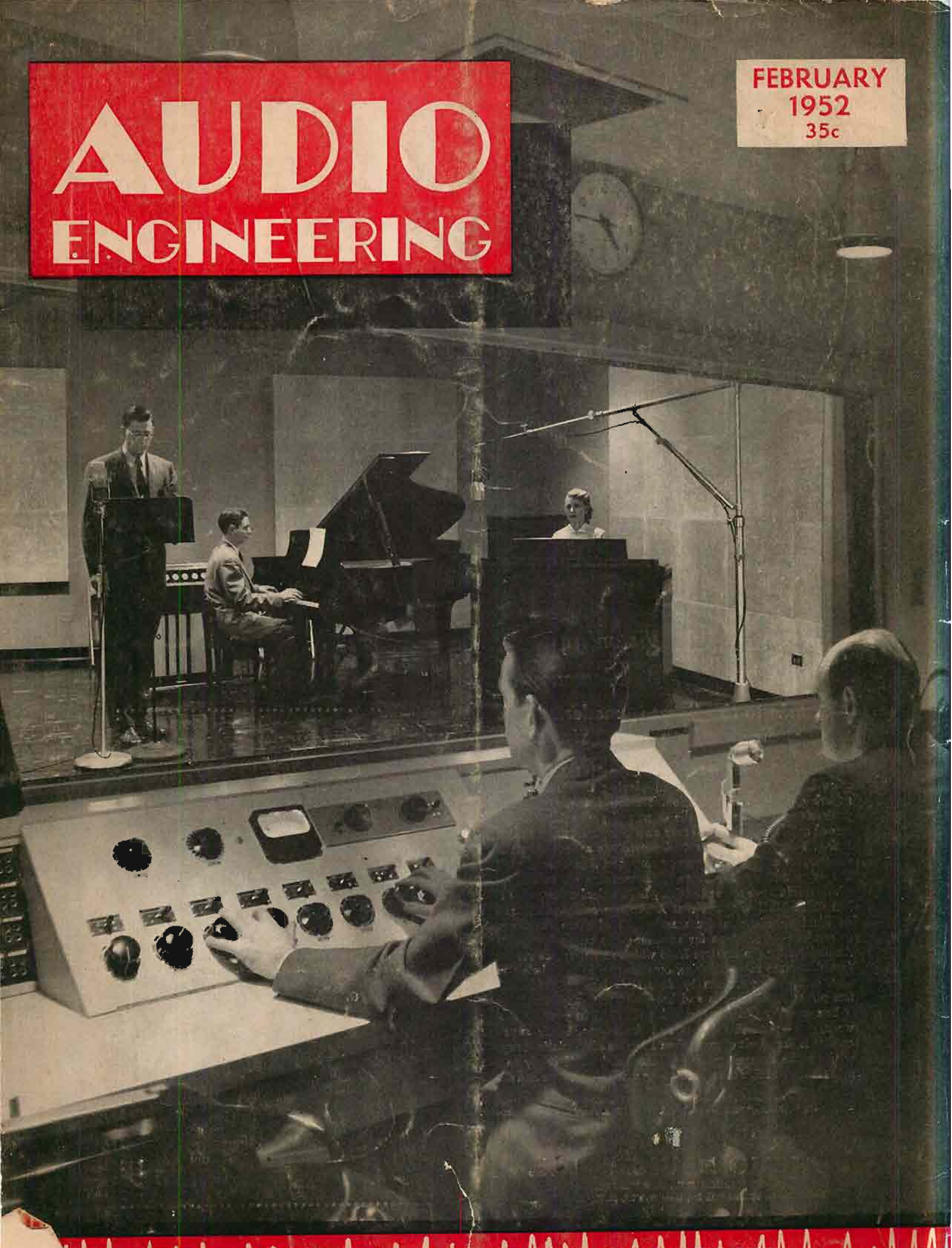
AUDIO ENGINEERING

FEBRUARY 1952
35c



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Music lovers everywhere know that Columbia LP records mean more listening pleasure—not in playing time alone, but in superb quality of reproduction. Yet few listeners outside the professional circle realize the degree of perfection which this record quality requires in every step of manufacture and processing. Take the original sound recordings and the processing masters, for example. Frequency response, signal-to-noise ratio, distortion and surface noise must measure up to standards which would have seemed entirely impractical a few years ago. But Columbia has found that Audiotape and Audiodiscs are an ideal combination for meeting all of these exacting requirements — Audiotape for recording the original sound and Audiodiscs for the masters from which stampers are made. In fact this same record-making combination is now being used with outstanding success by America's leading producers of fine phonograph records and broadcast transcriptions.

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. . . including

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for the original sound

. . . and **audiodiscs***

for the master recording

**Trade Mark*

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COVER

A recording session in Studio A of Audio-Video Recording Company, Inc. A complete remodeling of the quarters previously occupied by radio station WQXR has made this plant one of the recording showplaces of New York, with facilities for tape and disc recording, mastering, editing, and most other allied services. Photo by Jack Sharin.

RADIO MAGAZINES, INC., 342 MADISON AVE., NEW YORK 17, N. Y.

AUDIO ENGINEERING (title registered U. S. Pat. Off.) is published monthly at 10 McGovern Ave., Lancaster, Pa., by Radio Magazines, Inc., D. S. Potts, President; Henry A. Schober, Secretary-Treasurer. Executive and Editorial Offices: 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 February 9, 1950 at the Post Office, Lancaster, Pa. under the Act of March 3, 1879.

AUDIO PATENTS

RICHARD H. DORF*

Fig. 1

CONSTANT MARTIN is a Frenchman whose developments in electronic musical instruments have earned him widespread recognition in Europe. He is not well known in the United States, probably because none of his instruments have been marketed or, to the writer's knowledge, even demonstrated in this country. One of the Constant Martin organs appears in *Fig.* 1—a two-manual instrument with several separate oscillators per note. These organs are individually voiced by adjusting stop filter components at the time of installation to suit them to the auditorium and have the chorus effect so desirable in a good organ and so difficult to attain in an electronic one.

The latest U. S. Martin patent, No. 2,563,477, covers a simple monophonic (one-note-at-a-time) instrument. It has the virtues of simplicity and cheapness and entirely aside from any commercial value the circuit should provide a quick and easy way for those interested to build a useful little solo instrument.

The circuit of the tone-generator section is shown in *Fig.* 2. It has only three tubes and could easily be condensed to two (or one and a half) by using a 6SN7 for V_1 and V_2.

The oscillator is the simplest kind of two-tube unit. The output of V_1 is coupled to the grid of V_2, the plate of which is coupled back to the grid of V_1. The only capacitor concerned is C_1, C_2, or C_3, the coupling capacitor between the plate of V_1 and the grid of V_2. In conjunction with the resistance between the grid of V_2 and ground, it forms an R-C time-constant circuit which determines the frequency of oscillation. For a given value of this resistance, C_1, C_2, or C_3 may be selected to produce differing pitch ranges.

The resistance in the grid circuit of V_2 is divided into several parts and key switches select the amount of the resistance to be grounded and made part of the time-constant circuit, thus selecting pitches. Resistors R_1 should be selected by experiment to give consecutive notes of the chromatic scale with a suitable value for C_1. Then,

[Continued on page 4]

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

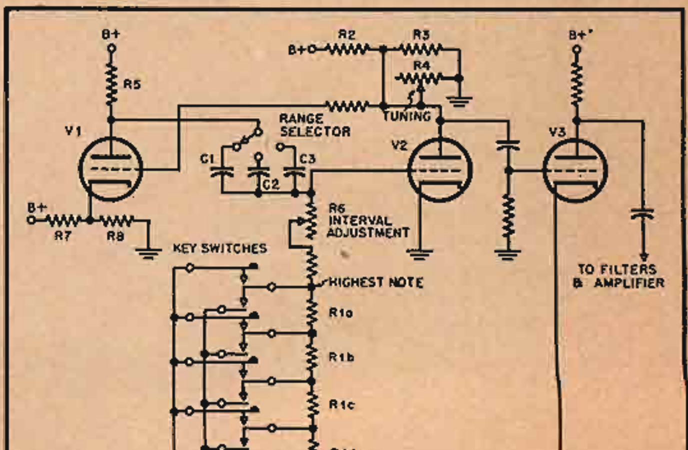

Fig. 2

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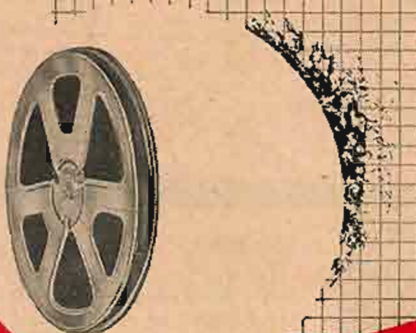

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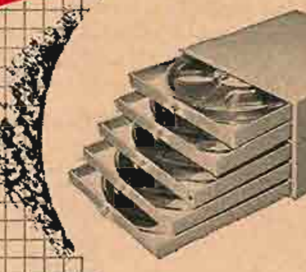

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since time-constant is equal to R×C, changing to C_2 or C_3 will simply shift the entire chromatic scale to another range without varying the half-tone intervals between keyed notes. One basis for selecting C_2 and C_3 would be to produce tones one and two octaves below or above that of C_1. Another idea (not mentioned in the patent) might be to provide twelve capacitors on the switch so that the instrument would be an automatic transposer which could be set to play a solo in any key while the player may use his keyboard as though the composition were written in *C*, the simplest and most familiar key.

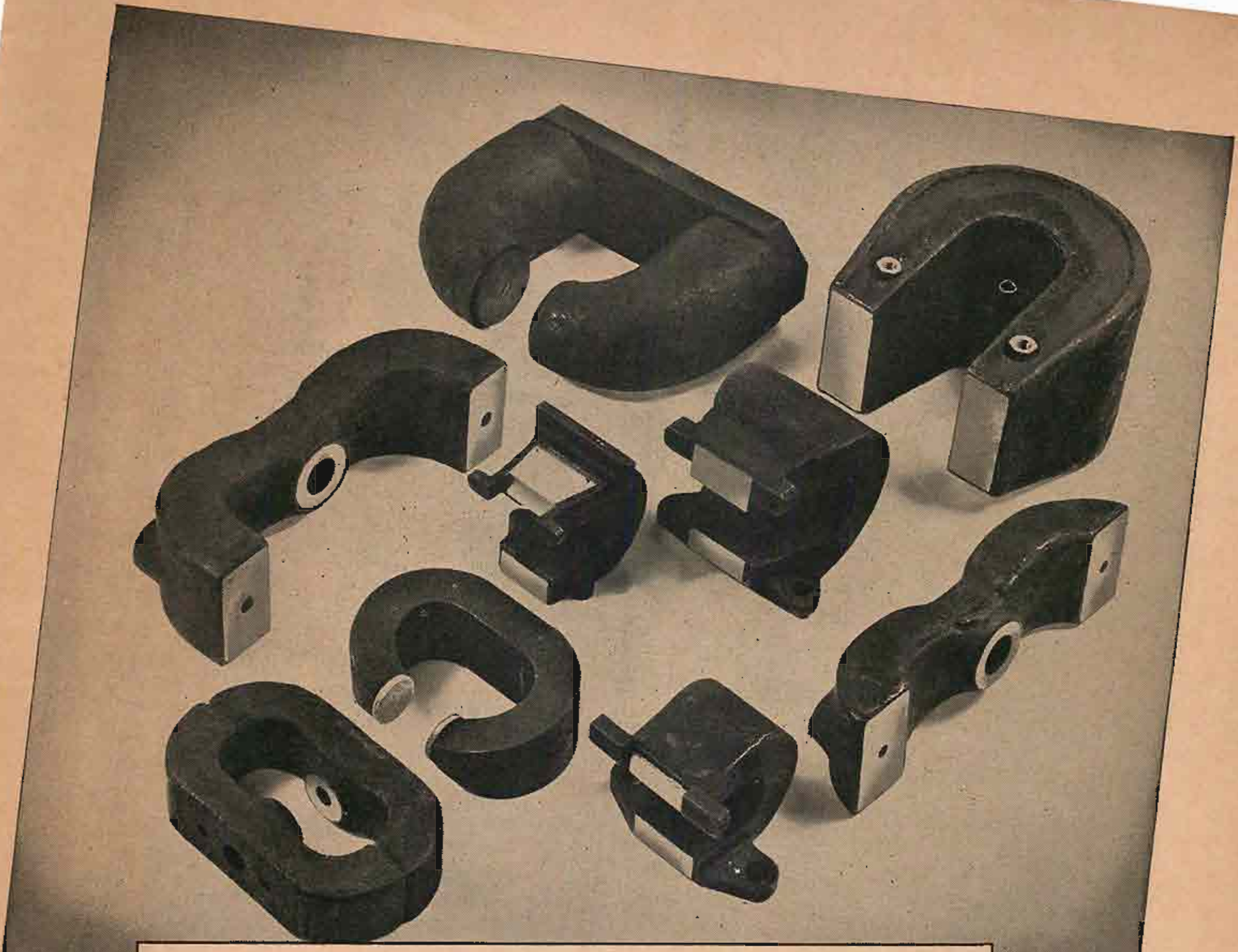
The plate-supply voltages for the oscillator will affect the pitch. Voltage for V_1 is taken directly from the supply through load resistor R_3, but that for V_2 is taken from a voltage-divider network R_4–R_5–R_1. To compensate for tube aging and for replacement tubes with slightly different characteristics R_4 is variable and is used for retuning. The first section of the V_2 grid resistance, R_6, is also made variable so that inter-note intervals can be touched up. This is possible because it is percentage change in grid resistance that determines the intervals and a change in a portion of the resistance will affect all the percentages.

To make it possible to have only one capacitor in the frequency determining circuits the grid of V_1 and the plate of V_2 are direct-coupled. This puts the grid V_1 at a positive potential equal to that of the plate of V_2. To bring the V_1 grid-cathode potential to the desired point the cathode is placed across a voltage divider R_7–R_8 between B-plus and ground. The output waveform of the oscillator, not mentioned in the patent, is probably roughly sawtooth. It should be possible to control the waveshape to a large extent by choosing suitable values for R_7 and R_8.

To get rid of clicks and thumps when the instrument is keyed, a simple and effective time-delay circuit is used in the first amplifier stage V_3. A voltage divider R_9–R_{10} across the B-supply places the cathode at a positive enough value to cut off plate-current flow. The cathode is connected through R_{11}, R_{12}, and R_{13} to a second free contact on each key switch so that when the key is pressed the switch first grounds a pitch-determining resistor and then grounds the cathode through its resistors. Capacitors C_4 and C_5 make the network a two-section time-constant filter, so that there is a gradual rather than sudden build-up of plate current when a key switch grounds the cathode through the resistors. Obviously, to obtain much of a delay the resistors must be fairly large, which means that R_{10} must also be large so that the series value of R_{11}–R_{12}–R_{13} will be enough of a shunt to lower the bias appreciably. A switch across R_{13} permits the total resistance of the delay network to be reduced for faster attack when desired.

An additional diagram in the patent shows a complex filter through which the tone may be passed after amplification to obtain a variety of colors. Any other suitable filters, such as those used in the Baldwin Organ, Minshall-Estey Organ, Organo, Solovox, and similar instruments, could be used. A third diagram shows a vibrato oscillator, but here again any arrangement for varying oscillator plate-supply voltage at about 6 cps will work well.

A copy of this or any other patent may be secured from the Commissioner of Patents, Washington 25, D. C., for 25¢.



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LETTERS

Likes Stereos

Sir:

I was much interested in the two stereo pairs on pages 20 and 21 of the January issue of Æ. I had little trouble in getting the desired results. It seems to me that such pictures could be used to good advantage in a technical magazine.

R. E. Kerney,
Alburnett, Iowa

Aid to Aunt Minnie

Sir:

I ran into the problem of simplified switching the last time (*most recent time!* Ed.) I rebuilt the sound reproduction apparatus in our home. The spouse had just learned to switch from phono to radio when I installed TV on the next switch position, thereby confusing her all over again. I have solved the problem on paper, and hope to soon rebuild again, (*See what we mean?* Ed.) incorporating the switching system described below:

Each program source has its own power switch, and its power plug and output plug are inserted into corresponding receptacles in a junction box having six power receptacles and six audio receptacles. In series with each power receptacle is a low-impedance a.c. relay with two pairs of contacts—one pair to energize the amplifier and another to connect the audio output of the source to the amplifier input. Tone controls are normal to all inputs, being in the input circuit of the amplifier.

As far as I know, I shall have to build the relays myself, as I know of no suitable ones on the market. Also I plan to use a solenoid on each changer—I use three separate ones—to engage the driving mechanism when the motor is turned on.

B. C. Barbee,
854 S. Fredonia,
Nacogdoches, Texas

Another Solution

Sir:

My method of solving Mr. Snively's problem is to control everything from one panel of the control center, with relays being housed in the lower part of the cabinet.

Each unit is switched on and off by a small 10,000-ohm DPST surplus aircraft relay, using d.c. to prevent noise and to keep a.c. circuits out of the preamplifier. The rectifier is on the line all the time, but draws an infinitesimal current through the bleeder. I use a two-wafer switch, with one wafer switching the audio circuits and another energizing the relays, which feed a.c. power to the amplifier through one pair of contacts on each relay, and to the individual input source through the other.

Thus the only operation required is to turn the selector switch from off to the desired program source. After the equipment warms up, the radio—for instance—is tuned at the tuner whose dial is lit, and the gain is controlled at the master loudness control on the control center.

This circuit has been in constant use for three years without any trouble, and it has proven to be very simple for non-technical people to operate.

Fred Paget,
356 5th Ave.,
Redwood City, Calif.

(*Two solutions—you pays yer money and you takes yer choice.* Ed.)

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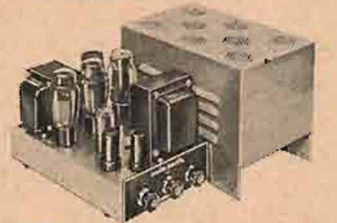
MODEL 4 LH—The basic amplifier of medium gain for use with tuners and as studio monitors, etc. Expressly designed for tuners incorporating bass and treble controls and pre-amplifier stage for phono. Tube compliment, 1-6J5, 1-6SN7, 2-6L6G, 1-5U4. Size 7"W x 8"H x 11" L. Net price **$64.00**

MODEL 4—Same as above with with remote control panel on which is located a master level control, four position selector switch, and a low level listening control designed to allow full round, rich tone at whisper levels. Tube compliment 1-6J5, 1-6SN7, 2-6L6G, 1-5U4. Size as above.

Net price **$68.00**



MODEL 3—Same as 4 LH but with an additional 1-6J5 for the bass and treble boost controls which are incorporated. Size same as Model 4 LH.
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Model 50PG. 10 Watt Amplifier with built-in pre-amp. Range: *20-20,000 cps ± .5 db (± k db 30-20,000 at 10 watts). Distortion: Harmonic 1.5%, Intermodulation 2%, at 10 watts. Hum and noise 80 db below output. 4 inputs.
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BELL AMPLIFIER Model 2122

Superb performance and excellent quality at a popular price! Ideal for reproducing the extended range of microgroove records and FM broadcast! Has separate bass and treble tone controls. Frequency range ±¾ db from 30 to 15,000 cps when controls are set for flat response. Hum level: —65 db below rated output of 10 watts with less than 3% distortion. 4 inputs; Radio or Tuner, Crystal Pickup, and 2 Magnetic Pickups, each with built-in preamplifier. Output impedances: 3.4 to 4 ohms, 6 to 8 ohms and 15 to 18 ohms—matching most high fidelity speaker systems.

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VM Model 950 GE With magnetic cartridge. Top quality Automatic 3-Speed Record Changer. It plays All Records—All Speeds, All Sizes, All Types, and STOPS AUTOMATICALLY after the last record is played, regardless of size or type! It is extremely simple to operate, having only ONE CONTROL KNOB for all functions: Features Automatic Set-Down Selection for all size records, including 7", and Automatic Manual Control (No Adjustments required). Plays 12-10", 10-12", or 12-7" records automatically—10" and 12" discs may be intermixed if same speed.

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EDITOR'S REPORT

AUDIANA AGAIN

If one were to pick up a few letters at random from those received in this office, one would gather that subscribers wanted (1) more technical articles, (2) more less-technical articles, (3) more record reviews, (4) less record reviews, (5) more articles about broadcast and other professional equipment, (6) no articles about professional equipment, (7) more articles about hearing aids, (8) more articles about home equipment —in short, more articles about everything.

Nobody but nobody, to borrow a phrase from a well known department store's advertisements, can please everybody all the time. Maybe if we were able to make Æ into a 500-page issue every month we could. However, we are not complaining—we wouldn't have it any other way. Our only course is to try to give our readers what they ask for—interspersed with what we think they ought to like.

But one thing that has been more and more obvious the last year is the desire for some articles which can be understood by the lay reader—and to that end we are reactivating Audiana, beginning with this issue as noted below. Henceforth it will be farther back in the magazine, but for its reintroduction it is here, right up front where everyone will see it. Many readers will remember Audiana from 1950, with a simplified discussion of the problems of sound reproduction in reasonably non-technical language. Experimentally, the new Audiana will "translate" the more important of the technical articles into more understandable terms, and sooner or later *all* readers will be on the same plane and nobody will have to read Audiana any more.

Of course, there was one reader who suggested that those to whom many of Æ's articles were not readily understandable might better follow his example—he studied up elsewhere so he *could* understand us. We can't agree with his viewpoint entirely—many simply do not have the time to learn a new subject from the ground up.

And so, while we are broadening our scope to include more of the interesting aspects of audio, we will still continue to carry the technical articles which have long been the backbone of Æ—those which have put Æ in the compilations of important articles on audio every year since the first issue. After all, there are many readers who wouldn't be satisfied without something new to build every month. Frankly we can't see how they can keep up with the procession of how-to-build-it articles, but since we have the same inclinations ourself, we can certainly appreciate their viewpoint.

SIMPLIFICATION

This simplification is in the direction of getting Æ each month. Beginning with the March issue, Æ will be on newsstands in eight of the larger cities of the country, and it will be simpler for readers to get it. Æ will still be available at your favorite jobber's, and perhaps regular buyers should leave the newsstand copies for new recruits to this interesting field.

AUDIANA

Design of Compensated Volume Controls

The ear does not hear all frequencies with the same sensation of loudness when they are reproduced at the same sound intensity or pressure. Loudness is a term used to identify how loud a sound appears to our ears, in contrast to sound pressure which is an absolute measurement. For example, if we were to attend a concert, we would hear a certain ratio between the sound produced by a clarinet and that produced by a bass viol. Each has its characteristic loudness in the ensemble. But when this same music is reproduced in our living rooms, it is rare that it is played at the same volume; and when we reduce the volume, we change the apparent character of the music. The ratio between the clarinet and the viol has changed, even though the reproducing system may be perfectly flat—that is, with a frequency characteristic which is identical with that of the original sound source.

The actual result of the ear's deficiency is primarily to decrease the apparent bass when music is reproduced at a volume level lower than the original performance—a condition which has been noticed by any listener who has heard music reproduction at a very low level. Considerable scientific effort has been expanded to analyze this effect, with the result that it is possible to predict just how much bass boost must be added to make the reproduction sound like the original, even though it may be much lower in absolute sound pressure.

We are generally accustomed to listening to a radio or phonograph at a sound pressure of 70 to 75 db above the threshold of hearing, at those times when we are actually paying attention to the music, and in the average living room. At a concert, we hear the music at a considerably higher level. In order to make the low-level music sound just like it does in the concert hall, we must therefore boost the low frequencies. This may be done by means of the bass-boost control, but it is more conveniently done by so constructing the volume control that it is done automatically. Thus when the volume control is turned well up, we hear the same volume as in the concert hall, and with the same frequency response —that is, flat. When volume is turned down, the bass is boosted automatically, due to the construction of the control itself. The author has discussed the technical aspects of this control, describing various methods for effecting the compensation as correctly as possible, and in an economical manner.

Loudspeaker Damping with Dynamic Negative Feedback

When we tow a trailer behind an automobile, we normally use a solid connection between the two vehicles, and the trailer follows closely the speed and direction changes of the car. To obtain high quality sound reproduction, the cone of a loudspeaker should follow the vibrations of the microphone diaphragm which picks up the original sound. In other words, there should be a tight coupling between the two.

However, such is not actually the case, and the speaker cone does not follow perfectly because of some flexibility in the "coupling," but acts somewhat like the trailer would if it were drawn by a long spring instead of by a solid drawbar—it would lag when the car started quickly, and it would crowd up against the car when the latter slowed down. The use of negative feedback in the amplifier tends to stiffen this spring, but still does not make it a solid connection. It is as though the solid drawbar were attached to one end of a lever mounted on the trailer while the other end was connected to the solid part of the trailer by a spring. This spring represents the resistance of the voice coil of the speaker, which can not be dispensed with. Now if we can connect another spring at this same point on the lever and extend it back to a point on the drawbar, the flexibility of the coupling will be greatly reduced.

The circuit connection described by Mr. Childs does just about that, and a large part of the flexibility of coupling between the amplifier and the speaker cone is absorbed by the addition of what the author terms "dynamic" negative feedback—the term dynamic denoting the ability to *change in proportion* to the amount the cone deviates from following the amplifier signal.

WHAT SPEECH INPUT FACILITIES WILL YOU NEED

10 years from now?

Vision into the future is a major requirement in good audio engineering to determine what speech input facilities will be as useful five or ten years from today as now. Certain is the fact that whether video or radio, broadcasting of the future will require more and more studio facilities.

We designed the SA-40 console with the future uppermost in our thinking.

Ultramodern today is the GATES SA-40 speech input console, generously equipped to fulfill the needs of video and radio stations for many years to come. It is known as the console with the extras — extra circuit and switching facilities, extra quality in construction and extra serviceability for maintenance.

If you are planning a studio installation today — think of tomorrow and then think of GATES. Write for your copy of the Gates SPEECH INPUT CATALOG and then study the functional block diagram therein and see for yourself why, if you are planning for the future as well as today, your needs can be best fulfilled by investing in the GATES SA-40 console of tomorrow.

GATES SA-40 CONSOLE

The SA-40 console is constructed in rugged tilt-back cabinet or available in matching desk (desk not illustrated). All amplifiers are individual units, quickly removable without disrupting remaining circuits; mixer keys of standard PBX type for long life; panel of lifetime anodized aluminum; key knobs in varied colors for circuit identification; beautifully streamlined. Size: 48 inches wide, 21 inches deep, 14½ inches high.

FACILITIES

Nine mixing channels; five preamplifiers; complete cue, talkback and override facilities; cue type turntable attenuators; and terminals for external patch panel, only a few of the many SA-40 features. Space for two additional preamplifiers provided.

The tilt-back-to-service feature of the SA-40 console provides complete accessibility of all components and terminal connections.

EXCLUSIVE TERMINAL FEATURE ASSURES FLEXIBILITY

Unusual flexibility of operation is provided by bringing many of the circuits such as preamplifier outputs, mixing channel inputs and program and monitoring amplifier inputs to terminal strips. These are, in turn, bridged to other terminals and back into the normal circuit. This permits breaking any major circuit in the console for a patch panel extension.

Front view of rack mounted power supply for SA-40 console. Heavy cast aluminum housing 19″ wide, 8¾″ high, 11″ deep, is designed to provide front panel servicing.

PERFORMANCE DATA

DISTORTION	Less than 1% from 50 to 15,000 cycles overall from microphone to program line. 2% from microphone to monitoring amplifier output.
NOISE	From preamplifier input measured at minus 60 Dbm. to program line measured at plus 8 Dbm. 65 Db. below output level. All other circuit combinations equal or superior.
RESPONSE	Within 1.5 Db., 30 - 15,000 cycles.

GATES

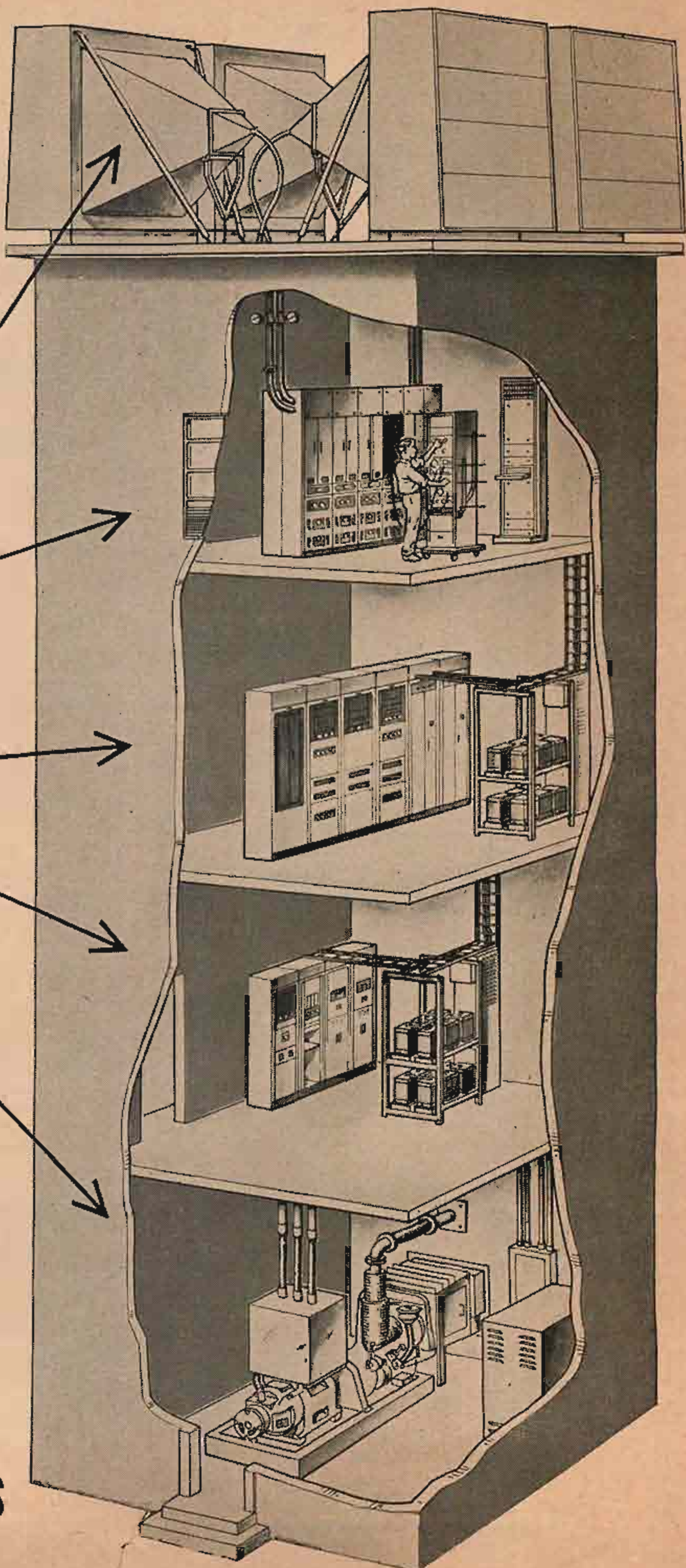
GATES RADIO COMPANY, QUINCY, ILLINOIS, U.S.A.

MANUFACTURING ENGINEERS SINCE 1922

2700 Polk Avenue, Houston, Texas • Warner Building, Washington, D. C. • International Division, 13 E. 40th St., New York City
Canadian Marconi Company, Montreal, Quebec

What's inside a *Radio-Relay* station?

Because microwaves travel in straight lines and the earth is round, there are 123 stations on the transcontinental television route between Boston and Los Angeles. This view of a typical unattended station shows the arrangement of the apparatus which amplifies the signal and sends it on.



ON THE ROOF are the lens antennas, each with its horn tapering into a waveguide which leads down to equipment

ON THE TOP FLOOR, where the signal is amplified, changed to a different carrier-channel and sent back to another antenna on the roof. Here are testing and switching facilities. Normally unattended, the station is visited periodically for maintenance.

ON THE THIRD FLOOR are the plate voltage power supplies for several score electron tubes.

ON THE SECOND FLOOR are filament power supplies. Storage batteries on both floors will operate the station in an emergency for several hours, but

ON THE GROUND FLOOR is an engine-driven generator which starts on anything more than a brief power failure.

Anything that happens—even an opened door — is reported to the nearest attended station instantly.

Coast-to-coast *Radio-Relay* shows again how scientists at Bell Telephone Laboratories help your telephone service to grow steadily in value to you and to the nation.

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Loudspeaker Damping with Dynamic Negative Feedback

ULRIC J. CHILDS*

A further study of the effect of introducing some current feedback in an amplifier to counteract the varying impedance of the loudspeaker. The author gives a practical circuit which is adaptable to any feedback amplifier.

AUDIO ENGINEERING has gone a long way since the day when any amplifier with an extended frequency range was considered to be "high fidelity." However, a number of misconceptions still remain. One of them is the question of loudspeaker damping—reduction of overshoot and lag of the speaker cone caused by its inertia, especially at low frequencies when cone excursion is large and the period between impulses is long enough to allow noticeable wave trains to exist. Because only the initial pulse of the wave train is caused by amplifier output signal, the remainder of the movements create signals that are entirely spurious and are detectable as muddiness in the music.

Negative feedback has been widely used in the last few years to lower the internal impedance of the amplifier so that the signal generated by the loudspeaker as a motor during its overshoot is short-circuited by the amplifier, and the same dynamic braking effect is obtained as though a motor armature were shorted with the field excited. However, as Warner Clements pointed out in the August, 1951, issue of Æ, there is still a considerable resistance in series with the "short circuit"—the comparatively large internal ohmic resistance of the voice-coil winding itself. Thus ideal dynamic braking is quite impossible with negative feedback of the usual type, since, even with a zero amplifier internal impedance, the average 16-ohm speaker voice coil still places about 10 ohms in the series circuit.

There are two possible methods of achieving perfect or nearly perfect damping in a loudspeaker. The first, obviously only a theoretical possibility, is to use a speaker whose voice-coil wire has no resistance. The second, suggested by Clements and explored in greater detail by the writer, is to add a new type of speaker-control network. The amplifier may be made so sensitive to the movements of the speaker that when the speaker tends to overshoot, the amplifier output is automatically reduced to cancel the overshoot; when the cone lags the signal the output is increased to make the speaker follow the excitation signal. This is done by controlling the inverse feedback present in the system so that it is largely dependent on the behavior of the speaker and varies from instant to instant.

* *1601 First Avenue, New York 28, N. Y.*

Although Clements chose to call this kind of feedback positive it is speaker-controlled *negative* feedback, and because its value is dynamic rather than fixed, *dynamic negative feedback* seems to the writer to be an appropriate term.

Equivalent Circuit

Figure 1 is the equivalent circuit of an amplifier with or without ordinary negative voltage feedback. If the negative feedback is high, the value of the amplifier internal impedance R_a which appears in series with the amplifier as an ideal generator G_a, is low, and the output voltage at the amplifier terminals does not vary greatly between load and no-load conditions.

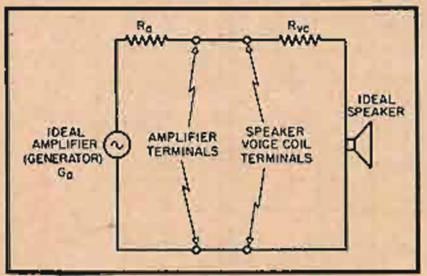


Fig. 1. Equivalent circuit of output-transformer secondary and loudspeaker in idealized system.

The ultimate in this type of design would be reached when $R_a = 0$, but this is impossible by ordinary means. However, even with a zero internal amplifier resistance, the internal resistance R_{vc} of the voice coil remains and is a severely limiting factor in the "short-circuit" current available for damping.

The ideal solution as a basic idea is quite simple: the voltage generated by the speaker due to overshoot, for example, must be applied independently to the amplifier in such a way that it will appear at the amplifier output terminals in the correct phase and at the correct amplitude to restrain the cone from overshooting. Stated in another way, the output of the generator G_a itself must be controlled by the speaker within wide limits of phase and amplitude so that the circuit will cancel R_a and R_{vc}. The speaker then looks back into an impedance of zero ohms and is perfectly damped.

Examination of this scheme indicates that under no condition can speaker damping be perfect. Using a philosophy applicable to any closed-loop control system, no error correction can be had until an error exists, since the error is necessary to create the correction signal. A more cogent limitation is oscillation, which must exist if damping is perfect. However, the method can be used within limitations to obtain improvement in speaker performance which is obvious to the discriminating listener.

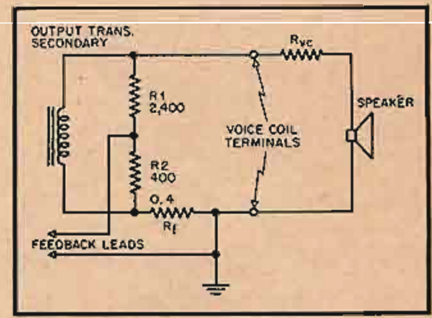


Fig. 2. Circuit which can be adapted to any feedback amplifier to provide improved damping.

Practical Circuit

Figure 2 shows a basic circuit used to obtain dynamic negative feedback. It is similar to the Clements circuit, but the *net* feedback is not positive. R_1 and R_2 are a voltage divider across the secondary of the amplifier output transformer. The feedback lead is connected to the junction of R_1 and R_2, with ground at right of the current feedback resistor R_f. The voltage across R_2 due to the output signal is, of course, in the same phase as that from the output transformer, while the voltage drop across R_f due to signal current is in opposing phase with respect to the junction of R_2 and R_f. The net voltage appearing across the feedback leads is therefore that of R_2 minus the R_f drop. Because the voltage across R_2 is much greater, the net feedback voltage is in the same phase as the amplifier output voltage. It is fed to an early stage at the correct point to make it *negative* feedback.

When the speaker overshoots it generates a voltage 180 deg. out of phase with the signal voltage. This counter-e.m.f. causes a reverse current to pass through R_f, reducing the existing signal drop across R_f. The result is an increase in voltage across the feedback leads, an

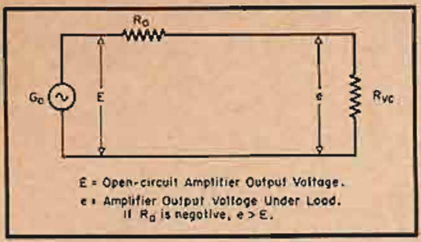


Fig. 3. Equivalent circuit to show effect of complete cancellation of voice-coil resistance by means of feedback.

increase in negative feedback to the amplifier, and a drop in amplifier output voltage.

The negative feedback is dynamically controlled at each instant by the current through R_f in such a manner as to cause the amplifier output to counteract the spurious actions of the speaker cone; the degree can easily be controlled by varying the value of R_f—the larger the value the greater the corrective effect.

Even with quite small values of R_f, the effective amplifier internal resistance may be zero or even negative. An overshooting (high-resistance) speaker causes increase in negative feedback and decreased output voltage; a lagging (low-resistance) speaker causes less negative feedback and more output. This contradicts Ohm's Law, according to which the output voltage of a generator with internal resistance falls as the load resistance decreases. This means that the internal amplifier resistance R_a is negative. It is still amenable to Ohm's Law except, that instead of causing a voltage drop, R_a causes a voltage *rise*, the amount of which depends on the value of the negative resistance.

The corrective effect may theoretically be raised as necessary to compensate exactly for all spurious movement in the speaker. In this case the effective internal resistance of the amplifier would be negative and exactly equal in magnitude to the sum of the R_{vc}, R_f, and any transformer secondary resistance. Regarding the speaker as an ideal zero-resistance generator in series with the voice-coil wire resistance, the generator would look back into a genuine zero impedance and, in effect, would be perfectly braked dynamically. Such a condition is, however, impossible of attainment, even in an amplifier with no phase shift at any frequency, because oscillation would result, as shown by the following demonstration.

Figure 3 is an equivalent circuit of the amplifier, consisting of zero-resistance generator G_a and internal resistance R_a, connected to a load R_{vc}. Assuming that R_a has a negative value, as would be necessary if it were to cancel out as much as possible of R_{vc}, the amplifier output voltage will rise when the load is connected. The load voltage e is therefore higher in amplitude than the open-circuit voltage E, and the output regulation of the amplifier may be expressed in db at 20 log e/E. Then

$$e = E\frac{R_{vc}}{R_{vc}+R_a}$$

and rearranging to find the ratio

$$\frac{e}{E}=\frac{R_{vc}}{R_{vc}+R_a} \qquad (1)$$

Eq. (*1*) may now be used to find the regulation with any desired amount of R_{vc} being cancelled out by a negative value of R_a. The result, if expressed in db, is a negative number since the regulation is opposite in direction to ordinary positive regulation, i.e., the voltage rises instead of falling when a load is applied.

If one-half the value of R_{vc} is to be cancelled, then

$$R_a = 0.5R_{vc}$$

$$\frac{e}{E}=\frac{R_{vc}}{R_{vc}-0.5R_{vc}}=2=(-)6\ db.$$

For example, if the speaker voice coil

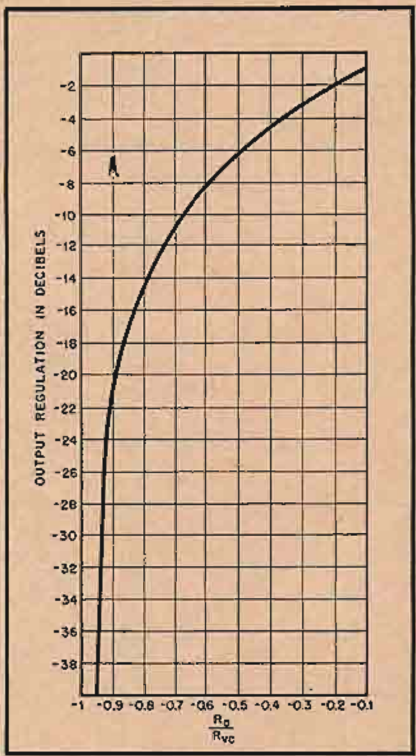


Fig. 4. Curve showing output regulation for varying ratios of amplifier output impedance to speaker voice-coil impedance.

resistance is 10 ohms and the internal resistance of the amplifier is made –5 ohms to cancel half of R_{vc}, the amplifier output voltage will rise 6 db between no load and full load.

To obtain complete cancellation of R_{vc}, $R_a = -R_{vc}$. Then

$$\frac{e}{E}=\frac{R_{vc}}{R_{vc}-R_{vc}}=\frac{1}{0}=\infty \qquad (2)$$

which means that adding any load whatever, no matter of how high a resistance, causes a rise in output voltage to infinity, which is oscillation. Therefore, it is obvious that perfect damping simply cannot be achieved.

But additional figures on this same subject are of interest. How far is it practical to go? How well *can* a speaker be damped with dynamic negative feedback? The graph of *Fig.* 4 was prepared by using Eq. (*1*) and converting the resulting voltage ratio to db. It shows what the output regulation of the amplifier must be in order to cancel given portions of R_{vc}. Note that to cancel as much as 0.8 R_{vc} the regulation must be –14 db. The decibel regulation figure indicates how much of the negative feedback in the loop will be cancelled when the dynamic negative feedback circuit is used. Thus, to cancel 8/10 of R_{vc}, this loop must have sufficient negative feedback from the junction of R_1R_2 of (*Fig.* 2) to keep net feedback negative even when a large portion of the negative feedback is removed for use in correcting spurious speaker cone movement. The figure for negative decibel regulation becomes inordinately large as the damping is increased, approaching infinity toward perfect damping, as shown in Eq. (*2*).

It appears, therefore, that only a limited amount of dynamic negative feedback may be used with the very best practical amplifiers, both for the reason just mentioned and because too great a figure causes the designer to run into severe difficulties with oscillation due to phase shift and response nonlinearity at extreme frequencies, even those far above and below audibility.

The Childs amplifier, which the writer has designed (and redesigns from time to time) and constructs for use in better-quality custom installations has flat frequency response to around 100,000 cps and down to 10 cps. About 3 db of dynamic negative feedback has been incorporated in recent models with no danger of instability and with noticeable improvement in the already impressive performance. Even so, intermodulation distortion at the 15-watt level rises from 0.1 per cent to 0.2 per cent.

The graph of *Fig.* 4 and Eq. (*1*) are additionally useful to the designer for measuring the dynamic negative feedback caused by a particular value of R_f in *Fig.* 2. Each time the value is changed, the open-circuit and loaded output voltages of the amplifier may be measured and converted to decibels. Reference to the graph will then indicate what portion of the speaker's internal resistance has been cancelled. Knowledge of the speaker's resistance will, of course, indicate the exact value in ohms of the internal resistance of the amplifier.

Perfect Damping Impossible

The above proof that perfect damping is impossible may be somewhat puzzling in view of Clements' statement that it could be obtained, accompanied by apparent verification with an oscilloscope and a square wave measurement. The error made by Clements was in assuming that an oscilloscope placed across the actual voice-coil terminals could indicate motion of the speaker. The following simple demonstration shows that it cannot do so and that there is, in fact, no practicable way of depicting on an oscilloscope what the speaker cone is doing without the use of fairly elaborate acoustic measurements under ideal conditions or possibly a special type of bridge circuit.

In *Fig.* 5, (A) and (B) show the amplifier output circuit and the speaker, each equated to an equivalent circuit. The amplifier becomes a zero-resistance generator G_a with internal resistance R_a in series, and the speaker consists of another ideal generator G_s with internal voice-coil resistance R_{vc}. (C) shows the amplifier connected to the speaker with a 10-ohm potentiometer R in series with the two and an oscilloscope connected between the zero-voltage reference point (ground) and the arm of R. The purpose of the demonstration is to show that for any value of negative amplifier resistance we can cause the oscilloscope to show no voltage generated by the speaker, giving us a false impression that the speaker is generating no spurious-movement voltage. The only requirement is that we must be able to place the above-ground lead of the oscilloscope at any desired point on the internal resistance of the speaker. Since it is impossible to do this, we have added R, which is merely additional voice-coil resistance placed out in the open so we can get at it.

The circuit is again a simple voltage divider as shown in more conventional form at (D). We are not interested in amplifier signal but only in speaker-generated voltage, so G_a may be considered as simply a short circuited element for the moment.

The voltage in the circuit appears in two phase relationships 180 deg. apart—Phase A being the positive speaker-generated voltage, and Phase B being the negative voltage appearing across the negative resistance of the amplifier R_a. If the speaker is ringing due to insufficient damping on a square wave it may be seen on the 'scope if it is connected across either a positive or negative voltage. In the former case the actual voltage generated by the speaker will be seen; in the latter the counter-voltage generated by the dynamic negative feedback will be seen, with the

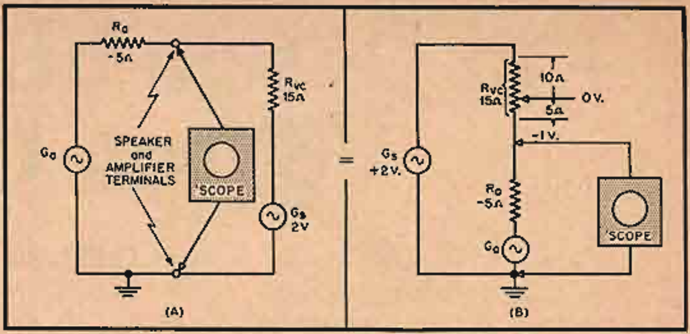


Fig. 6. Equivalents for further study of 'scope indications.

"wriggles" atop the square wave in reversed phase. With the 'scope across zero volts, however, neither is seen, but only the square-wave signal put out by the amplifier. If the amplifier is a good one, the signal will appear to have flat tops.

The total resistance around circuit (D) of *Fig.* 5 is $5 + 10 - 5 = 10$ ohms. Since the speaker is generating 2 volts we may say that each 5 ohms drops 1 volt (and each −5 ohms drops 1 volt in the opposite phase).

If the 'scope is connected between ground and point A it will show

$$E_R + E_{Ra} = 2 - 1 = 1 \text{ volt positive.}$$

Thus the 'scope is showing the speaker-generated voltage (Phase A) less a certain amount of correction voltage (Phase B), the resultant giving no useful information.

If the 'scope is connected to point B, it shows E_{Ra}, which is −1 volt. This is the correction voltage (Phase B) and it will show the "wriggles" in reversed phase. Since the points above and below R are respectively at +1 and −1 volt, when the arm of R is at the center, as shown, the 'scope will show no speaker-generated or correction voltage at all and the square wave will appear to be flat. However, the fact that the indication varies with the 'scope connection is proof enough that the appearance of a flat-topped wave is no indication of good speaker performance where there is resistance between G_s and either 'scope lead.

(A) in *Fig.* 6 is a similar circuit, this time showing an ideal speaker G_s with an internal resistance R_{vc} of 15 ohms and the 'scope connected across the speaker terminals. This duplicates the scheme used by Clements to adjust feedback. Redrawing the circuit in conventional voltage-divider form at (B) and finding the voltage across the 'scope by the same means as before, the 'scope shows −1 volt (Phase B), i.e., 1 volt of correction signal. It could be made to indicate zero by going into the voice coil and connecting it to the tap on R_{vc} labelled 0 volt, but this is an obvious impossibility.

It should be clear by now that in order for the 'scope to indicate zero, it must be connected at a point where the speaker-generated and the correction voltages cancel and produce zero. In the case of a perfectly damped speaker this point would be the terminals of the ideal speaker G_s which are hidden from access. It should also be clear that with the 'scope set at any point it can be made to indicate zero by adjusting the amplifier output impedance R_a but such an indication *will not indicate what the speaker is doing.* A third interesting point is that the 'scope cannot indicate zero when connected directly across the amplifier output terminals (across G_a and R_a in series) which is in practice also across the speaker terminals (G_s and R_{vc} in series) unless the balanced voltages are zero at that point, which means that amplifier output resistance R_a must be *zero*—not negative and not positive. Thus when Clements adjusted his amplifier in this way, he adjusted it only for zero resistance at the output terminals. The fact that voltage rose with connection of a load could only have indicated that the value of R_a was just enough negative to cancel out only the resistances of the output transformer and of R_f, not that of the voice coil.

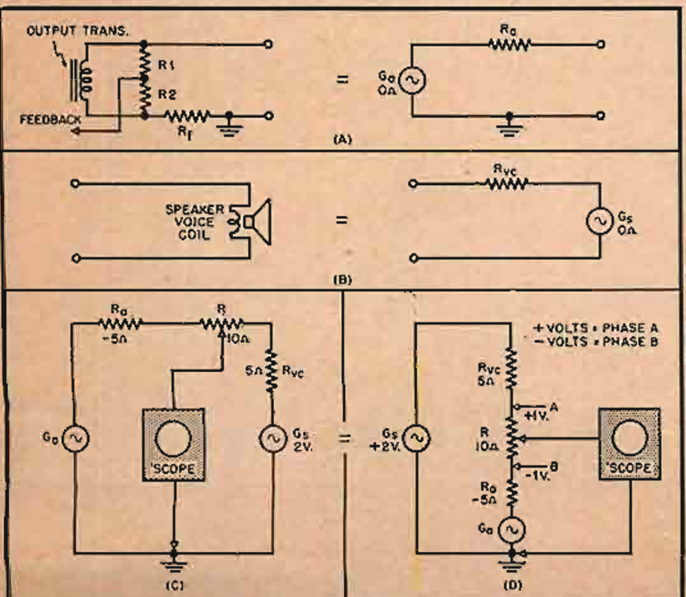


Fig. 5. Equivalent circuits for study of 'scope patterns as a measure of the effectiveness of output impedance cancellation.

Adjustment of Circuit

The difficulty of measuring the actual speaker performance is no real handicap, since adjusting the value of R_f the current feedback resistor does not require such measurement. It is impossible to approach perfect damping anyway and the limiting factor in practice is oscillation due to phase shifts. Even if the limit were the oscillation demonstrated by *Figs.* 3 and 4 and Eq. (*1*), the adjustment still would not be made to an optimum point but toward a maximum beyond which it would be impos-

[*Continued on page 33*]

The Design of Compensated Volume Controls

EMERICK TOTH*

Part 2. A study of the psychoacoustic considerations involved in designing a control which is practical in construction and adequate in performance.

All sorts of separate bass-boost amplifiers and other more complex and expensive schemes are possible, of course, but the happiest solution all around is probably to combine the low-frequency compensator with the usual volume-control potentiometer at the input to the audio amplifier for simultaneous one-knob operation. This makes it possible to avoid any large initial insertion loss caused by the compensator circuit and puts its volume control effect to good use by combining it with the volume control proper. With appropriate proportioning of amplifier gain and input, this combination will also insure a degree of automatic bass compensation which probably represents a reasonable compromise in favor of best theoretical average adjustment, as against individual misuse of an independent control.

Such a combined control has been used in one particular form, as at (B) of *Fig. 7*), in many receiver designs over a period of about twenty years, affording some, but usually not enough compensation. This form, as well as that of *Fig. 6*, is based on the fundamental compensator circuit of (A), *Fig. 7*. As the slider of potentiometer R_1 moves down toward R_2, the output voltage becomes more nearly the potential drop existing across capacitor C_1. R_2 is the limiting factor which determines the maximum high-frequency attenuation and, together with C_1, the upper limit of frequency compensation ($T = R_2C_1$, and $f_c = \frac{1}{\pi T}$ at +1 db from flat response). This circuit is simple and approaches a maximum of 6 db compensation per octave below f_c; unfortunately, as in *Fig. 6*, it has the fatal defect of not allowing the volume control to reach essentially zero output level, because R_2 must have a rather high finite value (about 1/20 of R_1). This difficulty can be overcome in inexpensive fashion by shunting R_2C_1 to ground with part of potentiometer R_1, which then also provides a d.c. grid-return path. The result is the familiar tapped volume control circuit of (B), *Fig. 7*. The response obtained with typical values in such a system is shown in *Fig. 8*. The compensation is not very close to the theoretical values of *Fig. 5* for two reasons: (1) R_2C_1 is shunted by a fixed value of resistance (from the potentiometer tap to ground) which is generally too low and which consequently seriously limits the rise in voltage across C_1 at the lower frequencies; and (2), the compensation remains fixed at all potentiometer slider positions below the tap.

* *Radio Techniques Branch, Radio Division II, Naval Research Laboratory, Washington, D. C.*

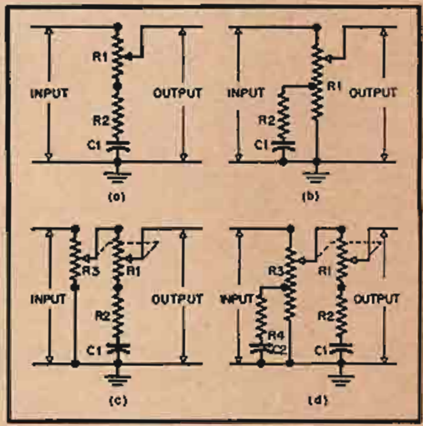


Fig. 7. Bass-compensation input circuits.

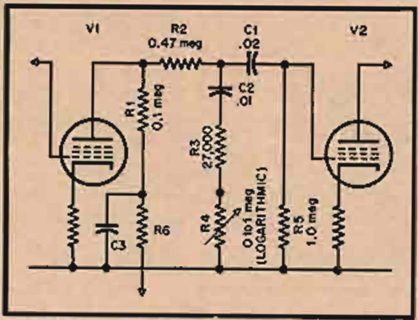


Fig. 6. Interstage bass-compensation circuit.

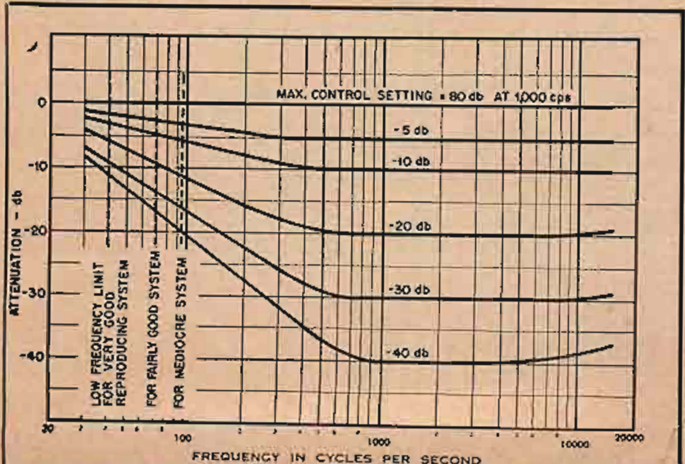


Fig. 5. Theoretical response of volume control compensated to 80-db standard.

Improved Tapped Bass-compensated Volume Control

The performance of this type of control can be improved by a departure from the usual design. Present designs generally have the tap at ½ or ¼ of the total resistance relative to the grounded end, at a point physically about 1/3 of the rotation from ground. It would be better to have the tap at about 20 per cent rotation from ground, with the resistance of tap to ground equal to at least the value from tap to high end. Each section should theoretically have as close to logarithmic taper as feasible, if approximately constant attenuation of sound pressure in decibels per degree of rotation is satisfactory. Linear attenuation in terms of loudness sensation will require a different taper. The tap-to-ground section, however, can be linear without serious disadvantage, since its main function really is to allow the slider to reach ground for "zero" output. Proper choice of values will enable such a control to have about 40 db of attenuation at a substantially constant rate of db per degree in the first counterclockwise 80 per cent sector of rotation. The remaining 20 to 40-plus db, which is usually seldom used, would be concentrated in the last counterclockwise 20 per cent of rotation. Typical values might be: $R_1 = 1$ megohm, tapped

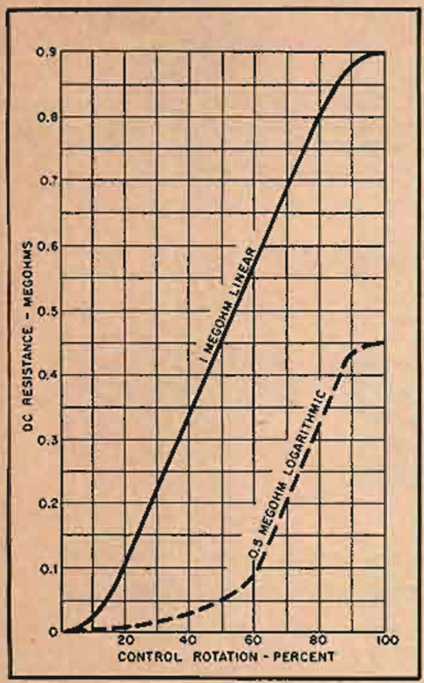


Fig. 10. D.c. resistance of ganged control elements of dual control circuit.

at 0.5 megohm at 20 per cent rotation from the low end; $R_2 = 27{,}000$ ohms; $C_1 = 0.01$ μf. The 0.5-megohm resistance shunting R_2C_1 would affect compensation at frequencies below about 60 cps.

A more expensive but generally better way of overcoming the low volume limitation of the basic circuit of (A), *Fig. 7*, is to add a linear voltage divider section ahead of it. Potentiometer R_3 in (C) accomplishes the purpose of reducing the output to "zero" in the region where R_2 prevents the slider of R_1 from reaching ground potential. The limitation on the low-frequency compensation afforded by this circuit to less than 6 db per octave maximum is primarily due to the reduction in signal current through branch $R_1R_2C_1$ at the lower frequencies. This takes place as a result of the rise in reactance of C_1 with decreasing frequency with a proportionate diversion of current through the lower shunt value of R_3 at reduced volume settings. It is also feasible to include high-frequency compensation in this network, as shown in the circuit diagram of *Fig. 9*. Here the 0.22 meg. and 150 $\mu\mu$f RC combination is used to minimize the drop in response above 5000 cps which is evident in *Fig. 8*. The output loading on both circuits for the measurements was a vacuum-tube voltmeter of about 50 $\mu\mu$f input capacitance and 2-megohm resistance. The 15-$\mu\mu$f capacitor from the high end to the slider of the second (0.5 megohm) potentiometer is used to produce the increasing high-frequency boost with increase in control attenuation required by the curves of *Fig. 5*.

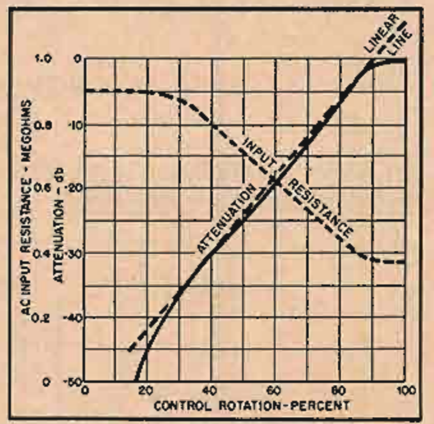


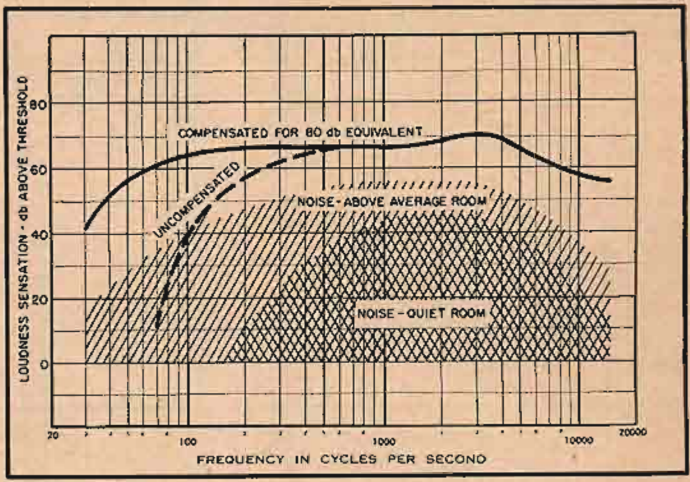
Fig. 11. 1000-cps calibration and input resistance of dual compensated control circuit.

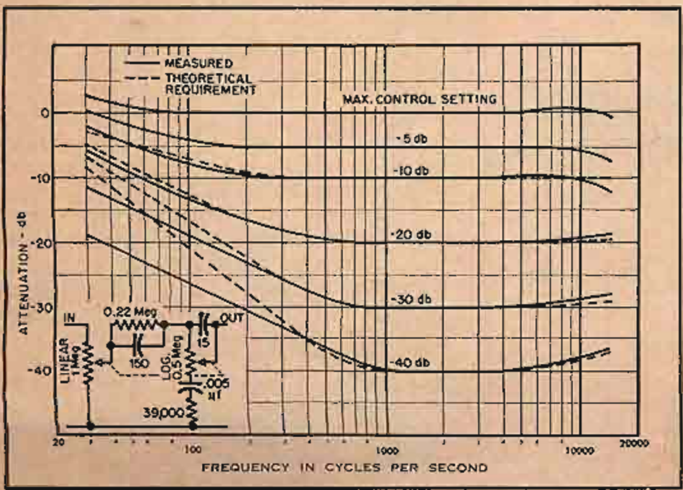
The curves of Fig. 9 were obtained with an input generator resistance of about 0.12 megohm, to simulate a median value of detector-circuit or phonograph-pickup-circuit impedance. (The generator was about 20,000 ohms in the measurements of *Fig. 8*). The low-frequency compensation is quite good, down to about −30 db control setting. Good control of high-frequency compensation is indicated. The input potentiometer should have a linear resistance taper, while the input potentiometer should be logarithmic if linear sound pressure variation is acceptable. The resistance characteristics of the nominal 1-megohm linear and 0.5-megohm logarithmic ganged controls used in getting the data for *Fig. 9* are shown in *Fig. 10*. The 1000-cps input resistance and the attenuation characteristics over the control rotation range are shown in *Fig. 11*. The rate of attenuation in signal voltage or sound pressure is constant within ±1 db over a range of 40 db, covering about 65 per cent of the total rotation or about 1 db per each 5 deg. for 200 degrees of rotation. This curve is also within 3 db of being linear in terms of loudness sensation at 200 cps, which is about the median frequency of maximum sound pressure in voice and music.

Still better compensation may be obtained by tapping R_3 as shown at (D) in

[*Continued on page 30*]

Fig. 12. Response of dual compensated control with gain adjusted for 50-db sound pressure at 1000 cps.





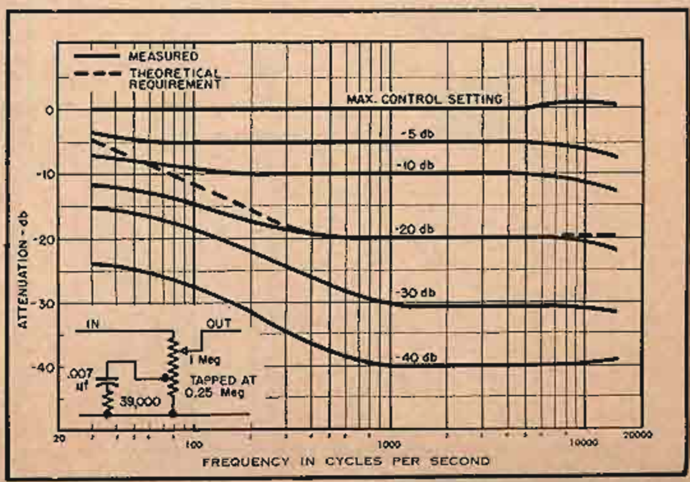


Fig. 8 (left). Response of typical tapped compensated volume control. Fig. 9 (right). Response of dual compensated control circuit.

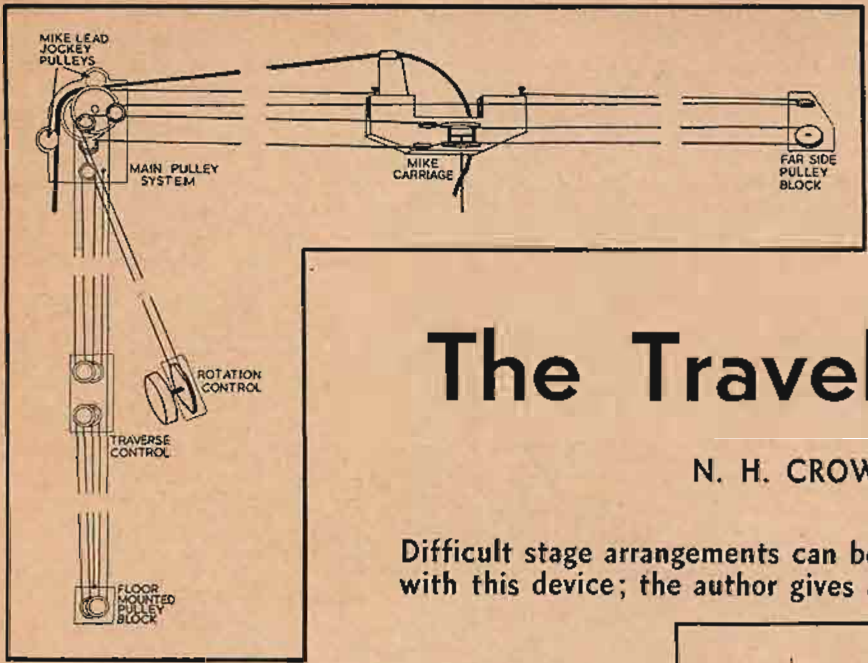


Fig. 3. Diagram of the complete pulley and cord system. (Spindles and other mountings, and also the tensioning arrangements, have been omitted in the interests of clarity.)

The Traveling Mike

N. H. CROWHURST*

Difficult stage arrangements can be covered easily from the wings with this device; the author gives adequate constructional details.

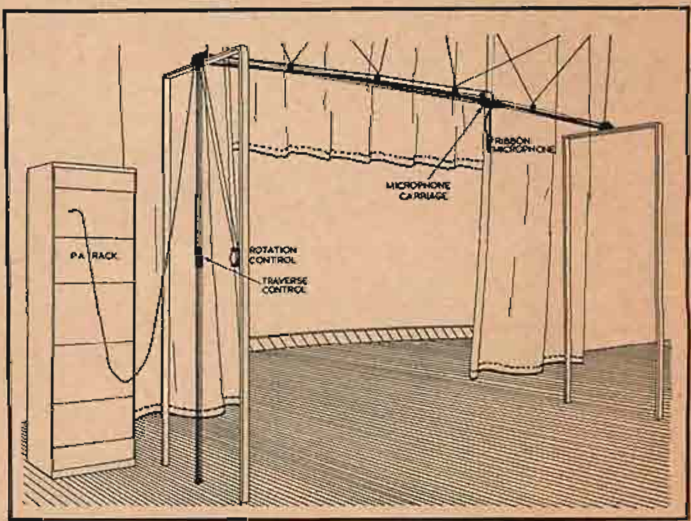


Fig. 1. General view of the traveling mike system. The mono-rail is supported at its ends by the vertical "trestles," and intermediately by the steel wires from overhead anchorages.

SEVERAL WAYS can provide the necessary coverage for sound reinforcing equipment in theatres and halls where sound pick-up is required from a stage of considerable area. Most of them involve the use of several mikes, but there are disadvantages in having several mikes "live" at the same time: One mike, appropriately placed can work with higher gain setting than a group arrangement before acoustic feedback sets in; and the multiple arrangement suffers some loss of quality when the artist occupies an "overlap" in the areas served by two mikes. The traveling mike here described overcomes these disadvantages, and is simple to construct.

The mike used is of the bi-directional ribbon type. This particularly suits dialogue pick-up, if placed between the artists so they speak to opposite sides of the mike. The traveling arrangement, combined with the ability of rotating the mike head, enables the mike to be placed at its best position quite readily. It is very useful in picking up dialogue from two people walking across the stage, and for various other scenes where the centre of interest moves about. Instead of the actors' having to modify their acting to suit the mike arrangement (which they seldom do successfully anyway), the mike can be moved about to suit the act. Everyone who has worked in this field will immediately appreciate the advantage.

The mike is fixed in height. The height chosen will depend to some extent on the height of the stage proscenium. The mike must be high enough to clear artists' heads safely, also it should not protrude too far below the overhead curtaining, so as to divert attention when moved. Generally the best height will be related to the size of the building.

Travel across the stage is achieved by mounting the mike on a carriage running on a mono-rail. Two "endless" cords running alongside the rail provide the means of control. One pulls the carriage back and forth along the rail, while the other rotates the mike by means of a

[*Continued on page 35*]

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

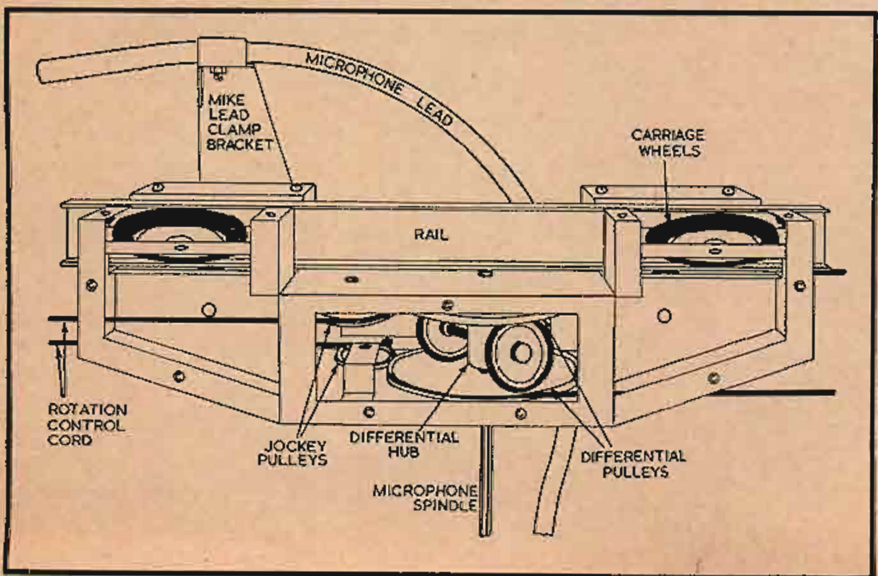


Fig. 2. The microphone carriage with one side-cover removed to show the arrangement of the differential rotation control system.

Linear-Scale A-F Wattmeter

C. G. McPROUD

Amplifier testing with an intermodulation distortion analyzer is considerably speeded up if power output can be read directly in watts on a linear-scale meter. One solution is presented by the author.

Fig. 1. Intermodulation analyzer built by the author for use in making series of amplifier distortion measurements, and in new equipment development.

INTERMODULATION-DISTORTION testing has been proven of sufficient value that most amplifier ratings are considered incomplete unless they are included. Since Æ begins a series of equipment reports in the next issue, such measurements were deemed necessary, and accordingly a simple IM analyzer was constructed, following the design employed in the instrument described over a year ago.[1] However, as will be apparent to anyone who has had occasion to make a number of such measurements, the amount of IM distortion should be plotted against power output in watts, and the conversion of an output voltage to watts involves considerable figuring, in addition to close interpolation of meter indications to take readings at 1-watt intervals. Accordingly, some means to indicate watts directly, preferably on a linear scale, was desired, and efforts made to develop one.

Power output from an audio amplifier is generally calculated by using the formula

$$P = \frac{E^2}{R}$$

with E being measured across the load resistor, R, which is selected to match the output of the amplifier under test. While an a.f. voltmeter could be calibrated in watts, the scale would be crowded at the upper end.

After discussing the problem with C. J. LeBel, who suggested that a thermocouple ammeter had a deflection proportional to the square of *current*, the use of such an instrument was investigated. Consider for example, the use of a 2-amp. thermocouple meter. Power may also be calculated by the formula $P = I^2R$, so a 2-amp. meter would give a full-scale indication equivalent to $4R$ watts. Thus for an 8-ohm load resistor, full-scale deflection would represent 32 watts, and for a 16-ohm load it would represent 64 watts. These ranges are about what would be suitable for measurement of the output power in amplifiers usually considered desirable for home music systems.

[1] John M. van Beuren, "Simplified intermodulation measurements," AUDIO ENGINEERING, Nov. 1950, p. 24.

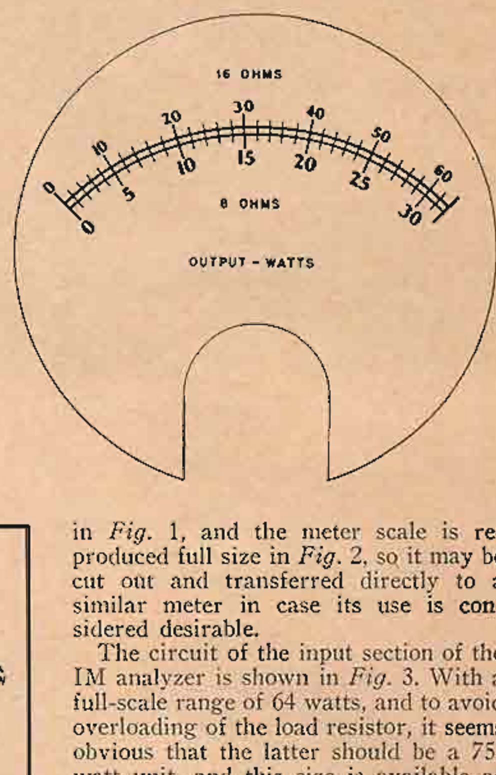


Fig. 2. Meter scale for use on 2-amp. G. E. thermocouple meter with calibrations directly in watts output for 8- and 16-ohm loads.

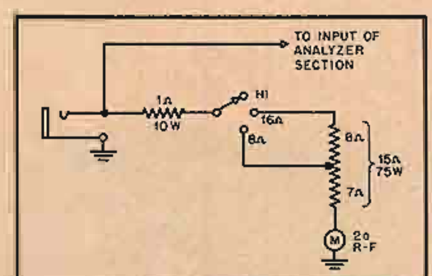


Fig. 3. Input circuit of IM analyzer modified to accommodate load resistor and direct-reading a.f. wattmeter.

Meter-Scale Configuration

Inspection of various r.f. meters shows a range of scale distributions. For a truly linear current-square scale, the mid-point of the current scale for a 2-amp. meter should be 1.414 amps., and one instrument found to meet this requirement is the 3-inch General Electric instrument. A new scale was hand drawn, with calibrations of 0 to 64 watts above the scale arc, and 0 to 32 watts below the arc. The two scales were labeled 16 ohms and 8 ohms respectively. The completed IM analyzer is shown in *Fig.* 1, and the meter scale is reproduced full size in *Fig.* 2, so it may be cut out and transferred directly to a similar meter in case its use is considered desirable.

The circuit of the input section of the IM analyzer is shown in *Fig.* 3. With a full-scale range of 64 watts, and to avoid overloading of the load resistor, it seems obvious that the latter should be a 75-watt unit, and this size is available as an adjustable 15-ohm resistor. The resistance of the meter (with its internal shunt) is of the order of 0.2 ohms, so it may be neglected. Since a 20-ohm resistor would not pass 2 amps. within its rating, and since a 16-ohm resistor was not available, a 10-watt, 1-ohm resistor was added, as shown, to make a total of 16 ohms. The switch is marked with three positions—HI is for use when measuring IM distortion in voltage amplifiers where a load resistor was not to be used, and 16 and 8 ohms where it was required. This arrangement provides the greatest facility of measurement, as proven by considerable use of the instrument.

One caution is important. Thermo-

[*Continued on page 37*]

Audio in the Home

William C. Shrader*

Converting a commercial radio-phonograph into a custom installation usually starts with the replacement of the record player and the addition of an FM tuner. The author tells you how.

Custom building has become quite a complex field. For purposes of simplicity, we shall discuss only one of its aspects in this article—the transition from commercial to custom sets. There is a large business in this field alone, if it is handled properly. For instance, it is estimated that it will take about 15 years for a complete transition to LP, even at the present rapid rates. Many people who would like to have a custom installation already have expensive consoles representing a considerable investment which they do not want to "write off" entirely. Commercial consoles, designed for the mass market, put a premium on space, but it is imperative that their owners recognize these pieces of furniture as a great asset. Custom equipment—a tuning device, an amplifier, and a three-speed record player—may be housed in such a cabinet with a modest cash outlay. Since it is the desire for three-speed record players that leads most music lovers to improve their existing sets, and since, in turn, a better record player creates a desire for improvement in the other components, we shall begin with a discussion of their installation.

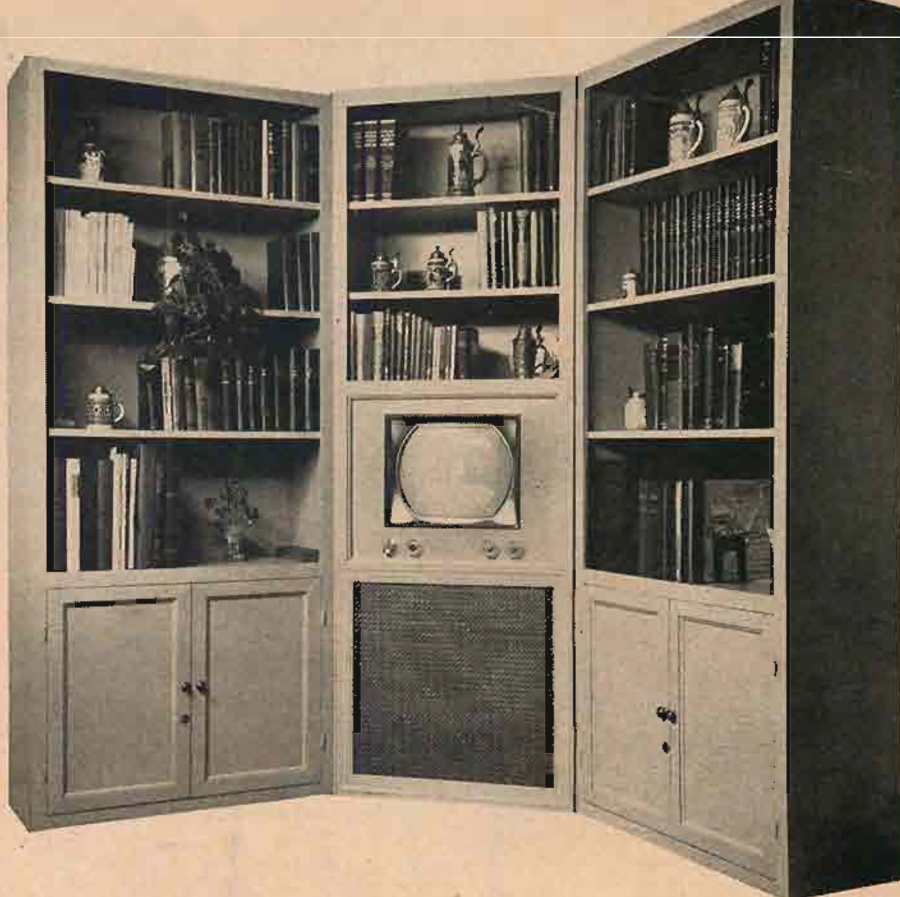
The Garrard RC80 and the Webster-

Typical home installations made by the author, again showing that the finished appearance is limited only by the imagination of the homeowner.

*President, Shrader Manufacturing Co., Inc., 2803 M Street, N.W., Washington 7, D. C.

Chicago 106-27 are the most satisfactory changers now on the market. Each model is designed for magnetic pickups—which are most desirable—but these require more amplification than is available in an ordinary radio. To overcome this, a pre-amplifier may be added. This sometimes sounds relatively easy. However, we have encountered several difficulties in installations of this type, notably the hum induced into magnetic pick-ups from the stray magnetic fields around power transformers and chokes. Turntable motors used in some changers do not lend themselves to use with extended range cartridges at all because of their excessive rumble.

Fisher and GE make the most satisfactory pre-amplifiers at a low price, and both may be obtained with built-in power supply to simplify installation. By attaching the electric cord to the same outlet as the record changer, no additional power is drawn from the transformers, and hum problems are minimized. In attaching magnetic pickups and pre-amplifiers to an existing radio, all networks of resistors and capacitors must be removed from circuits between the phono input of the radio and the volume control.



Where price is an important consideration, two GE cartridges—one for LP and one for standard, and each properly weighted—make an excellent combination, preferably with a diamond stylus for the LP. Shrillness may be encountered on LP records unless each cartridge is terminated with proper resistance. It is suggested that the GE LP be terminated with a 6800-ohm 1/2-watt resistor, and that the standard be terminated with a 15,000-ohm 1/2-watt resistor. In plug-in heads, such as used with both Garrard and Webster, these can be mounted right across the cartridge.

Pickering cartridges work best with their own pre-amplifier in combination with the 132-E Record Compensator, and with this set-up, no terminating resistors are necessary. When used with the GE pre-amplifier, a voltage divider should be installed between the compensator and the pre-amp. Such a voltage divider should consist of a 3900-ohm series resistor and a 6800-ohm shunt resistor to ground installed inside the pre-amp for the standard cartridge, as shown in *Fig.* 1. For the LP, an additional resistance of approximately 3900 to 5000 ohms—depending on personal taste and the other components in the system—may be placed across the pickup head.

With the exception of the Audak, dual cartridges are undesirable, and while the Audak works perfectly well with the Garrard, it is not recommended with the Webster because of hum from the motor. The Audak is the most successful of the dual cartridges because of its weight compensations. Although it could work with two grams on LP, eight grams are required for proper operation on 78's, and this is considered the optimum weight for a dual cartridge. It is a very convenient cartridge, especially for housewives. A table of termination resistor values is furnished with each cartridge, and these values may be used quite successfully with either the GE or Fisher pre-amp. The Pickering pre-amp has insufficient

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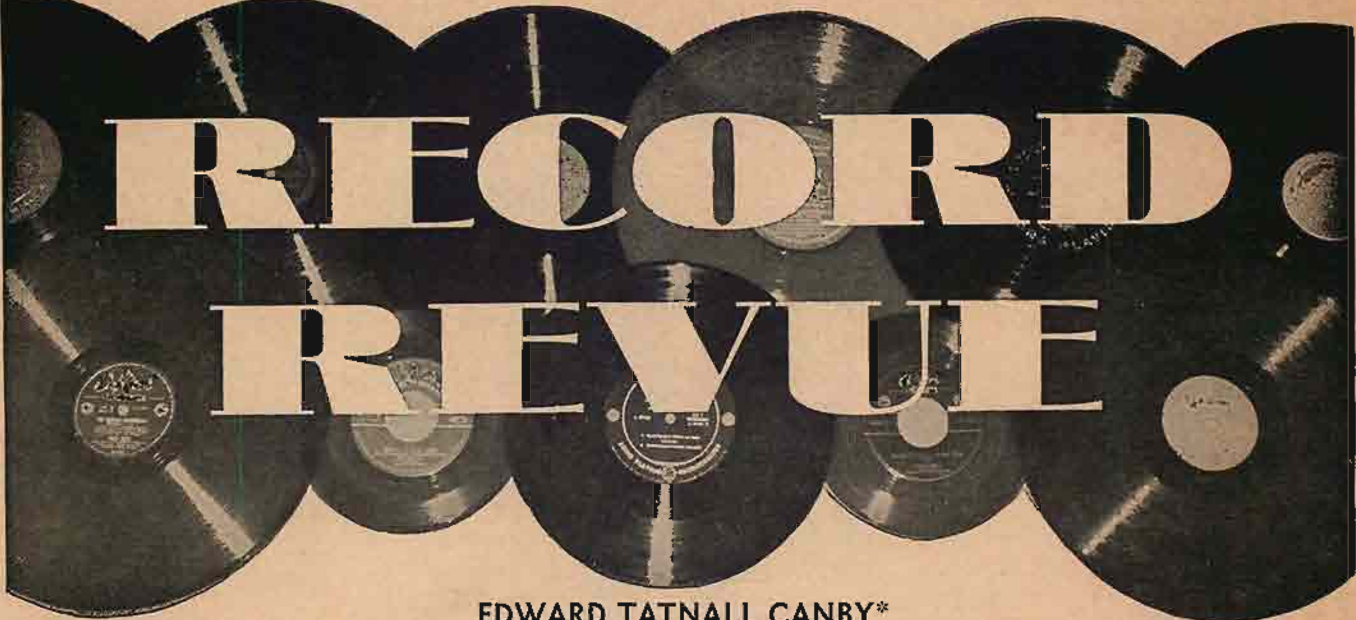

RECORD REVUE

EDWARD TATNALL CANBY*

"So-called Audio Engineer"

"THE MAIN PURPOSE of this letter," writes a radio listener to me, "is to tell you how happy I felt when you advised your listeners to 'open up your treble and bass' for the Schubert Octet LP. It so happens that the day before Thanksgiving, my long-anticipated hi-fi set was delivered and I have been in ecstacy ever since."

A happy sort of letter to introduce this month's discussion and I'll quote more of it in a moment, because this "hi-fi" convert expresses himself in a way that should be interesting to all audio makers and electronic experts—here is a fine laboratory specimen (if he will pardon me) of the very best type of audio fan, the person who takes up audio specifically because of what it can do for his music.

It still is a source of astonishment to me how many people are crazy over audio, yet quite apathetic towards the music it makes possible, or even downright antagonistic towards it! For every comment I get on improved musical effects, I run into dozens about improved highs, better transients, middles, lows, and so on, with never so much as a mention of the music in which these improvements (or faults) occur. One might, not knowing the situation, conclude that many an audio fan played nothing on his expensive equipment but audio tone records. Not true, of course. And yet how many people think of the music?

Walking Audio Analyzer

I'll have to admit immediately that the audio engineer's business is audio, and the more technical the better. I have long since found that my ear is not too trustworthy as to analyzing specific distortions, dips, peaks, etc. because I have too much trouble detaching myself from the music in order to listen specifically to the sound itself. I tend to hear *through* the sound, on into the music, which definitely interferes with my efficiency as a walking audio analyzer. I hear the performer, or more often the composer himself. Like looking through a clean —or dirty—window pane, transmitting a clear—or distorted—scene. It is clearly an expert art to be able to ignore the musical "scene" and focus the ear on the transmitting process itself which, ideally, should be aurally transparent and therefore inaudible.

Ultimate Consumer

But let's not get ultimate objectives mixed up with the means towards those objectives. The objective of better audio is, 99 per cent of the time, better music. And th final judgment on better audio is to be found in terms of music itself. And so I continue to quote from the above letter. This is what I mean by judgment in musical terms of an audio improvement.

"Part of the joy (of my new set) is due to your recommendation of the —— amplifier. I had my set assembled and cabineted at one of the jobbers so numerous in New York . . . (and) since Thursday I have enjoyed my records more than ever . . . and my FM programs. My outfit, actually a modest one in the atmosphere of $500 speakers and ultra-expensive amplifiers, is superb to me. Aside from the very adjustable —— amplifier, I have an —— FM-AM tuner (*N.B. I'm not giving plugs; the make is not significant in this situation! E.T.C.*), quite satisfactory if a bit thin on the bass end, a defect remedied somewhat by the amplifier bass-boost. The speaker, which I chose out of four or five I heard, is a 15-in. ——, giving sublime results.

"Of course I hear passages on my favorite records which I never knew existed, especially triangles, bells, and the like. The Polka from the Age of Gold by Shostakovitch, on that early 7-in. Columbia, is my pet demonstration record to shock friends with. And it feels so good to hear the stinging 'cello stab, in the first movement of the London disc of Beethoven's 15th Quartet. The Scherchen Haydn symphonies, and Mass in B Minor are extraordinary . . . they shocked me on my old set, but they throw me to the floor with this one.

"Toscanini's Brahms' First on Victor's 78's is monstrous in sound and my friend brought his old 78 of Toscanini's Beethoven 5th which rocked the walls, 8H and all. Naturally, Bach's 3- and 4-Harpsichord Concerti on Haydn Society are brilliant-er than ever, and Weiss-Mann's Italian Concerto on Allegro sounds like two symphony orchestras (a marvelous disc indeed, though quite unnatural).

"So as you see, I'm quite excited, and my house, always a haven for my friends, will be even more frequented by those that want to hear their Ansermet Sacre de Printemps and the like. Unfortunately, the neighbors shan't relish my new found joy."

Bet you were fooled by that. The man is no technical expert on music at all and his reactions are definitely not in professional musical terms. He's a listener, like you and me, a person who knows a lot of music by ear and has picked up plenty of his own knowledge concerning listening; his musical repertory is big. But he's an amateur, in both music and audio; and that, may I suggest is our man! Here is the true user of audio, to his and audio's greatest advantage.

Less Lovely Side

If all letters were as enthusiastic as the above, the audio business could congratulate itself on a job beautifully done. I'm bound, then, to quote a sad representative from a less lovely side of the audio area. This sort of thing goes on entirely too much. It ought to be stopped, for the good of us all. Granted there are plenty of potent problems in putting fancy technical equipment in the hands of those who know nothing about it. Nevertheless, we cannot stand, any of us, for the taking-advantage-of-babes-in-the-woods that is epitomized by this miserable hi-fi addict. I am acutely embarrassed, as will every reader be.

"I am a lover of good music and it means a lot to me to hear such music properly reproduced, over FM and phonograph records, since my wife and I don't go to any live performances.

"Many months ago, being a layman and not knowing better, I bought some expensive high-fidelity equipment from a so-called audio engineer. I realized too late I was spending too much for my pocket. I sold all the equipment save a 16-in. turntable with magnetic cartridges and a diamond styli. The table was held for me by this 'audio engineer' until recently in his store room. It is supposed to be a new machine yet the speed regulator was found to be on the *blink. I can't get satisfaction* from the above person . . . the manufacturer has not

[*Continued on page 22*]

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

answered a card I sent them on this several months ago.

"At present I have a high fidelity set which I bought from another so-called audio engineer many months ago. To this day the FM is much too bassy and not enough highs while the phono is fine on the highs but there is no bass response from it. I stopped dealing with the 'audio engineer' involved because, over the months, he kept promising to adjust the set and each time he either had some excuse for not coming or just didn't come at all.

"I also found that he was dishonest with me. He claimed that the set had a —— amplifier, but the name is nowhere in sight on the amp or preamp, and neither looks exactly the same as the present model on the market. He claimed he sold me a —— changer with a synchronous motor. I found out there is no such animal.

"All in all, I have been over-charged for a set that is not working properly. I am loaded down with surplus expensive equipment to sell, and I have been victimized by unreliable and dishonest 'audio engineers.' Can you put me in touch with a reliable 'audio engineer' who won't charge too much to make the necessary adjustments on my set?"

The tragedy of the above (and plenty of similar cases) is that, obviously, there is nothing seriously wrong with his equipment except perhaps the turntable speed control. "Too much bass," "thin highs"—these are, nine times out of ten, simple matters of equalization or matching; a magnetic cartridge is being used unequalized, or a crystal is fed into a preamplifier intended for magnetics, etc. Perhaps there is more trouble here, but I doubt it, having run into this sort of thing a thousand times before.

Perhaps the man is a grouch. (I don't know him.) Perhaps he is all wrong and his "engineers" all right But the evidence doesn't make it look that way, and I can assure you this letter stands for thousands of other helpless users who, because of utter lack of any audio knowledge, are agonizingly frustrated for months on end when a half hour's tinkering could fix things up to their eternal delight. Not a good situation at all, quite aside from the possible fraud being perpetrated by the "so-called audio engineers" involved. The turntable mentioned here is very expensive and should definitely operate correctly and professionally, to the best of my knowledge. The company's customer liason must be singularly poor. The changer, one of the standard makes, does have a "synchronous" motor like every other fixed-speed model; the implication is that the engineer was suggesting that the motor was something very special—a hysteresis motor, for instance—and he probably asked a special price for it on that score. If so, it was fraud. The whole deal, as they say, smells.

Better Business

The weakest aspect of the whole rapidly expanding home audio industry today is this twin business of installation and maintenance. The large distributors have done an excellent job, mostly mail order style, in simplifying installation and the initial choice of components; service is evidently possible through them too, if the ailing equipment can be mailed or shipped. The big-city radio outlets with their new sound-salons and the like also seem to do a good direct-sale job on the choice and installation end at least.

But the "so-called audio engineer," a lone-wolf operator (or even, perhaps, a company), taking advantage of customer enthusiasm and ignorance, is a real menace to

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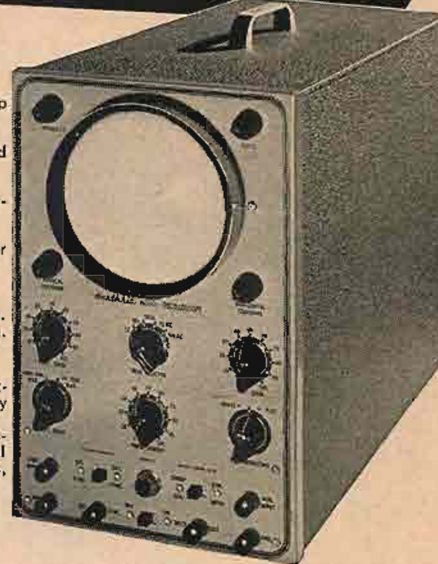

- New "spot shape" control for spot adjustment — to give really sharp focusing.
- A total of ten tubes including CR tube and five miniatures.
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All parts come right with kit, and complete instruction manual makes assembly a cinch.

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the whole field. So too, in a way, is the well meaning friend, amateur, or professional, who "loads down" the bewildered music lover with stuff he doesn't know how to use, then dodges the problem of making it work. Incalculable damage is done to audio's reputation by every instance of this sort of operation.

It's not for me to organize some sort of guidance in this area, but I strongly suggest that a "better business" committee or equivalent be set up in the audio industry to begin the huge job of regulating, by constructive suggestion or by force, the unscrupulous or misguided activities of those who sell audio too fast and too loosely. Unethical practices are rampant, I'd say, and opportunities are at hand everywhere, what with "high fidelity" a big appeal and knowledge of it abysmally low. But plain confusion is even more widespread.

Where can a purchaser of good equipment go for regular maintenance and repair service? What sort of guarantee should apply to composite outfits sold as complete packages? What service policy, if any, should an outlet offer on its components? How can we educate the average radio repair man to the point of servicing our better equipment? How can we placate him on the loss of a "list" sale when equipment is brought in from outside sources—as is almost universally the case these days? Important questions, if the name "audio engineer is to remain in public good standing.

Speech on LP

Romeo and Juliet—Margaret Webster Production. Eva Le Gallienne, Dennis King, Richard Waring. **Atlantic #401 (2)**

Shakespeare almost complete and an excellent production, in the traditional manner, the top roles good, the recording wide range and plenty clear. Modified Tchaikowsky for bridges and background, plus simple sound effects.

Romeo and Juliet Excerpts; Soliloquies from Hamlet; Five Sonnets. John Gielgud; Pamela Brown. **Decca DL 9504**

Gielgud is highly dramatic, with much vibrato, heavy breathing; some will be annoyed, others will enjoy! Excellent speech recording, minus music. Very smooth.

The Only Jealousy of Emer. Yeats. Paula Bauersmith, Gerald E. McGonagill, etc. Music by Lou Harrison. Verse choir. **Esoteric ES 506**

Frankly, this gives me the willies. The lyric, sing-song Irish dramatics, so special and rare an expression when done right by the Irish, is here (to my ear) absurdly exaggerated, in the worst manner of a "speech class" hard at work! Stage English is scarcely understandable. Nice, if rather limited music by Lou Harrison (might be better in a more proper atmosphere). Speakers mostly too far from mike; some blasting, and highs are lacking (tape alignment?).

Selections from "The Temple" (Herbert). 14 Poems of Emily Dickenson. Read by Austin Warren. ***Idiom LP EO-LQC 12957/8**

Here's an interesting technical exposition on the nature of monaural reproduction! This poetry is read by a "perfessor," clearly a man well used to reading poetry out loud, known and revered for it, effective at it. But monaurally, via the mike, his technique is astonishingly wrong, the poetry ineffective and hard to understand.

The "live" lecturer uses a wholly different speaking technique than the radio speaker. Sudden and large changes of volume for dramatic emphasis, excellent live, are death to the mike, as are slurrings-over of weak syllables, the tendency to mumble the less important parts of sentences. Diction must be far more even, via the mike. Emphasis must be achieved entirely in the pitch level and in the significant pause. These things a

* *809 Amherst, Ann Arbor, Mich.*

platform lecturer does not know (unless he catches on almost instinctively, as some do). On this score, the perfessors must learn from the radio announcers, like it or not. The old order changeth.

. . .

Abraham Lincoln. (Poetry and Prose of Lincoln, Markham, Rosemary Benet, Vachel Lindsay, Whitman, read by Walter Huston, Carl Sandburg, Agnes Moorehead, Orson Wells. (Some with Music).

Decca LP DL 8515

. . . And here is the necessary rejoinder. Words by, and concerning, Lincoln, read in this case by a galaxy of big professionals, expert in the craft of miked speech. Old Sandburg is a law unto himself, but that law included an instinctive understanding of the mike. Huston, Moorehead do usual standard effective radio-style job (the professors won't like it much, nor do I).

Orson Welles, though, is a genius at mike technique. If you want to study genius in this special area, try his "Second Inaugural' here. Welles conceives for this reading a tired Lincoln, exhausted by the long war, not far from his own death. To do this, Welles must slur over words, read in tired voice, trail off his sentences—i.e. disobey all the rules. Yet so perfectly does Welles know his mike that his reading here is completely intelligible, to the last word, and tremendously effective. This is the "art" of mike technique—to *simulate* an effect, act it, rather than to do it literally, as does Austin Warren in the preceding listing.

Spanish Through Pictures. I. A. Richards, Ruth Metcalf, Christine Gibson. With Pocket Book. ****Ed. Svces. LP (2)**

Second in an excellent LP series of modern language courses. Reader says sentences, you repeat, while looking at same in print in accompanying Pocket Book (same title); meaning comes through silly but effective little line drawings. Much skillful repetition of key words, phrases, gradually extends your vocabulary. LP allows lots of time at low cost. (How can anyone buy one of the old 78 language courses any more!) Recording below par, but adequate for intelligibility. I've tried this set—and by golly, it works. (See also "French Through Pictures," same system; more to come.)

The Quick and the Dead. vol. i, The Atom Bomb; vol. ii, The Hydrogen Bomb. Bob Hope, W. L. Laurence, etc. (NBC Broadcasts) **RCA Victor LM 1129/30**

Another LP issue of broadcast documentary. These were long educational programs on NBC, here transcribed over four LP faces. Hope, the dope, makes foolish comments, asks dumb questions; W. L. Laurence, top journalistic expert on A- and H-stuff, does the narrating. Laurence is folksy, sincere, gives first-hand information, but he goes terribly slowly, the whole production—for radio—is astonishingly slow-paced. Excellent stuff, but for record buyers it could be a lot more adult. And about half as long, maybe. Nevertheless, don't overlook these as unique educational material.

Robert Frost Reading his own Poems. Two 10" LP's (Also 78's).

*****Nat. Council of Teachers of Eng.**

Replacing an old but good set of shellac 12-in. records, these LP's have improved quality. But Frost, being older—though he still does an excellent job—tends here to read without full conviction; he's been reading these things for so many years, time after time. Frost knows his mike, instinctively, and it shows at once. You won't miss a word here, and the material is thoroughly enjoyable, beautifully natural, homespun, unaffected. Technical work by RCA.

Illegitimate Sonnets; Clinical Sonnets. Merrill Moore reading his poetry, with commentary. ******Harvard Vocarium LP**

A genuine experiment in pure LP and significant for all who follow progress in recorded art. The poet here "ad libs" his commentary, at ease,

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*** Educational Services, 1702 K St., N. W. Washington 6, D. C.*
**** 211 W. 68th St., Chicago 21.*
***** Bus. Mgr., Harvard Univ. Libr., Cambridge, Mass.*

informally, taking his time via LP, in lecture style. The "poems," slightly eccentric, verge on the unprintable, are amusing and sophisticated—it's hard to tell them from the commentary which, in the manner of people-pleased-with-the-sound-of-their-own-voice, is considerably longer than the poetry! All in all a slightly crack-pot but convincing demonstration of what can be done with tape and LP that could never be conceived in the old 78 medium. Play it over first before you try it on the ladies.

Readings from the Bible. Ronald Colman. **RCA Victor LM 124**

The Voice of the Preacher, actor-style, Colman is an old hand at mike work and these are perfect as to intelligibility with top recording to help. But the rather affected stage style will not please those who would prefer a more genuine and simple dignity in the reading of such texts.

Gertrude Stein read by Gertrude Stein. Dorian LP DR-331

For anyone who has been intrigued by the why and wherefore of this remarkable lady, these recordings should be priceless. Stein's operatic works, as set to music by Virgil Thomson ("Four Saints;" "The Mother of Us All") gave us a strong feeling that there was something vocal and musical about Stein's writing, that she made most sense when heard, not looked at on the page; music's own kind of repetition and development of an idea, by gradual alternation, seemed to be in her words themselves. Now, with Stein reading, giving her own intonations, emphasis, it's easy to hear the same. As read by her, the stuff makes enormously more sense than it does on the printed page. Worth a try, anyhow. The recordings were issued in limited-ed. back in 1935; now, on LP, are much improved, with intelligible highs to 6000 or so, plenty for speech.

EDMUND T. FLEWELLING

Edmund Thomas Flewelling, of Ashburnham, Mass., died Sunday, December 30, 1951 following a heart attack and automobile accident of two days before. Mr. Flewelling was 64.

In telephone and electrical work since 1903—when he was 16—Ned, as he was known to his friends, naturally gravitated into radio in the early 20's, with his first contribution in this field the super-regenerative circuit which revolutionized radio reception in those days. In later years, his short-wave adaptors made possible the reception of foreign stations on standard broadcast receivers.

Since 1938, he had been doing research work on wind generators and in the field of audio, in which he brought out within the last two years a low-frequency speaker enclosure.

AUDIO IN THE HOME

[*from page 19*]

gain for GE or Audak cartridges, but it works exceptionally well with Pickering cartridges.

Most record changer manufacturers and pickup manufacturers supply sufficient information about templates for motor-board cut-outs, some even furnishing a mounting board to replace existing wood work. If a record changer installation is made properly—keeping the above considerations in mind—the music lover will be gratified by the results. The replacement of other parts of the console are more difficult and require more thought and consideration.

The next improvement which the music lover will seek nowadays is a good FM tuner, largely because of the many good music programs which are broadcast exclusively on FM. Many southern cities affected by electrical storms (to cite an example of dependence on FM for static-free reception) are now able to get noise-free reception

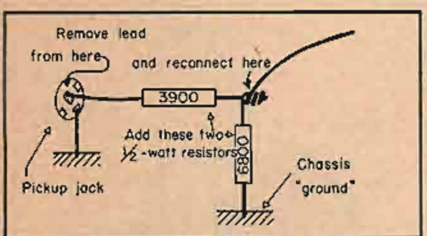


Fig. 1. Method of connecting two resistors at input of GE pre-amp to prevent overload when using with Pickering cartridge.

even from moderately powered FM transmitters, whereas 50-kw AM stations failed to cut through the noise.

Experience with most early post-war commercial sets and many FM tuners then available has left a bitter taste for many people. It is unfortunate that so many sets were sold that had no advantage over AM because of poor design. The biggest problems encountered in FM tuners are excessive drift, insufficient sensitivity, and frequent breakdowns, all of which make the FM receiver no better than mediocre table-model sets. The better FM tuners have none of these faults, however. Another cause of poor FM reception is the failure to install a proper antenna.

We could consider the Meissner 8C or 8CC the *minimum* quality for an FM tuner. With a proper antenna, this set will perform reasonably well, and will remain stable after a 15- to 20-minute warm-up perod. The latest models of Browning, Radio Craftsmen, and Brooks seem best suited to custom installations.

It is difficult—if not impossible—to install an FM set in some console models because of a lack of space on the control panel. In some cases, the set may be mounted in the record storage space, but then it is not handy to tune. The problem of mounting an additional tuner will be discussed in this column next month, along with suggestions about replacing the existing amplifier portion of the radio set in the never-ending quest for better sound reproduction.

NEW PRODUCTS

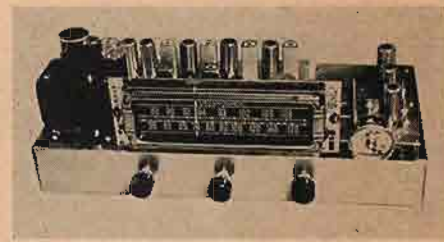
• Portable Transcription Player. Many needs of schools and industry will be served by the Model TR-16AM combination record player and public address system. Capable of handling records of any size up to 17$\frac{1}{4}$ in. diameter, the player provides operation at 33 1/3, 45, or 78 r.p.m., with a special control to provide

minor variation from the three standards. Weighted 10-in. turntable contributes to stability. Circuitry of the unit includes a built-in scratch suppressor. Standard equipment includes a GE variable reluctance pickup. Power output is 10 watts. Manufactured by Newcomb Audio Products Co., 6824 Lexington Ave., Hollywood, Calif.

• Wide Range Speaker. Exceptional dispersion of high frequencies is a feature of the new University Diffusicone-12, a 30-watt speaker designed to fill the need for a high-quality unit in the moderate price field. High-frequency response extends beyond 13,000 cps. The "diffusor" element provides dual horn loading of the speaker apex, thus substantially increasing efficiency in the upper frequency range, at the same time affording radial projection and aperture diffusion to assure

reception of the speaker's entire range of reproduction irrespective of the listener's location. Constructional features include a 1½ lb Alnico V magnet and a 2-in. voice coil. Design of the Diffusicone-12 permits replacement of either the diaphragm-basket assembly, or the magnet, in a matter of minutes with an ordinary screw driver the only required tool. A complete catalog sheet, including cabinet drawings, will be supplied free on request to University Loudspeakers, Inc., 80 S. Kensico Ave., White Plains, N. Y.

• Pre-Fabricated FM-AM Tuner Kit. A recent departure in tuner design is the new Collins "Pre-Fab" model. Made up of four wired and tested sub-assemblies, the tuner is easily completed by the user with substantial savings over the cost of a finished unit. The Pre-Fab kit is composed of (1) the FM r.f. tuning circuit, (2) the FM i.f. amplifier, (3) the AM tuning circuit, and (4) the chassis assembly which

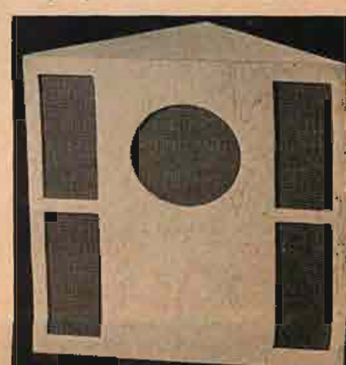


includes power supply and necessary hardware. Each unit is mounted, wired, tested, and aligned at the factory, and the same tubes used during tests are included with the kit when shipped, thus eliminating the need for intricate alignment procedures on the part of the user. Average sensitivity of the completed tuner is 6 to 10 microvolts. Physical dimensions are $6 \times 8 \times 17$ ins. Collins Audio Products Company, P. O. Box 368, Westfield, N. J.

• Miniature Audio Oscillator. Although tiny in size, the new Waveforms Model 510-B extended-range audio oscillator equals in performance many of its standard-size counter-parts. A precision instrument in every respect, it measures but $6 \times 4\frac{3}{4} \times 5\frac{1}{4}$ ins. Frequency range is 18 cps to 1.2 mc in five overlapping ranges. Constant output is within ± 0.5 db from 18 cps to 100 kc. Distortion is less than 0.2 per cent over most of useful range.

Output voltage is calibrated, and the unit is equipped with a 300-deg. vernier-drive dial. Operation with balanced output is afforded by means of Type T-10 matching transformer available as accessory. Manufactured by Waveforms, Inc., 333 Sixth Ave., New York 14, N. Y.

• Corner Cabinet Kit. A new kit which, when assembled, makes an acoustically correct folded-horn corner speaker enclosure, is the newest addition to the line of cabinetry manufactured by G & H Wood Products Co., 75 N. 11th St., Brooklyn 11, N. Y. Sold through jobbers under the company's trade name Cabinart, the



kit is remarkably low priced, and is supplied complete including cut lumber, grill cloth, hardware, plastic wood, acoustic insulation, and assembly instructions.

• **Vacuum-Tube Voltmeter.** Hickok's new Model 215 VTVM affords laboratory accuracy in an instrument designed essentially for field engineers and service technicians. Featured with the 215 is a new dual-purpose a.c.-d.c. probe with built-in switching. D.c. range is to 1200 volts with

10 megohms input resistance. Readable resistance range is 0.2 ohm to 1000 megohms with center scale reading of 10. A.c. ranges are to 1200 volts rms, and 3200 volts peak-to-peak. Input impedance is 30 megohms shunted by 150 mmf. Frequency response is 40 cps to 3.5 mc. Crystal probe is available as accessory to extend useful range to 250 mc. For complete information write to The Hickok Electrical Instrument Co., 10617 Dupont Ave., Cleveland 8, Ohio.

NEW LITERATURE

• **Tube Dpeartment, Radio Corporation of America,** Harrison, N. J. is now distributing a revised edition of the booklet titled Preferred Tube Types for New Equipment Design. Advances in tube design and application are reflected in many revisions in this latest version of an old standby in the engineering field. Copy will be mailed free on request.

• **Freed Transformer Company,** 1718-36 Weirfield St., Brooklyn (Ridgewood) 27, N. Y. is publishing in booklet form a summary of the many types of transformers and test instruments manufactured by the company, also information on the technical literature the company has available. Will be mailed free on request for "Freed Facts."

• **American Standards Association,** 70 E. 45th St., New York 17, N. Y. has approved and is distributing The American Standard Graphical Symbols for Single (One) Line Electrical Engineering Diagrams, Z32.1.1-1951. Offering for the first time a single volume in which are combined single-line diagrams for use in both power and communication work, this Standard coordinates the diagrams contained in the American Standard Graphical Symbols for Electrical Power and Control, Z32.3-1946, and for Telephone, Telegraph and Radio Use, Z32.5-1944. The Standard contains 81 sections covering symbols for almost all electrical circuits in the field of power and communication. Copy of the Standard may be obtained from the Association upon remittance of $1.40.

• **Antara Chemicals Division of General Dyestuff Corporation,** 435 Hudson St., New York 14, N. Y. has assembled in booklet form the complete story of the Company's unique product, Carbonyl Iron Powders. This booklet represents industrial publishing at its best. Lavishly illustrated and printed in many colors, it covers the manufacture and usage of iron powders in such a manner that even the most technical aspects of the subject are understandable to the engineer whose sphere of specialization may lie in other fields. A necessity irrespective of what your interest may be in electronic engineering.

VOLUME CONTROLS

[*from page 15*]

Fig. 7 and adding compensator R_4C_2. This is equivalent to combining (B) and (C). Proper choice of values and tap can yield a closer approximation to the theoretical curves of *Fig. 5*.

Apparent Loudness and Room Noise

The compensated control has the advantage of making listening easier in the presence of room noise, as indicated by *Fig. 12*. A good deal of the power in music and speech is concentrated in the frequency region below 500 cps. Compensating a 50-db-level program so that it approaches the over-all frequency response of an uncompensated 80 db average level can make the program sound much louder without increase in annoyance factor, because proper balance of bass and treble prevents the shrillness which often characterizes the uncompensated low-level reproduction of voice or music. This makes background music to meals or conversation much more soothing and pleasant.

Both the noise and the signal curves in *Fig. 12* have loudness sensation as it appears to the mind as the ordinate. The usual method of presenting room noise over the audio-frequency range in terms of sound pressure or intensity level tends to give a misleading impression of the annoyance effect of the low-frequency noise components. Fortunately, the ear responds so poorly to low frequencies at the usual room-noise intensity levels that noise such as the hum of 60-cps home machinery remains tolerable.

Listening at lower than concert-hall levels also pays another dividend besides

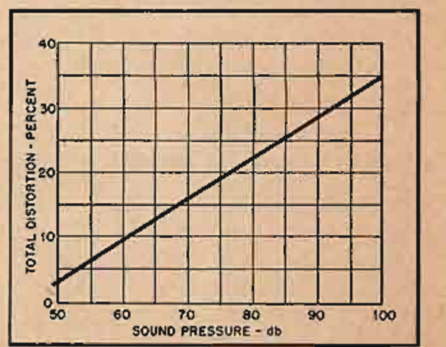


Fig. 13. Harmonic distortion of the human hearing system at 1000 cps. Includes harmonics from second to fifth, inclusive.

toleration by family and neighbors. As *Fig. 13* shows, the harmonic distortion of the human hearing system is quite low, less than 3 per cent, at a low sound pressure level such as 50 db.[3] At 80 db, however, the harmonic distortion is high, about 22 per cent, and *intermodulation* distortion components will be present in

[3] Derived from data on subjective tone measurements; Moe, *J. Acous. Soc. Am.*, 1942.

unpleasantly large quantity on complex tones. Many people react unfavorably to high sound levels; it seems rather likely that this is due not just to distorted reproduction but also to distortion in the individual hearing system. If this is so, no amount of improvement in amplifier and speaker fidelity, or other elements in the reproducer chain will sell loud sound to some persons.

Amplifier Power Requirements

It is desirable to have fairly definite knowledge as to the maximum output power requirement of the amplifier needed for the maximum average level of 80-db sound pressure on which the bass compensation previously considered is based. Since the low frequencies will be attenuated much less than the middle and high registers at low-level settings of the volume control, the amplifier will

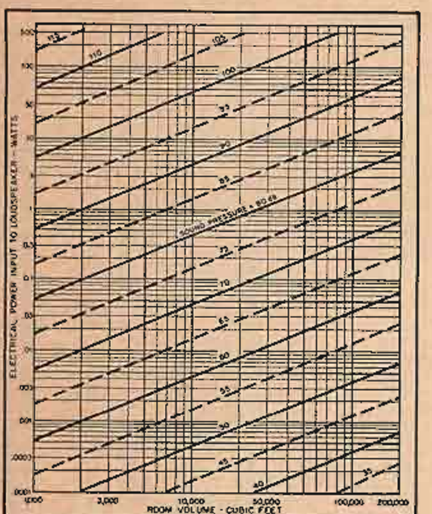


Fig. 14. Loudspeaker power input required for various sound levels, based on 3 per cent efficiency.

be working nearer to full-load conditions than it would without compensation. *Figure* 14 shows the value required for various room volumes,[4] on the basis of a loudspeaker electrical-to-acoustic power conversion efficiency of 3 per cent, which is fairly representative of the average direct radiator or cone loudspeaker installation. It can be seen that a room of 2000 cubic feet volume (for instance, a living room 17 × 13 × 9 feet) will require 0.1 watt electrical power input to the loudspeaker for 80 db level, and 10 watts for peak levels of 100 db sound pressure. This can be 10 watts of maximum "undistorted" output, which generally means about 5 to 10 per cent electrical distortion. A 5-watt amplifier will, of course, produce 97 db instead of 100 db peak level for the same distortion. As *Fig.* 13 shows, hearing distortion is about 35 per cent at 100 db sound pressure level, and the amplifier's 5 or 10 per cent will not be too important.

Input Level Adjustment

Since the compensation is based on 80

[4] Based on data for acoustic power required at 80-db sound intensity; Olson, *RCA Review*, 1936.

db average maximum sound pressure level, the input to the audio amplifier from radio receiver or phonograph-pickup circuits should be adjusted to produce about that output level at maximum output position of the compensated volume control. The curves of *Fig.* 14 will facilitate such adjustment if a standard frequency record (or audio oscillator) and output voltmeter are available. The proper input level is not a highly critical matter, since record and radio program average levels and balance vary. If the loudspeaker conversion efficiency is 1½ or 6 per cent instead of 3, it will produce only plus or minus 3 db error in setting up the level by the curves of *Fig.* 14. A good memory for the way music sounds in the concert hall may not be as unreliable a criterion for adjusting the input level as it may seem offhand.

Conclusions

The author has found that a compensator designed on the basis discussed above is a very desirable addition to a wide-band radio-phonograph system in home use. It appears to make music much more tolerable to the casual listener. Because of this factor of less annoyance to other people who may not particularly wish to listen, proper automatic bass compensation should always be considered for inclusion in entertainment receivers intended for either civilian or military use. The military types generally operate in rather noisy locations with many persons present, and especially need the advantage shown in *Fig.* 12.

The following conclusions have been reached as the result of this study:

(a) Automatic bass compensation, as obtained by combination with the volume control, is highly desirable in entertainment receiver and phonograph equipment.

(b) Because they are plotted on the basis of an arbitrary change in sound pressure or intensity level between curves, the so-called Fletcher-Munson curves do not provide a direct indication of loudness sensation. If a control having a linear rate of change in db of loudness sensation is desired, curves of apparent loudness sensation in the mind versus sound pressure level should be used to determine resistance taper.

(c) An average maximum sound pressure level of 80 db at the listener's ears appears to be a desirable value for designing compensating circuits for entertainment purposes.

(d) It is feasible to include fixed high-frequency compensation to correct for deficiencies in various parts of the reproducing system to a reasonable degree, because the high-frequency response of the human hearing system is substantially constant at the sound pressure levels of interest.

(e) Most engineers interested in sound reproduction and many musicians, if allowed to listen at the levels they prefer, will need reproducing equipment of about 10 times the power rating required by the general public.

LOUDSPEAKER DAMPING

[*from page 13*]

sible to go. The obvious approach is merely to increase the value of R_f until the amplifier oscillates and then back off to a safely stable value. After this has been done the actual values attained may be measured and calculated as shown.

An alternate method of measurement is interesting and useful because of its simplicity and because it may be used to measure either positive or negative values. An a.c. bridge and a resistor are required. The resistor should be somewhat larger than the negative resistance the amplifier is expected to have and should be measured first on the bridge by itself. Then the resistor, bridge, and amplifier are connected as shown in *Fig. 7* and the bridge is balanced.

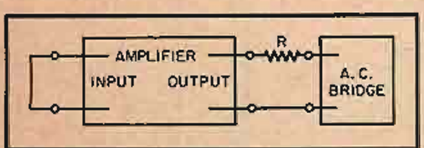


Fig. 7. Set-up for measuring output impedance.

The input terminals of the amplifier are shorted and the only signal source used is that within the bridge. The resistance of the amplifier is the indication of the bridge at balance minus the resistor value.

If, for example, the resistor is 10 ohms and in the circuit of *Fig. 7* the bridge balances at 5 ohms, the amplifier internal resistance is $5-10=-5$ ohms. A positive internal amplifier resistance may be measured simply by connecting the bridge to the amplifier without a resistor and accepting the indication of the bridge at balance.

All of the information given in this article has been checked extensively in the laboratory by independent empirical means. The writer has tried to be careful to include no assumptions that cannot be proved without so labelling them.

While it is true, as has been pointed out by Clements, that improved speaker damping demands a price in some decreased bass, the bass heard before was at least partly due to underdamping and consisted in some part of spurious cone excursions which tended to "compensate" for poor speaker-air coupling at low frequencies. The writer has not been able to detect any bass deficiency but has noticed a decided increase in clean and crisp sound. It is felt, in any case, that allowing a speaker to overshoot to compensate for deficient acoustic coupling between cone and air is a poor way of trying to get something for nothing.

The writer wishes to acknowledge the aid of Richard H. Dorf in organizing this material for publication and in acting as a reverberant sounding board against which to throw the ideas developed on dynamic negative feedback.

Relax and Listen

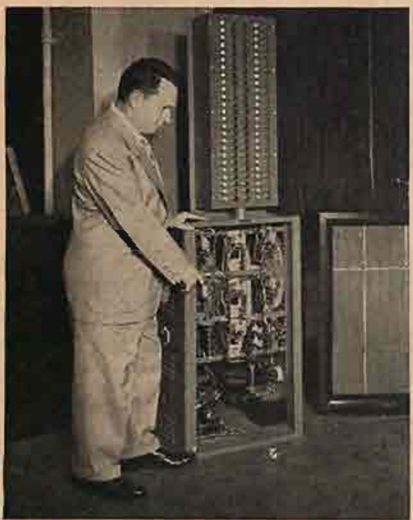
Unique new sound showroom makes selection of equipment an adventure in comfort, with literally hundreds of combinations available to the listener's fingertips from his easy chair.

NEWEST rendezvous in New York for the hi-fi enthusiast is the elaborately equipped sound studio of Hudson Radio and Television Corporation at 48 West 48th Street, in the heart of the Radio City area. Unusual facilities have been provided here for prospective customers to make comparative tests of tuners, amplifiers, speakers, turntables, and phonograph pickups.

Manager Max Baume demonstrates various amplifier-tuner-speaker combinations to a customer, using the small remote-control unit. This device saves salesmen a lot of walking back and forth.

The studio occupies the entire mezzanine floor, independent of the parts-sales floor on street level. Wall-to-wall carpeting, comfortable chairs, and attractive lamps convey a "home atmosphere."

Each equipment position is equipped with input and output jacks and a d.c. operated relay for turning power on and off. Combinations of one input, two amplifiers, and two speakers are set up from a control box in the living-room section. Actual switching is performed by telephone-type stepping switches, and A-B tests between the two amplifiers or speakers are made by relays, also actuated from the control box. Equipment volume controls are preset, and final adjustment of volume is made with a master pot at the remote position. This arrangement is popular with customers because it enables them to make their selections easily. As many as 25 inputs, 50 amplifiers, and 50 speakers can be accommodated, although there aren't that many available models.



Left: Control cabinet for selector system, with cover removed to show inside wiring. Below, left to right: Main bank of tuners and amplifiers along a 22-foot wall, and group of speakers in demonstration cabinets of uniform size and finish along far end of studio.

TRAVELING MIKE

[*from page 16*]

specially constructed differential arrangement.

Ordinary curtain rail serves for the required mono-rail, and fine steel wire supports it throughout its length. Supports are combined with brackets for the pulleys that carry the mike lead across, four such pulleys being shown in *Fig.* 1. Notice that the rail should be erected with a slight arch, to prevent a tendency to buckle with the weight of the mike loading. The best degree of arching can be set up when installing the system, by running the carriage across (with the mike attached) and adjusting the tension of the support wires until mechanical stability is achieved.

The movement of the carriage must be noiseless, as any sounds made by it will be picked up by the microphone. This is achieved by using pulleys with rubber tires fitted as running wheels for the carriage, and also for the small wheels of the differential arrangement. Take care in construction that all wheels run freely and without being able to touch the chassis so as to scrape when traveling.

Figure 2 shows the construction of the differential in the carriage. When the carriage traverses, the stationary rotation control cord causes the differential pulleys to rotate in opposite directions. The microphone spindle is anchored to the differential hub, so no rotation of the mike is caused by this traverse action. But when the rotation control cord is moved by its control knob, both differential pulleys rotate in the same direction, thus rotating the differential hub and the microphone coupled to it. It is important to see that the microphone mounting is positively anchored to the spindle, and the spindle to the differential hub, as these points take the full weight of the mike.

Payout and hauling in of the mike lead is coupled to the carriage movement by means of the large pulleys in the main pulley system shown in *Fig.* 3 at the control side. These are locked to the same shaft so that the mike cable moves with the traverse cord. The mike lead is kept in close contact with its drive pulley by means of two jockey pulleys mounted inside the cover of the pulley system housing. This arrangement ensures that the connecting cable requires no attention. A bracket is fitted to the side of the mike carriage to drop the mike lead into the bearer pulleys provided at intervals along the rail to carry it. *Figure* 4 shows how this works.

Operation

Control is two handed, but the mike stays put in any position so that the hands are not "tied to the controls." The right hand controls rotation of the mike head by means of a knob carrying a pulley for the endless cord operating the differential "gear" in the carriage. The left hand moves the carriage back and forth by raising and lowering a conveniently placed handle. This handle, in conjunction with the rail terminal fixing and the floor fixture below it, carries a pulley system to step up the foot or so of vertical movement (which is all that is comfortably available by moving a handle vertically) to a horizontal movement covering the whole length of the rail. *Figure* 3 clarifies this system, all except the essential pulleys and cord being omitted in the interests of clarity.

All types of cord are slightly elastic, although a cord giving a good combination of strength with pliability should be

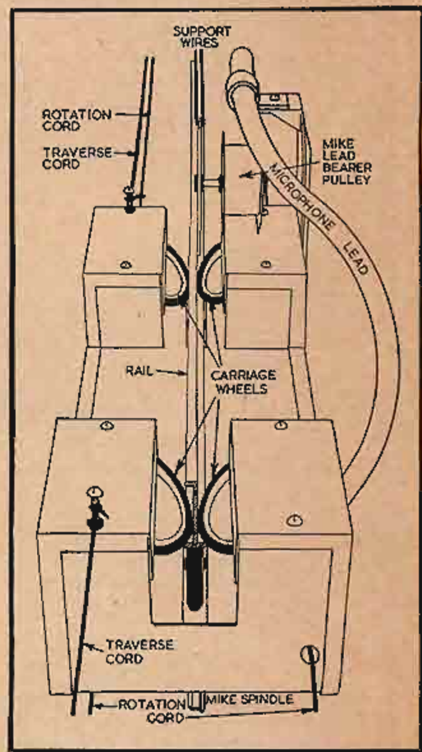


Fig. 4. End view of the microphone carriage on a section of monorail, to illustrate how the mike-lead clamp lays the lead in the bearer pulleys mounted on the rail supports.

chosen. It should be quite flexible, yet with little stretch. The residual possibility of stretching means that precautions must be taken to prevent cords from leaving their pulleys when tension in one place due to movement allows slackness to appear elsewhere. Lengths of tension spring are included in each cord to take up this slack automatically. Three springs are required, one for each of the three lengths of cord in the system. The "endless" rotary control cord has one, to connect together its two ends. The other two cords make up an "endless" arrangement, with the carriage inserted at one point and the control handle virtually at another. (Actually there are two ends, anchored at top and bottom of the pulley multiplying system, but if the drive were direct, i.e. so both handle and carriage moved at the same rate, the system would be truly "endless"). A spring is inserted in each of the ends of these cords, one to take up slack when pulling one way, and the other for pulling the other way.

In the traverse operation, even with springs, it would be possible to produce slack by pulling too hard in either direction, so one spring would extend more than intended and the other would completely relax. To avoid this possibility, limiting wires are added to the back and forth springs, so that they cannot be overstretched to the point where the other cord would become slack. This arrangement gives particularly smooth operation, with freedom from trouble.

All the parts, with the exception of the various pulleys, the monorail, and the mike itself, are constructed quite simply from sheet metal, using a little amateur tinsmith's art. The pulleys, rubber tires, and their spindles can be purchased as spares for any of the variety of toy construction kits on the market.

LINEAR-SCALE AF WATTMETER

[*From page 17*]

couple meters are not designed to stand much overload—probably not over 10 per cent at the most. Therefore, care should be taken to set the load switch to 16 ohms for a few initial measurements to make sure that the amplifier could not exceed the 32-watt level—with the leads being connected to the appropriate 16-ohm output terminals. If it is found that the amplifier output does not exceed 32 watts, the leads may be reconnected to the 8-ohm terminals and the more expanded scale employed.

Applications

Most steady-state measurements are made with a fixed output power for a period of time; i.e. the duration of the measurement is sufficient for the sluggish action of a thermocouple meter. Such a meter would not be suitable for any kind of program material because it is incapable of following the audio envelope at all closely. In making a series of IM measurements it has become standard practice to start at the maximum output power expected—or determined by measurement—and to progress downwards in power output, making distortion measurements at 1-watt intervals. This avoids the need for reducing the calibration setting before making each successive power-output increase. By starting at the top and reducing the power watt by watt, the calibration control is advanced slightly with each change in output.

Spot checks with an a.f. voltmeter have shown the thermocouple meter to be accurate within the needs of production testing, and the added convenience of direct output-power indications on a linear scale have made the additional investment for the meter well repaid in time saved.

AES News

The Third Lecture Series given by the Audio Engineering Society began on January 10 with H. H. Scott's paper on "The Amplifier and its Place in the Circuit—A Survey." W. R. Ayres gave the second lecture on "Power and Voltage Amplifiers" on January 17, and attendance was around 100 at both meetings.

Availability of lecture notes on this series will be announced at the close of the six-week course.

The Los Angeles Section of the AES recently elected new officers. Those chosen to serve during 1952 were: Boyd McKnight, Chairman; Richard Hastings, Vice-Chairman; Carl Shipman, Secretary; and Western Vice-President Howard Tremaine as Secretary.

Frank Gilbert of Stephens Manufacturing Company provided the technical portion of the December 18th meeting with a talk and demonstration of a new, small wireless microphone for use in TV and movie studios.

Employment Register

Positions open and Available personnel may be listed here at no charge to industry or to members of the Society. For insertion in this column, brief announcements should be in the hands of the Secretary, Audio Engineering Society, P. O. Box 12, Old Chelsea Station, N. Y. 11, N. Y., before the fifth of the month preceding the date of issue.

★ Positions Open • Positions Wanted

★ **Salesman.** For leading distributor of sound and recording equipment in metropolitan New York area. Box 201, AUDIO ENGINEERING.

★ **Repairman** for tape and disc recording equipment. Full or part time. Box 202, AUDIO ENGINEERING.

★ **Engineers.** White Sands Proving Ground needs several engineers of all types immediately, with excellent opportunities in research, engineering, and development on guided missiles and component parts. Classifications needed are: civil or mechanical, GS-11, $5940; electrical, GS-9, $5060; mechanical, GS-5, $3410; electronic (general), GS-9, $5060; mechanical GS-7, $4205; electronic (2) GS-11, $5940; mechanical, GS-11, $5940; engineers, all options, GS-5 and GS-7, $3410 and $4205; All salaries on per annum basis. Send Standard Application Form 57, obtainable at any Post Office of Civil Service Board of Examiners to Civilian Personnel Office, Ordnance Corps, at White Sands Proving Ground, Las Cruces, New Mexico.

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ELECTRO-VOICE "Slim-Jim" Professional Microphone, Model 655, cost $120—your price $95. Matched pair Pickering Diamonds, 78 and 33, cost $60—your price $45. Gray Model 602 Professional Equalizer, cost $49.50—your price $35. Above are all brand new, unused. Money orders only, f.o.b. New York. R. Bennis, Box CF-1, AUDIO ENGINEERING.

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TAPE RECORDER—Twin-Trax, ACA Model 540C. Automatic two-way switchover system for two rack-mounted Twin-Trax chassis. 4-in. VU meter, dubbing amplifier for copying tapes. 1 year old, excellent condition. Original cost $842; will accept best offer. Mr. Salerno, 65 Tonnele Ave., Jersey City, N. J. Henderson 5-6365.

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FOR SALE: Presto RC-10-14 recorder (three motors, hysteresis motor on capstan), 900-A-1 Amplifier, revolution counter, all on 4-ft. rack on casters; E-V 645 microphone, stand. 30 hrs. use, all in excellent condition. $1100 value for $725. Phone TRafalgar 9-7290, New York City, or Box CF-1, AUDIO ENGINEERING.

PRESTO 900R1 Tape Recording Mechanism, $325. RCA 15-watt P.A. amplifier, $60. Transcription arm with new G.E. cartridge, $25. Pilotuner and Presto AM tuner, $90. Reco-Art, 1305 Market Street, Philadelphia, Pa.

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RADIO MAGAZINES, INC.
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New York 17, N. Y.

Book Review

Make Music Live, by Irving Greene, James R. Radcliffe, and Robert Scharff. 256 pp. New York: Medill McBride Company, Inc., $4.50.

Covering the entire subject of high-fidelity reproduction of music in the home, this is the first volume directed entirely to the non-technical reader who has succumbed to the desire for better sound quality. The first four chapters are devoted to a description of the four basic elements of the home system—record player, tuner, amplifier, and loudspeaker—followed by a discussion of speaker enclosures and their requirements for good reproduction over the entire audio spectrum. The next five chapters cover the planning of the physical layout of the home system, with practical ideas for installation in bookshelves or other furniture elements, and another chapter covers the construction and fininshing of home-built cabinetry. The authors also discuss tape recorders, primarily from the viewpoint of the person who plans to assemble these units into a present or projected system. A glossary of hi-fi terms is included, along with chapters on High-Fidelity Records by Walter Grueninger, record reviewer for Consumers' Research, Inc., and on Tonal Quality and Fidelity by Peter Hugh Reed, editor of *American Record Guide*.

The book is recommended reading for the non-technical person who wishes to assemble a home music system for his own use, since it is full of valuable pointers on "how-to-do-it." It is not a book which would interest the technically minded individual who enjoys building the various components—the kind of person who is usually called an "audio hobbyist."

Industry People

R. S. Fenton, vice-president, announces appointment of Floyd J. Van Alstyne as Jobber Sales Manager of Permoflux Corporation. . . . **Arthur Priest** announces resignation as ad manager of Leonard Radio, Inc., New York—future plans will be announced soon. . . . **George Silber,** president of Rek-O-Kut, combining business with pleasure in trip to Florida with family (Ed's note: How he do dat?). . . . **Dr. Ralph Bown,** director of research for Bell Telephone Laboratories since 1946, elevated to vice-presidency. . . . **Herman Holstein** has resigned as ad manager of Lafayette Radio, Inc., New York. . . .

Kenneth Boothe, Audio & Video Products Corp. exexc, announces appointment of **Paul Baran** as field engineering representative. . . . Promotion of **Philip Barnes** to director of the sales division of Weston Electrical Instrument Co. is announced by **Earl R. Mellon,** president. . . . **Dr. A. W. Friend** has joined Magnetic Metals Co., Camden, N. J., as director of engineering and research. . . . U. S. Chamber of Commerce has expanded radio and television services with **George H. Sandefer,** formerly of NBC, as director. . . .

New manager of sales operations for RCA Tube Department is **Douglas Y. Smith,** eligible for a quarter-century pin in RCA service. . . . **R. N. Kellogg, Jr.** is new advertising director of Burlingame Associates, New York. . . . **Henry C. Roemer,** v.p. of Federal Telephone and Radio Corp. since 1950, has been elevated to presidency. . . . **Frank Robbins** and **Bill Joseph,** co-inventors of the R-J Speaker, are literally swamped with letters asking when and where the unit will be available. . . . **Rudy Bozak,** president, R. T. Bozak, Inc., Buffalo, N. Y., beaming at results of recent tests of Bozak speaker by a well-known Eastern university.

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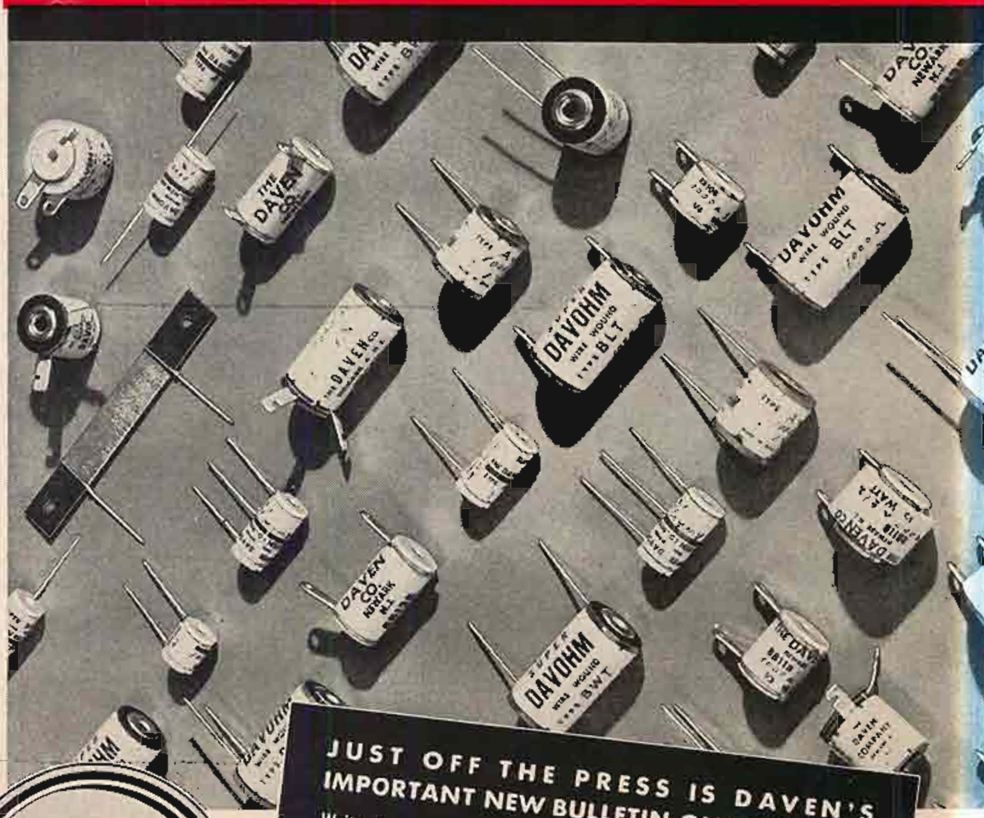

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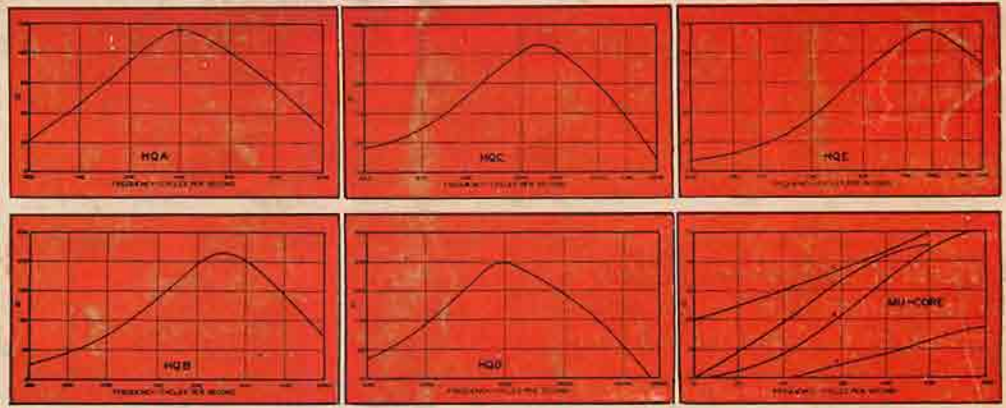

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HQA-4	30 mhy.	7.50	HQB-1	10 mhy.	16.00	HQC-4	10 mhy.	13.00
HQA-5	50 mhy.	8.00	HQB-2	30 mhy.	16.00	HQC-5	20 mhy.	13.00
HQA-6	80 mhy.	8.00	HQB-3	70 mhy.	16.00	HQD-1	.4 mhy.	15.00
HQA-7	125 mhy.	9.00	HQB-4	120 mhy.	17.00	HQD-2	1 mhy.	15.00
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HQA-9	300 mhy.	10.00	HQB-6	1. hy.	18.00	HQD-4	5 mhy.	15.00
HQA-10	.5 hy.	10.00	HQB-7	2. hy.	19.00	HQD-5	15 mhy.	15.00
HQA-11	.75 hy.	10.00	HQB-8	3.5 hy.	20.00	HQE-1	5 mhy.	6.00
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HQA-13	2. hy.	11.00	HQB-10	12. hy.	22.00	HQE-3	50 mhy.	7.00
HQA-14	3. hy.	13.00	HQB-11	18. hy.	23.00	HQE-4	100 mhy.	7.50
HQA-15	5. hy.	14.00	HQB-12	25. hy.	24.00	HQE-5	200 mhy.	8.00

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FILTER CASE M
1 3/16 x 1 11/16,
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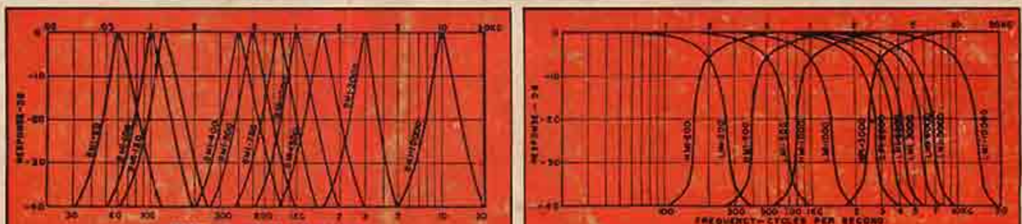

These U.T.C. stock units take care of most common filter applications. The interstage filters, BMI (band pass), HMI (high pass), and LMI (low pass), have a nominal impedance at 10,000 ohms. The line filters, BML (band pass), HML (high pass), and LML (low pass), are intended for use in 500/600 ohm circuits. All units are shielded for low pickup (150 mv/gauss) and are hermetically sealed.

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(Number after letters is frequency)
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BMI-400	HMI-200	LMI-2000	HML-500
BMI-500	HMI-500	LMI-3000	LML-1000
BMI-750	HMI-1000	LMI-5000	LML-2500
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