. It is the same inner compulsion that causes us to tap rhythm in the presence of a pleasing tune.

In view of the above, it is dark indolence to consider our audio systems only as reproducers. They must be exploited as a combination of reproducer and a new instrument. Without this, the owner is only a mechanized listener. But with our new audio system, music will undergo a manifest alteration under the hand of the listener. Some people will object that it is not traditionally proper to give this freedom indiscriminately to the layman. But such a reaction is not important. It is important that our non-live music, (viz, radio, phono) shall be conceived of in terms of the new audio resources.

Radio has given music currency and circulation. The next stage of development is upon us, and must be to unstandardize it, to re-animate it in the privacy of our homes. The old form, technical linearity, will co-exist with the new form, the *intimate, personal* and *readapted form.*

Saul J. White

c/o University Loudspeakers, Inc.
80 S. Kensico Ave.,
White Plains, N. Y.

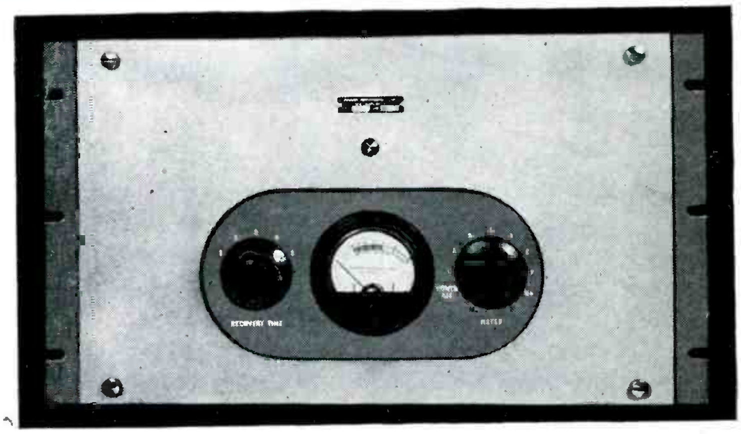
File this under A

[Two new Presto Amplifiers]

Engineers will welcome these two new additions to the PRESTO line of superior equipment.

Presto Peak Limiting Amplifier (*Type 41A*)

DESIGNED to control program peaks, Type 41A removes the cause of overcutting and distortion in recording and over-modulation in broadcasting. Proper degree of peak limiting permits an appreciable increase of the average signal with consequent improvement of signal to noise ratio. Serves simultaneously as a line amplifier; its 60 db gain adequately compensates for line losses due to pads, equalizers, etc.



Type 41A. Chassis construction is for vertical mounting in standard racks. Removable front panel gives access to all circuits. Meter and selector switch indicate amount of limiting taking place and current readings of all tubes.

Type 89A. Chassis construction is for vertical rack mounting. Removable front panel for easy access to all circuits. Meter and selector switch provide convenient indication of output level at 1000 cps and current readings of all tubes.

Presto Power Amplifier (*Type 89A*)

FOR recording, or monitoring use, 89A is the perfect high fidelity, medium power unit. 25-watt output, it fills the need for an amplifier between Presto 10-watt and 60-watt units. All stages are push-pull and sufficient feedback is provided to produce a low output impedance and general performance of the type 807 tubes which is superior to that of triodes.

FULL SPECIFICATIONS OF THESE TWO NEW AMPLIFIERS WILL BE SENT ON REQUEST.

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Technicana

Bridge and Ring Modulators

• The "Linear Theory of Bridge and Ring Modulator Circuits" using copper oxide or other fixed-type rectifiers is discussed from a practical viewpoint in an article under that title by Vitold Belevitch in *Electrical Communications* for March. Most information on this subject heretofore available has been essentially theoretical, and this reduction to more practical terms is welcome.

The author shows, by a series of assumptions of conditions and the solution of the resulting formulas, that the bridge rectifier shown in *Fig.* 1 is capable of improved performance if the terminating resistance R_2 is chosen correctly for a given source impedance R_1. The optimum value of R_1 for operation with an ideal filter in the output circuit is approximately 1.73 $\sqrt{r_s r_o}$, r_s and r_o being the short-and-open circuit resistances, respectively, of the rectifier. The optimum value for R_2 is approximately $0.87\sqrt{r_s r_o}$.

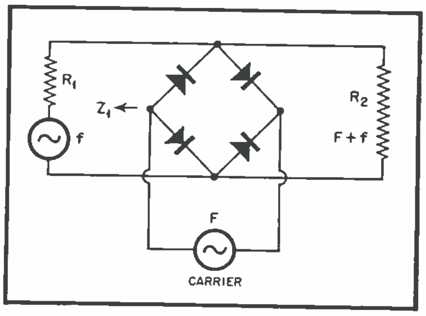
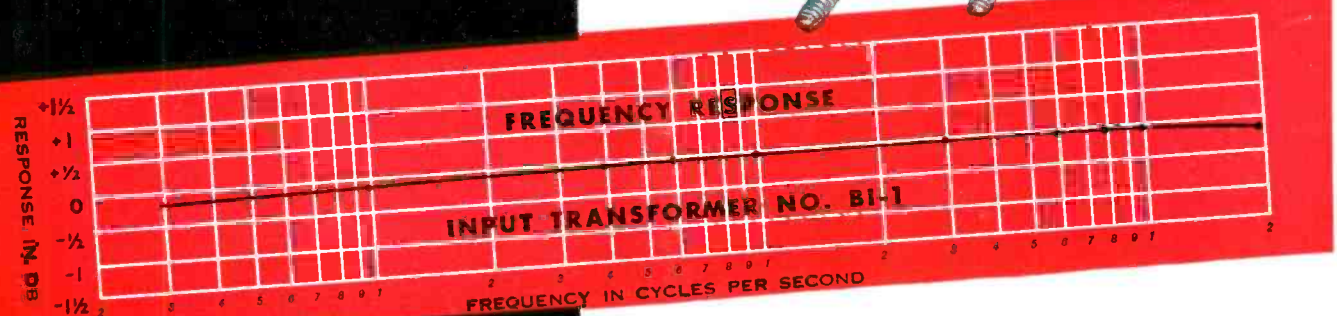


Fig. 1. Bridge rectifier schematic.

When filters are used in the input and output circuits, the optimum value for R_1 and R_2 is shown to be 0.39 r_o. However, this circuit is of high impedance, and is usually not practical. If, therefore, Z_1 is taken as a pure resistance R_1 at frequency f, and infinite at other frequencies, and Z_2 is a constant resistance R_2 except at frequency f, where it is infinite. Then it may be shown that the optimum value for R_1 and R_2 *is* $\sqrt{r_s r_o}$.

With bridge circuits, the requirements differ somewhat, and it is shown that R_1 should lie between 0.65 $\sqrt{r_s r_o}$, and $\sqrt{r_s r_o}$, while R_2 should lie between $\sqrt{r_s r_o}$ and 1.57 $\sqrt{r_s r_o}$. Experimental results shows reasonable correlation with the theory.

LOOKING FOR HIGH FIDELITY IN AUDIO COMPONENTS?



INPUT TRANSFORMERS

Catalog No.	Application	Impedance Primary—Secondary	Max. Power Level
BI-1	Line to Single or P.P. Grids..........	*Pri.—600/150 ohms CT *Sec.—50,000 ohms CT....	+20 dbm.
BI-2	Line to Single or P.P. Grids..........	*Pri.—600/150 ohms CT *Sec.—50,000 ohms CT....	+20 dbm.
BI-3	Line bridging to P.P. Grids..........	*Pri.—8,000/6,000 ohms CT *Sec.—50,000 ohms CT....	+20 dbm.
BI-4	Line to line...........	*Pri.—600/150 ohms CT *Sec.—600/150 ohms CT..	+20 dbm.
BI-5	Line to line...........	*Pri.—600/150 ohms CT *Sec.—600/150 ohms CT..	+30 dbm.
BI-6	Interstage—P.P. Plates to Single or P.P. Grids..	*Pri.—20,000 ohms CT *Sec.—50,000 ohms CT....	+20 dbm.

OUTPUT TRANSFORMERS

Catalog No.	Application	Impedance Primary—Secondary	Max. Power Level
BO-1	Single Plate to Line....	Pri.—15,000 ohms at 0 to 10 ma d-c........ *Sec.—600/150 ohms CT..	+20 dbm.
BO-2	P.P. Plates to Line.....	*Pri.—20,000 ohms CT.... *Sec.—600/150 ohms CT	+30 dbm.
BO-3	P.P. Plates to Line.....	Pri.—5,000 ohms CT..... *Sec.—600/150 ohms CT..	+40 dbm.
‡BO-4	P.P. Plates to Line.....	Pri.—7,500 ohms CT..... *Sec.—600/150 ohms CT..	+43 dbm.
BO-5	P.P. Plates to Line.....	Pri.—10,000 ohms CT.... *Sec.—600/150 ohms CT; 16/8/4 ohms......	+37 dbm.

‡Has tertiary winding to provide 15% inverse feedback.
*Split and balanced windings.

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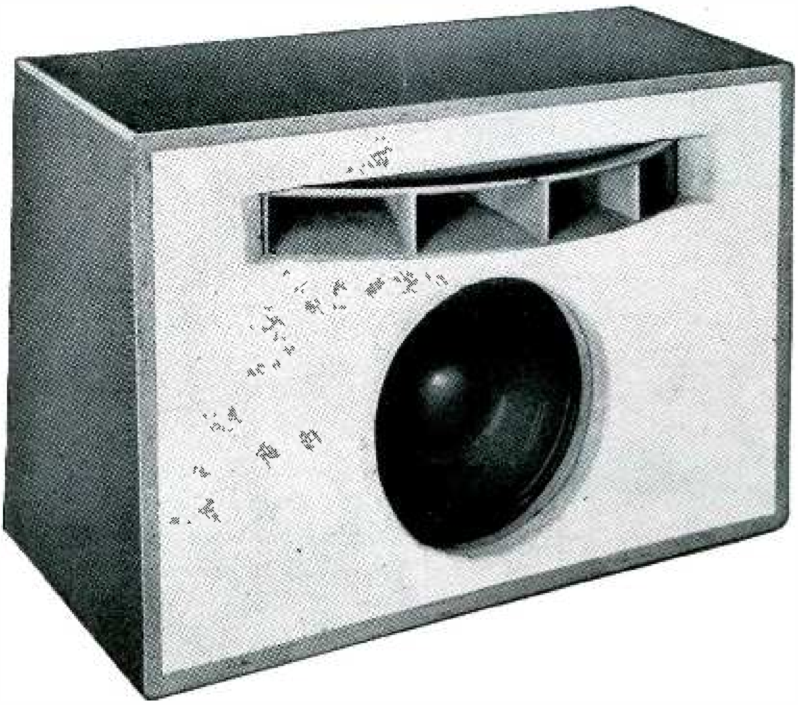

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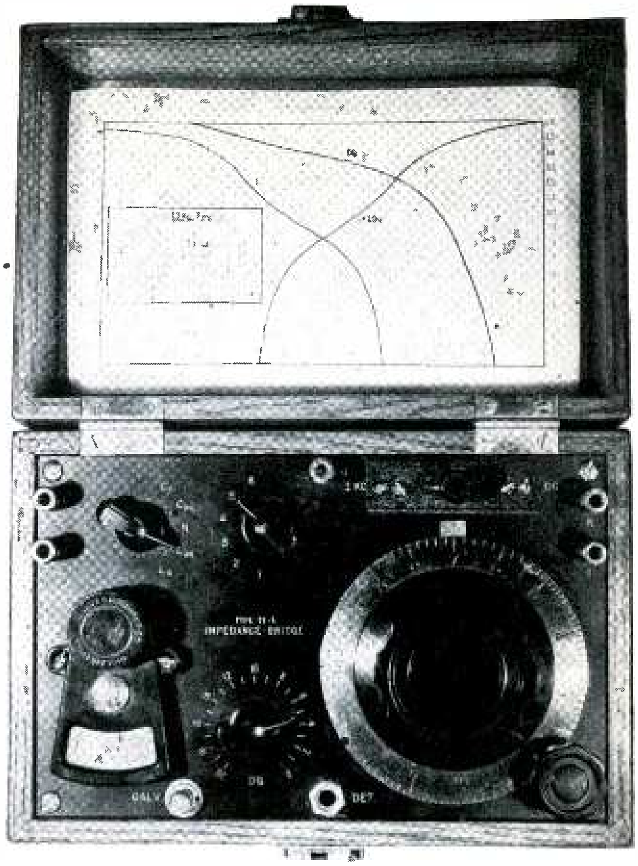
Completed bridge in its cabinet.



A Practical Impedance Bridge

JOHN WINSLOW

Complete constructional details for a desirable addition to the test equipment complement of the audio engineer or experimenter.

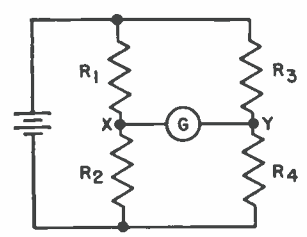
IN AUDIO WORK—as in all other branches of electronics—it is necessary to make various kinds of measurements. In addition to the more common quantities such as voltage, current, signal, frequency response, and gain, it is often necessary—or at least desirable—to be able to make measurements of inductance and capacitance, and to make accurate measurements of resistance. While deflection-type circuits, resembling the ordinary ohmmeter, will serve for many of these measurements, the accuracy is usually not adequate for critical applications.

The logical device for determining these values is the impedance bridge, which may be used in a number of common configurations for measurement of inductance and capacitance, as well as their related values of Q and dissipation factor, and for accurate measurement of resistance.

The general principle of the bridge is doubtless familiar to most readers, but a brief review may not be amiss. Consider the circuit of *Fig.* 1, which includes four resistances, R_1, R_2, R_3, and R_4, a galvanometer, *G*, and the battery, *B*. If all four resistances are equal, point *X* will have a potential exactly half way between the extremes of the battery voltage, and point *Y* will have the same potential. Therefore, with no potential difference between the galvanometer terminals, no current will flow through the galvanometer. However, let any one of the four resistances be changed and the potentials at *X* and *Y* are no longer identical, so current will flow through the galvanometer. If both R_2 and R_4 are changed by the same amount, the balance remains, and again no current flows. Thus the bridge is balanced, as evidenced by the null or no-current condition, when $R_1:R_2=R_3:R_4$, or when $R_1:R_3=R_2:R_4$.

Accepted bridge nomenclature and symbolism calls for different notations for the four arms, and for a particular form of portraying the bridge structure. In *Fig.* 2, therefore, the same electrical arrangement is shown in a different physical configuration. The *N* arm is variable, the *P* arm is the unknown, and the *A* and *B* arms usually have decimal ratios to facilitate the measurements. With the *N* arm calibrated accurately, it is seen that the unknown value is equal to NB/A, where all values are in ohms.

Usual practice is to employ a decade box for *N* when good accuracy is desired, but measurements within five per cent may be made readily with a potentiometer for *N* provided the dial is carefully calibrated. The ratio arms may be obtained as a separate unit, with easily selected decimal ratios, or they may be composed of a number of separate resistances.



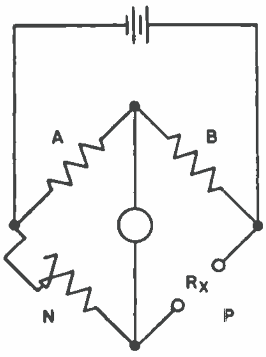


Fig. 1 (left). Basic principle of a bridge depends on ratios of various "arms" comprising the network.

Fig. 2 (right). Simple resistance bridge, shown in usual form and with accepted symbols.

Capacitance Measurement

If an a-c source is substituted for the battery of *Fig.* 2, the same bridge may be used for measurement of quantities which offer reactance to an alternating current, provided another reactance is substituted for one of the ratio arms. For convenience, the most suitable reactances to use for standards are capacitors, since condensers may be obtained in accurately known values, and are not affected by nor do they create external fields, and their reactance does not change with varia-

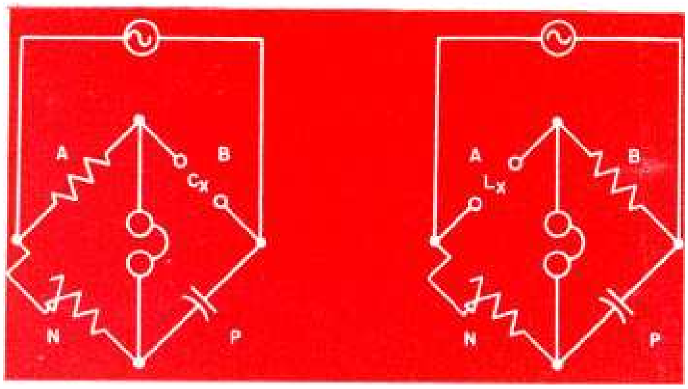


Fig. 3 (left). Substitution of a capacitor for one arm of the bridge permits measurement of capacitance values. Fig. 4 (right). Rearrangement of arms permits use of a standard capacitor for measurement of inductance.

tions in applied voltage, as does that of most types of inductors.

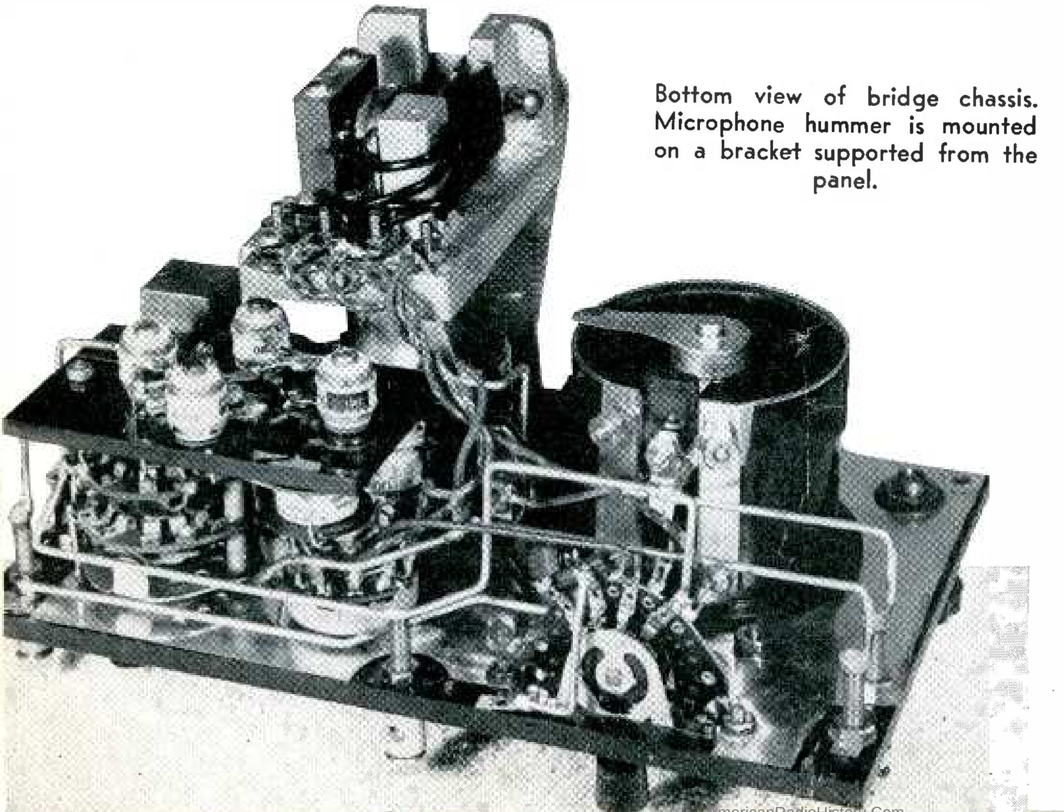
Since the reactance of a capacitor is inversely proportional to its capacitance, the *B* and *P* arms are effectively reversed, with the *B* arm becoming the unknown and the *P* arm becoming the standard. When so arranged, the calibration of the *N* dial may be read directly when a multiplier depending on the value of the *A* and *N* arms is applied. The configuration of the resulting bridge is then as shown in *Fig.* 3. When using an a-c source, the galvanometer is no longer of value as a null indicator, and a pair of phones is generally used. An amplifier and an output meter may be used, if desired, but for less stringent requirements than those of a laboratory, phones are quite suitable.

Inductance Measurements

Since the reactance of an inductor varies directly with the inductance, the bridge arrangement for these measurements can be similar to the resistance bridge if the standard used is also an inductance. But, for reasons mentioned above, it is not especially desirable to use inductors as standards. By interchanging the positions of the various bridge arms, however, a capacitor may be used for this purpose. The circuit for such an inductance bridge is shown in *Fig.* 4. Note that the inductance and the capacitance are in opposite arms, so that an increase in the reactance of one arm is compensated by a decrease in the opposite arm, and the ratio of the two reactances is given by the ratio of the *N* and *B* arms.

In addition to pure inductance and capacitance, components have losses which must be considered in the measurement of their characteristics. These losses have the same effect as a resistance in series with the inductance or capacitance. On account of these losses, a true null point is difficult to obtain in the phones due to a phase difference in the reactive arms of the bridge. This may be compensated for by the addition of a variable resistance in series with the standard capacitor, so that the phase shifts in the two arms may be equalized, thus permitting the user to obtain a better null indication. This additional resistance also indicates the efficiency of the unknown capacitor or inductor, and gives a numerical value to the Dissipation Factor, *D*, of the former, or the Energy Factor, *Q*, of the latter.

The compensating resistance is used in two ways. For measuring capacitors, it is inserted in series with the standard, and to facilitate measurements, is in two ranges to cover a wire variation in dissipation factor. For measurements of inductance, the same two resistance ranges may be used, with the lower range connected in series with the standard capacitor for values of *Q* in excess of 10, or with the higher range connected across the standard for lower values of Q. The first of these circuits is known as Hay's bridge, while the latter is known as Maxwell's bridge.



Bottom view of bridge chassis. Microphone hummer is mounted on a bracket supported from the panel.

The Practical Impedance Bridge

The combination of these five circuits into a single instrument furnishes a compact means for measuring fundamental properties of components, and the completed unit will be found practically indispensable. It provides for the measurement of resistance values from 0.1 ohm to 1 megohm, of inductance values from 1 microhenry to 10 henries, and of capacitance values from 10 μμf to 100 μf. To make these reactance measurements, only one standard capacitor is used, with a value of 0.01 μf. Eight accurate fixed resistors are required, and the *N* arm is composed of a 10,000-ohm potentiometer. The two resistors used for *D* and *Q* measurements are a standard dual potentiometer, and they may be calibrated by the resistance bridge after the instrument is completed.

Inspection of the complete circuit, *Fig.* 5, will show that the instrument is very similar to the General Radio 650-A Impedance Bridge, a popular laboratory instrument. However, the commercial model is somewhat more costly than the average experimenter can afford, and it is often desirable to assemble an instrument from more or less standard parts. The circuit configurations for the five positions of the selector switch are shown in *Fig.* 6.

The bridge shown is constructed on a ¼-inch Bakelite panel, 5½x8⅝ in., this being the size required to fit the case from another bridge of different manufacture. This bridge had been irreparably damaged, and the case was available. During the construction, the entire panel was shielded by a thin sheet of coke tin, with sufficient clearance for the terminals. The lever-

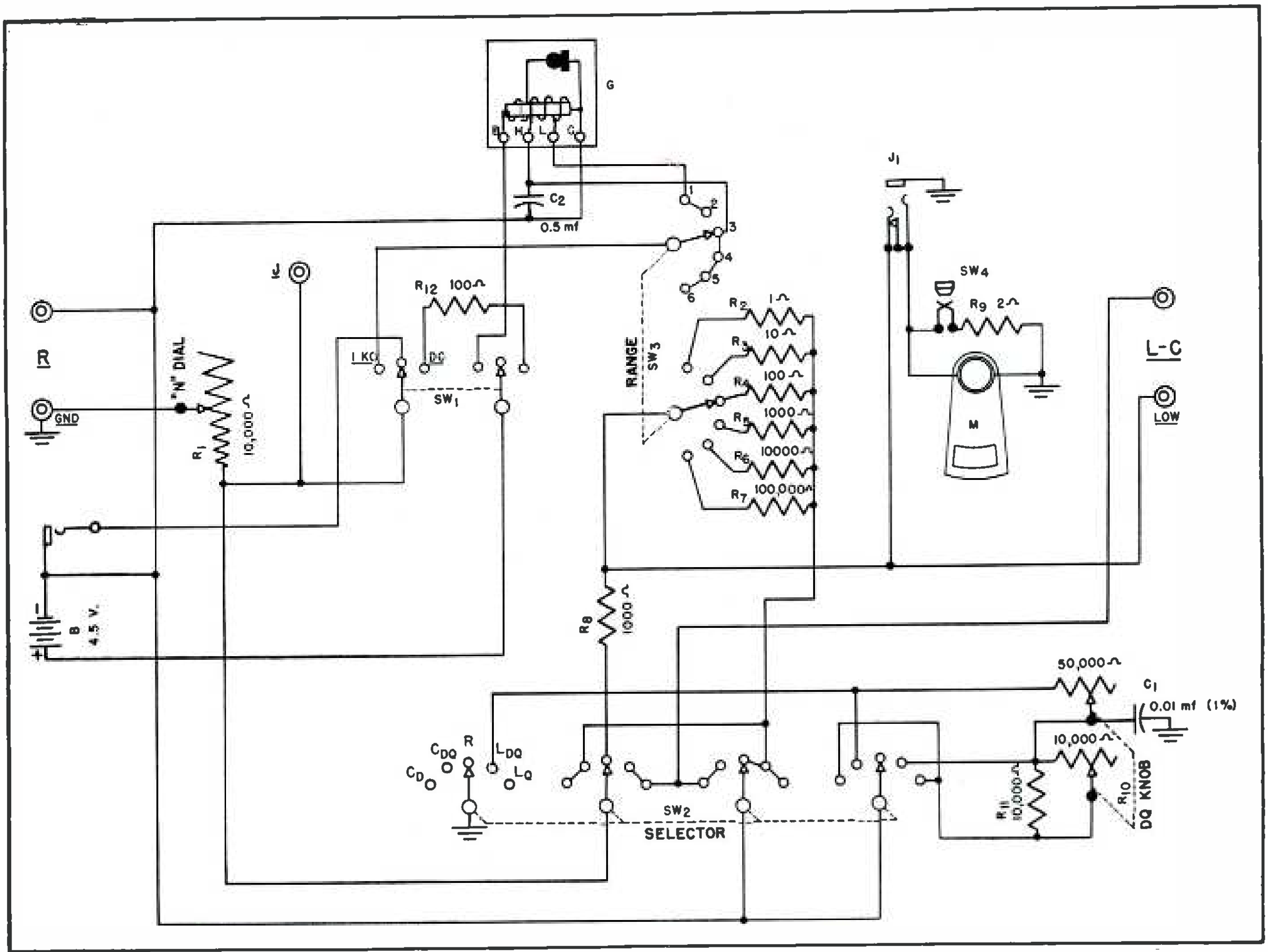


Fig. 5. Complete schematic of the impedance bridge described in the text and shown in the photos.

- B 4½-volt "C" battery, RCA VS-030 or equivalent
- C_1 0.01 μf, 1%, General Radio Type 505-L
- C_2 0.5 μf, generator bypass type
- G General Radio, Type 572-B microphone hummer
- J Mallory 702B jack
- M Leeds & Northrup galvanometer unit
- R_1 General Radio Type 371-T, 10,000-ohm tapered potentiometer
- R_2 1.0 ohm, 1%, wire-wound instrument resistor
- R_3 10 ohms, 1%, wire-wound instrument resistor
- R_4 100 ohms, 1%, wire-wound instrument resistor
- R_5,R_8 1,000 ohms, 1%, wire-wound instrument resistor
- R_6 10,000 ohms, 1%, wire-wound instrument resistor
- R_7 100,000 ohms, 1%, wire-wound instrument resistor
- R_9 2 ohms, wire-wound strip resistor
- R_{10} IRC 61-1623 dual potentiometer, 10,000 and 50,000 ohms
- R_{11} 10,000 ohms, ½ watt, carbon or metallized resistor
- R_{12} 100 ohms, ½ watt, carbon or metallized resistor
- SW_1 Centralab 1454 switch, with P1760 mounting plate
- SW_2 Centralab 1415 switch
- SW_3 Mallory 3226J switch
- SW_4 H&H push-button switch, normally closed
- Dial General Radio Type 703, (any graduation)
- Binding Posts General Radio Type 138-V

type switch, SW_1 in the schematic, is used to connect either the microphone hummer for *L* and *C* measurements, or to connect the battery through a 100-ohm current limiting resistor, R_{21}, for resistance measurements. In the center position, a jack is connected to the bridge circuit, permitting the use of a 45-volt battery for more accurate measurement of high values of resistance; or for use with other frequencies as furnished by a separate audio oscillator for measurements of inductance and capacitance at other than 1000 cps. The galvanometer is a Leeds & Northrup unit, with an unshunted sensitivity of 4 μa per division. It is shunted with a 2-ohm resistor in series with a normally-closed push-button switch which may be depressed for greater accuracy in reading as balance is approached. The jack for the phones is equipped with tip and ring springs, together with a normal spring, and is so wired that when no plug is inserted, the tip and ring are connected together, thus connecting the galvanometer without the need for a switch. This arrangement permits the use of the galvanometer for external connection simply by connecting to the ring and sleeve circuits of a three-way plug.

The *N* arm of the bridge is a General Radio Type 371-T potentiometer, with a total resistance of 10,000 ohms. The dial is hand calibrated with "1" at 1,000 ohms, "2" at 2,000 ohms, and so on. Any 10,000-ohm variable can be used for this purpose, but the taper of this particular potentiometer spreads the scale out so that the accuracy of reading the dial is more closely proportional to the inherent accuracy of the bridge itself.

The scale for the *DQ* control is arbitrary, since it applies to three separate ranges, and it is much simpler to plot a graph to show the various values of D and Q than it is to try to get three scales on a single control. In a small instrument it is also more convenient to mark the range dial with numbers, referring to a table for the actual multiplying factor for the various ranges.

From the photo of the underside of this bridge, it will be noted that the microphone hummer is mounted on a bracket supported from the panel. The 0.5 μf capacitor C_2, used to improve the waveform of the hummer, is mounted directly on the base of the hummer. To avoid acoustic transmission of the 1000-cps tone from the hummer to the panel, it is desirable to isolate the former from its bracket by live rubber grommets, using flexible wire for the connecting leads. In the case used for this instrument, the battery connections to the panel were made through the brackets supporting the panel, but this is only a constructional feature which would be of interest if the same type of case were available. In general, it would be much simpler to provide a three-wire cable and a plug to connect to the battery and the external generator jack. The "J" binding post shown in the photo is used on the General Radio bridge, and accordingly was placed on this instrument, but to date no use has been found for it. It is suggested that it be omitted.

Calibration

The main calibration problem is that of the *N* dial. To do this accurately requires the use of a resistance bridge which is of itself accurate, for it is upon this calibration that the over-all accuracy of the completed bridge depends. The calibration of this dial may be done after the construction is finished. Place the selector switch in the *R* position, insert an open plug into the phone jack, and disconnect the battery. The dial may then be calibrated by means of the other bridge, and the dial marked suitably. In this particular instrument the dial plate was turned over and calibration hand engraved, although a simple paper scale would suffice. After the *N* dial is calibrated, the data for the *DQ* dial may be obtained. using the instrument itself for the measurements. Reconnect the battery, remove the plug from the phone jack, and connect the high *R* binding post to the undergrounded terminal of one of the DQ potentiometers. Check the resistance value at each calibrated point on the scale, making a chart of the values. Then do the same with the other section of the dual potentiometer.

Having these values, it is then desirable to make a series of curves such as those shown in the cover of the case. The value for D, based on the use of a 1000-cps microphone hummer for the a-c source and a 0.01-μf capacitor for the standard is given by the formula

$$D = .000628\ R$$

where *R* is the measured resistance of the DQ potentiometer. This applies to both the C_D and C_{DQ} positions of the selector switch, and both should be plotted.

The values of *Q* for the L_{DQ} position of the selector switch are identical with those of *D* for the C_{DQ} position. Thus the one curve suffices for both C_{DQ} and L_{DQ} positions. For the L_Q position, the value for *Q* is given by the formula

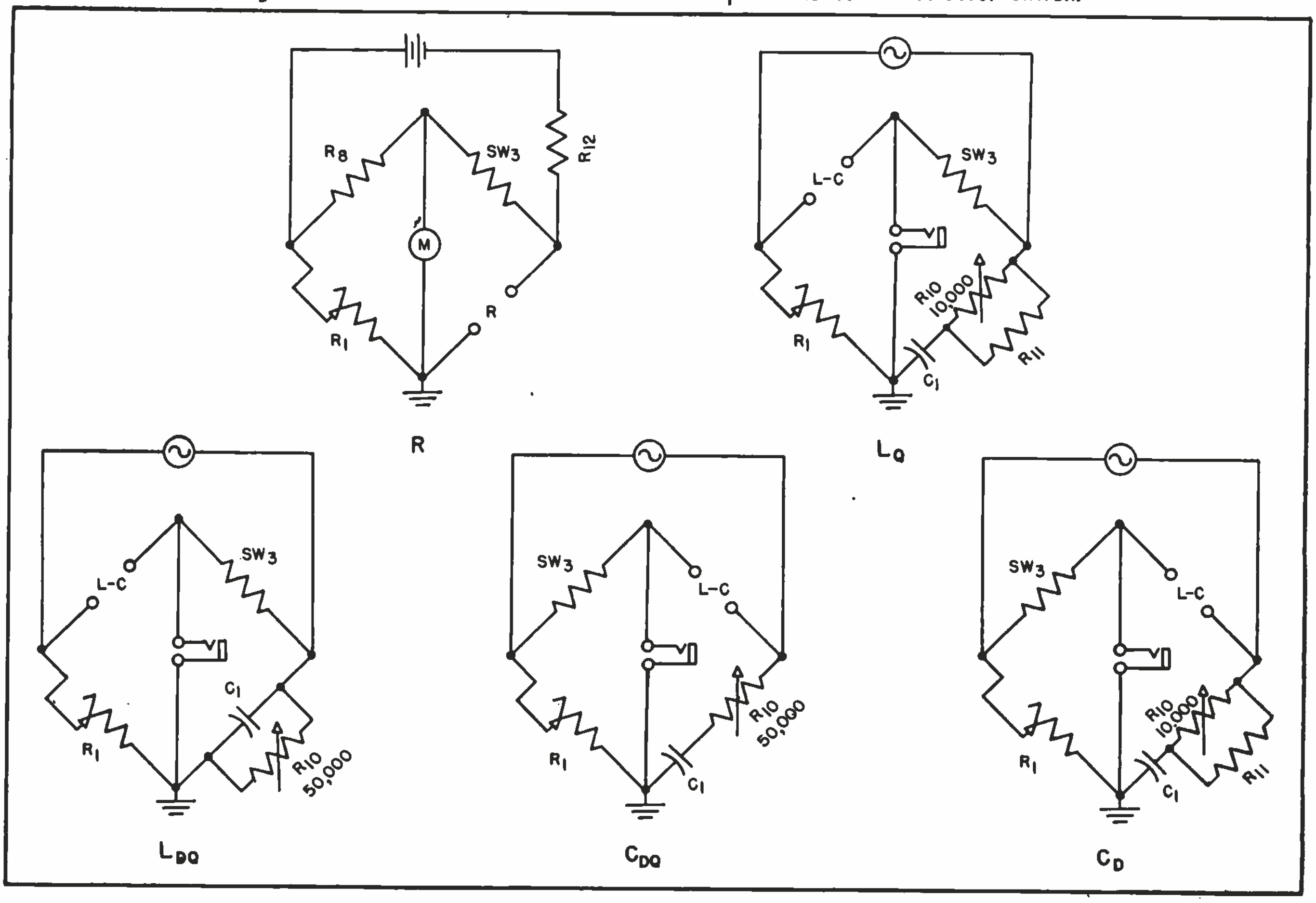
$$Q = \frac{16{,}000}{R}$$

so a third curve is necessary for this position of the switch.

For this type of bridge, satisfactory values for the two sections of the *DQ* potentiometer would be 5,000 and 50,000 ohms, respectively. However, while even this is a compromise, no such dual potentiometer is regularly listed by any manufacturer. The nearest is the IRC 61-1623, which consists of 10,000 and 50,000-ohm units. To limit the maximum value of the 10,000-ohm section to 5,000 ohms, it is shunted by a 10,000-ohm fixed resistor, which should be in place when the resistance measurement is made.

[*Continued on page 35*]

Fig. 6. Actual circuits in use for the five positions of the selector switch.



Electron Tube Phonograph Pickup

H. F. OLSON* and J. PRESTON*

...erformance characteristics of a new type of pickup

...ation results in ...as well as ex- ...the vibration ... 4 is sche- ...nts of the ...electron ...ted in a ... 5. A ...hown ... ex- ...the ...le

...m- ...st- ...ns- ...for ...ing ...ect ...in- ...em- ...and ...a ...ped, ...that ...to ...con- ...pur- ...an elec- ...in which the anode of ...t the variations ...eam correspond to ...n the record.

...tronic Transducers

...diode type of mechano-electronic transducer, a voltage is de-...ed by the motion of the anode. ...e mechano-electronic transducer possesses the following fundamental advantages; namely, the vibrating element can be made very small with a correspondingly low mechanical impedance because the electrical power output is not derived from the actuating force but from the power supply, there is no reaction of the electrical system into the vibrating system and the electrical impedance appears as a resistance and therefore does not vary with frequency.

The question arises as to the reason why a mechano-electronic transducer has not been developed. The fundamental problem is the transfer of controlled vibrations through a vacuum-tight shell. There must be a vacuum on the inside of the shell and ambient air pressure on the outside. The differential in pressure is 15 pounds per square inch. One specific problem is to design a vacuum-tight link that can be actuated by force of less than a millionth of a pound and still withstand 15 pounds per square inch static pressure.

During the past few years the progress that has been made in the development of mechanical and acoustical vibrating systems is primarily attributed to fundamental experimental and theoretical investigations that have been made in these fields. As a result of this work, it appeared possible to develop a link of the type outlined above. The progress in the development of all types of metal electron tubes, metal-to-glass seals, and miniature tubes are other factors which make the mechano-electronic transducer a possibility.

The essential elements of a diode mechano-electronic transducer are shown in *Fig.* 1. The movable electrode passes through a thin diaphragm in the envelope of the tube which permits movement of the anode with respect to the cathode. In the diode mechano-electronic transducer, a variation in the current or voltage output is obtained by varying the distance between the anode and the cathode by moving the anode rod.

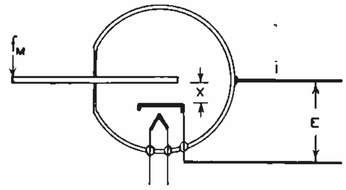


Fig. 1. The elements of a diode mechano-electronic transducer.

Under normal operation of the diode mechano-electronic transducer, the plate potential and the spacing may be considered to be fixed with the plate voltage and the deflection varying about these fixed values. For these conditions the plate current in a diode type mechano-electronic transducer may be expressed as

$$i = f\left(E_{P0} + e, X_0 + x\right) = \sum a_{mn} e^m x^n = f\left(E_{P0}, X_0\right) + a_{10}e + a_{01}x + a_{20}e^2 + a_{11}ex + a_{02}x^2 + \dots$$

where

$$a_{mn} = \frac{1}{m!\,n!} \frac{\delta^{m+n} f\left(E_{P0}, X_0\right)}{\delta^m E_P \delta^n X} \qquad (1)$$

E_P=plate potential,
X=spacing between the anode and cathode,
e=voltage variation from E_{P0}, and
x=deflection variation from X_0.

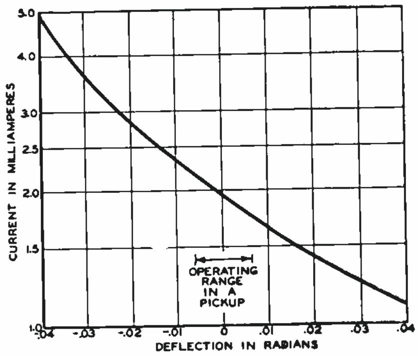


Fig. 2. Experimentally determined current deflection characteristic of a diode mechano-electronic transducer.

The coefficients are a function of the operating point E_{OP}, X_O.

A typical experimental current deflection characteristic for a diode with constant plate voltage is shown in *Fig.* 2. Unlike the conventional vacuum tube, in which the operation extends over the major portion of the tolerable operating range, the mechano-electronic transducer operates over a small portion of the tolerable operating range when employed in phonograph pickups and microphones. The maximum deflection, in actual use in a phonograph pickup or microphone, is about .07 radian. For this condition the higher order components in *Eq.* (1) are negligible and the plate current for a constant plate potential may be expressed by

$$i = i_0 + a_{01}x \qquad (2)$$

The alternating plate current may be expressed by

$$i_{ac} = a_{01}x_{ac} \qquad (3)$$

It can be shown that a further reduction in higher order components occurs when the plate load is an electrical resistance.

*RCA Laboratories, Princeton, N. J.

Construction of Mechano-Electronic Transducers

The diode type of electronic transducer employing a small metal shell one-quarter of an inch in diameter and one inch in length was developed by G. M. Rose of the Tube Department of the RCA Victor Division. A sectional view of the mechano-electronic transducer is shown in *Fig.* 3. The cathode

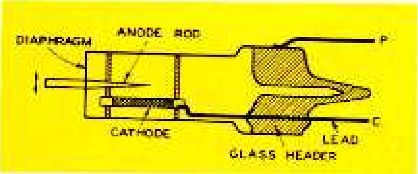


Fig. 3. Sectional view of a diode mechano-electronic transducer.

lead and the two heater leads are brought out through a glass seal at one end. At the other end a flexible metal diaphragm permits transferring external motion to a movable electrode within the tube. The anode rod is made conical in shape. The use of a conical anode rod instead of a cylindrical rod reduces the effective mass by a factor of 166 to 1. The ratio of effective masses of cylindrical and conical bars is so tremendous that the use of a tapered bar in a mechano-electronic transducer is almost imperative, particularly where a low mechanical impedance is desirable, as for example, in a phonograph pickup.

Electron Tube Phonograph Pickup

A phonograph pickup is an electromechanical transducer actuated by a phonograph record and delivering energy to an electrical system, the electrical current having frequency components corresponding to those of the wave in the record.

An electronic phonograph pickup employing the mechano-electronic transducer is depicted in the schematic view of *Fig.* 4. The mechanical network of the vibrating system is also shown in *Fig.* 4.

The response frequency characteristic may be determined from the mechanical network of *Fig.* 4. The amplitude of the mass m_2 is given by

$$x_5 = \frac{f_M z_{M2} z_{M4}}{\omega A} \qquad (4)$$

where

$\omega = 2\pi f$, f = frequency

m_1 = mass of the stylus and the stylus arm,
r_{M1} = mechanical resistance of the stylus arm,
C_{M1} = compliance of the stylus arm,
m_2 = mass of the internal part of the bar,
r_{M2} = mechanical resistance of the internal part of the bar,
C_{M2} = compliance of the internal part of the bar,
m_3 = mass of the diaphragm,
r_{M3} = mechanical resistance of the diaphragm,
C_{M3} = compliance of the diaphragm,
m_4 = mass of the tone arm, and
r_{M4} = mechanical resistance of the pivot.

The amplitude of the tone arm is

$$x_3 = \frac{f_M z'_{M3} z_{M2}\left(z_{M4}+z_{M5}\right)}{\omega\left(r_{M4}+j\omega m_4\right)A} \qquad (5)$$

The amplitude of the anode with respect to the cathode is the difference between the amplitude of the mass m_2 and the mass of the tone arm as follows,

$$x_A = x_2 - x_3 \qquad (6)$$

the force, f_M, is given by

$$f_M = z_{MR}\, z_{MP}\, x / z_{MR} + z_{MP}\,, \qquad (7)$$

where x = velocity of the record groove, Z_{MR} = mechanical impedance of the record, and Z_{MP} = mechanical impedance of the pickup at the stylus.

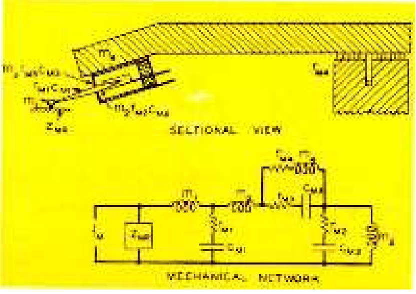


Fig. 4. Sectional view and mechanical network of an electronic phonograph pickup. In the mechanical network: Z_{MR}, the mechanical impedance of the record, m_1, the mass of the stylus and the stylus arm r_{M1} and C_{M1}, the mechanical resistance and compliance of the stylus arm. m_3, r_{M3} and C_{M3} the mass, mechanical resistance, and compliance of the diaphragm. m_2, r_{M2}, and C_{M2}, the mass, mechanical resistance, and compliance of the anode rod. r_{M4}, the mechanical resistance at the tone arm pivot.

$$z_{M1} = j\omega m_1\,,\quad z_{M2} = r_{M1} + \frac{1}{j\omega C_{M1}}\,,\quad z_{M3} = j\omega m_3 + \frac{\left(r_{M4}+j\omega m_4\right)\left(r_{M3}+\frac{1}{j\omega C_{M3}}\right)}{r_{M4}+j\omega m_4+r_{M3}+\frac{1}{j\omega C_{M3}}} = j\omega m_3 + z'_{M3}\,,$$

$$z_{M4} = r_{M2} + \frac{1}{j\omega C_{M2}}\,,\quad z_{M5} = j\omega m_2\,,$$

$$A = z_{M1}\left(z_{M2}+z'_{M3}\right)\left(z_{M4}+z_{M5}\right) + z_{M4} z_{M5}\left(z_{M1}+z_{M2}\right) + z_{M2} z_{M3}\left(z_{M4}+z_{M5}\right)$$

po...
mec...
mech...

Equation (7) illustrates the im-
pedance of a pickup with a small
... If the pickup is comparable

Fig. 5. Mecha... mounted in a ... p...

to the record mech... considerable part of ... of the record will be ... the record. This con... excessive record wear, ... cessive noise produced by ... of the pickup and record.

The system shown in *Fig.* ... matic and depicts the eleme... vibrating system. In actual ... tube pickups, the tube is moun... subassembly as shown in *Fig.* ... photograph of the subassembly is ... in *Fig.* 6. A photograph of an ... ploded view of the elements of ... subassembly is shown in *Fig.* 7. T... stylus arm is fitted with either ... sapphire or diamond stylus. The other end is soldered to the anode rod of the mechano-electronic transducer at the mid-point, .055 inch. One end of a steel wire is soldered to a brass plate which is fastened to the bakelite block of the subassembly while the other end is soldered at the mid-point of the stylus arm. In this way, the mid-point of the stylus arm is constrained in a

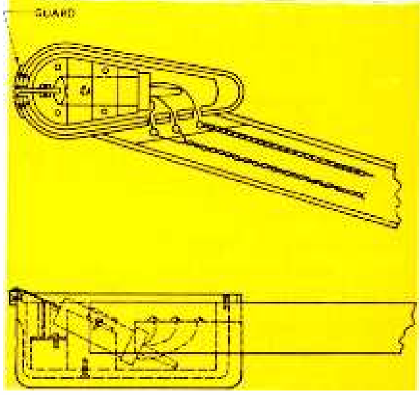
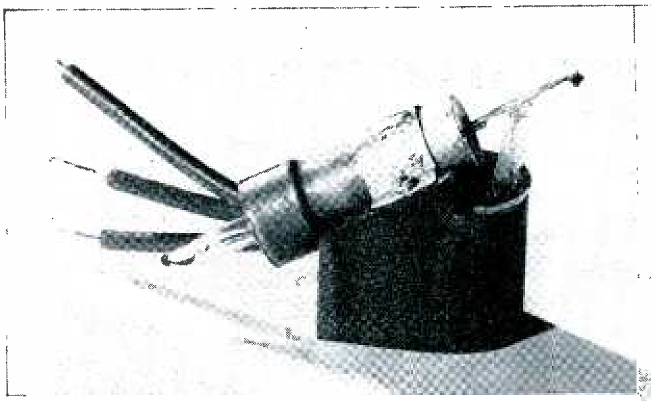


Fig. 8. Subassembly mounted in the tone arm.

◆ ◆



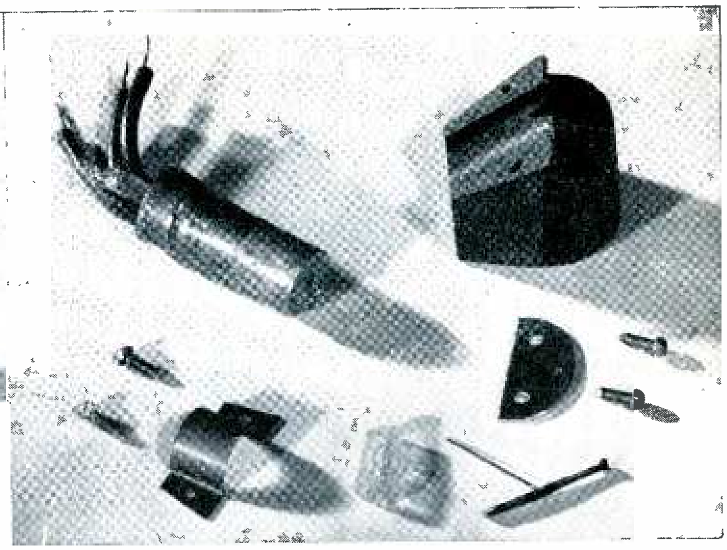


Fig. 6 (left). Subassembly of the pickup.

Fig. 7 (right). Components of the subassembly.

vertical direction. Under these conditions, the vertical stiffness is supplied by the vertical compliance of the stylus arm. Since the vertical wire is slender and subject to many resonances within the audio-frequency range, it is damped with viscoloid so that the deleterious effects of these resonances are negligible. This is the only damping in the system. Aside from supplying the vertical stiffness, the vertical wire and viscoloid do not influence the response.

The subassembly is mounted in the tone arm as shown in *Fig.* 8.

A photograph of the long tone arm suitable for the reproduction of transcription records is shown in Fig. 9.

A photograph of a short tone arm suitable for the reproduction of smaller records (home type, 10 and 12 inch) is shown in *Fig.* 10.

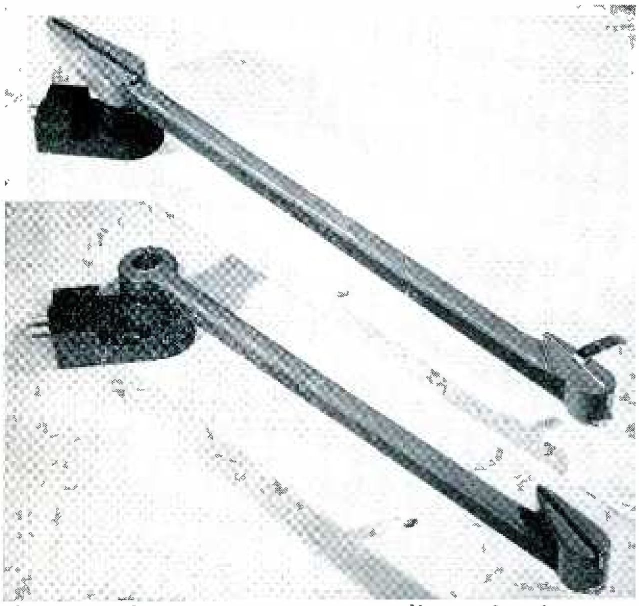


Fig. 9 (top). Long tone arm for transcription records.

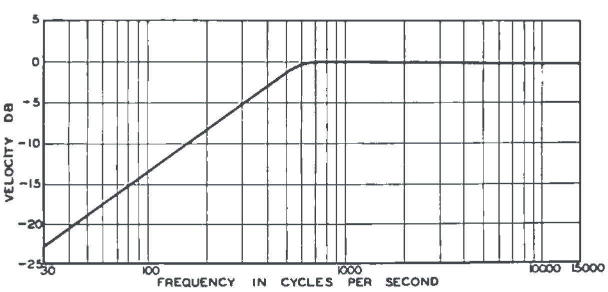
Fig. 10 (bottom). Short tone arm for smaller records (home type, 10 and 12 inch).

In the case of a frequency record used for obtaining response-frequency characteristics of pickups, the general procedure is to cut the record so that the amplitude is constant below 500-800 cycles and the velocity constant above this transfer frequency region. The velocity response-frequency characteristic of an ideal frequency record is shown in *Fig.* 11.

The voltage output characteristic may be determined from the mechanical network, *Fig.* 4, the above equations, and the response-frequency characteristic of the record of *Fig.* 11. In general, the mechanical impedance Z_{MR} of the record is considered to be infinite.

The electrical circuit diagrams for use with electron tube phonograph pickups are shown in *Fig.* 12. The plate current should be about 2.5 milliamperes. The average plate potential under these conditions is about 22 volts. The plate potential may be supplied either by a high voltage source and a resistor or a low voltage source and an inductance or a transformer as shown in *Fig.* 12. The effective plate impedance of the electronic pickup is 5000 ohms. The heater current is 150 milliamperes. The heater potential is 6.3 volts. The output with standard records is about 0.4 volt with circuits *A* or *C* of *Fig.* 12. An output of 2 volts may be obtained with circuit *B* of *Fig.* 12.

A schematic diagram of the apparatus for obtaining the response-frequency characteristic of a phonograph pickup is shown in *Fig* 13. An automatic recorder is synchronized with the phonograph turntable. If the frequency



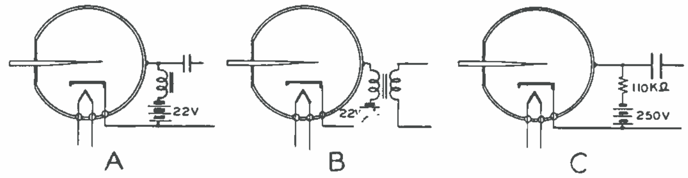


Fig. 11 (left). Velocity-response-frequency characteristic of an ideal frequency test record.

Fig. 12 (above). Electrical circuit diagrams for use with the electronic pickup.

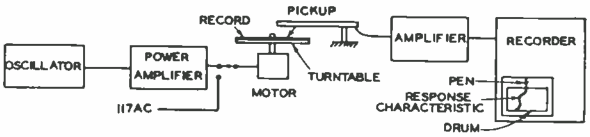


Fig. 13. Apparatus for obtaining the response/frequency characteristic of phonograph pickups.

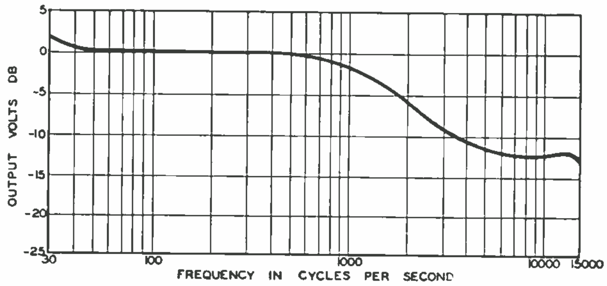


Fig. 14. Typical response/frequency characteristic of electron tube phonograph pickup. O db=.5 volt.

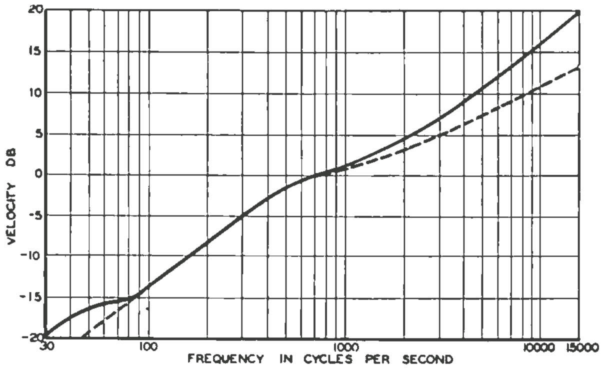


Fig. 15. Velocity frequency characteristic of two types of recording characteristics. Solid line—orthacoustic records. Dotted line—home type records.

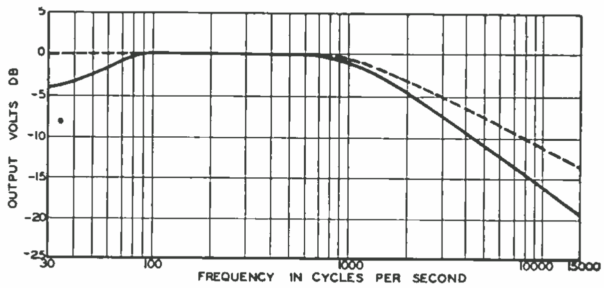


Fig. 16. Ideal voltage response frequency characteristic of phonograph pickups for the reproduction of orthacoustic and home type records.

record is recorded so that at constant rotational speed the frequency increases at a logarithmic rate, the conventional logarithmic frequency paper may be used to obtain the response-frequency characteristic. The ordinate scale is usually recorded in decibels.

A typical response-frequency characteristic of the electronic pickup employing a frequency record with the velocity response-frequency characteristic depicted in *Fig.* 11, is shown in *Fig.* 14.

Recording Characteristics

Two types of recording characteristics, in use today, are shown in *Fig.* 15. The voltage response-frequency characteristics of a phonograph pickup using the record characteristic of *Fig.* 11 should be as shown in *Fig.* 16, in order to obtain a uniform response-frequency characteristic for home and transcription records. Comparing *Figs.* 14 and 16, it will be seen that compensation required in the electronic pickup to obtain uniform response for either the home or transcription records is relatively small, the maximum deviation being about 5 db.

A response-frequency characteristic of a phonograph pickup may also be obtained by using a fixed frequency record; that is, a record in which the frequency does not vary if the speed of rotation of the turntable is a constant. To obtain a response of a phonograph pickup with this type of record, the rotational velocity of the turntable is varied to obtain a change in frequency. In this system shown in *Fig.* 13, the output of a low-frequency oscillator is amplified and fed to the synchronous motor which drives the turntable. The oscillator and automatic recorder are synchronized and a response-frequency characteristic is obtained on conventional logarithmic frequency paper. The response-frequency characteristic obtained under these conditions depicts the performance of the pickup rather than the pickup and record, because the amplitude of the record is independent of the resultant frequency and the groove shape is the same for all frequencies. However, it has been found that in the case of the electronic phonograph pickup the response-frequency characteristic obtained with the fixed frequency record agrees with that obtained with the variable frequency record.

The electronic pickup described in the preceding text was developed for the reproduction of lateral type records. An electronic pickup has also been developed for the reproduction of vertical type records. The vibrating system is essentially the same, the essential difference being that the entire vibrating systm and the tube is rotated ninety degrees about the axis of the tube. A photograph of a combination lateral and vertical pickup is shown in *Fig.* 17. Two separate electronic pickups are mounted in cylindrical subassembly. The cylindrical assembly is mounted in the tone arm. Either lateral or vertical type records may be reproduced by rotating the cylinder to bring the proper pickup into position.

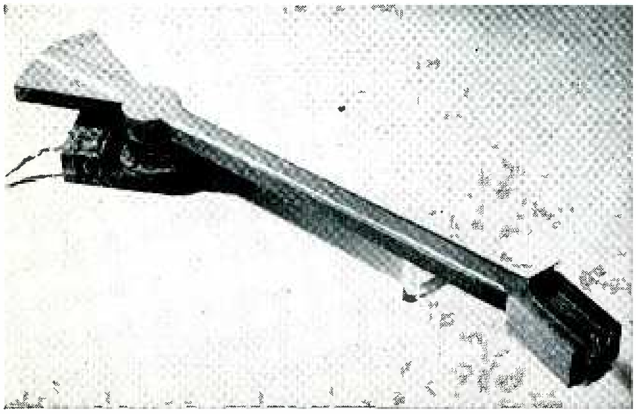


Fig. 17. Combination vertical and lateral pickup.

Speech Recording in the Classroom

WILLIAM J. TEMPLE*

Recording equipment requirements for teaching speech in school classrooms.

IT IS THE PURPOSE of this brief note to present in general terms the argument that satisfactory recording of speech for classroom purposes can not be done with inferior equipment, and to express the hope that when engineers and manufacturers fully understand the requirements of classroom recording they will be able to produce equipment suited to educational uses. The writer is a teacher of speech, and consequently the illustrative problems to be described are drawn from that field, but it should be understood that the problems of instruction in foreign languages have close similarities.

Speaking habits, like table manners, are highly personal. Most people, including students, are inclined to resent personal criticism. It is a tactful and persuasive teacher, indeed, who can tell a student in front of his classmates that he lisps, mumbles, whines, drawls, or talks baby-talk without arousing feelings of resentment and personal affront strong enough to strangle any desire to remedy the faulty habits.

A recording machine makes no judgments. It simply furnishes a transcription, faithful within its limitations, of the sounds which the student produced. The student must choose either to believe what he hears or to deny that the record is a faithful transcription of his speech. For fifty years, speech teachers have been waiting for a practical classroom recording (and reproducing) machine that doesn't lisp so badly itself that it is useless in a speech-improvement class for students who lisp.

Even the most primitive instantaneous recording machines gave adequate reproduction of some of the important aspects of speech, and serious students and teachers of speech and languages were using them as early as the turn of the century. Classroom recording has been discussed in the professional journals of speech education for many years.

In a typical article,[1] published nearly thirty-five years ago, a teacher of public speaking says, "I have found the phonograph so useful in my own classes that I mean to make it a permanent part of my classroom equipment," although he admits with seeming reluctance, "that while force, pitch and time are recorded with absolute precision, there often seems to be a failure in recording quality." Both his enthusiasm and his criticism have a familiar sound, even in 1948.

For several reasons, the enthusiasm for recording as a teaching aid which most such articles express has not led to universal adoption and systematic daily use of the available machines in all speech and language classrooms. (A notable exception to this statement is in the record of the armed services during the late war. In the military classrooms for instruction in languages and communications skills, some kind of recording device was considered indispensable.)

One of the reasons has been the cost of recording equipment and the never-ending expense of blank records. But a more important reason is that the quality of classroom recordings, made by amateur operators with the equipment available to them, has too often been disappointing after the novelty has worn off. The appearance of a recording machine in the classroom stimulates students and teachers at first, but a critical attitude replaces the first enthusiasm as soon as recording becomes a familiar routine. Magnetic recording devices present advantages over other types in respect to both these objections. The magnetic recording material can be used over and over again, and the fidelity of magnetic recordings does not depend nearly so much on the operator's skill, since the operator is not required to make any critical mechanical adjustments, such as those for stylus angle and depth of cut.

Fidelity

The fidelity required in the classroom recording of speech depends on the objectives of the instruction. It is well known that mere intelligibility of speech survives an astonishing amount of mutilation and distortion. The pitch patterns of sentences, the rate and rhythm of speech, and the stress and pronunciation of words are sufficiently well reproduced by even an old-fashioned acoustic dictating machine to enable a listener to recognize the speaking mannerisms of friends and acquaintances, or familiar public speakers and radio personalities. If it were possible for the teacher and students to limit their instructional objectives to such matters as these, almost any old recording machine would suffice.

[*Continued on page 33*]

Remounted Brush Soundmirror, Brooklyn College Department of Speech.

Associate Professor of Speech, Brooklyn College Brooklyn 10, New York.

[1] *Newcomb, Charles M., The Phonograph as an Aid to Classroom Work. The Public Speaking Review, Vol. III., No. 7, March 1914.*

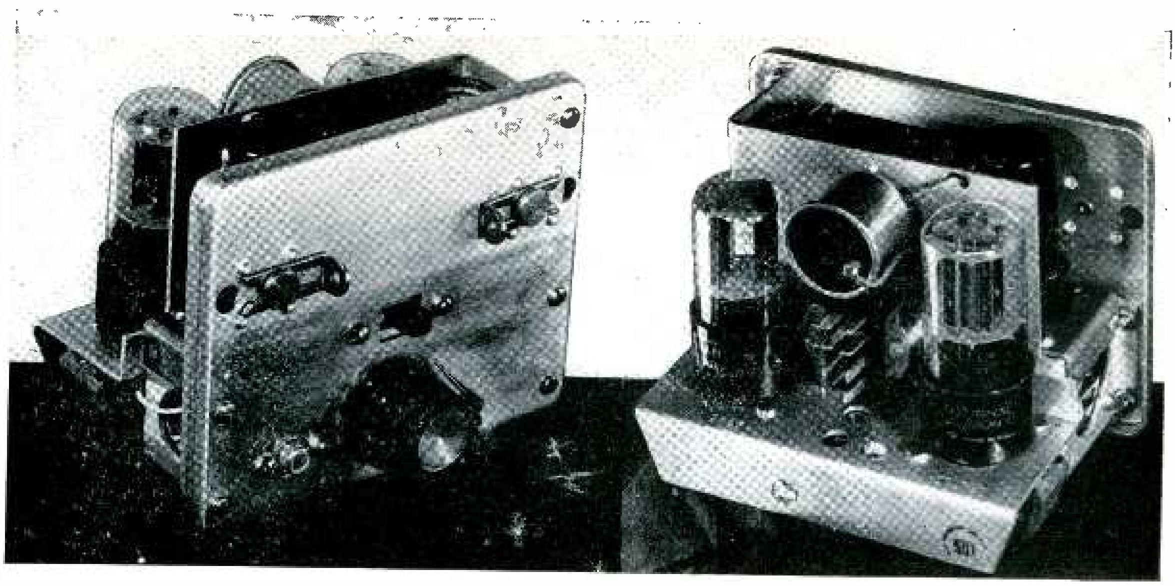


Fig. 1. Equalizer-suppressor amplifier as built on surplus preamplifier chassis.

Simplified Dynamic Noise Suppressor

C. G. McPROUD*

A three-tube preamplifier combining low-frequency equalization and a new type of dynamic noise suppressor for use with magnetic pickups.

ONE of the most outstanding circuit developments in the audio field to be publicized during the last few years is that of the dynamic noise suppressor. While its performance is a definite improvement in record reproduction over fixed filter circuits, it cannot be denied that the circuits are somewhat complicated, and considered by many to be beyond their capabilities for construction.

In attempting to simplify the noise suppressor problem so that the advantages might be enjoyed by more record users, the writer listed a variety of partially related facts and assumptions, from which the circuit to be described was derived.

1) To reduce noise, it is desirable to employ a low-pass filter.
2) To avoid degradation of musical quality—i.e., a reduction of high-frequency response—the cutoff frequency should be adjustable.
3) For convenience, it is desirable to have the cutoff frequency varied automatically by the signal itself.
4) Constant-k filters usually "sound" better than filters with a sharper cutoff.
5) The qualities of a high-quality magnetic pickup that provide a wider range of signal frequencies also cause the reproduction of a higher needle scratch level.
6) Magnetic pickups are low-level devices, and require both amplification and low-frequency equalization for use with conventional radio-phonograph amplifiers.
7) Since a magnetic pickup is effectively a generator having an internal impedance which is essentially an inductance, a reasonably sharp cutoff can be obtained solely by the use of a shunt capacitor.

Having these basic premises listed, how can the problem be solved *in the simplest manner?*

Design

The use of a magnetic pickup demands a low-frequency equalizer and additional amplification, so the first step in the solution is to set down such a circuit. The high-frequency cutoff may be provided by a shunt capacitor, with the cutoff frequency being varied by changing its capacitance.[1] Suppose, therefore, that the shunt capacitance is supplied by a reactance tube. By varying its grid bias, the cutoff frequency can be changed at will. To make the variation of capacitance automatic requires a side amplifier and rectifier, together with some form of manual control.

Putting these separate elements together, the equalizer-suppressor amplifier is now seen to consist of three sections — the equalized preamplifier, the reactance tube across the input, and a control tube consisting of an amplifier and a rectifier. From this point, then, it is possible to design a wide variety of circuits to perform all of these functions.

One such circuit is shown in the schematic of *Fig.* 2. Built as an accessory unit, it employs a series heater string, a dropping resistor, and a selenium rectifier and filter capacitor, thus operating the heaters from the 115-volt a-c line to avoid overloading the filament windings of the amplifier to which it is connected. Plate current is obtained from a convenient 200-300 volt point in the amplifier to which it is connected.

The equalized preamplifier consists of the two sections of V_1, a 12SL7, connected in cascade, and employing a feedback circuit to provide the low-frequency boost. The voltage amplification of this two-stage amplifier is approximately 25 at 1,000 cps, with a low-frequency boost of nearly 6 db per octave below a transition frequency of

*Managing Editor, AUDIO ENGINEERING.

500 cps. This results in a fair compromise for various types of phonograph record characteristics, since the bass tone control on a conventional radio phonograph or amplifier should suffice to make the finer adjustments. However, if desired, C_2 can be made adjustable by a separate switch, using a value of 0.005 μf for a 300-cps turnover, and 0.0015 μf for 800 cps turnover.

The reactance tube V_2 is connected in shunt across the input terminals, isolated by a 0.1-μf capacitor C_5 to keep d-c voltage off of the pickup. The effective capacitance of V_2 is a function of C_6 and the mu of the tube. Therefore, with a given set of operating voltages on this tube, C_6 controls the static cutoff frequency. A value of 750 μμf provides a cutoff that is down 3 db at 4,000 cps with the Pickering Cartridge. This value should be increased to 0.001 μf when used with the General Electric variable reluctance pickup. Without going into the operation of a reactance tube circuit, suffice to say that an increase in the negative bias voltage applied to the control grid causes a reduction in the mu of the tube, with a consequent decrease in the effective capacitance of the tube.

From the chart shown in the previously cited reference[1], it is noted that for a 4,000-cps cutoff, the shunt capacitance must be of the order of 0.02 μf for the Pickering, or 0.03 μf for the GE. The effective capacitance of the tube is in series with C_5, so it is necessary that C_5 be relatively large, as shown. Since the maximum plate voltage is applied across C_5, its voltage rating must be at least 400 volts. Any high-gain pentode should work in this circuit, but it is desirable to use a tube of the semi-remote cutoff type to obtain smooth operating characteristics. A 12SG7 was chosen for this application.

The side amplifier and rectifier consist of the two sections of a second 12SL7, the first serving as the amplifier, while the second—with the plate and grid connected together—serves as the rectifier. The coupling circuits between V_1b and V_2a and between V_2a and V_2b are so designed that the response cuts off quite rapidly below 1,000 cps, providing a d-c control voltage which is developed mainly from the upper middle frequency range. Thus, low frequencies do not appreciably affect the reactance tube.

However, when the signal contains frequencies in the upper middle range, the rectifier circuit causes a d-c voltage, negative with respect to ground, to be developed across R_{13}, a potentiometer used as the manual control.

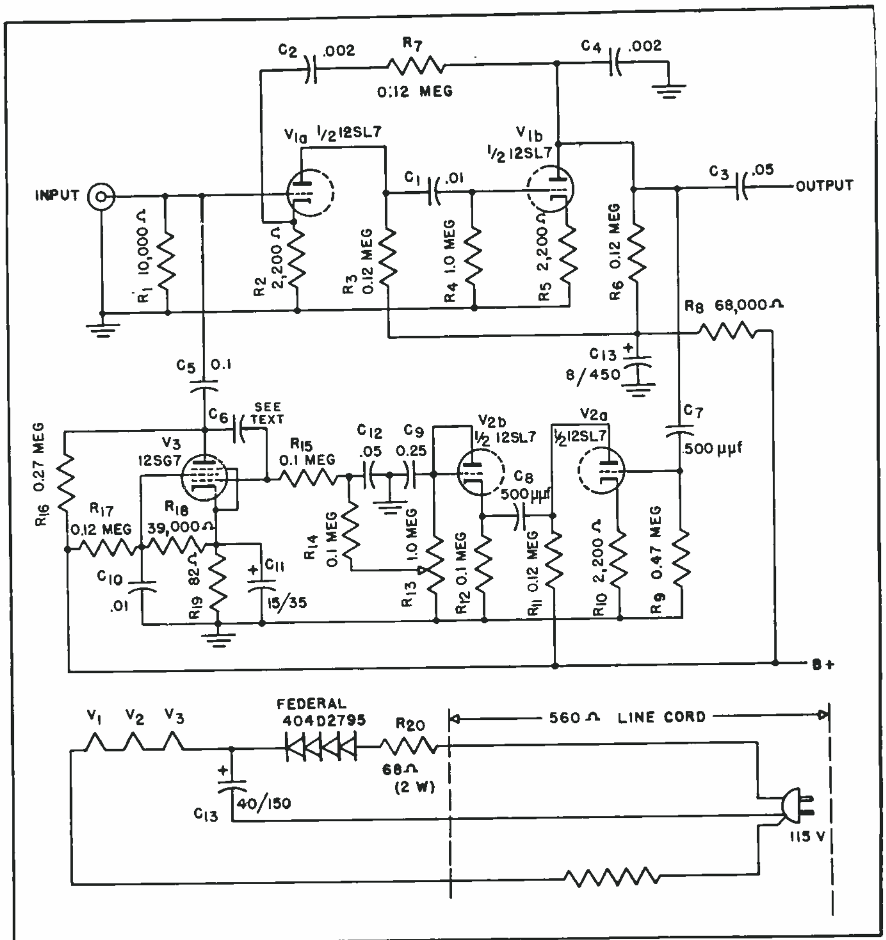
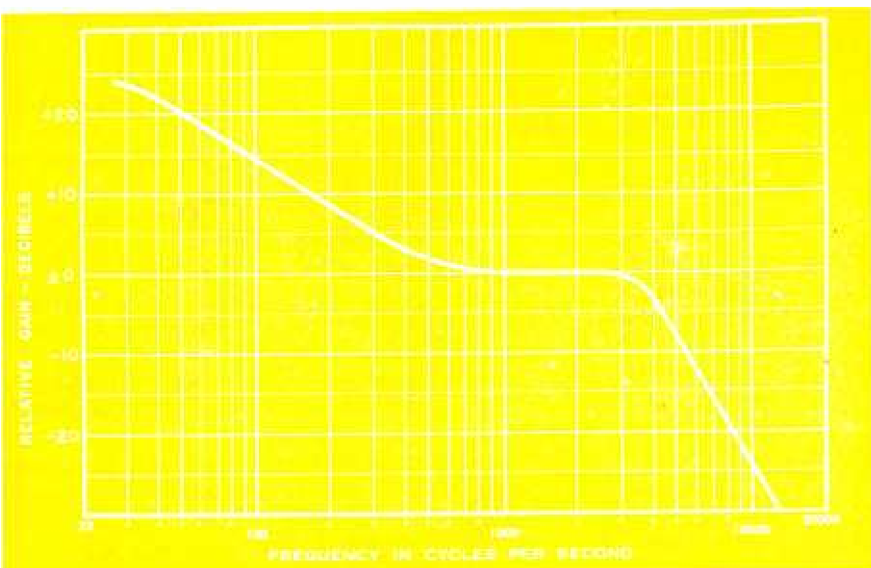


Fig. 2. Complete schematic of dynamic noise suppressor amplifier utilizing single reactance tube directly across magnetic pickup, and furnishing adequate low-frequency equalization to correct for average recording characteristics.

[1] "*High Frequency Equalization for Magnetic Pickups*," *C. G. McProud*, AUDIO ENGINEERING, *September*, 1947.

Fig. 3. Curve of equalized preamplifier with control at minimum, showing cutoff at 4,000 cps and a droop of 15 db per octave above cutoff.



Operation

There are several unusual conditions existing in this suppressor. In the first place, the control signal is obtained from the output rather than from the input. The action, therefore, is aided by the raising of the cutoff frequency, since this raising applies a larger high-frequency signal to the side amplifier. In the second place, there is a small contact potential existing across R_{13}. This potential is of the correct polarity (negative) to raise the cutoff frequency. Thus the manual control varies the cutoff frequency gradually at the same time that it increases the sensitivity of the automatic control circuits.

In operation, the equalizer-suppressor amplifier is connected between a magnetic pickup and the usual phonograph input jack. If this connection is followed by the usual RC network to compensate for the high-frequency droop of crystal pickups, this network should be removed. In the schematic, C_4 is used to compensate for the high-frequency boost present in most recordings. The value shown is suitable when the following amplifier and the speaker system is flat. For optimum results, it may be desirable to increase or decrease this capacitance.

When the control R_{13} is in the maximum clockwise position, the response of the equalizer-suppressor is essentially flat from normal records, with no high-frequency cutoff. This is the result of (1) the contact potential across R_{13}, and (2) the d-c voltage developed as a result of the residual scratch. Thus, there is sufficient negative bias applied to the 12SG7 to reduce its gain, and consequently to reduce the effective capacitance shunted across the pickup. If the scratch is objectionable, the control may be rotated counterclockwise until the best balance is obtained between musical quality and noise. In the intermediate positions of the control, it will be noted that the noise is reduced during low level passages, but that the noise appears to increase when high level passages—containing high frequencies—are reproduced. The more the control is turned counterclockwise, the greater the reduction of noise. Two actions take place simultaneously as the control is turned: (1) the cutoff is lowered gradually, and (2) the sensitivity of the automatic action is reduced. This results in a single smooth range of control from no cutoff at all to a fixed filter with a cutoff at 4,000 cps, with a gradual increase in dynamic action over the range of the control.

Construction

The experimental version of this amplifier, shown in *Fig.* 1, was built on a chassis available as a surplus item. However, the amplifier is not limited to such a construction, and any suitable small chassis is suggested. If there is an adequate supply of heater voltage, or if the unit is being constructed as a section of a complete amplifier, 6.3-volt tubes should be used instead of the 12-volt types, and their supply obtained in the usual manner from the power transformer. However, if the equalizer-suppressor amplifier is to be added to an existing radio phonograph, it is advisable to provide a separate heater supply, as shown in the schematic. The connections shown are for use with a 560-ohm line cord and a 200-ma selenium rectifier, fur-

[*Continued on page 32*]

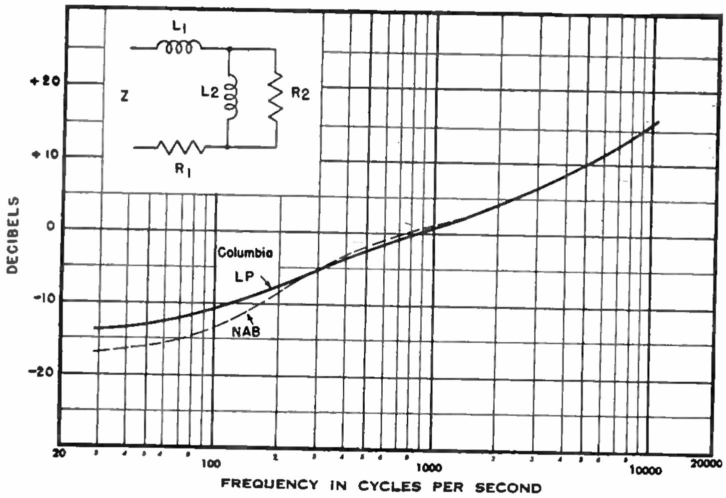
Columbia LP Microgroove Records

ENGINEERS and music lovers alike are enthused over the recent announcement by Columbia Records, Inc. of a new library of recorded music. This library consists of long-playing Microgroove records, already available in over a hundred separate discs. The advantages are numerous: the records are pressed on vinylite, with a consequent reduction of needle scratch; a single 12-inch disc plays for as long as 45 minutes on the two sides, making it possible to record a complete symphony on one disc, simplifying the storage problem, and what is also of great importance, the recording characteristic is uniform throughout the entire library.

While the music lover is especially interested in the subject material of the library, engineers are more curious about the technical characteristics of the recordings themselves. We are indebted to Dr. Peter C. Goldmark, CBS Director of Engineering Research, for this information.

Characteristics

The new LP records are recorded with the characteristic shown by the solid curve of *Fig.* 1. This curve is similar to the NAB characteristic for lateral transcriptions, shown by the dotted line, except for the low-frequency end, the level being approximately 3 db higher at 100 cps on the LP records. Therefore, these new records may be reproduced quite satisfactorily by a NAB-equalized channel, if played with a 6-gram pickup having a .001-inch stylus. The characteristic may be equalized perfectly with simple RC networks.



The curve itself is identical with that of the network shown in the insert on the curve, when

$$R_2 = 4R_1$$

$$\frac{L_1}{R_1 + R_2} = 100\ \mu\text{sec}$$

$$\frac{L_1 + L_2}{R_1} = 1590\ \mu\text{sec}$$

Stylus velocity for full modulation is stated to be 3.5 cm/sec., which is approximately 4 db below standard 78 rpm phonograph records. Using the Astatic crystal cartridge developed for the new system, the output is of the order of one-half volt.

Groove Shape

The groove shape is that made by a stylus having an included angle of 87°, plus or minus 3°, and a tip radius of less than .0002 in. The width of the groove is from .0027 to .003 in. As is generally known, the rotational speed is 33-1/3 rpm, and the records are made in 10- and 12-in diameters.

Each record plays up to 22-1/2 min-

[*Continued on page 32*]

RECORD REVUE

EDWARD TATNALL CANBY*

THE MICROGROOVE recording is officially announced—yet at this date of writing a hiatus exists between that announcement and the first actual appearance of the new development. Silence reigns—and it seems a fine time, therefore, to do a little tall speculating as to what Microgroove may be expected to involve.

First, two axioms: If Microgroove recording is to survive commercially, it must spread throughout the industry until it is in effect co-standard with present recording. If not, then the whole experiment will either collapse or lead to a suicidal war between rival systems within the industry. That being unthinkable, let us assume that Microgroove recording is going to stick.

It is also clear—axiom two—that though other systems can give as good results as Columbia's, the die is now cast; for the Microgroove system not only works amazingly well (far better than a lot of rumor I've run into might suggest) but, more important, the vital and enormously complex processes of commercial mass production and distribution have been worked out and set in motion. A recording method that merely works is a far cry from one that is actually adapted for mass production. By virtue of this alone, Columbia's system is way out in front.

So, with Microgroove a fact, let us speculate:

1) *The player.* At present there is only one pickup, available in one player, or in several lines of home combination machines. The next steps to expect must be the appearance of (a) complete players from other concerns, (b) Microgroove-equipped machines from most of the dozens of present phonograph manufacturers. How long will this take?

2) *Separate pickups, motors.* Three stages of development to come soon, we hope: (a) The present pickup becomes available separately. (b) Other pickup assemblies appear, from various manufacturers, in differing types corresponding to those obtainable for standard records. There should be exciting developments here. (c) Microgroove cartridges, arms sold separately. (The present Philco-Columbia cartridge is replaceable, as is its stylus.) When all these stages have been reached, Microgroove playing will be substantially on a plane with present recording. It is likely that dual purpose pickups for playing both standard and microgroove records will appear. Experimental models of this type of cartridge are already being used, with two styli mounted in this same cartridge.

As to motors, we can expect cheap and satisfactory adaptations of the present low-priced phono motors, in two types, (a) single speed, long-playing only, as in the present Philco player, and (b) two-speed motors. Most will be of the smallest and lightest types, with 8- or 10-inch tables. Judging from performance of present models, I don't see any need for fancier equipment, even for professional purposes; however, inevitably some fancy small-size precision two-speeders will appear, at a good high price. Compactness will be a virtue. Note that the present Microgroove pickup arm is too small for use on a 16-inch table.

3) *Recording equipment.* It's obvious that if Microgroove is here to stay, both "home" and professional instantaneous recording equipment are necessities, and quick. No doubt every manufacturer is hot on the trail now, exploring possibilities. No doubt too, the basic idea of recording at such-and-such a groove size and pitch and speed is free for all concerned. Whether Columbia's particular equipment and method gets around depends on their licensing arrangements, but if not, then alternative equipment can surely be developed to accord with the basic standards as set up by Columbia.

Note well that instantaneous type Microgroove recording is likely to make its own minor revolution. 22 minutes on a 12-inch side, proportionately more if the process is applied to professional 16-inch recording, will tend to overthrow all sorts of existing procedures. The present field of wire and tape recording may be re-invaded by this alternative long-playing system. Above all, the need for dual recording machines is very much reduced, in most cases eliminated. This has been the biggest headache for the small user of instantaneous equipment and one of the main reasons for the success of wire and tape, where one machine is sufficient. Whether Microgroove recording will be easier to manage than standard recording, especially in respect to the bothersome problem of the chip, is not yet answered. In any case, there should be exciting developments in this field—if, as we are assuming, Microgroove takes hold.

4) *Microgroove records from other manufacturers.* This is the crucial matter for the future. Either the others go along with Columbia, or the Microgroove is done for. At the moment of writing there is an ominous silence. Without any doubt, no matter how superior the new process may be, other manufacturers will force it out if they can. The big freeze is unquestionably already on. Its success can not be measured for a good while, but

[*Continued on page 36*]

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

HEATER SUPPLIES

For Amplifier Hum Reduction

FREDERICH W. SMITH*

Practical methods of reducing hum to a minimum.

WHEN hum is perceptible in the output of an amplifier, the listener notices a lack of "presence" in the reproduction of program material. This effect is especially objectionable where the background noise level of the signal is extremely low, as in frequency modulation reception.

The existence of hum in an amplifier usually may be attributed to three sources [1,2,3]:

a) Insufficient plate supply filtering.
b). Electrostatic or magnetic pickup in low level stages.
c). The cathode heater circuits.

Of these three, the first is the easiest to eliminate, because little practical difficulty is experienced by the designer in reducing plate supply ripple below any predetermined value.

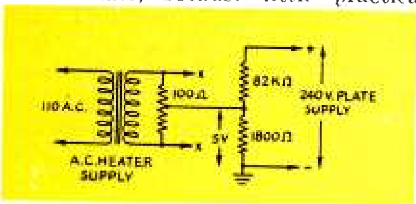


Fig. 1. Hum reduction method used in a program amplifier.

Electrostatic or magnetic pickup may be reduced by a variety of devices which include shielding, the isolation of power supplies from the amplifier proper, and the use of a non-magnetic amplifier chassis.

Cathode Heater Hum

The remaining and most obstinate source of hum is that due to the cathode heater circuits. If the heaters of the tubes incorporated in an amplifier are supplied with alternating current of power line frequency, a hum having both fundamental and second harmonic components will appear in the amplifier output. This hum is due to various causes. Direct sources naturally include hum pickup from heater circuit leads and hum leakage through socket capacitances. Less obvious, however, are such other sources as heater-to-cathode leakage, capacitive coupling between the heater and other electrodes, or actual heater emission to other elements within the tubes.

A number of methods have been devised to eliminate some of these defects with varying success. A representative arrangement employed in a commercial program amplifier is illustrated in *Fig.* 1. In this circuit, a positive bias of approximately five volts is applied to the heater circuits of the amplifier stages through a hum-balancing potentiometer placed across the 6.3-volt heater supply transformer winding. The positive bias on the heaters prevents heater emission while the effects of capacitive coupling between the heaters and control grids are balanced out by proper adjustment of the potentiometer.

However, even with special precautions and care in the design of an amplifier stage having an a-c heater supply, there generally remains a residual hum amounting to from five to fifteen microvolts between grid and cathode, which is not negligible in a low-level stage.

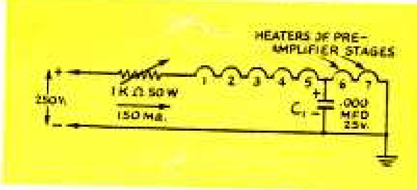


Fig. 2. Typical 150-ma d-c heater circuit.

The ultimate solution to the hum problem, therefore, is to use heater power sources that are either of the direct current or the high-frequency alternating current type. Substitution of either of these in the usual amplifier will result in a minimum reduction of five to ten db in hum level, and consequently this feature has been incorporated in many of the newer equipment designs.

The two types of heater excitation just mentioned may be classified in actual application according to whether a series or parallel heater connection is employed.

Series Connection

With the advent of tube types having 150-ma heaters, it has been possible to employ conventional power supplies to furnish direct-current heater excitation. A typical circuit of this type described by Clark[4] is shown in *Fig.* 2. Here the output voltage of a power supply capable of furnishing sufficient current for both plate and heater circuits is applied to the series connected, 12 volt, 150-ma heaters of the amplifier tubes. Heater current is adjusted to the proper value by means of *R*1 and additional filtering is supplied for the heaters of the preamplifier stages by the inclusion of capacitor *C*1, which is of the order of 1000 μf.

A number of difficulties can be experienced with this type of circuit as follows: when a burnout occurs in the heater string it is difficult to determine rapidly which of the several heaters is defective. Also, in the event that either of the heaters on the ground side of capacitor *C*1 should open up, *C*1 will fail unless it is rated to accommodate the full supply voltage, thus endangering the remaining heaters in the string. It is also possible for this same filter capacitor to discharge itself through a new replacement tube, causing a second burnout, if it is not provided with a bleeder resistance.

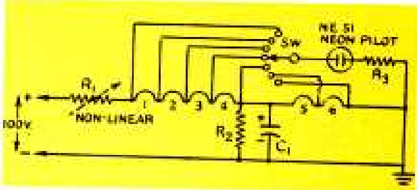


Fig. 3. Improved d-c heater supply circuit.

An improved circuit designed to avoid these difficulties is presented in *Fig.* 3. Here the series resistance, *R*1, is a special non-linear type having a

**Engineering Department, National Broadcasting Company, New York, N. Y.*

negative temperature coefficient such that initial current surges during the warmup period are eliminated. Non-linear resistors designed for this application are obtainable either from the Keystone Carbon Co. (Type 701) or the Carborundum Corp. (Type F). A typical unit suitable for this purpose has a resistance of approximately 1400 ohms at room temperature and 200 ohms at its normal operating temperature of about 300° F[5]. The filter capacitor for the preamplifier stages, *C1*, is rated to accommodate the full supply voltage and is furnished a discharge path through *R2*. Finally, a simple voltmeter circuit consisting of a neon pilot lamp in series with a current-limiting resistor, *R3*, has been included to facilitate rapid checking of heater circuit operation. Should an "open" occur, the lamp will give no indication when switched to the ground side of the defective tube and will indicate the full supply voltage on the other.

Parallel Connection

The excitation of parallel-connected heater circuits naturally poses a problem in low voltage, high-current, power supply design. The heater current requirements of even a modest amplifier may be from 3 to 5 amperes, and only a rectifier of the selenium type can handle such a load efficiently. A suitable circuit employed by the author to eliminate hum in a recording amplifier is shown in *Fig.* 4. The out-

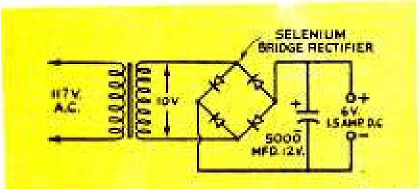


Fig. 4. Hum-free heater supply for parallel heaters.

put of a 10 volt rms filament transformer is applied to a bridge-type selenium rectifier, producing sufficient current in this case to excite all heaters except those of the power amplifier tubes. If the power supply and power amplifier are located on a chassis separate from the lower level stages, it is advisable not to employ a common ground return for both the heater and signal circuits, because any remaining hum component in the heater current will introduce a hum voltage in series with the signal which appears at the input of the power amplifier stage.

H-F Heater Supply

Because of space requirements, the type of supply just discussed may not be very convenient to install in existing equipment. A much neater solution to the problem of equipment modification for hum reduction may be found in the high-frequency alternating current type of heater supply. Such a supply may be compactly installed in a chassis space of 2" by 2" and requires but 40 ma of plate current and .45 amperes of heater current.

The circuit itself, as illustrated in *Fig.* 5, is based on the high-frequency

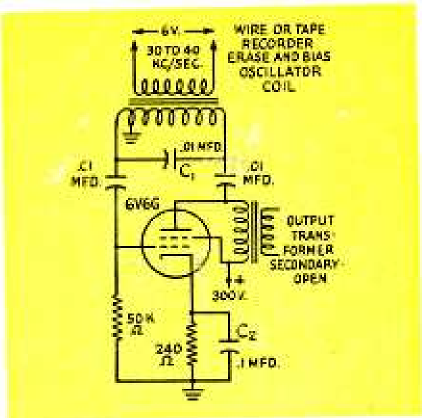


Fig. 5. High-frequency power supply for heater excitation.

oscillator circuits currently employed in magnetic tape or wire recorders to supply supersonic bias and erase current. Such a supply will furnish up to two amperes at six volts, depending on the plate voltage applied to the oscillator, and generally operates at a frequency of from 30 to 40 kc/sec.

Best results will be obtained if *C1*, the oscillator tank capacitor, is of the mica variety, and it should be emphasized that the cathode bypass, *C2*, must not be omitted, since the resulting degeneration will make the oscillator difficult to start and cause its regulation to be poor. The waveform produced by this type of circuit tends to be rather impure, and some difficulties with harmonic radiation may be experienced where such a stage is installed near or on a radio receiver or video amplifier chassis.

Regulated Supplies

In a number of specialized applications, not only is it necessary to employ d-c heater supplies, but in addition, all heater voltages must be closely regulated. Such instances arise in the design of the direct-coupled amplifiers associated with certain types of electroencephalographs, spectrophotometers, and apparatus for nerve potential studies.

In these cases, regulation of heater potentials serves to eliminate cathode drift resulting from the variation of electron emission velocities with cathode temperature. The necessity for regulation in these applications can be appreciated from the fact that for a typical tube type, the heater voltage must be held constant within 1% if an effective voltage fluctuation of 10 millivolts in the cathode circuit is to be avoided.[6]

The heater circuits employed may again be either series or parallel, depending upon the type of regulated source which is available.

For the series arrangement, the conventional voltage regulated power supply which has been fully discussed elsewhere[7] may be employed. In this type of supply, a single 6AS7G, used as the series regulating tube, will deliver sufficient output to supply not only 150 ma. of heater current but plate currents as well. It may be noted that in certain of these units, where a highly regulated output is achieved through the use of a large loop gain, the heaters of the control amplifiers are themselves placed across the output of the supply.

If a parallel connection of the heaters is desired, a regulated supply based on the circuit illustrated in *Fig.* 6 may be used. Here, regulation of the rectifier unit is achieved by amplifying the voltage variations appearing across the load and applying them to the d-c control winding of a saturable reactor in the primary circuit in such a manner as to cause a compensating change in the a-c line voltage applied to the rectifier.

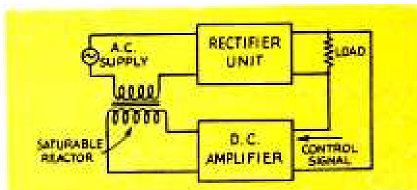


Fig. 6. Regulated d-c heater supply.

A six-volt power supply of this type designed by the author[8], exhibited a change in output voltage of .05 volts with a change in load current from zero to 15 amperes, and negligible variation in output was observed for line voltages ranging from 105 to 140 volts.

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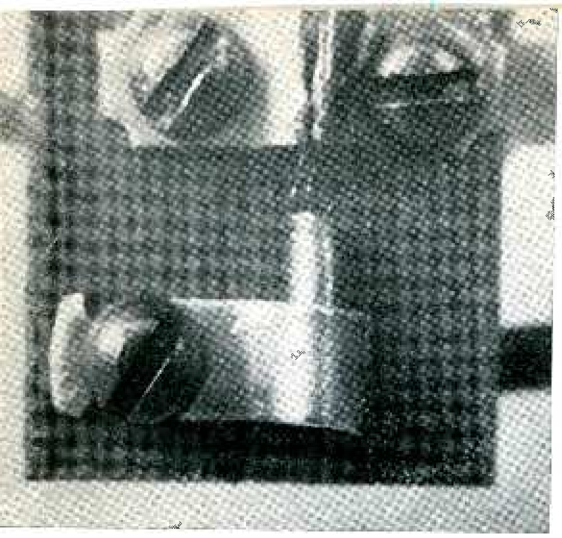


Photo of germanium crystal unit.

Experimental Germanium Crystal Amplifier

S. YOUNG WHITE*

Constructional data on the germanium crystal amplifier.

THE ANNOUNCEMENT[1] of the amplifying properties of germanium and silicon crystals offers an extraordinary opportunity that has not occurred for years. With only a few batteries and a universal test meter we can make a set-up to investigate fully the characteristics of those crystals readily available to the public.

After working with the devices for a week or so, the writer strongly advises that the first set-up be in effect for curve drawing, although usually only one point on the curve be taken. If an amplifying set-up is the first one undertaken the extreme variability of the crystals leads to very confusing results, so it is necessary to build up some data and acquire the feel of the fascinating problem of how to locate an active spot or spots.

Selecting the Crystal

The most generally available type is the Sylvania germanium type 1N34, with 1½ inch wire leads. It is a good idea also to obtain several silicon type 1N21s or similar. The germaniums are about $1.25, and some 1N21s are needed to supply the tungsten cat-whiskers, which will hereafter be called the "points", as they are longer and have more spring.

Since crystals vary in resistance with applied voltage, they should not be checked with an ohmmeter, as the resistance indicated will vary in accordance with the scale used on the ohmmeter, which changes the applied voltage. You will need a one-volt source of d.c. anyway, so it is well to acquire a large dry cell and a 10-ohm wire-wound, adjustable 10-watt resistor, for test purposes. You can set the slider to give one volt, and at this stage of the experiment it is useless to have a more accurate source.

Also, a 40-volt negative source of d.c. is necessary, which can be a tap on a power supply. The regulation should be good for a ten-mil drain, so a bleeder of at least 50 mils is needed.

An alternative source is a 22½-volt B battery with several 7½-volt "C" batteries added so as to give 1½-volt steps in the vicinity of 40 volts. This can be done by bucking the batteries at times.

Now check the crystals you have acquired by putting 1 volt positive to them. This positive bias current will range from 2 to 5 mils. The second test is reverse current at minus 40 volts. This will often lie between 2 and 200 microamps. This is interesting, as these crystals have been adjusted for maximum rectifying action on low-level signals, and the reverse current is very low. As we put this crystal to work in amplification we must find spots whose reverse current runs 2 to 10 milliamperes, or else our "gm" will be too low. This emphasizes the fact that we are dealing with a phenomenon entirely different from rectification of low-level signals, at least. While we are on the subject, it is obvious that the present crystals are too highly variable in all their characteristics to offer too much promise for a stable commercial product, as for the new requirement they have too few active spots, too widely distributed. Since they were developed for an entirely different purpose, however, any future development in the body of the crystals should show marked improvement in amplifying action and stability.

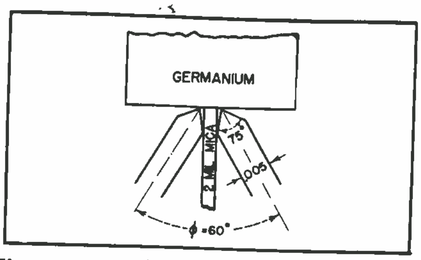


Fig. 1. Method of adjusting point separation.

Crystal Disassembly

The end caps on the 1N34 seem to be for the purpose of isolating the heat of the soldering iron from the crystal itself. They are 17/64ths inch diameter, and in general should be removed. One way that avoids later damage to the crystal is to hold them gently in a vise and make a longitudinal slot in both at once. They can then be peeled off like opening a sardine can, using a small pair of pliers.

You will then find that you have exposed two brass end pieces 0.250 inch in diameter. These are screwed into the ceramic body of the device, and the assembly locked with glyptal or something similar. By chucking these in a collet in the lathe, or even a drill press chuck, they can be unscrewed in turn. The crystal will be found on the end marked "plus". At this time clean off the glyptal with solvent, using great care to remove all of it, as otherwise it will interfere with subsequent soldering.

Under a glass the crystal will be found to be about .060" diameter and about .040" long. Sometimes they are dead flat and lapped true on the end, but also they come quite rough and with a slanting end.

The crystal is actually mounted on a 0.073 brass rod which is given a rough taper down to the crystal diameter of 60 mils. This rod is slightly over a quarter inch long, and is a loose press fit into the large end piece. It is held in place by a small screw which can be removed with a jeweler's screwdriver with a 1/16th inch blade. Because it is locked with glyptal, take that off first.

*Consulting Engineer, 52-12 Van Horn St., Elmhurst, L.I., N.Y.

1 "Experimental Germanium Crystal Amplifier," by Winston Wells, AUDIO ENGINEERING, July, 1948.

The tungsten point is a wire .005 in. in diameter with a conical point of about 75° included angle. The point itself is not needle sharp, but about equivalent to a half-mil radius point, or smaller. This has two bends in it to allow spring action, and the far end is about 3/16th inch long and plated for soldering.

This catwhisker can be soldered about twice before the plating is spoiled. It can also be gently bent about twice, but then it fractures. The silicon crystals are usually fairly rough and irregular. Since they are quite soft, they can readily be lapped with crocus cloth on a piece of plate glass and given a dead flat and true end. They can also be lapped on the side in a lathe giving a sharp shoulder. The germanium is somewhat more difficult to polish and true up. We are still experimenting on this.

Preliminary Tests

The easiest possible set-up is to use two cheap crystal holders with ball and socket joints and long phosphor-bronze catwhiskers. With a little experimenting, and with about 50,000 ohms in the plate circuit, a voltage step-up of about 4 can be obtained. This is not true amplification, however, as the wattage out is usually much lower than the wattage input to the grid. With greater plate current, apparently oxides form on the point that seriously complicate the action.

Incidentally, when operated at 10 mils and 40 volts, the plate dissipation is 0.4 watt. But since the area involved is about one square mil, and there are a million square mils to the square inch, the power density is about 400 kw to the square inch. No wonder many of the active spots burn out before we have time to investigate them.

Complete Assembly

We illustrate two types, the catwhisker and the edge-gap type. The catwhisker has little to recommend it.

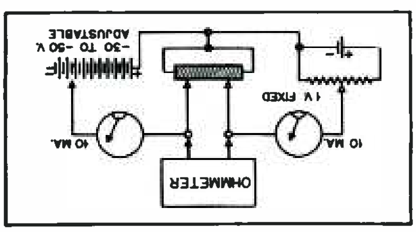
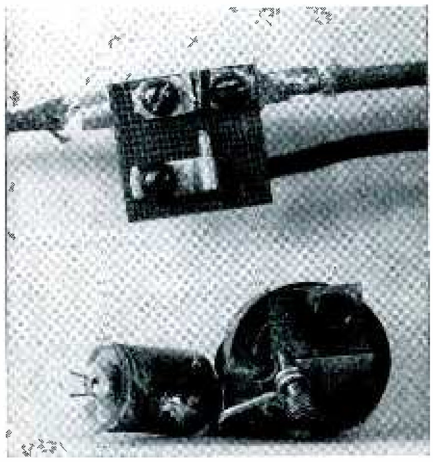


Fig. 2. Test setup for crystal amplifier.

It is true this amplification seems to be a very small area, or point, phenomenon, but there are many ways of obtaining small areas without sharp points, especially since the germanium has a definite surface and is quite hard, or rather resistant to penetration. The first difficulty with the practical mounting of the tungsten points is the combination of considerable thickness of 5 mils plus the 75-degree cone on the point, if we mount them side by side, there will be a point separation of about 5 mils, even if they are touching. So we must mount the points at an angle between 45 and 60 degrees, so that the points can approach each other within a mil or so. Then we can insert spacing means so that they exceed the minimum spacing by any desired amount. Work must be done in the separation zone of between 5 and 2 mils. (*Fig.* 1.)

The first type of mounting tried was that shown in the photo below. The crystal is held down by a strap made of a lug, and can be readily rotated and moved into the twin catwhiskers.



Two forms of crystal amplifier design. Miniature bulb shows relative size.

The catwhiskers were unsoldered with a miniature iron (be careful that all the glyptal is removed) and resoldered onto two bent-up lugs. This was a major operation, as the points must be about the same height and very nearly the same length toward the crystal. This was finally accomplished by making up Bakelite guides in the form of a small plate having a hole just spotted with a number 60 drill. By clamping this so the hole was where the crystal surface was going to be, each catwhisker was firmly pressed into this spotted conical depression and soldered in place. Thus the points were pretty well lined up. They do not have to be very specially aligned. It is a help to have oversize holes in the lugs, so they can be slid around for alignment. All three elements are mounted with number 2 screws, and lugs are locked on the bottom with nuts, so connections can be made without disturbing the setting. Linen Bakelite 0.550 inch square, 3/32-inch thick, was used for the base. In working with

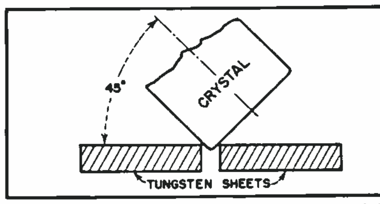


Fig. 3. Wedge contact assembly.

this assembly, the crystal is brought up to the catwhiskers and gently but firmly pushes them back so that good contact is established. With at least a 20-power magnifying glass and a needle, these points can then be pushed around over a large area of the crystal, and will stay in practically any place they touch.

Tests

Assuming you have a test meter, a 1-volt source of d.c. as described, and a 40-volt supply that is able to supply up to ten mils with fair regulation, we can proceed.

Test #1—Connect the ohmmeter between the two catwhisker points, with no other connections. Adjust the two points until they short circuit. Your spacing is now about 1 mil if you have mounted the points at a 60° angle. Then take a mica sheet about 2 mils thick and insert it between the points. One will slide over, and the actual spacing is about 3 mils, which is adequate. Leave the mica in place, as it prevents shorts. Your ohmmeter should indicate between 5,000 and 50,000 ohms. Resistances about 500 ohms often give a spot that promptly burns out, and above 100,000 the spots will draw too little current.

Test #2—Put one-volt positive on each point in turn. The readings should be reasonably steady and between 2 and 4 mils. The battery should return to the crystal with its negative pole.

Test #3—Put 40 negative on each in turn. If you are lucky each will draw 4 to 10 mils on this reverse current.

Test #4—Leaving the meter connected in one negative 40-volt lead, touch the other tungsten lead to plus 1 volt. A change in the plate current will result. With a good plate spot, the increase will be from 7 to 8 mils, for instance.

Test #5—Insert meter in grid lead and measure current—for instance, 3 mils. Thus, 3 mils at 1 volt in the grid equals 3 milliwatts input. This causes a change in the output current of 1 mil, which at 40 volts is 40 milliwatts. Therefore, the power gain is the ratio of 40 to 3, or 13 times. Then reverse plate and grid biases and obtain the gain again. If a spot fluctuates 20 per cent or more in current, it will seldom become stable. A variation of 2 to 4 per cent will often freeze in position and be a good spot.

Test #6—After locating a good spot, raise the plate voltage by 1½ volt steps. Sometimes no greater gain results, but sometimes it increases markedly. If you are really an experimenter, you will continue raising the plate until the spot burns out.

Shoulder-gap Mount

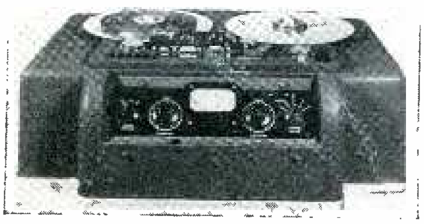
This mount is believed to be original with the writer. It usually requires lapping the crystal to form a cylinder with a well-defined edge. Two sheets

[*Continued on page 39*]

NEW PRODUCTS

RANGERTONE RECORDER

• MR-3 Rangertone Magnetic Tape Recorder. Self-contained unit with recording, playback, erase and power supplies all self-contained. 30" or 18" per second tape speed. At 30" speed, frequency response 30 to 12,000 cycles plus or minus 2 db. Signal to noise, 57 db. Minus 10 dbm input, 600 ohms,



125 ohms; minus 10 db output, 600 ohms, 125 ohms. Monitor switch connects volt meter across input, output, bias or erase voltages. Heigth 36", Depth 26". High speed rewind controls provided which work smoothly in either direction to expedite editing. A tape indicator gives minutes of playing time. Recording head is readily adjustable as to vertical alignment. The machine operates throughout by push button control setting up relays. All relays are in a plug-in chassis which may be readily removed for servicing.

This equipment represents the accumulated experience of these equipments in the field for the past six months, and provides a very smooth operating, rugged equipment which requires very little operational experience to obtain excellent results.

For further information, address Rangertone, Inc., 73 Winthrop St., Newark 4, N.J.

WIDE RANGE SPEAKERS

A new series of Concert-type Wide Range Speakers has been announced by Utah Radio Products, Huntington, Indiana. These speakers are thoroughly tested and proved. They provide high quality sound reproduction up to 10,000 cps.

Designed and built for high-fidelity sound applications, Utah's Wide Range Series is excellent for monitoring in broadcasting stations and for special laboratory uses as well as in the home. Speakers are designed for use in either AM or FM sets.

At present two sizes are being produced. Eight and 12 inches in size, they are the SP8JW and SP12LW. They are finished in gold hammered lacquer. Immediate delivery is offered.

For further data, please write the manufacturer.

STANCOR CATALOG

The publication of a new 24-page catalog (140-H) has been announced by Standard Transformer Corp. Listed are over 400 Stancor stock items, including audio and power transformers and reactors, power packs, volt adjusters, radio transmitter kits and television components. Also included are charts on transmitting tubes, driver-modulator combinations, and matched power supplies. Catalog 140-H is available at no cost from Standard Transformer Corp., Dept. P, Elston Kedzie and Addison Sts., Chicago, Ill.

POCKET-SIZE SOUND LEVEL METER

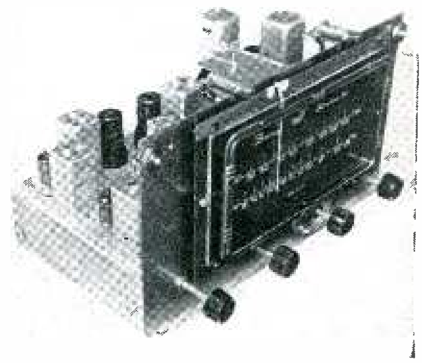
• Utilizing subminiature tubes and new circuit techniques, the Type 410-A Sound Level Meter manufactured by Herman Hosmer Scott, Inc., Dept. AE, 385 Putnam Ave., Cambridge 39, Mass., represents the first light, pocket-size instrument of its kind. Designed by engineers responsible for the most successful of previous designs, this new instrument features improved stability and dependability, simplicity of operation, and accuracy, in addition to the obvious advantages resulting from its surprisingly small size and weight.

This sound level meter covers the range from 34 to 140 db above the standard ASA reference level, includes all three standard ASA weighting characteristics to duplicate the response of the ear at various levels, has a two-speed meter, provision for using extension cable, optional types of microphones, vibration pickups, etc., and analyzers or filters. The unit is 10½" long, 2½" in diameter, and weighs only slightly over two pounds including batteries.

FM-AM TUNER

Browning Laboratories, Inc. of Winchester, Mass. announces a quality fm-am Tuner, Model RJ-12A.

The separate f-m and a-m circuits which are employed throughout allow designing for



maximum performance. An rf amplifier is used in both f-m and a-m sections. The audio-frequency response of the f-m section is flat from 10 to 15,000 cycles, ±1½ db. A drift-compensating network eliminates drift after a two-minute warmup period. Less than 10 microvolts is required to produce 30 db noise reduction. This is accomplished by dual limiters in the Armstrong circuit. The a-m section employs recently developed triple-tuned i-f transformers and a high frequency extending network so that the audio response is flat from 20 to 6600 cycles ±3 db. Sensitivity is 5 microvolts.

A connector in the rear of the chassis for phono input allows the volume control to be employed when playing records. A front panel switch selects a-m, f-m, or phono. The fm antenna input is 300 ohms balanced to ground and connected so that the entire fm antenna and feeder system also functions as the am antenna. The large 8" x 4" glass edge-lit slide rule dial is easily read.

Complete performance curves on fm and am sections are available on request from the Browning Laboratories, Inc., 750 Main St., Winchester, Mass.

PROFESSIONAL DIRECTORY

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NEW
High Fidelity Dynamic
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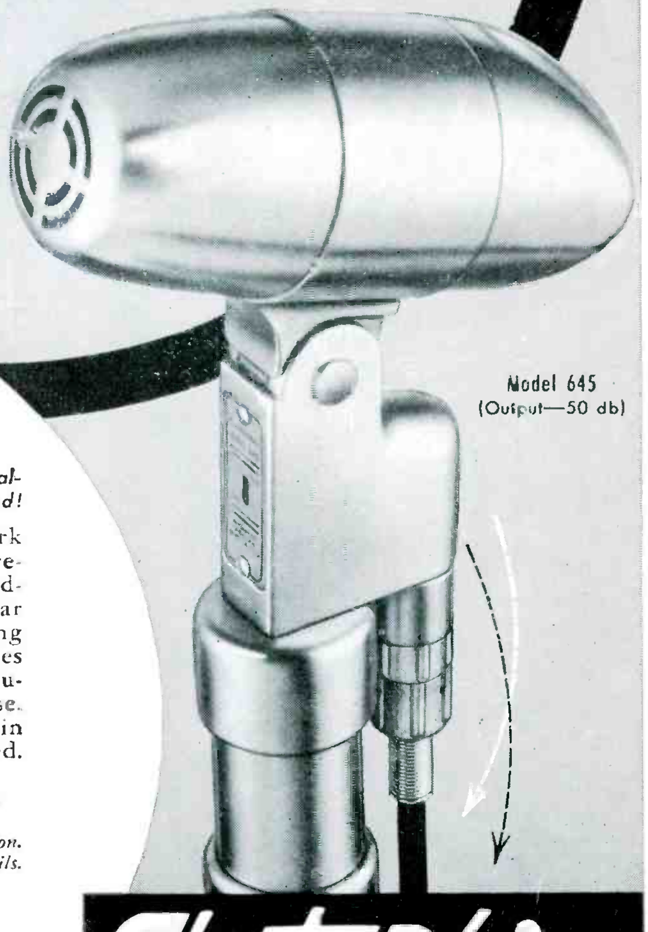

Model 645
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Flat out to 15 kc! Extremely high output! Impedance selector! Dual-type shock-mount! Remarkably rugged! Individually calibrated!

Developed in cooperation with station and network engineers, the new "650" and "645" meet exacting requirements of modern high fidelity FM and AM broadcast service. Proved in studio and remote use. Polar pattern is non-directional at low frequencies, becoming directional at high frequencies. Recessed switch gives instant selection of 50 or 250 ohms impedance. Exclusive Acoustalloy diaphragm withstands toughest use. Many other important features assure the ultimate in broadcast quality. Satin chromium finish. Fully guaranteed.

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Microgroove Records

[*from page 24*]

utes, so there is little reason to employ a changer, particularly since the drop-type changers would not play the records in sequence. Dispelling doubts about the playability on equipment that was not perfectly level, the standard player was operated at a 30° tilt with no noticeable change in operation, and without any tendency for the stylus to slide out of the grooves. Since the groove pitch varies from 230 to 300 lines per inch, depending upon the length of the selection, this question has arisen in the minds of some engineers.

A completely revised quality check system is in operation to ensure that all LP records come up to the standards set for them. When played with the recommended pickup weight and stylus radius, no degradation is discernible on a high-fidelity system after 250 playings. With ordinary home equipment, it is doubtful if any change could be detected after 500 or more playings. This represents considerable use of any record, with only 250 playings lasting for 5 years with one playing per week.

While a special player has been developed by Columbia Records and Philco working together, a number of other manufacturers have already announced equipment to accommodate the LP records, some such instruments being combination units with 78 rpm changer facilities, and an additional pickup arm and speed change feature for the new records. Separate crystal pickup arms will be ready for users by the time the records themselves are in general distribution. Some record shops in larger cities are already stocked with the new library.

C. G. McP.

Noise Suppressor

[*from page 24*]

nishing a 150-ma d-c supply for the three 12-volt heaters in series. Since no signal voltage appears across the control potentiometer, it may be mounted on the front panel or the phonograph motor board in a convenient location. Input and output connections should be shielded. The unit shown in *Fig.* 1 was built with a switch to cut in or out the suppressor section, but this was found to be unnecessary. The single control is adequate for all operation.

Parts Hints

The voltage rating of C_9 and C_{12} need not be over 150 volts, so hearing-aid type capacitors can be used to conserve space. The product of R_{14} and C_{12} controls the attack time, which should be short enough to permit operation without appreciable delay, yet long enough to prevent opening the filter circuits on "pops" or "ticks." As shown, the delay is only 5 milliseconds. The release time is the sum of the products of R_{13}-C_9 and R_{14}-C_{12}, 255 milliseconds in this instance. It appears satisfactory in subjective tests, and since there are no accepted standards for these values, such tests must be relied upon for determination of optimum values. The potentiometer R_{13} is linear.

Operation

Under normal operating conditions, the voltage on the plate of V_3 is approximately 15 volts with no signal and with the control at the maximum counterclockwise position; 40 volts at the maximum clockwise position. In the presence of high-frequency signals with the control at the clockwise position, the voltage at the plate of V_3 is approximately 160. The screen potential is approximately 32 volts with no signal.

The voltages at the plates of V_1 are about equal, approximately 80 volts; the cathode potentials, also about equal, are of the order of 1.0 volt. The voltage at the plate of V_2 is 180; at the cathode, 2.0. A contact potential of 0.7 volts appears across R_{13} with no signal. The rectified d-c voltages across R_{13} with signal from a frequency record reach a maximum of about 40 volts at frequencies above 500 cps. These measurements were made with a vacuum-tube voltmeter having an input resistance of 15 megohms. The plate supply was 300 volts, and the potential across C_{13} was 120 volts.

Advantages and Limitations

This equalizer-suppressor amplifier has several advantages over the more complicated noise suppressor in that it is much simpler to construct and requires fewer parts. There are no complicated adjustments required in the construction. Since only one control is furnished—or needed—this suppressor is much easier to use effectively. However, it is limited to use with magnetic pickups, and is not usable on radio tuner outputs or with crystal pickups. While some effect could be obtained, the cutoff rate of 15 db per octave is available only when the source is inductive. It does not have as great flexibility as the H. H. Scott Dynamic Noise Suppressor, but for those who must occasionally compromise cost with performance, it is a definite improvement over the use of capacitors providing fixed cutoff frequencies.

Classroom Recording

[from page 21]

But comparisons are inevitable nowadays with the quality of reproduced speech heard at home from a-m and f-m radio receivers and from commercially produced phonograph records. If the teacher of public speaking makes use of the commercially available recordings of famous public speakers as models for his students, he places himself and his classroom recordings in direct competition with the professional product, usually to the detriment of his prestige in the classroom. Perhaps this disadvantage was not so great thirty-five years ago as it is now. Then, William Jennings Bryan and Theodore Roosevelt went to the recording laboratories and shouted stale repetitions of their public addresses into the horn of the recording machine, but now the words of a world figure are captured with "broadcast quality" at the original moment of utterance with all the flavor of the immediate occasion.

Requirements

The requirements for classroom recording are more difficult to meet when the aims of instruction include the improvement and correction of faulty or defective voices and of the common faults of articulation. In this kind of work the aim is not to make a recording that sounds good, but to get a recording that is faithful to the original, good or bad, as the case may be.

Excessively hoarse or nasal voices are almost always recorded and reproduced so that the fault is apparent to a convincing degree, but less extreme vocal faults do not appear in the recording unless the equipment is capable of wide-range reproduction with low distortion. Microphone technique and the performance of such associated equipment as microphones and loudspeakers become more important, too, when there is a necessity for discriminating between good and poor voices. With most of the available equipment, especially in the portable and table-model forms, a good voice may be penalized and a poor voice flattered in the reproduction. Incidentally, there is an almost unconquerable tendency to play back a weak and breathy voice at a level higher than that of the original performance, so that the reproduction is a strengthened and enhanced version of the original. If such a recording happens to give a glamor-struck bobby-soxer the idea that her hoarse little voice makes her sound like Lauren Bacall, the speech teacher might as well give up at once.

The accurate reproduction of consonant sounds makes the most stringent demands on recording and reproor the production of the over-stressed sibilant and explosive consonants such as is often heard from speakers who come from a foreign-language environment require really good recording for clarity. Crandall[2] showed many years ago that "s" sounds contain characteristic components as high as 8000 c.p.s. Fletcher[3] points out that "s" is recognized only 50 per cent of the time (which is pure guessing) when the frequencies above 4000 c.p.s. are suppressed. Obviously, in dealing with a case of lisping, speech correctionists cannot count on much help from recording devices which do not record or reproduce the full frequency range of these sounds.

What is required is not merely a reproduction of the normal "s" sound that can be distinguished from an "f" or a "th", but reproduction that shows unmistakably the difference between the defective "s" and an acceptable "s". Here again correct microphone technique is required because of the directional emission of the high-frequency components in the fricative sounds. It is not difficult to provide a barrier to prevent talking too close, and a target for the student to face as he speaks, but such measures are not worth the trouble if the associated equipment is not capable of passing the required frequency band.

In short, the classroom teacher needs equipment equal to the best, but simpler to operate and cheaper to buy and maintain in use. All we ask is the impossible. We hope it may be just around the corner.

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[2] *Crandall, I. B., The Sounds of Speech. Bell System Technical Journal, Vol. IV.,* pp. 586-626, *Oct.* 1925.

[3] *Fletcher, Harvey, Speech and Hearing. D. Van Nostrand Company, New York,* 1929.

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8. Acoustic Materials Association, Bulletin IX, 205 West Monroe Street, Chicago, Illinois, 1947.
9. National Bureau of Standards, Letter Circular LC870, Washington, D.C., 1947.
10. C. F. Eyring, "Reverberation Time in 'Dead' Rooms," *Journal of the Acoustical Society of America*, Vol. I, No. 2, p. 217, January, 1930.
11. A symposium of six papers on "Auditory Perspective," *Electrical Engineering*, Vol. LIII, No. 4, p. 239, April, 1934.
12. H. Fletcher, "Transmission and Reproduction of Speech and Music in Auditory Perspective," *Journal of the Society of Motion Picture Engineers*, Vol. 22, No. 5, p. 314, May, 1934.
13. A symposium of five papers on "Auditory Perspective," *Journal of the Society of Motion Picture Engineers*, Vol. 13, No. 2, p. 89, October, 1941.
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15. Jensen Technical Monograph No. 4, "The Effective Reproduction of Speech," Jensen Radio Manufacturing Company, Chicago, Illinois, 1946, p. 8.
16. V. O. Knudsen, "The Propagation of Sound in the Atmosphere—Attenuation and Fluctuations," *Journal of the Acoustical Society of America*, Vol. 18, No. 1, p. 90, July, 1946.

Impedance Bridge

[*from page 16*]

Use of Bridge

In use, this bridge is simple and rapid. For resistance measurements, the unknown resistor is connected to the *R* binding posts, the selector switch placed in the *R* position, and the lever switch thrown to *DC*. Then rotate the range switch to the position where the galvanometer swings from one extreme to the other. Adjustment of the *N* dial should then be made to reduce the galvanometer deflection to zero. As this balance is approached, the push button is depressed to increase the galvanometer sensitivity by removing the shunt. This will permit greater accuracy in setting the *N* dial.

For capacitance measurements, place the selector switch in the C_{DQ} position, connect the unknown component to the *LC* binding posts, and throw the lever switch to 1 *kc*. Plug a pair of phones into the jack, and adjust the range switch and the *N* dial together to obtain a minimum sound in the phones. As the null is approached, it will be found that a perfect balance can be obtained only at a specific position of the *DQ* dial. High-quality capacitors, such as mica and oil-filled paper units, may require the use of the C_D position of the selector switch to obtain a satisfactory null point.

Inductance measurements are somewhat more difficult, but only until some experience is obtained in the use of the bridge. Using the L_{DQ} position of the selector switch in the C_{DQ} position, at 5, rotate the range switch until some indication is obtained of the proximity of a null. This may require some adjustment of the *DQ* knob in the various positions of the range switch in order to obtain any such indication. Once the correct position of the range switch is determined, adjust the N dial and the DQ knob simultaneously to obtain a null in which any change of either shows an increase in the signal in the phones. When a good balance is obtained, the passage of the potentiometer arm over the individual turns of wire can be detected readily. After some experience in the use of the bridge, it will be found that this null determination becomes relatively simple.

When constructed in accordance with *Fig.* 5, the values for L, C, and R are equal to the setting of the N dial multiplied by the values shown by the following table:

TABLE I

MULTIPLIER FOR N DIAL

Range	L	C	R
1	10 μh	10 μf	1 ohm
2	100 μh	100 μf	10 ohms
3	1 mh	.1 μf	100 ohms
4	10 mh	.01 μf	1,000 ohms
5	100 mh	.001 μf	10,000 ohms
6	1 hy	100 μμf	100,000 ohms

This table should be placed on the curve sheet where it is readily visible while using the bridge.

Precautions

This bridge is not directly suitable for the measurement of electrolytic capacitors of high value. Such measurements require a polarizing voltage. However, an approximate value may be obtained by subjecting the capacitor to its normal operating voltage for a few minutes before making the measurement, discharging it just before connecting it to the bridge terminals. The indication is only approximate, and should not be considered as absolute. When making measurements on capacitors of low value, it is desirable to determine the residual capacitance of the bridge itself. This may be done by obtaining a balance with no leads connected to the binding posts. With careful construction, the residual capacitance should be found in the vicinity of 20-30 μμf. This value should be subtracted from the indicated value of small capacitors up to about 500 μμf. From the bottom view of the bridge, it will be observed that most of the wiring is of bus-bar type to reduce stray capacitance as much as possible.

While any good 0.01-μf capacitor can be used as a standard, it is suggested that the specified unit be selected, since it has a low value of D, and is accurate in capacitance value. In the author's bridge, a Sangamo mica capacitor was employed, but its capacitance was checked on another bridge of excellent accuracy. Such a substitution is satisfactory provided it is possible to obtain a capacitor of accurate value.

Record Revue

[*from page 25*]

we can bet our bottom dollar it is there—unless Columbia manages to rig up a full-scale bandwagon to stampede the industry. It would be a good thing, but I doubt if it occurs. Points to speculate upon:

a) *Big Companies.* The larger companies can, if they will, very easily tool up for microgroove recording (and re-recording) and for record manufacturing. The adoption of the whole Microgroove set up, from start to finish, is therefore more *a matter of policy* with the big companies than one of technology. They have the power and the means to do what they will. Can Columbia persuade them to go along with Microgroove? That's the biggest question of all. Perhaps it'll be answered by the time this is in print.

b) The small companies are another matter altogether. They will need Microgroove recording equipment for their studios (if they have any), but this is a relatively minor item. These concerns will depend for their very existence on the availability of Microgroove record pressing facilities. Few small outfits own their own pressing plants and so the searchlight turns upon the major commercial record pressing plants. Will Microgroove pressing be available to them either through Columbia or via some other development? Apparently it is not simply a mere substitution of a different master; there are tremendous new problems of precision, of absolute control of airborne dust, etc. With details unavailable, it is still obvious that Microgroove pressing must require higher standards of manufacturing accuracy than may be practicable for smaller pressing concerns. What, then, will happen to the small record companies?

My own feeling is that Microgroove recording cannot be called a permanent success until the smallest companies are able to make and press Microgroove records on a budget comparable to their present one. I would hate to see Microgroove an exclusive feature of big-company operations, forcing the small companies to exist precariously if at all, on the old-style records. It will be intensely interesting to see what happens here.

5) *Problem of Contractual Relationships.* A whole slew of interesting minor problems occur to me here, and many more will pop up as time marches on. For example, how about record

royalties? Roughly speaking, six standard records equal one microgroove, same size. Will recording sessions continue as four-minute or three-minute slices, to be patched together later (as are the present Microgrooves from Columbia) or will "long playing" sessions be instituted, with new rules and regulations?

(b) This introduces a potentially major problem—the Musician's Union. Nothing so far. But—remember that ban on AM-FM duplication? What are the comparable problems involved in standard-Microgroove duplication, if any? One wonders, will Columbia and/or the union consider the present duplication irrelevant? To my speculative mind it would seem it is remarkably like the AM-FM duplication. The same opposing arguments apply that were used as bargaining points in the AM-FM controversy: 1) Microgroove opens up new sales territory and therefore should be considered as a widening of the audience, or 2) every Microgroove buyer gained is a standard-record buyer lost, and thus the balance is *not* changed. That argument was settled indirectly, as part of a larger settlement in radio; it seems likely that this question will have to be included in the settlement that will eventually come between the record companies and the union.

c) Manufacturing contractual relationships. Here, we on the outside can merely wonder what agreements Columbia and others may have signed, what sort of licensing arrangements are available, how much the present set-up is actually protected.

It's pretty safe to guess that in the long run it will not be the technical feasibilities of Microgroove recording, but rather these relationships — performer-composer agreements, union relationships, and manufacturing agreements—that will determine the future course of Microgroove development.

6) *Obsolescence.* What aspects of recording will be discarded because of Microgroove? What of the record album, the record changer, the phonograph needle—already well on the way out? What about untold acres of expensive shelf space in a thousand record stores? What about a hundred complex publicity routines, album display racks and so on, that are now obsolescent? (I hate to think what has been going on at headquarters of the recently announced 200-record automatic player with the traveling crane pickup!) Speculate as you will, but it is evident that on the one hand there will be a sullen pressure against Microgroove recording, both from manu-

facturers out on a limb and from the record dealers, to whom every new development is just another headache when it first appears. And on the other hand there will be, as always, some enterprising concerns that will quickly jump on the looming bandwagon. Resistance to change will depend, rather picturesquely, on the personalities of those in charge of the various concerns —die-hards will die hard, progressives will move enthusiastically into the Microgroove field. In any case, much money will be spent, perforce, and many existing plants will be expensively junked.

7) What about the problems of dual and "triple" playing? Two speeds, two stylus sizes, now, plus the usual variance of record characteristics. Will we use separate equipment or some form of combination? Tendencies are well indicated in (a) the new Philco line with standard record changer, two-speed motor, and *separate* Microgroove pickup. The separate arm is less inconvenient than might be expected because of its small size and inconspicuousness. (b) The dual cartridge, already developed, with two styli in one head, which turns around to play either sized groove. Given proper outside equalization, this has much promise but such problems occur as the different out-puts due to different degrees of lateral excursion in the two groove-types, and of course, the problem of weight and lateral friction in the arm; the dual pickup will first have to satisfy the Microgroove requirement. A three-way pickup, for both speeds, standard groove (to 16 inches), and for Microgroove, might be possible, but a compromise in the arm would be necessary since the ideal Microgroove arm is too short for transcription use. The longer arm would introduce more counterbalancing and inertia—unless we take to Balsa wood!

Such are my somewhat aimless speculations at this point, written in the country, in a fine informational vacuum. These are not so much fanciful predictions as they are possibilities on which you, are reader, consumer, manufacturer, may carry on your own further speculations ad lib. When both Microgroove equipment and records

RECORD LIBRARY

In this spot a continuing list of records of interest will be presented. This list specifically does not suggest "the" best recordings or versions. It will draw predominantly but not entirely from postwar releases. All records are theoretically available, directly or on order; if trouble is experienced in finding them Audio Engineering will be glad to cooperate. Records are recommended on a composite of musical values, performance, engineering; sometimes one, sometimes another predominates but records unusually lacking in any of the three will not be considered. Number of records in album is in parenthesis.

Symphonies and concertos of Brahms, Beethoven—with an eye to the sound man's "high fidelity" equipment.

Beethoven, Symphony No. 2.
Pittsburgh Symph., Reiner.
Columbia MM 597 (4)

Beethoven, Symphony No. 3.
Boston Symphony, Koussevitsky.
RCA Victor DV 8 (5 pl.)

Beethoven, Symphony No. 4.
Cleveland Orch., Szell.
Columbia MM 705 (4)

Beethoven, Symphony No. 6.
Philadelphia Orch., Walter.
Columbia MM 631 (4)

Beethoven, Symphony No. 9.
Philadelphia Orch., Westminster Choir, Ormandy.
Columbia MM 591 (8)

Beethoven, Piano Concerto No. 2.
Kapell; NBC Symphony, Golschmann.
RCA Victor DM 1132 (4)

Beethoven, Violin Concerto.
Szigeti; N. Y. Philharmonic, Walter.
Columbia MM 697 (5)

Brahms, Symphony No. 1.
N. Y. Philharmonic, Rodzinski.
Columbia MM 621 (5)

Brahms, Symphony No. 2.
N. Y. Philharmonic, Rodzinski.
Columbia MM 725 (5)

Brahms, Symphony No. 3.
Philadelphia Orch., Ormandy.
Columbia MM 443 (5)

Brahms, Symphony No. 4.
Philadelphia Orch., Ormandy.
Columbia MM 567 (5)

Brahms, Piano Concerto No. 1.
Curzon; National (British) Symph., Jorda.
London Decca EDA 47 (6)

Brahms, Piano Concerto No. 2.
Serkin; Philadelphia Orch., Ormandy.
Columbia MM 603 (5)

Brahms, Violin Concerto.
Szigeti; Philadelphia Orchestra, Ormandy.
Columbia MM 603 (5)

are finally available—not at this date —I will report more factually on things as they are, rather than as they may or might be.

Recent Recordings

Brahms, A German Requiem.
a) Robert Shaw. RCA Victor Chorale and Orch. Eleanor Steber, James Pease.
RCA Victor DM 1236 (9)
b) Vienna Gesellschaft der Musikfreunde, Vienna Philharmonic, Karajan. Elizabeth Schwartzkopf, Hans Hotter.
Columbia MM 755 (10) (2 vols.)

After twenty years with no recording at all of this well known work of Brahms (sung by every chorus in this country that can manage a large-scale work)—suddenly there are twins. Strange coincidence, and not the first by any means. Both recordings are excellent jobs, musically and technically. Robert Shaw's American version is the most accurate, the most controlled musically; technically it has the most clarity of detail. The Viennese version, though, full of inaccurate singing on the part of the chorus, is a more profound, more moving intrepretation and has therefore been the choice of many critics already. The Viennese recording is in the old European tradition, very live, mikes at a considerable distance, much detail lost in pleasant blur of sound. Many people prefer this type recording in spite of loss of detail. The two soloists in the Viennese version outrank Shaw's soloists by far. Elizabeth Schwartzkopf's one piece (number 5) is worth the whole album's price. Both these recordings do a remarkable job in compassing the huge climaxes of chorus and orchestra that must be crammed into the dynamic range of the recording process.

Ravel, La Valse; Debussy (orch. Ravel), Danse.
Pittsburgh Symphony, Reiner.
Columbia MX 296 (2)

Another major Ravel work to add to the three reviewed last month, but not quite as successful. Musically, Reiner is a bit too cold and calculating for the white hot music in this score. It's all there, but it doesn't overheat, and it should. Technically, the recording matches Reiner's cold energy—it us ultra-clear, wide range, but on the steely, dead side, not overly good for Ravel. However if you want perfection in the mere mechanics of reproducing the tremendous brass and percussion sounds in this music, try this on your wide-range equipment. Without a doubt it gets more of the actual music to your ear than any previous recording of the work.

Stravinsky, Baiser de la Fée (The Fairy's Kiss); Divertimento. (1928)
RCA Victor Orch., Stravinsky.
RCA Victor DM 1202 ((3)

An interesting ballet piece, in which Stravinsky incorporates a number of Tchaikowsky themes into his own style of writing. This is a good work to try as an introduction to the more recent Stravinsky music. The Tchaikowsky influence makes it more mellow, easier listening, than other works of same period. Some really entertaining Swiss Dance music, full of yodels and the like, somewhat reminiscent of Petrouchka. Recording is excellent acoustically, but a wider audible tonal range would have made it even better. With the composer conducting, this is a top-notch interpretation.

Kabalevsky, The Comedians
New York Philharmonic, Kurtz.
Columbia MX 295 (2)

A companion recording (probably same recording session) to the two Khatchaturian "Gayne" suite albums. Technically it is just as good as the famous First Gayne Suite, the original killer-diller among noisy wide-range show records! The first side of this features the same fancy orchestral colors as the Khatchaturian. But Kabalevsky's music, 100% derivative, is milder that K's, less pretentious, more melodic, and as far as I'm concerned, a good deal better. It imitates everybody and anybody—you'll hear bits of Offenbach, Tchaikowsky, Prokofieff, Johann Strauss—almost any composer *except* a modern one! For high-fidelity demonstration (especially if the "Gayne" records drive you nuts) try this.

CRYSTAL AMPLIFIER

[*from page* 29]

of tungsten .005 thick or so (not critical) are fastened to a Bakelite plate. By inserting a thickness gauge they can be adjusted to a desired spacing, for instance, three mils, and locked up. (*Fig.* 3.)

The crystal is jammed into the gap with its end held at 45 degrees. It will be found that this occurs easily, as the crystal shoulder falls naturally into the gap as it is slid over it. On some crystals, very considerable pressure must be used. New spots are presented as the crystal is rotated. Sometimes it is well to dull the too-sharp edge of the tungsten sheets with a rubber eraser bearing an abrasive. Very small spherical crystals could be used with this gap. Since only the edges of the sheet are used, they could actually be replaced with say two to four-mil round wire laying in a depressed trough in a ceramic piece.

This assembly is extremely stable and easy to work with, and much easier to make. Unfortunately, tungsten sheet is difficult to procure, but the wire can be obtained by breaking a straight filament tungsten lamp. These filaments contain a little thorium on the surface that might give difficulty.

Conclusion

We have here a Class C triode, with practically all the circuit elements present. So we have power gain, low impedance, feedback both positive and negative, and also overloads and burnouts. The crystals available to the experimenter seldom exceed a power gain of 25 or so, and every spot on every crystal has somewhat different characteristics. Until we have a large number of experiments we cannot well talk of impedance and gain values. Twenty points were investigated with catwhiskers. Seven were too erratic to use, about seven drew too little current, three had little gain, and three spots were good, the best giving a gain of about 30 on too high plate voltage. This from just one crystal picked at random.

ADVERTISING INDEX

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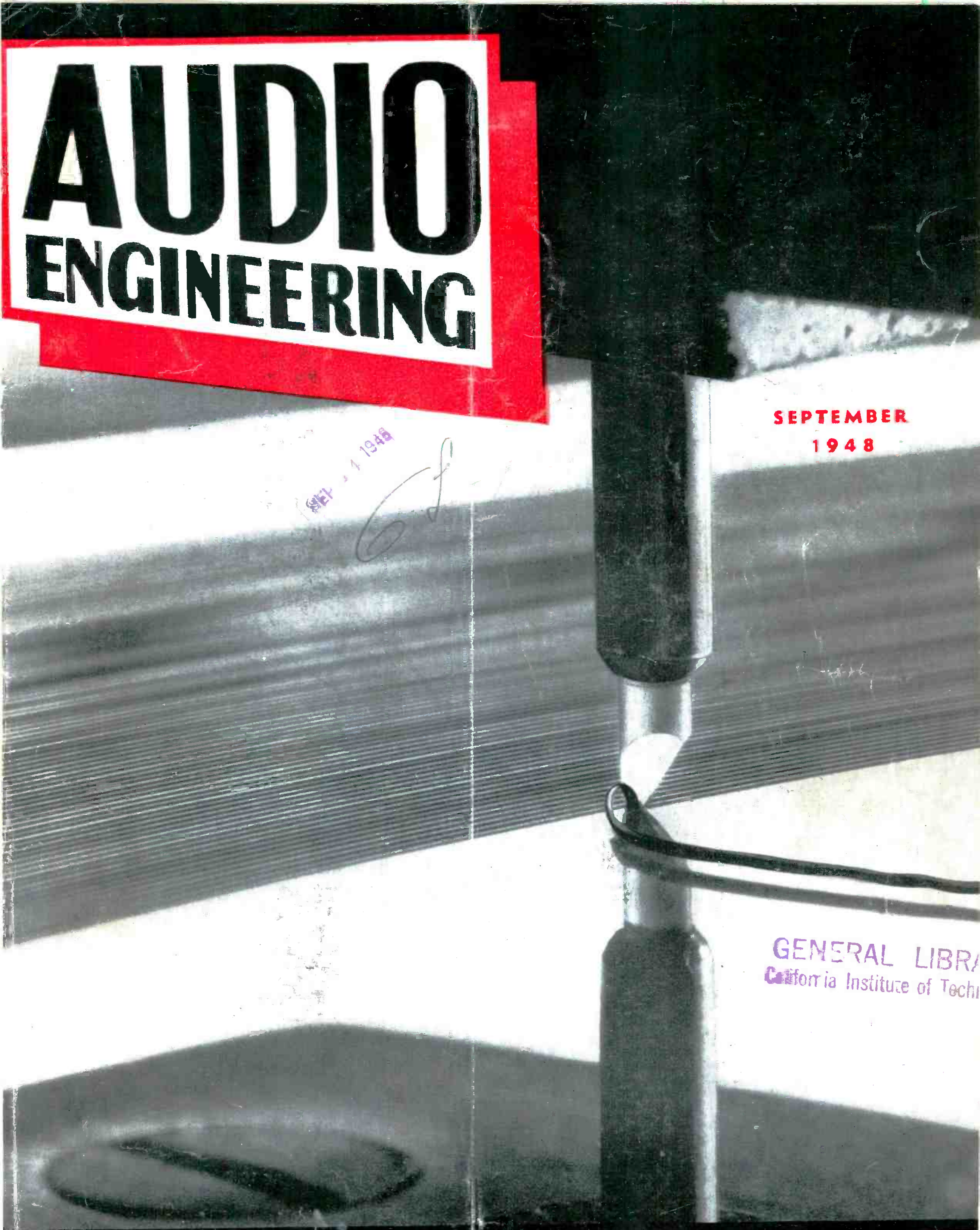
AUDIO ENGINEERING



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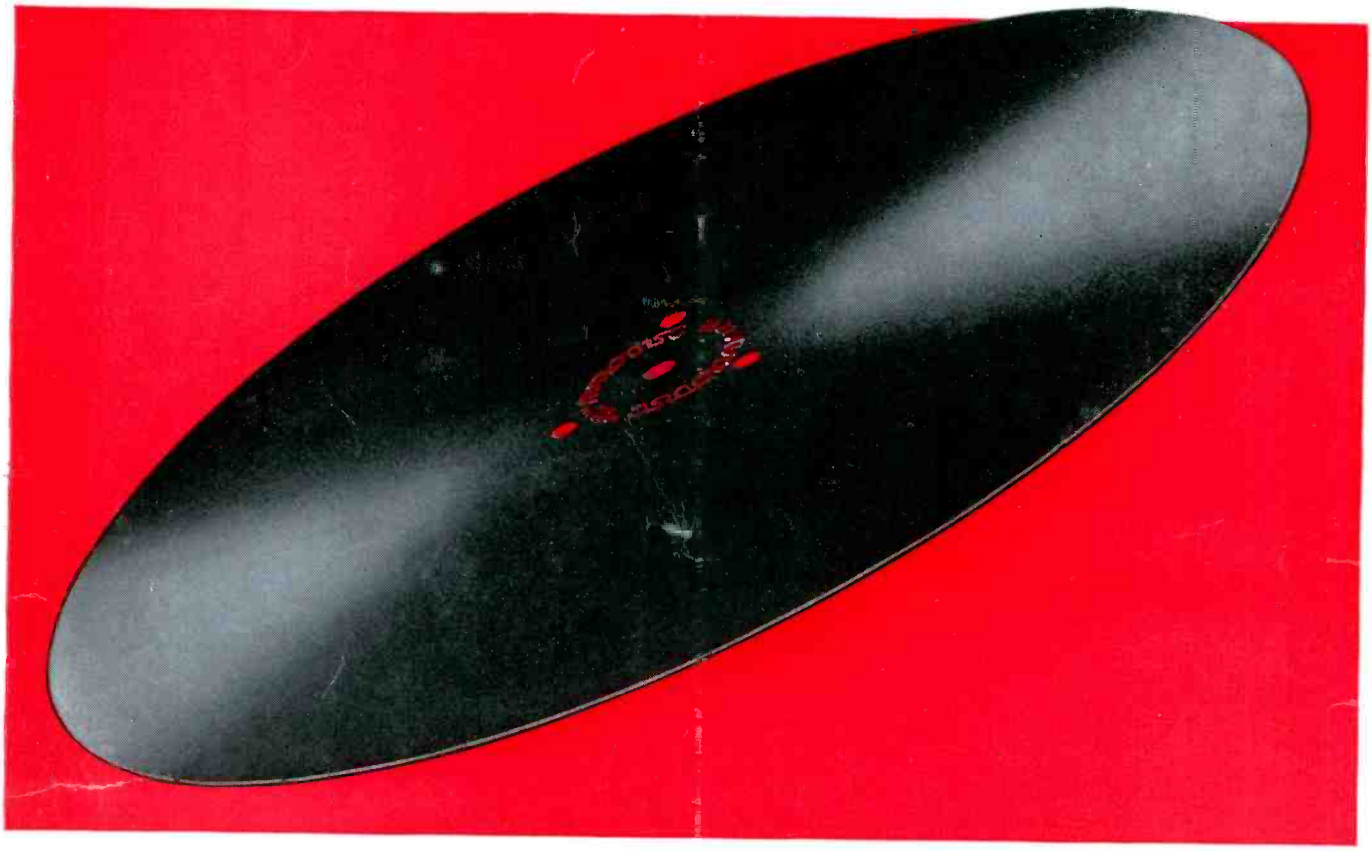
PRICES AND AUDIODISCS



A Statement On Our Price Policy

As of September 1st, aluminum prices are again increased. This means higher cost for the principal raw material used in the manufacture of AUDIODISCS. In fact, the cost of the aluminum base has always been the main item in the cost of production. Thus, any increase in aluminum prices is of major importance.

But beyond the cost of raw materials and labor there is a basic factor which determines the cost of manufacturing professional recording discs. This factor is the extent to which the particular process of manufacture enables the producer to turn out a large proportion of first quality discs. There are several methods of production used. None of these will give anything like a 100% yield. It is, however, obvious that as the percentage of yield increases there is a resulting drop in the average cost of aluminum, lacquer and labor.

Fortunately, our patented, precision-machine process—now used for over a decade and continuously improved—gives a more consistent yield of high quality discs than any method of production now used. And we have tested every other process in use.

So our position with respect to the present increase in aluminum prices is this:

1. We are *not* increasing prices of AUDIODISCS as of September 1st.

2. We shall make every effort to absorb this new aluminum price raise and thus continue our prices at the present level. Our calculations indicate that with some improved efficiency, now under way, and continued large volume production, we shall be successful in this hold-the-price effort.

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